Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

| | |
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| AP42 Section: | 11.19.1 |
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NSPS - AP-42

# Review Emissions Data Base and Develop Emission Factors for the Construction Aggregate Industry

FINAL REPORT

SEPTEMBER 1984

PREPARED FOR

**CONSTRUCTION AGGREGATE INDUSTRIES STEERING COMMITTEE**

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# REVIEW EMISSIONS DATA BASE AND DEVELOP EMISSION FACTORS FOR THE CONSTRUCTION AGGREGATE INDUSTRY

Final Report

September 1984

Prepared for

CONSTRUCTION AGGREGATE INDUSTRIES STEERING COMMITTEE

Prepared by

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# PREFACE

This project was initiated as a cooperative effort between the Construction Aggregate Industries Steering Committee and the U.S. Environmental Protection Agency. The Committee which consisted of representatives of the National Industrial Sand Association, the National Sand and Gravel Association, the National Crushed Stone Association, and the National Lime Institute provided financial support for Phase I of the total effort which generally covered review of the emission data base, selection of and emission factor matrix according to operational and mineral classifications, and recommendations for emission factors. The U.S. Environmental Protection Agency, under the coordination of Mr. James H. Southerland, Air Management Technology Branch, U.S. EPA, RTP, NC, provided many reference documents and offered valuable comments on draft materials. Chairman of the Construction Aggregate Industries Steering Committee, Mr. John H. Bennett, Director, Environmental Matters, CalMat Co., acted as project officer for the Committee. Mr. Robert J. Bryan, Engineering-Science, Inc., was project manager.

Phase II of the overall effort is being supported by the U.S. Environmental Protection Agency under contract with Engineering-Science and covers the preparation of a revised Section 8.19 CONSTRUCTION AGGREGATE PROCESSING in "Compilation of Emission Factors," AP-42. Recommendations are also being prepared for source testing needed to fill the existing data gaps.

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# SECTION 1

# BACKGROUND

## SECTION 1

## BACKGROUND

Particulate matter emissions from construction aggregate operations are generally classified as fugitive emissions; that is, unless controlled they are not emitted from a stack or a duct. In the case of fugitive emissions it is important to identify and understand the influencing factors which result in the generation of particulate matter to the atmosphere. For example, there must be some force exerted to make any given particle become airborne. (Note: Once particles become airborne, they are considered to be part of the atmospheric emissions although recent practice has been to include only particles under 30 micrometers in diameter as part of those emissions classified as total suspended particulate matter.) This force can come from impact, centrifugal acceleration, shock, vibration, or exposure of the particle to an aerodynamic force such as wind.

Particles resist becoming airborne by their inertia, cohesion with other particles (which can be aided by agglomerating agents such as water or various chemicals), or by being protected from the influence of wind forces. Once airborne, some particles are redeposited very quickly depending upon settling speed. This speed is determined by the particle's aerodynamic diameter and its density. Thus, it is important to define just what is meant by the term fugitive particulate matter. In ambient studies designed to develop emission factors for sources of fugitive particulate matter, measured values for suspended particulate matter using open air samplers can be significantly influenced by particle size distribution and density of emitted materials depending on the distance from the source. When sampling methods do not provide any size distribution information, subsequent use of emission data based upon these studies to predict air quality impact using dispersion models, can produce data biased on the high side.

If consideration is given to the aforementioned forces which affect particle generation, suspension and subsequent deposition, some improvement should be possible in evaluating emissions test data and in categorizing sources. In the case of construction aggregate processes, such factors might include nature and strength of particle generating or suspending forces such as impact resulting from drop, crushing forces, wind forces, etc. Material properties such as size, density, moisture content, hardness, and friability also influence particle production and must be considered.

The actual development of emission factors has involved a variety of approaches. Some single valued factors have been developed by techniques as simple as estimating emissions using engineering judgment and dividing by a throughput value. Others are based upon actual test data and are also presented as single valued factors. More recently, a number of fugitive particulate matter emission factors have been developed using empirical predictive equations derived from regression analysis techniques. Such factors vary depending upon the values chosen for the variables used in the equation.

All of the techniques based upon actual test data are dependent upon the validity of the model used to develop the factor, the accuracy of input parameters such as fines and moisture content, meteorological parameters (if used), and the range of conditions experienced during testing.

Unfortunately, in the case of fugitive emissions, it is difficult to obtain accurate information on all parameters possibly influencing the generation of emissions. Further, there is substantial inherent variability in many of the test methods used. Also, the model assumptions used in such procedures as the "upwind-downwind", "plume profiling" and tracer techniques are difficult to verify.

Thus, it is very important to examine the test data and the literature reports used in developing emission factors against a set of criteria to determine the acceptability of approach, the soundness of the test procedures, the range of conditions experienced, the number of test replications, the possibility of interferences, and the consistency of results.

The most recent emission factors relating to the construction aggregate industry are published in Supplement 14 of AP-42[1)] under section 8.19, CONSTRUCTION AGGREGATE PROCESSING. The only factors given in this supplement are for SAND AND GRAVEL PROCESSING, Section 8.19.1, and are classified as open sources, including Continuous Drop, Batch Drop, Active Storage Piles, and Vehicle Traffic and Unpaved Roads. Table 8.19.1-1 listing these uncontrolled emission factors is reproduced as Table 1. No factors for crushing or screening are given. Reference is made in Section 8.19.1 to the empirically derived emission factors for general fugitive emissions in Chapter 11 of Supplement 14. A draft narrative for proposed Section 8.19.2 has been prepared, but it was not included in Supplement 14 as revised emission factors for stone crushing operations were not available at the time of publication. Section 8.19, including the draft narrative for sub-section 8.19.2, is reproduced in this report as Appendix A.

