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Respirable Dust Control in Grinding Gray Iron Castings

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High speed grinding of gray iron castings long has been associated with excessive exposure to crystalline silica. Not all workers engaged in these operations are protected by conventional ventilation techniques. Dust in the air that has been entrained by the spinning grinding wheel and not captured in the grinder hood has been postulated to be a major exposure source. A pilot grinding operation was constructed, and the size distribution and concentration of airborne particles were measured with the aerodynamic particle sizer (APS). Various control measures proved effective in reducing the respirable dust concentration: increased exhaust ventilation, and installation of baffles and/or the use of an air jet to deflect the entrained air stream. The concentration of respirable dust in the breathing zone was reduced approximately 20-fold through the combined use of increased ventilation, interior baffles, and an air jet. The air jet and baffle utilized at the base ventilation rate reduced the respirable dust concentration by a factor of three to four, whereas the baffle alone halved the concentration.

Introduction

High speed grinding of gray iron castings long has been associated with excessive exposure to crystalline silica. Recent environmental studies suggest a continuing overexposure to free silica for workers engaged in grinding.⁽¹⁻³⁾ These studies indicate that from 25% to 50% of grinding personnel are exposed to free silica in excess of the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL).

Pedestal-mounted or stand grinders are used in the cleaning rooms of foundries to remove gate and riser connections and parting line fins from castings. The grinding operation produces a dust cloud in the breathing zone of the operator. The major dust hazard in grinding gray iron castings arises from the molding sand that adheres to the casting surface. Even when castings have been cleaned well by blasting with steel shot, the surface still will contain some silica from the molding sand.⁽⁴⁾ When the casting is ground, this silica is shattered and part of it becomes airborne.

Grinding dust can be classified according to its behavior into primary and secondary dust streams.⁽⁵⁾ Large particles leave the wheel more or less tangentially from the point of contact with the casting. If this point of contact is close to the workrest, these particles descend into the hopper of the machine. If the point of contact is some distance above the workrest, some of the particles will be deflected by the workrest into the general workroom atmosphere. Small particles separate more slowly from the surface of the wheel, but some still are large enough to escape from the wheel and be exhausted from the hopper. The dust particles that separate from the wheel and strike the workrest or collect in the hopper and those present in the air that is exhausted from the hopper are referred to as the primary dust stream. The small particles that do not separate appreciably from the wheel are referred to as the secondary dust stream. The layer of entrained air containing these particles is stripped from the wheel by the casting. Once it has been stripped from the

grinding wheel, it moves across the top of the casting with considerable velocity and is deflected by the operator's body into his breathing zone.

The objective of this study was to determine the significance of the secondary dust stream as an exposure source and to investigate possible control measures, by real-time measurement of the concentration and size distribution of grinding dust directly in the air stream entrained by the grinding wheel.

