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J. S. Kinsey

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MRI REPORT

Assessment of Outdoor Abrasive Blasting

Interim Report

For Office of Air Quality Planning and Standards (MD-61)
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Attn: Charles C. Masser

EPA Contract No. 68-02-4395
Assignment No. 29
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September 11, 1989

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PREFACE

This report was prepared for the Office of Air Quality Planning and Standards (OAQPS), U.S. Environmental Protection Agency (EPA), under EPA Contract No. 68-02-4395, Assignment No. 29. Mr. Charles Masser was the requester of the work. The report was prepared by Mr. John Kinsey, Principal Environmental Scientist.

Approved for:

MIDWEST RESEARCH INSTITUTE

Chatten Cowherd, Director
Environmental Systems Department

September 11, 1989

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SECTION 1

INTRODUCTION

On July 1, 1987, the U.S. Environmental Protection Agency (EPA) promulgated a National Ambient Air Quality Standard (NAAQS) for PM_{10}* which triggered requirements for developing State Implementation Plans (SIPs). In response to those requirements, several local agencies have expressed concern about outdoor abrasive blasting emissions and the associated PM_{10} component. Specific questions have also arisen concerning the magnitude of airborne lead emissions from lead-painted surfaces being cleaned by abrasive blasting.

To address the above concerns, this project was initiated with the intent of developing uncontrolled TSP, PM_{10}, and lead emission factors for outdoor abrasive blasting (with emphasis on lead-based painted structures) if available data are sufficient to support such emission factors. This report summarizes the results of a literature review and subsequent data analysis of published test data for outdoor abrasive blasting. Based on the contents of this report, EPA will decide whether existing data are adequate to support emission factor development or whether additional research is required.

The remainder of the report is organized as follows:

- Section 2--Process Description
- Section 3--Literature Review and Data Analysis
- Section 4--Conclusions and Recommendations

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* PM_{10} is defined as particulate matter having an aerodynamic diameter of less than 10 μm.

SECTION 2

PROCESS DESCRIPTION

The following sections briefly describe the types of abrasives, blasting methods, and dust control techniques commonly used in outdoor abrasive blasting. More detailed information can be found in References 1 through 6 listed in Section 5.

2.1 TYPES OF ABRASIVES

Abrasive materials are generally classified as: sand, metallic shot or grit, or other.[1] The cost and properties associated with the abrasive material dictate its application. The following discusses the general classes of common abrasives.

Sand is the least expensive abrasive material. It is commonly used where reclaiming is not feasible such as in unconfined abrasive blasting operations. Sand has a rather high breakdown rate which can result in substantial dust generation. Synthetic abrasives, such as silicon carbide and aluminum oxide, are becoming popular substitutes for sand. Although the cost of synthetic abrasives are three to four times that of silica sand, they are more durable and have a lower tendency to create dust. Synthetic materials are predominantly used in blasting enclosures and some unconfined blasting operations where abrasive reclaiming is employed.

Metallic abrasives are made from cast iron and steel. Cast iron shot is hard and brittle and made by spraying molten cast iron into a water bath. Cast iron grit is produced by crushing the oversize and irregular particles formed during the manufacture of cast iron shot. Steel shot is produced by blowing molten steel. Steel shot is not as hard as cast iron shot, but is much more durable. Due to the higher costs associated with metallic abrasives, they are predominantly used in abrasive blasting enclosures with reclaiming equipment.

Glass beads, crushed glass, cut plastics, and nutshells are included in the "other" category. As with synthetic and metallic abrasive materials, they are generally used in operations where the material is reclaimed.

The type of abrasive used in a particular application is usually specific to the blasting method. Dry abrasive blasting is usually done with sand, aluminum oxide, silica carbide, metallic grit, or shot. Wet blasting is usually done with sand, glass beads, or any materials that will remain suspended in water. Table 2-1 lists common abrasive materials and their applications.[1]

2.2 BLASTING METHODS

Typically, all abrasive blasting systems include three basic components: an abrasive container (i.e., blasting pot), a propelling device, and abrasive blasting nozzle(s). The exact equipment used depends on the application.

The three propelling methods used in abrasive blasting systems are: centrifugal wheels, air pressure, or water pressure. Centrifugal wheel systems use centrifugal and inertial forces to mechanically propel the abrasive media.[2] Air blast systems use compressed air to propel the abrasive to the surface being cleaned.[3] Finally, the water blast method uses either compressed air or high pressure water.[4] The most popular systems use either air pressure or water pressure to propel the abrasive material. Therefore, only these methods will be described.

The compressed air suction, the compressed air pressure, and the wet abrasive blasting systems utilize the air blast method. Hydraulic blasting systems utilize the water blast method.

In compressed air suction systems, two rubber hoses are connected to a blasting gun. One hose is connected to the compressed-air supply and the other is connected to the bottom of the abrasive supply tank or "pot".

TABLE 2-1. MEDIA COMMONLY USED IN ABRASIVE BLASTING[a]

Type of medium	Sizes normally available	Applications
Glass beads	8 to 10 sizes from 30- to 440-mesh; also many special gradations	Decorative blending; light deburring; peening; general cleaning; texturing; noncontaminating
Aluminum oxide	10 to 12 sizes from 24- to 325-mesh	Fast cutting; matte finishes; descaling and cleaning of coarse and sharp textures
Garnet	6 to 8 sizes (wide-band screening) from 16- to 325-mesh	Noncritical cleaning and cutting; texturing, noncontaminating for brazing steel and stainless steel
Crushed glass	5 sizes (wide-band screening) from 30- to 400-mesh	Fast cutting; low cost; short life; abrasive; noncontaminating
Steel shot	12 or more sizes (close gradation) from 8- to 200-mesh	General-purpose rough cleaning (foundry operation, etc.); peening
Steel grit	12 or more sizes (close gradation) from 10- to 325-mesh	Rough cleaning; coarse textures; foundry welding applications; some texturing
Cut plastic	3 sizes (fine, medium, coarse); definite-size particles	Deflashing of thermoset plastics; cleaning; light deburring
Crushed nutshells	6 sizes (wide-band screening)	Deflashing of plastics; cleaning; very light deburring; fragile parts

[a] From Reference 1.

The gun (Figure 2-1a) consists of an air nozzle that discharges into a larger nozzle. The high velocity air jet (expanding into the larger nozzle) creates a partial vacuum in the chamber. This vacuum draws the abrasive into the outer nozzle and expels it through the discharge opening. Figure 2-1b shows a typical suction type blasting machine.

The compressed air pressure system consists of a pressure tank (pot) in which the abrasive is contained. The use of a pressure tank forces abrasive through the blast hose rather than siphoning it as described above. The compressed air line is connected to both the top and bottom of the pressure tank. This allows the abrasive to flow by gravity into the discharge hose without loss of pressure (see Figure 2-2).

Finally, wet abrasive blasting systems (Figure 2-3a) use a specially designed pressure tank. The mixture of abrasive and water is propelled by compressed air. An alternate method uses a pressure tank and a modified abrasive blasting nozzle. This modified abrasive blasting nozzle is shown in Figure 2-3b.