Previous editions of AP-42 covered certain rock handling processes under Section 8.20 STONE QUARRYING AND PROCESSING. Table 2 reproduces Table 8.20-1 PARTICULATE EMISSION FACTORS FOR ROCK HANDLING PROCESSES. While all of the emission factors given in these two tables are defined as being uncontrolled, the text of Section 8.19.1 states that the emissions from handling wet or moist materials are often negligible and that use of wet suppression techniques at transfer points and material handling operations for dry materials can reduce emissions from 70 to 95%.

(NOTE: Emission Factors given in AP-42 are generally listed as "uncontrolled." In the case of a confined process type point source, the best source of information for such a factor would be conventional stack test data. In the case of open fugitive emission sources, the act of confining and ventilating the source can change the rate of emission. Various techniques have been used to estimate emissions from sources falling within the "open fugitive source" category. These include open air sampling, stack sampling on such sources which have been confined and ventilated, and estimations using engineering judgment. The emission factors given in Table 1 are from open air testing. The sources of the data for Table 2 are not readily available.)

TABLE 1

TABLE 8.19.1-1. UNCONTROLLED PARTICULATE EMISSION FACTORS FOR OPEN DUST SOURCES AT SAND AND GRAVEL PROCESSING PLANTS[a]

| Uncontrolled dry operation | Emissions by particle size range (aerodynamic diameter)[b] | | | | Emission Factor Rating |
|---|---|---|---|---|---|
| | Total particulate | TSP < ~30 μm | < 10 μm | Units | |
| Continuous drop[c] | | | | | |
| Transfer station | 0.014 (0.029) | NA | NA | kg/Mg (lb/ton) | E |
| Pile formation - stacker | NA | 0.065 (0.13) | 0.03 (0.06)[d] | kg/Mg (lb/ton) | E |
| Batch drop[c] | | | | | |
| Bulk loading | 0.12 (0.24) | 0.028 (0.056)[e] | 0.0012 (0.0024)[e] | kg/Mg (lb/ton) | E |
| Active storage piles[f,g,h] | | | | | |
| Active day | NA | 14.8 (13.2) | 7.1 (6.3)[d] | kg/hectare/day (lb/acre/day)[i] | D |
| Inactive day (wind erosion only) | NA | 3.9 (3.5) | 1.9 (1.7)[d] | kg/hectare/day (lb/acre/day)[i] | D |
| Normal mix of active and inactive day[j] | NA | 11.6 (10.4) | 5.6 (5.0)[d] | kg/hectare/day (lb/acre/day)[i] | D |
| Vehicle traffic on unpaved road[c] | | | | | |
| Heavy duty vehicle | 14.7 (52.0) | 9.31 (33.0)[e] | 0.87 (3.1)[e] | kg/VKT (lb/VMT) | C |

[a] NA = not available. TSP = total suspended particulate. VKT = vehicle kilometers traveled. VMT = vehicle miles traveled. Predictive emission factor equations, which generally provide more accurate estimates of emissions, are presented in Chapter 11.

[b] Total particulate is airborne particles of all sizes in the source plume. TSP is what is measured by a standard high volume sampler (see Section 11.2).

[c] Reference 3.

[d] Extrapolation of data using k factors for appropriate operation from Chapter 11.

[e] For physical, not aerodynamic, diameter.

[f] Reference 4.

[g] Includes the following distinct source operations in the storage cycle: 1) loading of aggregate onto storage piles (batch or continuous drop operations), 2) equipment traffic in storage areas, 3) wind erosion of pile surfaces and ground areas among piles, and 4) loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

[h] 8 to 12 hours of activity per 24 hours.

[i] Pounds/acre of storage (includes areas among piles)/day.

[j] Assumes a 5 day work week.

TABLE 2

Table 8.20-1. PARTICULATE EMISSION FACTORS FOR ROCK-HANDLING PROCESSES
EMISSION FACTOR RATING: C

| Type of Process | Uncontrolled Total[a] | | Settled Out in Plant | Suspended Emission | |
|---|---|---|---|---|---|
| | lb/ton | kg/MT | % | lb/ton | kg/MT |
| Dry crushing operations[b,c] | | | | | |
| Primary crushing | 0.5 | 0.25 | 80 | 0.1 | 0.05 |
| Secondary crushing and screening | 1.5 | 0.75 | 60 | 0.6 | 0.3 |
| Tertiary crushing and screening (if used) | 6 | 3 | 40 | 3.6 | 1.8 |
| Recrushing and screening | 5 | 2.5 | 50 | 2.5 | 1.25 |
| Fines mill | 6 | 3 | 25 | 4.5 | 2.25 |
| Miscellaneous operations[d] | | | | | |
| Screening, conveying, and handling[e] | 2 | 1 | | | |
| Storage pile losses[f] | | | | | |

a Typical collection efficiencies: cyclone, 70 to 85 percent; fabric filter, 99 percent.
b All values are based on raw material entering primary crusher, except those for recrushing and screening, which are based on throughput for that operation.
c Reference 3.
d Based on units of stored product.
e Reference 4.
f See section 11.2.3.

The U.S. EPA sponsored source tests at a number of stone crushing plants as part of a larger testing program conducted to support preparation of a proposed New Source Performance standard for the Non-Metallic Minerals industry. Most of the crushed stone operations tested were limestone operations and testing was limited to plants where fabric filter control devices were installed on various operations including crushing, grinding, screening, and transfer. The draft EIS[2)] for the proposed standard summarizes these tests but only reports on the control equipment discharge. In general, most of the tests showed particulate discharge concentrations below 0.01 grain/SCF with only one being as high as 0.02 grains/SCF. The document states, that this is equivalent to a 99 percent control efficiency. It is difficult to use this information to develop uncontrolled emission factors because of the assumptions necessary on flow rates through capture devices, specific equipment controlled, etc.