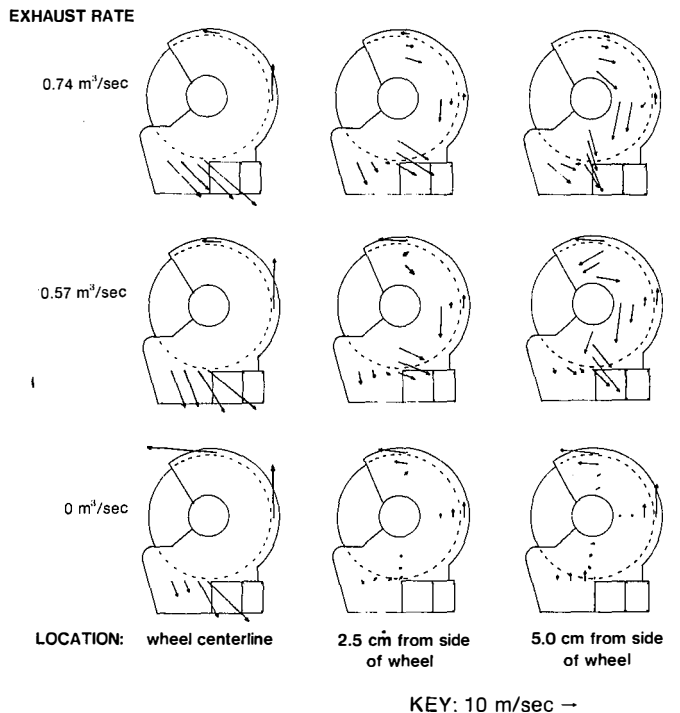


Figure 1 — Air velocity vectors within the grinding enclosure in the plane of the wheel centerline and at planes 2.5 and 5.0 cm from the wheel side (76 cm diameter wheel, 63.5 m/sec wheel surface speed).

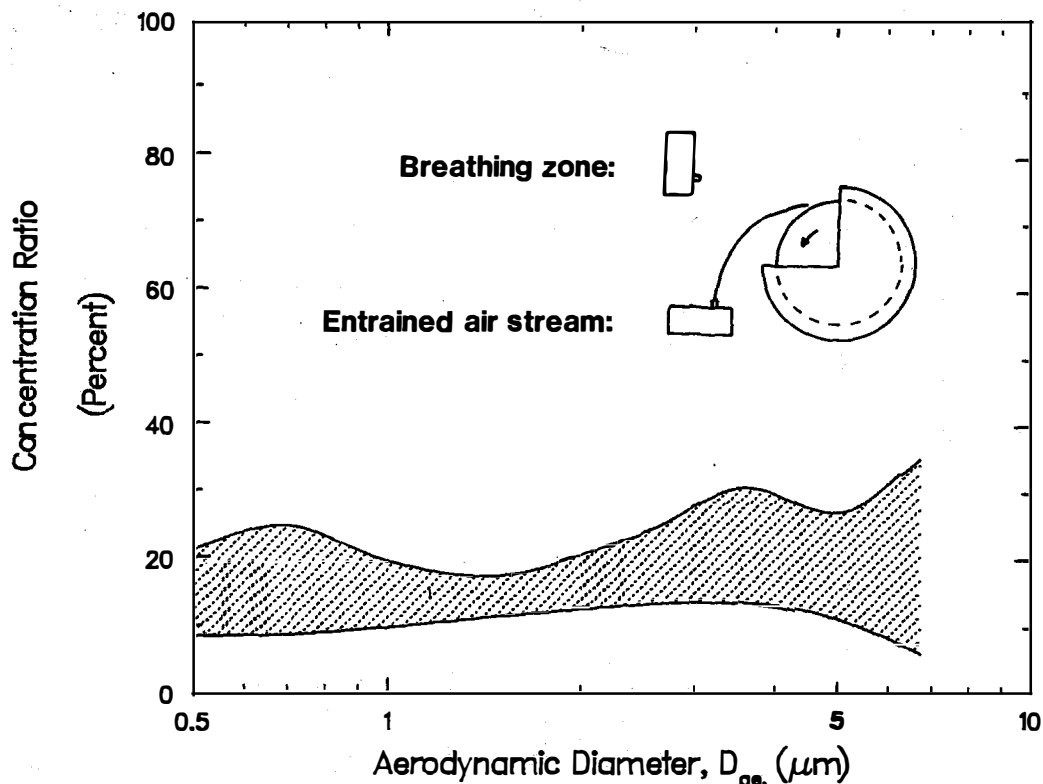


Figure 9 — Comparison of entrained air and breathing zone size spectra. (Concentration ratio: breathing zone/entrained air).

Grinding rate, wheel surface speed and type of control are three factors cited as affecting dust control in stand grinding.⁽⁴⁾ Number spectra obtained in the entrained air stream at grinding rates of 1.9, 3.4, 4.1 and 5.0 g/sec are plotted in Figure 3. Increasing the grinding rate increases the number of particles and median particle size.