Hydraulic blasting incorporates a nozzle similar to that described above for air suction systems with the exception that high pressure water is used instead of compressed air as the propelling media. A diagram of this type of nozzle is shown in Figure 2-4.

Pressure blast systems generally give a faster, more uniform finish than suction blast systems. They also produce high abrasive velocities with less air consumption as compared to suction systems. Pressure blast systems can operate as low as 1 psig to blast delicate parts and up to 125 psig to handle the most demanding cleaning and finishing operations.[1]

Suction blast systems are generally selected for light-to-medium production requirements, limited space, and moderate budgets. However, suction blast systems can blast continuously without stopping for abrasive changes and refills.[1]

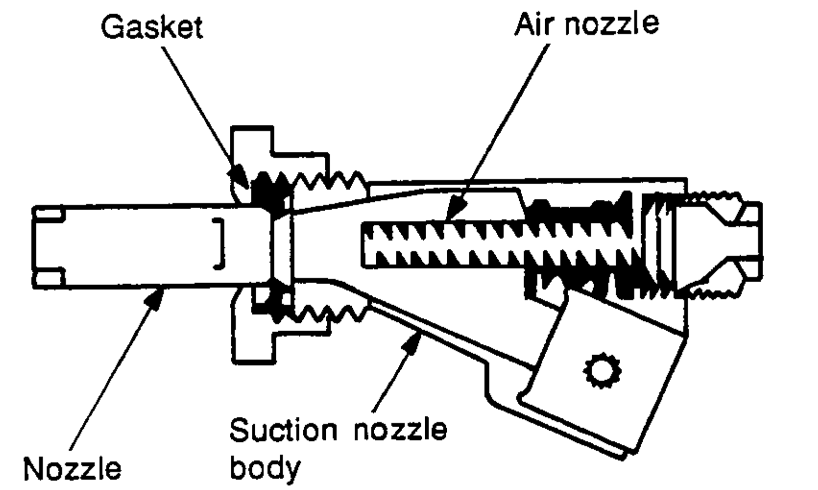

Figure 2-1a: Suction Blast Nozzle Assembly

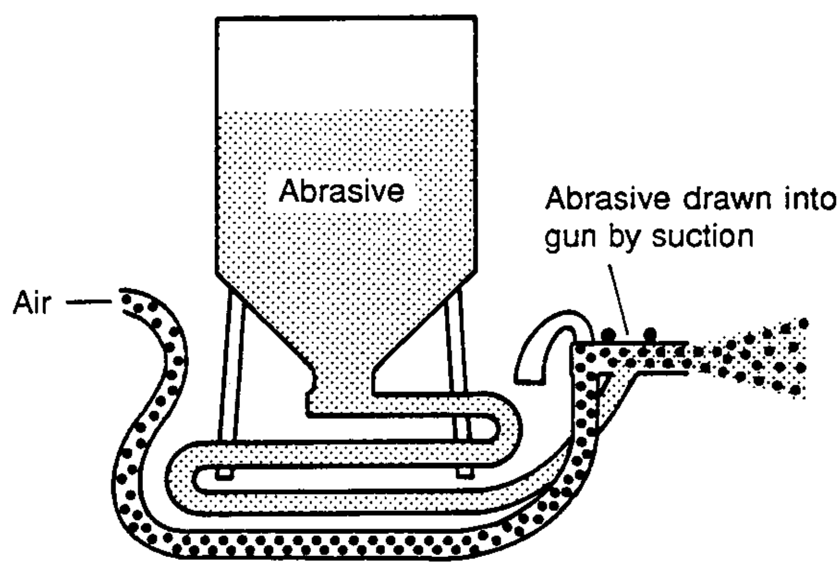

Figure 2-1b: Suction-Type Blasting Machine

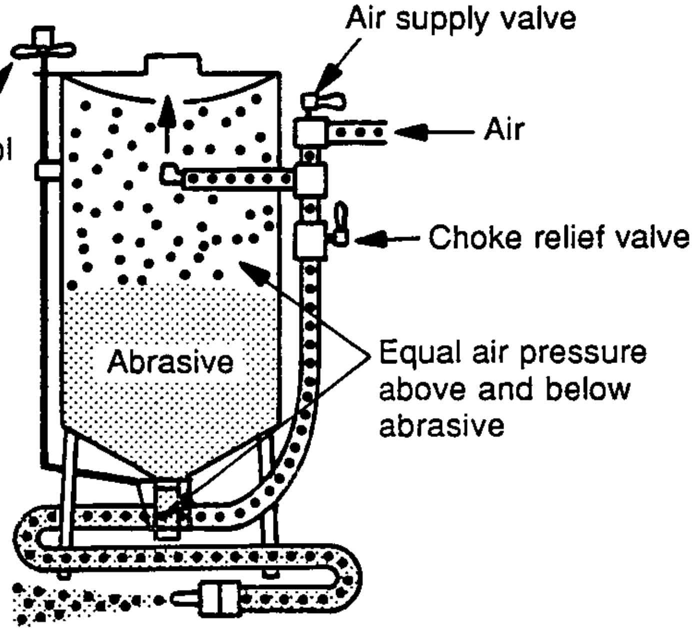

Figure 2-2: Pressure-Type Blasting Machine

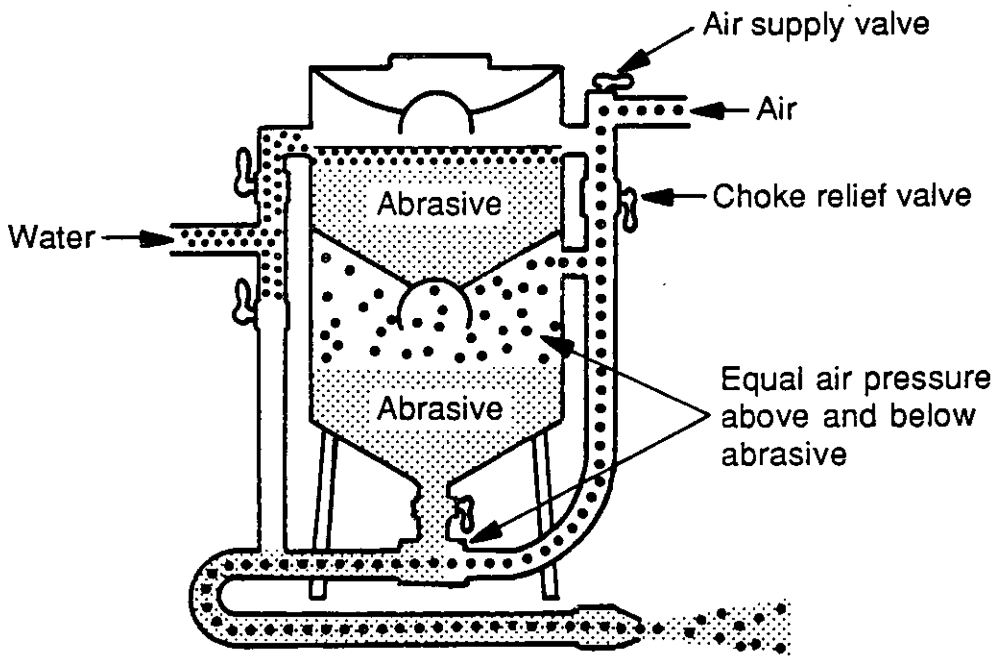

Figure 2-3a: Wet Blasting Machine

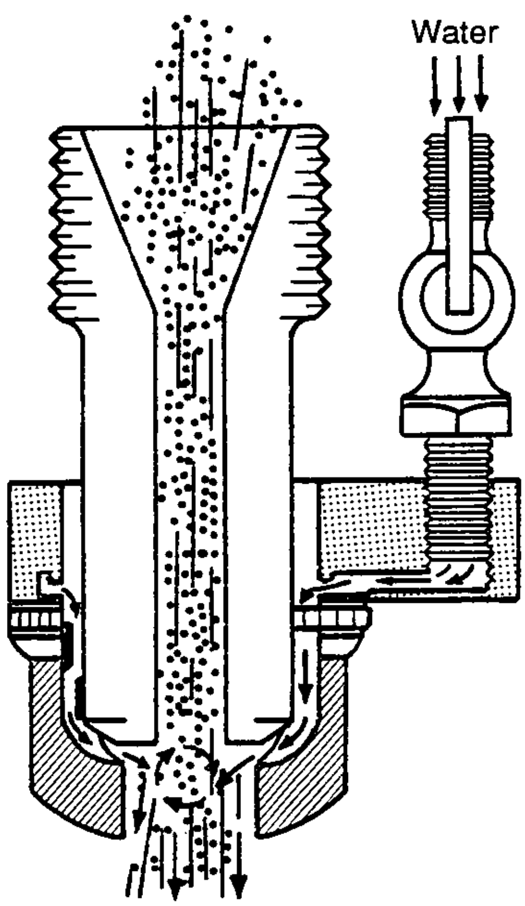

Figure 2-3b: Adapter Nozzle Coverting a Dry Blasting Unit to a Wet Blasting Unit

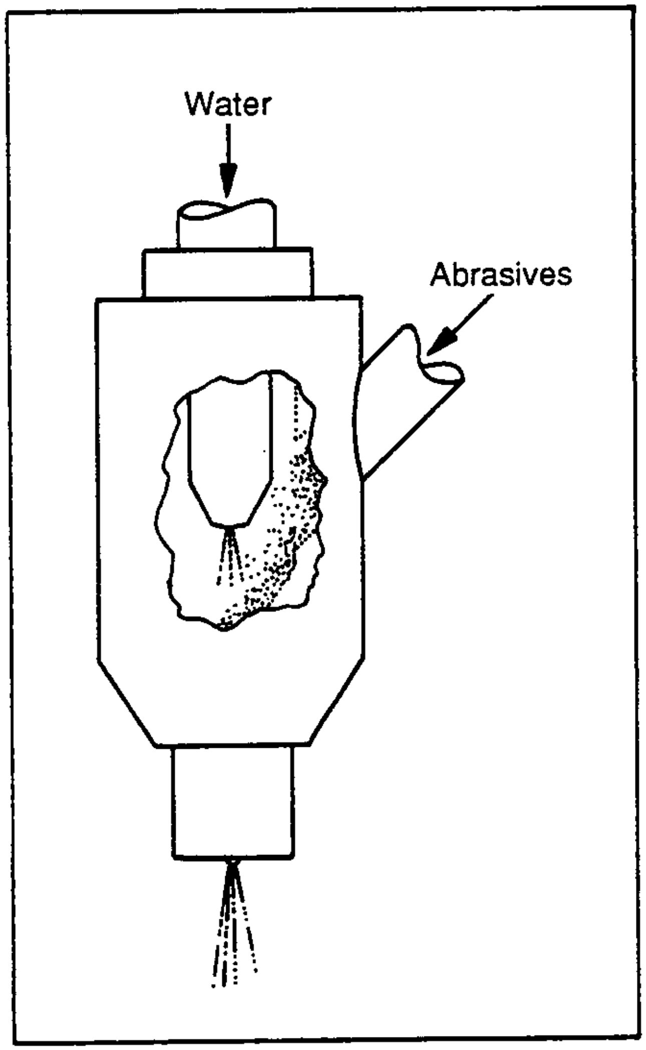

Figure 2-4: Hydaulic Blasting Nozzle

The amount of sand used during blasting operations can be estimated by the use of Table 2-2. By knowing the inside diameter of the nozzle (inches) and the air pressure supplied (psig), the sand flow rate is provided. For different abrasives and nozzle diameters, the following equation can be used:[1]

$$\dot{m}_a = \dot{m}_s \times \frac{(D_a)^2}{(D_s)^2} \times \frac{\rho_a}{\rho_s} \qquad (2\text{-}1)$$

where: $\dot{m}_a$ = mass flow rate (lb/h) of abrasive with nozzle internal diameter D_a