Some of the tests used in preparation of the draft EIS plus others conducted in conjunction with development of a proposed NSPS for the metallic minerals industry were reviewed and reported upon to the U.S. EPA as part of an effort to develop information for revising AP-42.* In this report, both extractive source tests and atmospheric profiling tests were reviewed. In the case of the extractive source tests, both uncontrolled (control device inlet) emissions and controlled emissions were reported. These tests constitute a major portion of the available data relating to construction aggregate industry emission factors and are considered in this report.

* The original documents are for the most part test reports performed under contract to the U.S. EPA, or reports prepared for industry groups. In the case of the NSPS testing, other documents such as trip reports and test observer reports are in the relevant EPA docket. Data from selected tests are contained in a report prepared by the GCA Corporation for the U.S. EPA titled "Particulate Emission Factors for the Construction Aggregate Industry," GCA-TR-CH-83-02 (February 1983).

# SECTION 2

# GENERAL DESCRIPTION OF INDUSTRIES INVOLVED

SECTION 2

GENERAL DESCRIPTION OF INDUSTRIES INVOLVED

The construction aggregate industry covers a range of sub-classifications which have been included by the U.S. EPA in the broader classification of the Non-Metallic Minerals industry. Many operations and processes conducted by the various subgroupings are shared in common. These include mineral extraction from the earth, loading, unloading, conveying, crushing, screening, and load-out. Other operations are restricted to specific sub-categories. These include wet and dry fine milling or grinding, air classification, drying, calcining, mixing, and bagging. These latter operations are not in general associated with the construction aggregate industry but can be conducted in sequence with the same raw material used also to produce aggregate. Two common examples involve the processing of limestone and sandstone. Both can be used as a source of construction materials and be further processed for other uses at the same location. Limestone, for example, is a common source of construction aggregate but is also further milled and classified at some location to produce agricultural lime. Sandstone can be processed to produce construction sand but also wet and dry milled, dried, and air classified to produce industrial sand.

The construction aggregates category generally includes the subcategories of crushed stone, sand and gravel, and lightweight aggregates such as pumice. The crushed stone sub-category, in descending order of production, covers limestone and dolomite, granite, traprock, sandstone, quartz, and quartzite. Limestone and dolomite are sedimentary rocks composed of crystalline or granular calcium carbonate (limestone) and calcium-magnesium carbonate (dolomite). Granite consists of any light-colored coarse grained igneous rock. Trap rock includes any fine grained igneous rock composed of ferro-magnesium minerals and feldspar with little or no quartz. Sandstones are sedimentary rocks composed predominantly of cemented quartz grains. The cementing materials can be calcium carbonate, iron oxide, or clay. Quartzites are metamorphosed siliceous sandstones. Essentially all of the materials in the crushed stone category are extracted from deposits by blasting. Consequently the materials entering the process can range in size from granular material to large boulders.

Sand and gravel are products of the weathering of rocks and are unconsolidated or poorly consolidated rock particles consisting of siliciferous and calcareous materials. Most often these materials are removed using bulldozers, draglines, and dredges. In rare instances, light charge blasting may be used to dislodge materials. In some areas much of the sand and gravel is recovered while still wet.

In the case of construction aggregates, the crushing operations are designed to minimize production of fine siltlike material which often must be removed by washing. Therefore, crusher selection, size reduction ratios, throughput, among other factors, are selected so as to optimize the desired final size distribution of product.

The processing operations conducted in the broad construction aggregate category are similar throughout the industry up to the point that specialized grades of material are produced. Those operations which are common include initial size classifications of raw materials (usually with a vibrating grizzly), surge pile formation, primary crushing, crusher plant screening, secondary and tertiary crushing, product screening, and distribution to bin or ground storage. Plant configurations can vary considerably depending upon the original material and product mix.

A simplified flow chart showing these operations is shown in Figure No. 1.

In the case of many sand and gravel plants a substantial portion of the initial feed by-passes any crushing operations. Some do no crushing at all. After initial screening, this material is conveyed to a portion of the plant which can be described as the sand and gravel section or the wet processing section. In this section of the plant wet screening and silt removal is conducted to produce washed sand and gravel. In this