Dust control is more difficult with 63.5 m/sec (12500 fpm) grinders than with ones operated at 48.3 m/sec (9500 fpm).⁽⁴⁾ Use of a 0.61 m (24 in.) diameter wheel allowed operation over a range of speeds from 50 m/sec to 62 m/sec (9800 to 12200 fpm). Number spectra obtained in the entrained air stream at these wheel speeds are plotted in Figure 4. Particle number concentration increases as the wheel surface speed increases. Particle size appears to decrease slightly as the wheel surface speed increases. In this series of experiments, sampling conditions deviated from isokinetic. If corrections for worst case sampling errors are made,⁽⁸⁾ the number concentration becomes essentially independent of wheel surface speed; however, since the volume of entrained air increases with wheel surface speed, the mass flux of particles also would increase.

The type of control is a third parameter cited as affecting the dust generated in stand grinding.⁽⁴⁾ Number spectra obtained in the entrained air stream at exhaust ventilation rates of 0.49, 0.57, 0.67, 0.75 and 0.88 m³/sec (1030, 1200, 1410, 1580 and 1850 cfm) are plotted in Figure 5. Particle number concentration decreases as exhaust ventilation rates increase. Particle size appears to decrease slightly as the exhaust rate increases.

The Steel Castings Research and Trade Association of the United Kingdom has proposed the use of baffles between the grinder body and the wheel to minimize air entrainment.⁽⁹⁾ Another method of disrupting the entrained airflow is to deflect it by means of a high velocity air jet mounted perpendicular to the direction of flow. Positioning the jet or baffle as close as possible to the exhaust takeoff will minimize the chances of particle reentrainment. Installation of a baffle and air jet is depicted in Figure 6. In this experiment air for the jet was supplied through an absolute filter to avoid the introduction of any particles not produced from grinding. Since the filter limited flow to 200 Lpm (corresponding to a nozzle velocity of 95 m/sec), no attempt was made to optimize the flow rate. In a prototype installation it would be necessary to have either the baffle or the jet coupled to the speed control linkage so that their position would change as the wheel decreased in size. Number spectra obtained in the entrained air stream with and without the addition of the baffle are plotted in Figure 7. Number spectra obtained in the entrained air stream with and without the addition of the air jet are plotted in Figure 8. Both particle number concentration and particle size decrease with use of the baffle or the air jet. Both the baffle and the air jet produced lower dust levels than the unmodified grinder.

Number spectra obtained in the entrained air stream and in a position representative of an operator's breathing zone are compared in Figure 9. The comparison is performed by dividing the number concentration for each size interval of one spectrum by the number concentration for the corresponding size interval of the second spectrum. The 95% con-

TABLE I
Breathing Zone Concentrations of Respirable Mass
for Various Control Scenarios

Condition			Normalized Respirable Mass (mg/m ³)	Standard deviation (mg/m ³)
Exhaust (m ³ /sec)	Air Jet	Baffle		
0.57	No	No	0.39	0.078
0.57	No	Yes	0.18	0.049
0.57	Yes	Yes	0.11	0.055
0.90	Yes	Yes	0.02	0.010

fidence interval of the resulting ratio is plotted in Figure 9 as a function of particle size. The particle number concentration in the breathing zone is about an order of magnitude lower than in the entrained air stream, and the ratio appears to be independent of particle size.