$\dot{m}_s$ = mass flow rate (lb/h) of sand with nozzle internal diameter D_s from Table 2-2

D_a = actual nozzle internal diameter (in)

D_s = nozzle internal diameter (in) from Table 2-2

ρ_s = bulk density of sand (lb/ft^3)

ρ_a = bulk density of abrasive (lb/ft^3)

The density of several different abrasives are shown in Table 2-3.

2.3 DUST CONTROL TECHNIQUES

Although the emphasis of the study was directed towards uncontrolled emissions from abrasive blasting operations, some limited control efficiency data were collected. Therefore, this section will describe various techniques available for the control of dust emissions from such operations. A more detailed discussion of each method can be found in a separate MRI report.[5]

TABLE 2-2. FLOW RATE OF SAND THROUGH A BLASTING NOZZLE AS A FUNCTION OF NOZZLE PRESSURE AND INTERNAL DIAMETER[a]

Nozzle internal diameter (in)	Sand flow rate through nozzle (lb/h)							
	Nozzle pressure (psig)							
	30	40	50	60	70	80	90	100
1/8	28	35	42	49	55	63	70	77
3/16	65	80	94	107	122	135	149	165
1/4	109	138	168	195	221	255	280	309
5/16	205	247	292	354	377	420	462	507
3/8	285	355	417	477	540	600	657	720
7/16	385	472	560	645	755	820	905	940
1/2	503	615	725	835	945	1,050	1,160	1,265
5/8	820	990	1,170	1,336	1,510	1,680	1,850	2,030
3/4	1,140	1,420	1,670	1,915	2,160	2,400	2,630	2,880
1	2,030	2,460	2,900	3,340	3,780	4,200	4,640	4,060

[a] From Reference 1.

TABLE 2-3. BULK DENSITY OF COMMON ABRASIVES[a]

Type of abrasive	Density (lb/ft^3)
Aluminum oxides	160
Sand	99
Steel	487

[a] From Reference 1.

A variety of techniques have been used to contain and recover the debris generated during abrasive cleaning operations. These techniques may be categorized into the following: blast enclosures, vacuum blasters, drapes, water curtains, wet blasters, and centrifugal blasters. Brief descriptions of each are provided below.