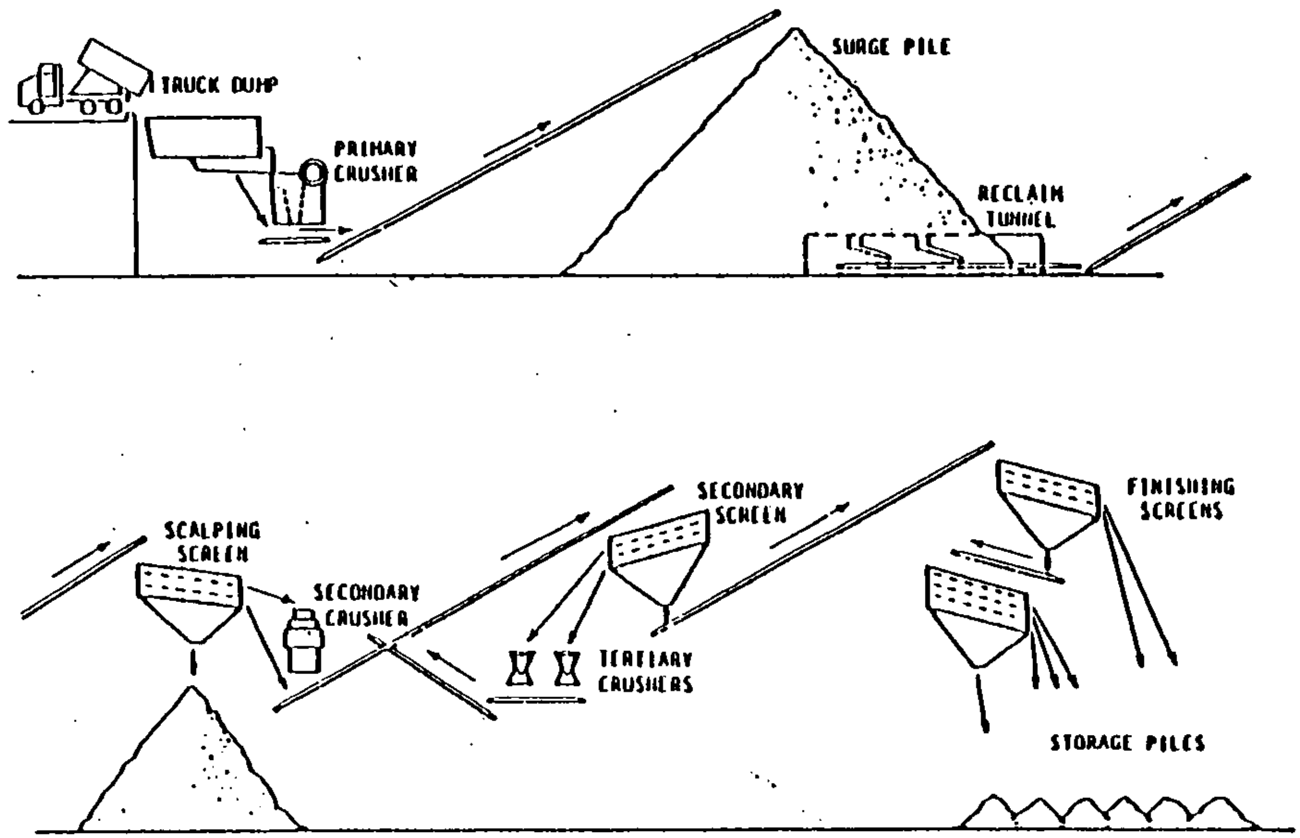


FIGURE 1. FLOWSHEET OF A TYPICAL CRUSHING PLANT

(Reproduced from Draft EIS - Non-Metallic Mineral Processing Plants - Background Information for Proposed Standards) usage, gravel is distinguished from crushed rock which may have similar size classifications. Negligible air emissions are expected from the wet portion of a sand and gravel plant.

# SECTION 3

## POSSIBLE SOURCES OF EMISSIONS AND FACTORS AFFECTING THEIR VARIABILITY

## SECTION 3

## POSSIBLE SOURCES OF EMISSIONS AND FACTORS AFFECTING THEIR VARIABILITY

The possible sources of fugitive emissions in a construction aggregate processing plant can be broadly divided into plant process related emissions and open dust sources. These are listed in Table 3. In this report we deal only with the process fugitive emission sources.

In general the factors that influence emissions from the process fugitive sources include: type of material processed, the type of equipment and operating practices employed, the moisture content of the material processed, and various weather and terrain factors. The preceding factors are important because they affect the introduction and suspension of particles in the atmosphere. Thus, in the case of materials, the softer rocks produce a higher percentage of fine particles than do harder rocks because of their greater friability and lower resistance to fracture. Surface moisture enhances the agglomeration of small particles to larger rock faces. The design of size reduction equipment influences both the relative quantity of fine material produced, and the kinetic energy imparted to any particle formed. Screening equipment design and selection influences screen loading and efficiency and thus the degree of exposure to wind forces. Transfer point design affects the kinetic energy imparted to the particle and the degree of exposure to wind forces. The important weather factors include windspeed and the amount and frequency of precipitation. For these factors to be useful in selecting appropriate source categories for development of emission factors they must be expressed in terms of parameters which can easily be identified or measured. A listing of possible factors is given in Table 4.

TABLE 3

POSSIBLE EMISSION SOURCES AT
CONSTRUCTION AGGREGATE FACILITIES

Process Fugitive Emission Sources

- Crushing
- Screening
- Grinding/Milling
- Material Handling
  - Transfer Points
  - Conveyors
  - Chutes

Open Fugitive Dust Sources

- Mining Operations
  - Overburden Removal, Excavation, Loading and Hauling
  - Blast Hole Drilling
  - Blasting
- Bulk Loading (Products)
- Stockpiles
- Plant Yard Traffic

## TABLE 4

## PARAMETERS INFLUENCING PROCESS FUGITIVE EMISSIONS

### Material Parameters

Material hardness and fracture characteristics
Material feed size distribution
Moisture content
Density of material

### Equipment Parameters

#### Size Reduction Equipment

| Type | | |
|---|---|---|
| Type - Jaw crusher | ) | Compression |
| Gyratory crusher | ) | |
| Double roll crusher | ) | |
| Cone crusher | ) | |
| Impact breaker | ) | Impact |
| Hammermill | ) | |
| Other mills and grinders | | |

Size Reduction Ratio
Feed Rate (% of capacity)

#### Size Classification Equipment

Screens
- Type - Grizzly
  - Single or multiple deck
  - Trommel
- Size gradations - Percent passing each deck
- Efficiency/Loading