The rate of exhaust ventilation was increased, baffles were added to reduce the amount of air entrainment, and an air nozzle was used to deflect the particle stream in order to achieve reductions in the particle number concentration in the entrained air stream. These same control techniques were reapplied singly and in combination to estimate the reductions in the concentration of respirable mass in the breathing zone that might be achieved. Size distributions based on particle mass can be calculated from number distributions with assumption of particle sphericity and uniform density. (A density of 2.6 g/cm³ was used in the calculations.)¹⁰ The respirable dust concentration can be calculated from the mass distribution by multiplication of the mass concentration for each size interval by the ACGIH⁽¹¹⁾ respirable dust criteria and addition of the results. Since a decline in the production of respirable dust of about 4% for each 10 sec of accumulated grinding time was observed (Figure 2), respirable dust concentration in each set of measurements were normalized for this wheel deterioration by use of a correction factor based on the observed decline. Respirable mass concentration data from four control scenarios are presented in Table I. Significant differences were observed for each control scenario. Differences were determined to be significant (p=0.05) by a Student's t-test, assuming that the variances of the measurements for each control scenario were both unknown and unequal. An approximately 20-fold reduction in the concentration of respirable mass in the breathing zone was achieved through the use of increased ventilation, interior baffles and an air jet. The air jet and baffle utilized at the base ventilation rate (0.57 m³/sec) combined to reduce dust levels by a factor of three to four, whereas the baffle with no air nozzle halved the concentration. The breathing zone dust reductions achieved by the baffle and air jet were comparable to those obtained in the entrained air stream. The reduction in the breathing zone achieved by the increased ventilation rate was more than would have been predicted by the measurements made in the entrained air stream. This factor can be attributed to the higher capture velocities outside of the grinder enclosure and to the increased effectiveness of the baffles at the higher flow rate.

Conclusions

Contamination of the breathing zone can occur by deflection of the entrained airstream by either the casting or the worker's body. Measurements in the entrained air stream confirm that this air stream does contain fine particles; the concentration becomes hygienically significant if the quartz content of the dust exceeds about 2.5%. Comparison of the size spectra of the particles in the breathing zone with those in the entrained air stream demonstrates the similarity of these two size distributions.

Results in a production setting may differ in magnitude from those reported here. Production variables not addressed in this study include the worker's technique, the size and shape of the casting, the cleanliness of the casting surface, and the room air currents within the foundry. All might alter the effectiveness of the controls studied herein.

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References

1. **Zimmerman, R.E. and J.M. Barry:** Determining Crystalline Silica Compliance Using Respirable Mass. *Trans. Am. Foundrymen's Soc.* 84:15-20 (1976).
2. **National Institute for Occupational Safety and Health:** *An Evaluation of Occupational Health Hazard Control Technology for the Foundry Industry* by R. Scholz (NIOSH Pub. No. 79-114). Cincinnati, Ohio: NIOSH, 1979.
3. **Oudiz, J., J.W. Brown, H.E. Ayer and S. Samuels:** A Report on Silica Exposure Levels in United States Foundries. *Am. Ind. Hyg. Assoc. J.* 44:374-376 (1983).
4. **National Institute for Occupational Safety and Health:** Some Design Criteria for Reducing Dust During the Cleaning and Finishing of Iron Castings. In *Proceedings of the Symposium on Occupational Health Hazard Control Technology in the Foundry and Secondary Nonferrous Smelting Industries* by F. Shaw (NIOSH Pub. No. 81-114). Cincinnati, Ohio: NIOSH, 1981.
5. **Higgings, R.I. and J.A. Bright:** British Cast Iron Research Association System on Dust Control for a High Speed Pedestal Grinder. *Foundry Trade J.*: 73-77 (1971).
6. **Seymour, J.:** Personal communication with the Norton Company, 1981.
7. **Willeke, K. and K.T. Whitby:** Atmospheric Aerosols: Size Distribution Interpretation. *JAPCA* 25:529-534 (1975).
8. **Hinds, W.C.:** *Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles.* New York: Wiley-Interscience, 1981. p. 191.
9. **Radia, J.T.:** "Dust and Fume Control for Cleaning and Finishing Operations in Foundries." Paper presented at the AFS-CMI Conference *Cleaning Room Technology — An Update for the 80s.* Rosemount, Ill., 14-15 October 1981.
10. **O'Brien, D., P. Baron and K. Willeke:** Size and Concentration Measurement of an Industrial Aerosol. *Am. Ind. Hyg. Assoc. J.* 47:386-392 (1986).
11. **American Conference of Governmental Industrial Hygienists:** *Threshold Limit Values.* Cincinnati, Ohio: ACGIH, 1984.

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