2.3.1 Blast Enclosures

Blast enclosures are designed to completely enclose one or more abrasive blast operators thereby confining the blast debris.[5] The enclosure floor is usually equipped with funnels to divert the captured debris into adjacent trucks. In one design, a ventilation system is used to remove the airborne dust from the enclosure with the particles removed from the effluent airstream air by a wet scrubber. The enclosures are moved as the work progresses.

Blast enclosures can be very effective in containing and recovering abrasive blast debris. However, they are specifically designed for a particular application, relatively expensive, and tend to slow down the overall cleaning rate due to the time required to move the enclosure as the work progresses.

Some leakage of abrasive and paint debris can also occur at the joints between the blast enclosure and the structure being cleaned. Although attempts have been made to seal the joints with canvas, this is usually not very effective, particularly when the blast is directed into these areas. A better method to minimize leakage from enclosure joints is to fasten a flexible seal made of rubber, plastic, or thin metal to the inside edges of the enclosure walls. The end of the flexible seal rests on the structure being cleaned, thus reducing the escape of airborne dust.

2.3.2 Vacuum Blasters

Vacuum blasters are designed to remove paint and other surface coatings by abrasive blasting and simultaneously collect and recover the spent abrasive and paint debris with a capture and collection system surrounding the blast nozzle (Figure 2-5).[3] In this type of system, the abrasive is automatically reclaimed and reused as work progresses. Vacuum blasters are made in a variety of sizes but even the smaller units are comparatively heavy and awkward to use. Furthermore, the production rates of the small units are low, and costs are relatively high.

2.3.3 Drapes

Porous drapes (or curtains) on both sides of a truss-type structure (e.g., bridge) have been used to divert debris downward into a barge or lined net under the blasting operation. The top of the drapes are tied to the top of the structure. This technique is relatively inexpensive but also not very effective because dust penetrates the porous drape and spillage occurs due to wind effects.

2.3.4 Water Curtains

In this technique, a water header with a series of nozzles is installed along the edges of the structure being blasted. The water spray from the nozzles is directed downward creating a water curtain to collect debris from abrasive blasting performed below the header which is subsequently washed down to the ground.[5] This technique is relatively inexpensive and does reduce the amount of airborne dust. However, one disadvantage is that the debris-laden water spills onto the ground (or into the water under a bridge) creating additional contamination and clean-up problems.

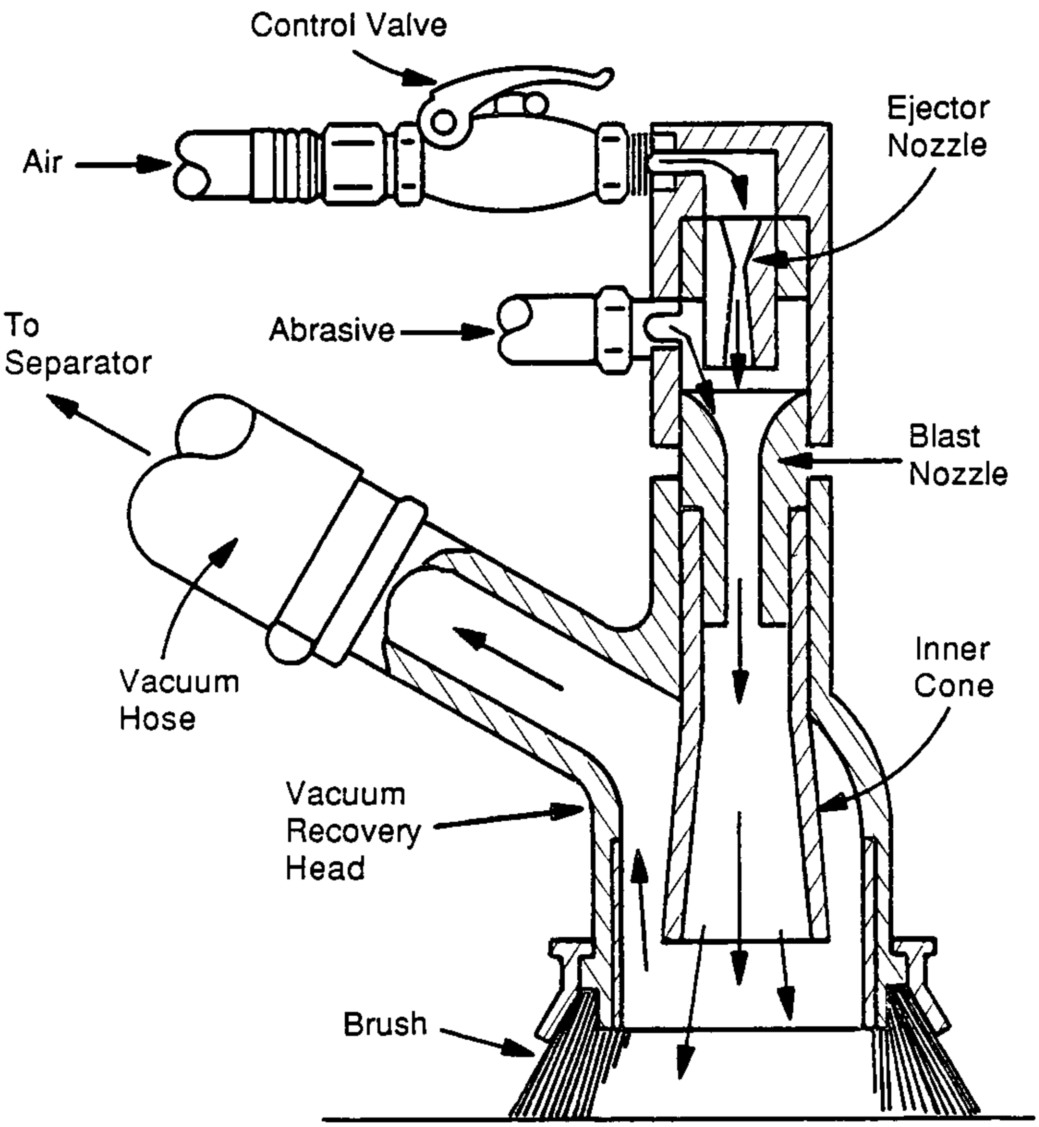

Figure 2-5: Schematic of Vacuum Blaster Head

One method used to solve the spillage problem associated with water curtains involves the placement of troughs under the spray pattern to catch the water/abrasive mixture and divert it to an appropriate container (e.g., tank truck) for disposal. For low structures, the troughs can be placed on the ground. For high structures, the troughs can be supported from the structure itself. To minimize wind effects, porous drapes can be added, extending from the blast area down to the troughs.

2.3.5 Wet Blasting

Wet blasting techniques include: wet abrasive blasting; high-pressure water blasting; high-pressure water and abrasive blasting; and air and water abrasive blasting.[4,6] The type of wet blasting method used depends on the application.