#### Material Handling

Bulk Transfer
Continuous Transfer
- Belt to belt
- Feeders
- Chutes

Drop height
Velocity

#### Miscellaneous Design Factors

Transfer point enclosures
Belt scrapers
Chutes/covers

TABLE 4--Continued

<u>Climatological Parameters</u>

- Wind speed
- Precipitation - amount and frequency
- Temperature
- Humidity

# SECTION 4

## DATA NEEDED TO ASSESS INDUSTRY EMISSIONS AND VARIABILITY

# SECTION 4

## DATA NEEDED TO ASSESS INDUSTRY EMISSIONS AND VARIABILITY

From the previous section it is obvious that there are a large number of potential combinations of material, equipment types, material conditions, operating parameters, and climatological conditions which could be identified and used as the basis for developing and categorizing emission factors. Within the broad crusher category alone, it is possible for many combinations of material feed hardness and friability, feed moisture content, feed size distribution, and crusher type to exist in the industry. The number of combinations possible, in fact, is large enough that some consolidation is needed to reduce the emission factor categories to a reasonable number. Data are necessary, therefore, to provide an estimate of the range and variability of emissions from crushing operations. The classic aproach to designing an experimental program to develop such data would be to select the principle parameters to be examined and set several levels for each parameter which would cover the range of expected conditions. From these, a matrix would be prepared with each cell representing a unique combination of equipment and material parameters. As an example, we could construct a test matrix for crushers using three types of crushers, each operating at two different conditions of feed size (e.g. primary and secondary, or secondary and tertiary). Three material categories, possibly limestone, granite, and sand and gravel, each at two different moisture contents, would serve as the material parameters. The total number of cells in such a matrix would be: 3 x 2 x 3 x 2 = 36. If tests were scheduled for each cell the approach would be described as a full factorial design. In order to determine the inherent variability for each combination of factors, several replicates of each test condition would have to be run. The cost effectiveness of such a program is very questionable. While there are statistical techniques for reducing the number of experimental conditions while still preserving much of the power to analyze the source of variability in the results, a discussion of such techniques is beyond the scope of this report.

Test data now available from construction aggregate operations are from two broad categories of testing. The first category covers tests conducted by conventional extractive sampling procedures at the inlet and/or outlet of permanent physical air pollution control equipment serving the source equipment or operation of interest. Such tests have the advantage of using conventional established testing procedures for which estimates of precision are available. Disadvantages are that the test points often serve more than one piece of equipment or operation and that in the case of uncontrolled emissions, the hooding and exhaust system can perturb the process. The other class of tests involve upwind-downwind or plume profiling techniques where particulate matter samples are collected in the open ambient atmosphere and the resulting measured concentrations used to infer a source strength using some type of dispersion model. This approach does not perturb the system and can be used where capture of emissions is not practiced or difficult to perform. However, it can be difficult to isolate the influence of nearby sources from the source of interest; further, and the expected inherent test variability is greater than with conventional testing.

Regardless of the type of testing, certain supplementary process related information is necessary to evaluate emission data for use in developing emission factors. Such information classified as to type includes:

Equipment Information

Type
Size
Settings, e.g. crusher discharge opening

Transfer and Conveying Design Information

Belt size and speed
Transfer chute design factors
Conveyor skirting and covers (where used)
Rock boxes
Use of enclosures
Drop height

Material Information

- Mineral classification
- Feed size distribution
- Moisture content

Process Information

- Feed rate (by equipment unit)
- Use of wet suppression
  - Location
  - Type
  - Water rate
  - Use of surfactants
  - Use of wet processing
    - Separation
    - Washing
    - Hydraulic classification

Meteorological Data

- Wind speed
- Precipitation history
- Temperature
- Relative humidity

Dust Control Systems (where used)

- Hood design and location
- Capture velocities
- Exhaust flow rates

# SECTION 5

# DISCUSSION AND CRITIQUE OF AVAILABLE DATA

## SECTION 5

## DISCUSSION AND CRITIQUE OF AVAILABLE DATA

### 5.1 AVAILABLE DATA

The data base used for this project consisted of formal test reports, data summaries, comment memoranda and letters, flow sheets, technology related reports, and environmental assessment documents. These materials were supplied from both U.S. EPA and industry sources. Mr. Jim Southerland, Chief, Source Analysis Section, AMTB, U.S.EPA, coordinated the acquisition of the EPA supplied materials, while Mr. John H. Bennett, Chairman - Construction Aggregate Industries Steering Committee, arranged for the submittal of industry supplied materials. Over 70 separate documents were reviewed and annotated in the first phase of the project.

At a later date, the docket for the U.S. EPA Non-Metallic Minerals Industry NSPS was reviewed by ES staff and copies of a trip report and two test reports were obtained to supplement summary data in the originally supplied U.S. EPA data base. While many of the documents reviewed had been published and incorporated some sort of identifying number, some (e.g. letters) did not. The complete list of documents reviewed is given in the Appendix.

During the course of the project, ES was engaged by CONROCK, Co., Los Angeles, California, to conduct tests of emissions from crushed rock screening operations at two separate sand and gravel plants in southern California. These tests were conducted by extractive source testing procedues at test points in exhaust ducts ventilating temporary screen enclosures constructed specifically for these tests. Tests were conducted on screens handling a fairly wide range of feed sizes. Most tests were conducted with the wet suppression system at the crushers in use. One series of tests was conducted with the wet suppression sprays off. Tests were conducted using a wet impingement train* with back-up filter for

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* South Coast Air Quality Management District method

total particulate matter and with a cascade impactor for size selective data. Process data, including process weight, size classification of feed, and moisture content were also obtained. ES has received permission to report these data as an attachment to the main body of the report. This procedure is being used because the test reports have not received independent peer review.

Other than the data originally supplied by the U.S. EPA, the construction aggregate industries committee, and the ES screen emissions test data, no other data relating to uncontrolled emissions from construction aggregate process sources were discovered. Of the above data sources, 16 documents were utilized by GCA in their report titled "Particulate Emission Factors for the Construction Aggregate Industry," GCA-TR-CH-83-02, February 1983.[3] Because of the importance of the sources in the GCA report, Tables 3-2, 3-3, 3-4, and 3-5 covering primary crushing, secondary crushing, tertiary crushing, and dry grinding and fines crushing are reproduced in the Appendix. Three categories of tests were considered in the GCA report. These were (1) extractive tests of inlets to particulate matter control devices serving various crushing, grinding, screening, and transfer operations, (2) upwind-downwind sampling conducted in the open atmosphere with emission rates calculated using dispersion models, and (3) plume dispersion techniques based upon use of a tracer gas to measure dilution. Emission rates in the latter case were calculated by applying the ratio of tracer source strength versus downwind tracer concentrations by the downwind measured concentration of particulate matter.

Another plume profiling study not incorporated in the GCA report was conducted by Pacific Environmental Services at several sand and gravel plant in southern California.[4] In this study, the mass of particulate matter passing through a vertical plane downwind of a source was defined by profiling the particulate matter concentrations in the plume by using directional samplers arranged in horizontal and vertical array in the plume. The mean concentration within the plume boundaries multiplied by the wind speed and the cross-sectional area of the plume provides the estimate of source strength.

Each of the several source strength evaluation procedures referred to above have advantages and disadvantages for use with open fugitive emission sources in developing emission factors. In general, as compared to ambient sampling approaches, the extractive test approach is simpler, more straightforward in that no model assumptions are necessary, and tends to provide better repeatability in the test results. Of course, this test approach cannot be used unless emissions are captured by some hooding and air evacuation procedure and ducted to some point where the sample can be extracted by conventional source sampling equipment. Where such exhaust systems are not incorporated as part of the aggregate processing installation, it is sometimes possible to install a temporary apture and exhaust system. The principal potential problem with the extractive testing approach is that in some cases, particulate matter can be induced into the exhaust system by excessive exhaust velocities at the pick-up points. This normally would not be a problem as hood capture velocities do not often exceed 200 ft/min (about 2 miles per hour). However, branch duct velocities are much higher, typically 3500 ft/min. Therefore, in smaller enclosures or in cases where the point of emission generation is very close to the branch duct entry, air velocities can be equivalent to a wind speed of about 40 miles per hour.

The various ambient techniques for testing emissions have the principal advantage of not perturbing the operation of interest. For the three ambient techniques mentioned, the main advantages and disadvantages are listed below:

| Technique | Advantages | Disadvantages |
| --- | --- | --- |
| Plume Profiling | 1) More easily isolates source of interest<br>2) Model concept simpler than upwind-downwind approach | 1) Must sample close enough to define plume<br>2) Does not work well with very light winds<br>3) Sampling equipment must be specially fabricated and arrayed in vertical as well as horizontal direction |

| Technique | Advantages | Disadvantages |
|---|---|---|
| Upwind-Downwind | 1) Most easily performed of ambient techniques | 1) Subject to interference from other sources<br>2) Model assumptions must be carefully considered |
| Tracer Technique | 1) Simple concept | 1) Must ascertain whether release of tracer properly simulates emission distribution<br>2) Assumes tracer behaves as suspended particulate matter |
| All | — | 1) Must determine and subtract background<br>2) Poor in variable wind conditions |

No single test procedure is clearly best for measuring emissions from open fugitive particulate matter sources in construction aggregate processing plants. Where the exhaust ventilation system is designed not to induce particulate matter into the exhuast system which otherwise would not become airborne or would settle immediately, the extractive source test technique is the most straghtforward. Some large open sources such as storage piles are not susceptible of being sampled in this way, however. Of the ambient procedures, the plume profiling technique would seem to offer the most advantages if sampling points immediately downwind of the source can be established.

## 5.2 SUMMARY OF TEST RESULTS FROM DATA SOURCES

For purposes of summarizing the available test data for construction aggregate process fugitive emissions (uncontrolled) we categorize the testing approaches as follows. Abbreviations used are in parentheses.

- Extractive sampling from vented sources (Ex)
- Ambient sampling using tracer technique (Tr)

- Ambient upwind-downwind sampling applied to dispersion model (U-D)
- Plume profiling technique with calculation of plume mass flux (PP)

Emission factors for two source categories - crushing and screening - are summarized by source for total particulate matter in Table 5. Particle size data, where available, are given in parentheses immediately following the emission factor for the particular source. In the case of the extractive tests on screens, cascade impactors were utilized to obtain particle size data. Individual cumulative size distribution plots are included in the Appendix. In general, 60-90% of the particulate matter collected in these screening tests was below 10 micrometers in diameter (based on unit density spheres).

## 5.3 RATING CRITERIA FOR EMISSION FACTORS

Emission factors are most representative and reliable when the source category is fairly homogeneous and the emissions data obtained are appropriately determined, representative of the source category, and exhibit low variability among individual test results. The current guidelines for emission factor development published by the U.S. EPA[5] include criteria for rating emission factors. The pertinent section of this document is reproduced in the Appendix. In general, however, the rating factors are based upon two broad categories of criteria: (1) test related and (2) sample population related. The salient features of each are shown below:

<u>Test Criteria</u>

Consistency of operations during test
Appropriateness of test methodology
Availability of process data
Completeness of test documentation
Consistency of test results

<u>Sample Population Criteria</u>

Sample size
Variability of emissions within industry
Variability of emissions within source
Representativeness of sources tested as compared to total population