Wet abrasive blasting is accomplished by adding water to conventional abrasive blasting nozzles as shown in Figure 2-6.[4] High-pressure water blast systems include an engine-driven, high-pressure pump, high-pressure hose, and a gun equipped with a spray nozzle. If abrasives are introduced to this type of system, high-pressure water and abrasive blasting is provided. Finally, in air and water abrasive blasting systems, each of the three materials can be varied over a wide range making them very versatile. As compared to dry blasting, all wet blasting techniques produce substantially lower dust emissions.

Most wet abrasive blasters mix the water with the abrasive prior to impact on the surface. This interaction can cause the rate of surface cleaning to be lower than with dry abrasive blasting. To solve this problem, a retrofit device (designed to minimize premixing of the water with the abrasive blast) has been developed to fit over the end of conventional abrasive blast nozzles. This device is shown in Figure 2-7.[5]

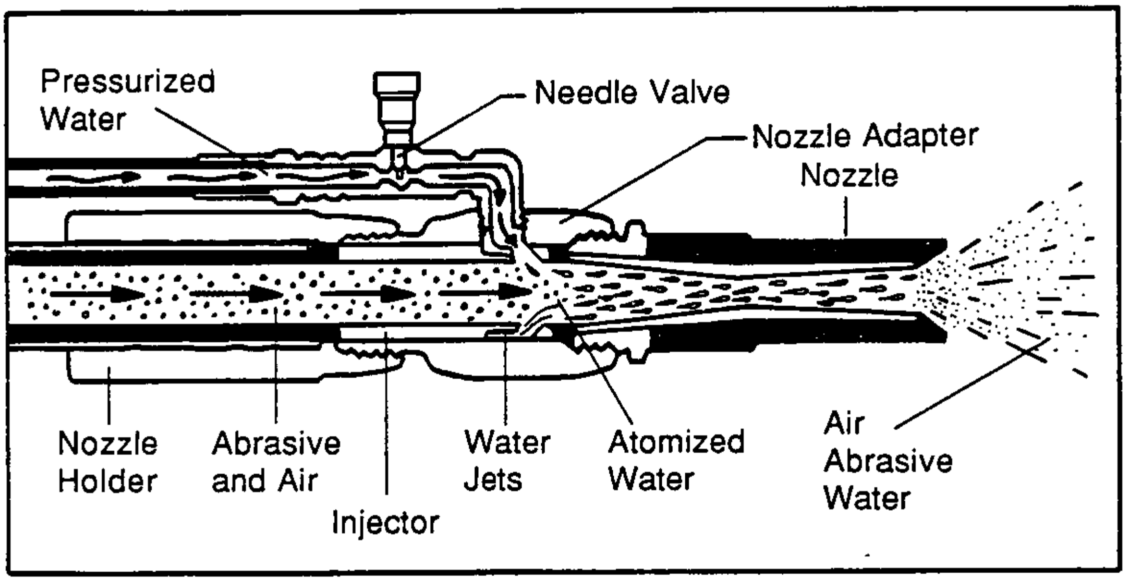

Figure 2-6: Nozzle for Air Abrasive Wet Blast

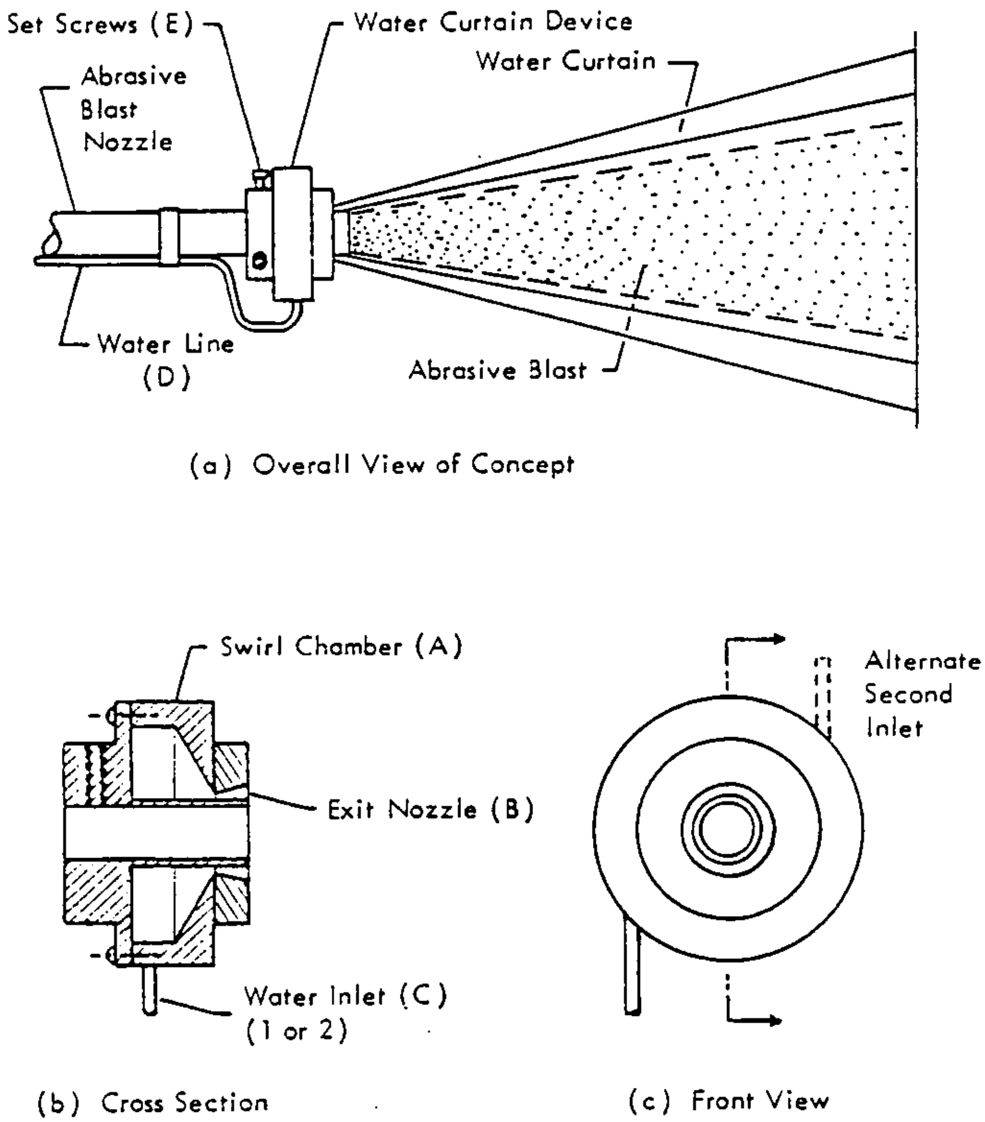

Figure 2-7: Water Curtain Device for Abrasive Blast Nozzle

The two principal parts of the device (Figure 2-7) are a swirl chamber and an exit nozzle. The swirl chamber is equipped with a tangential water inlet. The incoming water swirls around the inside of the chamber and then out the exit nozzle. Centrifugal force causes the water to form a hollow cone pattern around the abrasive blast stream. The angle of the water cone is controlled principally by the shape of the exit nozzle and centrifugal forces.