TABLE 5

AVERAGE UNCONTROLLED EMISSION FACTORS FOR CONSTRUCTION AGGREGATE PROCESS SOURCES

| Source Category (Rock Type) | Test Type (No. Runs) | Avg E.F.* | EF Units | | Avg. EF for Source - Test Type Category |
|---|---|---|---|---|---|
| PRIMARY CRUSHING | | | | | |
| Dry (limestone) | Ex (2) | 0.017 | lb/ton | ) | |
| (limestone) | Ex (3) | 0.686 | lb/ton | > | 0.508 |
| (copper ore) | Ex (3) | 0.658 (4.6) | lb/ton | ) | |
| (traprock) | Tr (6) | 0.0015 (53) | lb/ton | | 0.0015 |
| (limestone) | U-D (1) | 0.0011 (27) | lb/ton | | 0.0011 |
| Wet (ore) | Ex (3) | 0.041 (46) | lb/ton | ) | |
| (sandstone) | Ex (3) | 0.0014 (85) | lb/ton | > | 0.0264 |
| (quartzitic ore) | Ex (3) | 0.034 (43) | lb/ton | ) | |
| SECONDARY CRUSHING | | | | | |
| Wet (limestone) | Ex (1) | 0.0006 | lb/ton | | 0.0006 |
| Dry (limestone) | Ex (1) | 1.2 | lb/ton | ) | |
| (quartz-monzonite) | Ex (3) | 0.088 (23) | lb/ton | > ) | 0.366 |
| (traprock) | Tr (6) | 0.0006 (17) | lb/ton | ) | |
| (limestone) | Tr (13) | 0.0002 (50) | lb/ton | > | 0.0296 |
| (limestone) | Tr (12) | 0.088 (73) | lb/ton | ) | |
| (limestone) | U-D (1) | 0.0003 (67) | lb/ton | ) | |
| (traprock) | U-D (1) | 0.0014 (43) | lb/ton | > | 0.0157 |
| (traprock) | U-D (2) | 0.0011 (64) | lb/ton | ) | |
| (granite) | U-D (2) | 0.045 | lb/ton | ) | |
| TERTIARY CRUSHING | | | | | |
| (zinc ore) | Ex (3) | 2.76 | lb/ton | | 2.76 |
| (traprock) | Tr (6) | 0.0016 (50) | lb/ton | ) | 0.0043 |
| (limestone) | Tr (9) | 0.0070 (86) | lb/ton | ) | |
| (traprock) | U-D (1) | 0.0007 (14) | lb/ton | | 0.0007 |

* % <10 um shown in ( )

TABLE 5—Continued

| Source Category (Rock Type) | Test Type (No. Runs) | Avg E.F.* (% <10 um) | EF Units | Avg. EF for Source - Test Type Category |
|---|---|---|---|---|
| CRUSHING (Undesignated) | | | | |
| Dry (sand & gravel) | PP (unk) | 0.258 | lb/ton | 0.258 |
| Wet (sand & gravel) | PP (unk) | 0.0243 | lb/ton | 0.0254 |
| SCREENING | | | | |
| Dry (sand & gravel) | PP (unk) | 0.360 | lb/ton | 0.360 |
| | Ex (9) | 0.118 | lb/ton | 0.118 |
| Wet (sand & gravel) | PP (unk) | 0.0165 | lb/ton | 0.0165 |
| | Ex (12) | 0.0071 | lb/ton | |
| | Ex (9) | 0.00161 | lb/ton | 0.0051 |
| | Ex (3) | 0.0066 | lb/ton | |
| Wet (sand & gravel "dust")** | Ex (3) | 0.0411 | lb/ton | 0.0411 |

* % <10 um shown in ( )

** "Dust" is defined as 1/4" x 8M and is the term used by the plant. According to ASTM D448, the material is also known as pea gravel or No. 8 coarse aggregate

The general procedure in rating emission factors using the above approach is to first rate the tests forming the data base. In the EPA scheme these range from A to D. Secondly the sample population criteria are used to evaluate the data base against criteria that in essence are used to judge confidence limits and representativeness of the data. An emission factor rating is then assigned. As an example, the following statement describes an "A" rated factor:

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

The rating factor approach briefly described above (and in detail in the Appendix) is appropriate for evaluating the data base and resulting emission factors for the construction aggregate industry source categories when properly applied. The data base currently available are reviewed in the next section in accordance with these procedures.

## 5.4 CRITIQUE OF DATA BASE

The data presented in Section 5.2 as augmented by individual test summary data in the Appendix comprises the data currently available for consideration in preparation of uncontrolled emission factors for construction aggregate industry processes. The following general observatrions are made regarding the data base taking into account the rating criteria discussed in Section 5.3.

1. The test methods used to develop the data vary in approach. All of the ambient based procedures provide some opportunity for material to settle out between the source and the samples. Within the ambient methods three different procedures are used to calculate emission rate from the mass concentration at the sampling point.

2. Operating conditions and influencing environmental conditions varied from test to test at some locations. In one case with two tests in the series, testing was conducted on two different days with rainfall occurring on one of the days.

3. Process data reported were incomplete in some tests. It was not possible to determine whether the process weights used were specific to the overall plant or to the source being tested.

4. In the case of crusher tests using extractive source sampling not all were limited to a single source of emissions. In some cases, emissions attributed to crushing included material transfers and even screen emissions.

5. In a few cases, tests at the same location of source varied over a wide range (more than an order of magnitude).

6. The terms "wet" and "dry" referring to material condition are not clearly defined because there is no continuity of data which shows a clear distinction at some cut point for moisture that determines "wet" vs. "dry" in terms of emissions. In Section 8.14 of AP-42 covering Metallic Minerals, moisture content at 4% and above is described as being "wet". In the data available there is a gap between 4% and 1.5% with materials having less than 1.5% moisture being defined as dry. Actually the surface moisture in terms of mass of water per unit area varies with particle size for any given moisture content expressed as overall percent by weight. Therefore, on a conceptual basis, at least, the definition of "wet" material should be based on a sliding scale depending upon particle size. Since the surface area per unit volume of any given aggregate material varies inversely as the diameter of constituent pieces, the mass (or volume) of water per unit area decreases linearly with a decrease in screen size for a given moisture content expressed in percent by weight. As an example, 1/4" aggregate would require 4% water by weight to give the same amount of water per unit of surface area as 1" aggregate at 1% water by weight.