The above device is expected to be an improvement over traditional wet abrasive blasting. The modified water nozzle design provides a water curtain around the abrasive/airstream. Thus, the cleaning effectiveness of the abrasive/airstream should not be substantially affected. The device is simple to install and operate with conventional abrasive blasting equipment.

2.3.6 Centrifugal Blasters

Finally, centrifugal blasters use high-speed rotating blades to propel the abrasive against the surface to be cleaned. These blasters also retrieve and recycle the abrasive by the use of a capture and collection system which allows little abrasive or paint debris to escape. Present centrifugal blasters are designed primarily for large, flat, horizontal surfaces such as ship decks. Some have been designed for use on large vertical surfaces such as ship hulls and storage tanks. Some effort has been made to develop small hand-held units for use on bridges and similar structures.

SECTION 3

LITERATURE REVIEW AND DATA ANALYSIS

This section provides the results of the literature search and analysis of test data performed during the study. Each topic is discussed below.

3.1 LITERATURE REVIEW

To collect suitable documents for analysis, a computerized literature search was performed. The data bases queried were: NTIS, TOXLINE, and DIALOG. From this search, 341 individual citations were available on the subject of abrasive blasting. Upon review of these citations (and from various telephone contacts made to vendors, etc.), 37 individual documents were eventually identified for further evaluation. These documents are listed in Table 3-1.

Upon review of the reference documents listed in Table 3-1, 15 were determined to contain some type of applicable air monitoring data. Of these 15 documents, only 9 contained data which are potentially useful in the development of candidate emission factors. The documents containing air monitoring data and those selected for detailed analysis are also indicated in Table 3-1.

To supplement the computer search, telephone surveys of selected regulatory agency personnel and vendors of abrasive blasting equipment were conducted. The purpose of these surveys was to collect available test data in addition to those published in the open literature. The results of both surveys are summarized in Tables 3-2 and 3-3 for regulatory agencies and vendors, respectively.

TABLE 3-1. REFERENCE DOCUMENTS REVIEWED DURING LITERATURE SEARCH

Blair, A. W., "Abrasive Blasting Protective Practices Study--Preliminary Survey Results," *Am. Indus. Hyg. Assn. J.*, 34(2), 1973.

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(continued)

TABLE 3-1 (continued)

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Tobey, M. H., "Lead-Free Painting: Mystic River Bridge in Boston," *TRNews*, No. 110, January-February 1984.

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ANSI Subcommittee Z9.4, "American National Standard for Exhaust Systems-Abrasive Blasting Operations-Ventilation and Safe Practices," ANSI/ASC Z9.4-1985, American National Standards Institute, New York, NY, 1985.

*Lehner, E., et al, Memo to D. M. Moline, Department of Public Utilities, Division of Environmental Services, City of Toledo, OH, January 31, 1985.

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(continued)

TABLE 3-1 (continued)

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Woodruff, S. L., "Providing Safe Respiratory Protection in the Protective Coatings Industry," *J. Protective Coatings and Linings*, 5(8), August 1988.

Sowell, D. A., "Hazardous Waste Minimization of Abrasive Blast Media: Addressing Corrosion Control and Environmental Risks," *JAPCA*, 38(8), August 1988.

*South Coast Air Quality Management District, "Section 2: Unconfined Abrasive Blasting," Draft Document, El Monte, CA, September 8, 1988.

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* Indicates those documents which contain useful air monitoring or emission factor data.

** Indicates those documents which contain some type of air monitoring or emission factor data.

TABLE 3-2. RESULTS OF AGENCY SURVEY[a]

Name and location of government agency	Person contacted and telephone number	Date of contact	Summary of conversation
Minnesota Department of Transportation, St. Paul, MN	Norman Mellem (612) 296-1656	6/9/89	No studies of abrasive blasting emissions performed by MnDOT.
South Coast Air Quality Management District, El Monte, CA	Joe Tramma/Joel Nenzell (818) 572-6220/6259	6/9/89	SCAQMD emission factors developed from a source test of an indoor blasting operation using the quasi-stack method. Original test report was issued in the early 1960s and is no longer available. Use of lead-based paint was outlawed in the State of California a number of years ago.
Allegheny County Bureau of Air Pollution Control, Pittsburgh, PA	George Manown (412) 578-8111	7/5/89; 7/20/89	Allegheny County has required ambient air monitoring during abrasive bridge cleaning. Monitoring data were requested and received. Also, the Pennsylvania Department of Transportation will be issuing a guidance document on this subject in the near future.
Pennsylvania Department of Transportation, Pittsburgh, PA	Pat Remy (412) 937-4500	7/5/89; 7/20/89	Requested copy of abrasive blasting guidance document. (Document was never received. Called back 7/20/89 but was not returned.)
Michigan Department of Transportation, Lansing, MI	Eileen Feifer (517) 322-5722	7/13/89; 7/20/89	Air monitoring around MiDOT bridge cleaning projects was performed by Michigan Department of Natural Resources. Ms. Feifer will try to locate these data and send to MRI. (She was unable to provide data but is still attempting to do so.)

(continued)

TABLE 3-2 (continued)

Name and location of government agency	Person contacted and telephone number	Date of contact	Summary of conversation
Puget Sound Air Pollution Control Agency, Seattle, WA	Jim Noland (206) 296-7435	7/14/89	Puget Sound APCA has no air monitoring data for outdoor abrasive blasting.
Toledo Division of Environmental Services, Toledo, OH	Paul Munn (419) 693-0350	7/20/89	Ambient air monitoring has been performed for Wayne Bridge project. Data were provided to MRI. Also knows of a test performed by WhiteMetal, Inc., in Houston, TX (see Table 3-1 for WhiteMetal citation).

[a] Includes only those agencies where contact was actually established.

TABLE 3-3. RESULTS OF VENDOR SURVEY[a]

Name/address of vendor	Person contacted and telephone No.	Type of equipment sold	Test data available (yes/no)
Alpheus Cleaning Technologies Corporation 9105 Milliken Avenue Rancho Cucamonga, CA 91730	Pamela T. Cheatham (714) 944-0055	CO_2 Cleanblast equipment	No (video tape received)
Complete Abrasive Blasting Systems Inc. 18250 68th Avenue South Kent, WA 98032	Glenn Seaverns (206) 251-0820	Enclosed blasting facilities, recyclable steel grit	No
Corcon 3763 McCartney Road P.O. Box 106 Lowellville, OH 44436	Tom Psaras (216) 536-2133	Industrial painting	No
Corrosion Control Consultants and Labs Inc. 1104 Third Avenue Lake Odessa, MI 48849	Gary L. Tinklenberg (616) 374-8185	Technical Analytical Services; Paint testing lab; Blast testing	No
Duyond Chemicals Inc. 1501 Broadway New York, NY 10036	Customer service rep. (212) 869-6350	Peel-Away Paint Removal System	No
Eagle Industries of Louisiana P.O. Box 10652 New Orleans, LA 70181	Dave Cottrell (504) 733-3510 (did not call back)	Containment screens	Unknown
(Ervin Industries) B&U Corporation	Volker Kuehn (517) 263-0502	Dust Collection Systems	No
Tank Industry Consultants Inc. 4912 West 16th Street Speedway, IN 46224	Gregory Howearth (317) 224-3221 (did not call back)	Water storage tanks--design, construction, and maintenance	Unknown
Harrison Industrial Technologies Inc. P.O. Box 8340 Holland, MI 49422	Customer service rep. (616) 459-8878	Paint removal	No

(continued)

TABLE 3-3 (continued)

Name/address of vendor	Person contacted and telephone No.	Type of equipment sold	Test data available (yes/no)
Indian Valley Industries Inc. P.O. Box 15 60-100 Corliss Avenue Johnson City, NY 13790	Phil March (607) 729-5111	Containment Systems (screens)	No
IPEC P.O. Box 996 Quonset Point Davidsville Industrial Park Davidsville, RI 02854	Kevin Haggerty (401) 295-8802	Enviroblast System (blast and recovery system)	No
LTC International Suite 555 1555 Wilson Boulevard Arlington, VA 22209	Secretary (703) 243-0002	Vacuum blasting equipment	Yes (tests by NC State Univ.)
MARCO 1044 South Dittmer Street Davenport, IA 52802	Sharon Voelkers 1-800-252-7848	Blasting equipment	No
Nilfisk 300 Technology Drive Malvern, PA 19355	Paul Miller 1-800-645-3475	Vacuum/filtering systems	No
North Coast Associates Inc. Suite 405 361 Delaware Avenue Buffalo, NY 14202	Michael Lodick (716) 855-3575	Spent abrasive recycling	No
WhiteMetal Inc. 6300 Midvale Houston, TX 77087	Mike Castillo (713) 643-2251	WaterJet Stripping Equipment	Yes (downwind ambient sampling)
Steel Structures Painting Council 4400 Fifth Avenue Pittsburgh, PA 15213-2683	Publications Dept. (412) 268-3326	Technical publications	Yes (proceedings document)

[a] Descriptive literature available for all vendors surveyed.

It should be noted that the literature search and telephone surveys performed during the program were thorough but not exhaustive. In the literature search, only information contained in the open literature was reviewed. Also, only selected agencies and vendors were surveyed based on information provided by the EPA work assignment manager. It might be expected, therefore, that additional data may exist but were not included in the analysis described below.

3.2 RESULTS OF DATA ANALYSIS

The individual data sets were evaluated using the criteria and rating system developed by the EPA's Office of Air Quality Planning and Standards for the development of AP-42 emission factors.[7] This scheme entails the rating of test data quality followed by the rating of the adequacy of the data base relative to the characterization of uncontrolled emissions from the source.

Using the EPA system, a particular test data set was rated based on the following standards:

* A--Tests performed by a sound methodology and reported in enough detail for adequate validation. These tests are not necessarily EPA reference method tests, although such reference methods were used as a guide.

* B--Tests that are performed by a generally sound methodology but lack enough detail for adequate validation.

* C--Tests that are based on an untested or new methodology or that lack a significant amount of background data.

* D--Tests that are based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

An A-rated test may be a source test, results of personnel sampling or ambient monitoring, or some other methodology, as long as it is generally accepted as a sound method.

In those cases where emission factors were presented in the reference document, the reliability of these emission factors was indicated by an overall rating ranging from A (excellent) to E (poor). These ratings took into account the type and amount of data from which the factors were derived, as follows:

- A--Excellent. Developed only from A-rated test data taken from many randomly chosen operations in the industry population. The source category is specific enough to minimize variability within the source category population.

- B--Above average. Developed only from A-rated test data from a reasonable number of operations. Although no specific bias is evident, it is not clear if the operations tested represented a random sample of the industry. As in the A rating, the source category is specific enough to minimize variability within the source category population.

- C--Average. Developed from A- and B-rated test data from a reasonable number of operations. Although no specific bias is evident, it is not clear if the operations tested represent a random sample of the industry. As in the A rating, the source category is specific enough to minimize variability within the source category population.

- D--Below average. Developed only from A- and B-rated test data from a small number of operations, and there may be reason to suspect that these operations do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor were footnoted.

- E--Poor. Developed from C- and D-rated test data, and there may be reason to suspect that the operations tested do not represent a random sample of the industry. There may be evidence of variability within the source category population. Limitations on the use of these factors were footnoted.

A summary of the available test data for uncontrolled and controlled abrasive blasting operations are provided in Tables 3-4 and 3-5, respectively.

A number of comments should be made with regard to the data contained in Tables 3-4 and 3-5. In the case of Table 3-4, eight individual data sets were analyzed with two containing particulate and/or lead emission factors. The other six studies involved some type of industrial hygiene or ambient air monitoring in the vicinity of the blasting operation. None of the industrial hygiene/ambient air studies characterized the blasting operation in sufficient detail for further analysis and emission factor development.

Certain problems were also noted with the two emission factor studies contained in Table 3-4. Both sets of emission factors were generally of poor quality and thus were given a D rating based on the criteria discussed above.

With regard to Table 3-5, only two data sets were identified which address control efficiency applied to abrasive blasting operations. Both data sets were found to be extremely limited in scope and of poor quality (i.e., E-rated control efficiencies). As with the data for uncontrolled emissions, documentation of process operation was nonexistent in both cases.

TABLE 3-4. SUMMARY OF TEST DATA FOR UNCONTROLLED ABRASIVE BLASTING OPERATIONS[a]

Reference document	Test of operation tested	Type of abrasive	Sampler location	Particle size fraction (umA)[b]	Time weighted average concentration (mg/m³)	Data quality rating	Emission factor (mass/source extent)	Emission factor rating	Comments
Samini, 1973; Samini et al., 1975	Outdoor sandblasting at two steel fabrication yards	Silica sand	Within 5 yd (4.6 m) of sandblaster	TP	1.46-76.8	A	N/A	N/A	31 samples; no process data
				< 11	11.8	A	N/A	N/A	16 sample average; no process data
				RP	0.109-8.93	A	N/A	N/A	29 samples; no process data
Samini et al., 1974	Abrasive cleaning of ship hull	Stan-Blast	< 5 yd (4.6 m) from source	TP	10.2	A	N/A	N/A	Sampling time = 185 min
				RP	4.58	A	N/A	N/A	Blasting time = 180 min; no process data
			Sandblaster's chest	RP	88.8	A	N/A	N/A	Sampling time = 181 min; blasting time = 150 min; no process data
			< 10 yd (9.1 m) from source	RP	2.26-9.88	A	N/A	N/A	No process data available
				< 11	6.98	A	N/A	N/A	
Landrigan et al., 1980	Abrasive bridge cleaning of lead-based paint	Grit (Black Beauty)	27 m downwind of bridge	TSP (Pb)	0.0129	B	N/A	N/A	Data for a 6.1-h sampling period during which canvas shroud was not in place for a 2-h period; Pb contributions from paint chips, vehicle exhaust, and grit; no process data available
Bareford and Record, 1982	Abrasive bridge cleaning of lead-based paint	Sand	Center of plume exiting sandblasting bay	TP	-	-	57-455 lb/h/sandblaster	D	2.5% Pb for particles < 2.4 um; sand usage ~ 700 lb/h/blaster (no exact throughput available)
				TP (Pb)	-	-	1.5-4.8 lb/h/sandblaster	D	< 1% Pb for particles > 75 um; sand usage ~ 700 lb/h/blaster (no exact throughput available)

(continued)

TABLE 3-4 (continued)

Reference document	Test of operation tested	Type of abrasive	Sampler location	Particle size fraction (umA)[b]	Time weighted average concentration (mg/m^3)	Data quality rating	Emission factor (mass/ source extent)	Emission factor rating	Comments
Bareford and Record, 1982 (continued)		Sand	Center of plume exiting sandblasting bay	< 10	-	-	24 lb/h/ sandblaster	D	Sand usage ~ 700 lb/h/blaster (no exact throughput available)
				< 10 (Pb)	-	-	0.46 lb/h/ blaster	D	Sand usage ~ 700 lb/h/blaster (no exact throughput available)
Beddows, 1983	General abrasive blasting of lead-based paint	Grit	Breathing zone samples	TP	3-30+	C	N/A	N/A	8-h time-weighted averages; grit from coal slag typically contains from 20-40 ug of Pb/g of material; grit from copper smelting can contain up to 6,000 ug Pb/g of material; no process data reported
Lehner et al., 1985	Abrasive bridge cleaning of lead-based paint	Sand	300-400 ft (91-122 m) downwind of bridge	TSP	0.339-0.482	B	N/A	N/A	24-h time-weighted averages; no process data or controls specified; assumed to be essentially uncontrolled
				TSP (Pb)	0.00122-0.00215	B	N/A	N/A	
WhiteMetal Inc., 1987	Outdoor blasting of steel panels coated with lead-based paint	30-60 mesh (0.59-0.25 mm) silica sand	5 ft (1.5 m) downwind	TSP	257.61	C	N/A	N/A	Hi-vols installed downwind of dry blasting operation to demonstrate control effectiveness of "Jet Stripper"; no sampling time or process data reported
			50 ft (15 m) downwind	TSP	45.99	C	N/A	N/A	
			100 ft (30 m) downwind	TSP	6.18	C	N/A	N/A	
			200 ft (61 m) downwind	TSP	2.71	C	N/A	N/A	
			500 ft (152 m) downwind	TSP	0.90	C	N/A	N/A	

(continued)

TABLE 3-4 (continued)

Reference document	Test of operation tested	Type of abrasive	Sampler location	Particle size fraction (umA)[b]	Time weighted average concentration (mg/m^3)	Data quality rating	Emission factor (mass/ source extent)	Emission factor rating	Comments
South Coast Air Quality Management District, 1988	Outdoor abrasive blasting	Sand	In ventilation system duct	TP	N/A	N/A	0.041 lb/lb sand	D	Emission factors determined by source test of an uncontrolled indoor blasting operation using a quasi-stack technique; original test report not available
		Grit		TP	N/A	N/A	0.010 lb/lb grit	D	
		Shot		TP	N/A	N/A	0.004 lb/lb shot	D	
		Other		TP	N/A	N/A	0.010 lb/lb abrasive	D	

[a] From references listed in Table 3-1. N/A = not available or not applicable.

[b] TP = total particulate matter.
RP = respirable particulate matter (~ $\leq$ 3.5 umA) as determined using a 10-mm nylon cyclone followed by a 37-mm filter cassette.
TSP = total suspended particulate matter ($\leq$ 30-50 umA) as determined by a high volume air sampler.

TABLE 3-5. SUMMARY OF AVAILABLE CONTROL EFFICIENCY DATA FOR ABRASIVE BLASTING OPERATIONS[a]

Reference document	Type of operation tested	Type of abrasive	Control technology employed	Sampler location	Particle size fraction (umA)[b]	Average dust concentration (mg/m^3) Uncontrolled	Average dust concentration (mg/m^3) Controlled	Data quality rating	Measured control efficiency	Control efficiency rating	Comments
WhiteMetal Inc., 1987	Outdoor blasting of steel panels coated with lead-base paint	30-60 mesh (250-590 um) silica sand	Water jet blasting nozzle (i.e., "Jet Stripper")	5 ft (1.5 m) downwind	TSP	257.6	42.3	C	84	E	Comparison of uncontrolled and controlled dust concentrations assumes identical test conditions; original test data not available; no process data or sampling time reported.
				50 ft (15 m) downwind	TSP	46.0	3.3	C	93	E	
				100 ft (30 m) downwind	TSP	6.2	0.55	C	91	E	
				200 ft (61 m) downwind	TSP	2.7	0.32	C	88	E	
				500 ft (152 m) downwind	TSP	0.90	0.19	C	79	E	
So. Coast Air Quality Management District, 1988	Outdoor abrasive blasting	All	Wet blasting (as compared to dry blasting)	-	TP	NA	NA	-	50%	E	No basis of control estimate provided

[a] From references listed in Table 3-1. NA = not available.

[b] TSP = total suspended particulate matter (~ ≤ 30-50 umA) as determined by a high volume air sampler.

TP = total particulate matter.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

Based on MRI's review of available data, the following conclusions were reached:

1. The ambient monitoring and industrial hygiene data collected and analyzed in the study were found to be of reasonably good quality but limited in scope. These studies did not, however, adequately characterize the blasting operation tested such that candidate emission factors could be developed.

2. The limited particulate and lead emission factors presented in the literature are of poor quality due to lack of documentation and process characterization.

3. The data analyzed with regard to controls for abrasive blasting operations are limited at best and of poor quality.

On the basis of the above conclusions, it is recommended that no emission factors be published at the present time for abrasive blasting operations. Instead, it is further recommended that well designed and controlled tests should be performed specifically for this purpose. These tests should determine both uncontrolled and controlled emissions from both wet and dry blasting systems typical of current industry practice. Also, if possible, different types of abrasives should be evaluated in the experimental program.

SECTION 5

REFERENCES

1. South Coast Air Quality Management District, "Section 2: Unconfined Abrasive Blasting," Draft Document, El Monte, CA, September 8, 1988.

2. Mallory, A. W., "Guidelines for Centrifugal Blast Cleaning," *J. Protective Coatings and Linings*, 1(1), June 1984.

3. Baldwin, B., "Methods of Dust-Free Abrasive Blast Cleaning," *Plant Engineering*, 32(4), February 16, 1978.

4. Appleman, B. R. and J. A. Bruno, Jr., "Evaluation of Wet Blast Cleaning Units," *J. Protective Coatings and Linings*, 2(8), August 1985.

5. Snyder, M. K. and D. Bendersky, "Removal of Lead-Based Bridge Paints," NCHRP Report 265, Transportation Research Board, Washington, DC, December 1983.

6. Bruno, J. A., "Evaluation of Wet Abrasive Blasting Equipment," Proceedings of the 2nd Annual International Bridge Conference, Pittsburgh, PA, June 17-19, 1985.

7. U.S. Environmental Protection Agency, "Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections," Office of Air Quality Planning and Standards, Research Triangle Park, NC, April 1980.