   The terms "wet" and "dry" defining material should be distinguished from wet operations as the term is used in the sand and gravel industry where water is used to wash, classify, and transport the material from one stage to another in such a way that there is a virtual absence of emissions.

7. Emission rates from testing using extractive testing from ventilation systems are much higher in general than those from ambient sampling based techniques.

8. Not all aggregate types are equally represented in the data base. There are no data for crushing operations in the sand and gravel category and no data using extractive testing procedures for trap rock or granite.

Specific comments have been prepared for some data sources to illustrate the general problems listed above. The source of the data is identified by publication number or by performing organization.

## 5.5 EXTRACTIVE SOURCE TESTS

### Primary Crushing Sources

1. Exxon Highland (79-MET-1) Type of Rock: Tertiary Fluvial Sandstone

At this source, ore is loaded onto a grizzly which separates 15" and larger pieces. The larger sizes are set aside and intermittently recrushed by a portable crusher. Undersize material from this crusher is conveyed to a vibrating grizzly with greater than 3" material being fed to an impact type crusher. After being moved by two conveyor belts in series, a vibrating screen separates ore into >1-1/2" which is returned to the crusher and undersize which is conveyed to fine ore bins. A primary crusher scrubber is described by the report as controlling emissions from the vibrating grizzly, primary crusher, screens, and conveyor transfer points. Material had an average moisture content of 5.6%.

Three locations were tested. These were described as the crusher transfer point exhaust duct, crusher-grizzly exhaust duct, and crusher scrubber inlet. (Note: The scrubber outlet was also tested but we are concerned with uncontrolled emissions.)

Comments: The crusher scrubber inlet test results were used in calculating the uncontrolled emission factor for this source. It cannot be determined from the test report whether the crusher transfer point exhaust duct and the crusher-grizzly exhaust duct are the only two ducts feeding into the scrubber inlet. However, the sum of the mass loading (lb/hr) from the two exhaust ducts was about one-half the loading in the scrubber inlet duct. This apparent discrepancy could possibly be due to another source feeding the scrubber inlet which was not reported or to variability in emissions as a function of time (Note: All tests were not run simultaneously). This test series illustrates the varying results which could have been obtained depending upon the sources which were considered to be part of the primary crushing operation.

2. Anaconda (79-MET-3) — Type of Rock: Chalcocite, Chalcopyrite, enargite, bornite

In this plant, grizzlies separate oversize (>4") from undersize and the oversize is crushed in a gyratory type crusher. The average moisture content of material handled was 1.5%. Emissions are collected at each of the two grizzlies, the primary crusher, and the conveyor removing material from the crusher. Wet suppression is used in addition to bag-houses for control.

Three points were tested - (1) crusher grizzly west, (2) crusher hood duct, and (3) crusher bag-house inlet. Emission rates for the three sources above were as follows: (1) 13.5 lb/hr, (2) 220 lb/hr, and (3) 1372 lb/hr. Presumably there was a pick-up point at the crusher grizzly east, even though it was not tested. Even so, there is a great discrepancy between the sum of the particulate matter loadings in the two exhaust ducts tested and the bag-house inlet. The brief description of the process in the report stated that there was a wet suppression system with sprays located near the grizzlies, at the entrance under the feeder belts to the crusher, and near the conveyor belt leaving the crusher.

3. Climax Co. (79-MET-2) — Type of Rock: Quartz/fluorite/molybdenumite, quartz/sericite/pyrite, quartz/fluorite/sphalerite/galena/rhodochrosite

The primary crusher complex includes a crusher pit (including railcar ore dump, crusher, surge bin, apron feeder, and conveyor transfer points. The average material moisture content was 4.0%. There is a wet scrubber.

The uncontrolled emissions were tested while sprays were off. The emission rate reported in the GCA report represents the sum of the tests on the primary crusher TP-1 transfer points exhaust duct and the primary crusher TP-2 crusher pit exhaust duct.

The principal comments on this test series are that a rail car dump was included within the primary crushing system and that the production rate used for calculation of the emission factor was an average rate reported in a report filed with the Security Exchange Commission.

Secondary Crushing

1. J.M. Brenner (75-STN-7) Type of Rock: Limestone

Pick-up points for a baghouse serving the secondary crushing activity are listed as "scalping screen, hammermill, etc." Tests were conducted at the inlet to the baghouse.

Two test runs were made at this test point. The results are summarized below:

| Test No. | Feed Rate | Particulate Concentration | Emission Rate | Emission Factor |
|---|---|---|---|---|
| 1 | 119 T/hr | .001 gr/dscf | .07 lb/hr | .0006 lb/T |
| 2 | 127 T/hr | 2.48 gr/dscf | 158 lb/hr | 1.2 lb/T |

These emission rates differ by a factor of about 2500 to 1 even though the two production rates given differed by less than 7%. Tests were on two separate days with moderate to heavy rain falling during Test No. 1. Test No. 2 was conducted under dry weather conditions. Feed moisture content was given as under 0.5% for Test No. 2. No data on moisture are available for Test No. 1.

Tertiary Crushing

1. New Jersey Zinc (80-MET-6) Type of Rock: Franklinite, Willemite, Zincite

This test was performed on a baghouse inlet serving a tertiary crusher. In this case, however, the feed had been processed through a drier. This is not comparable to crushing operations in the aggregate industry itself.

Dry Grinding

1. Union Carbide (80-MET-8) — Type of Rock: Mixture of igneous rock complexes with sedimentary (clay) intrusions

In Table 3-5 of the GCA report this test is erroneously referred to as 80-MET-5. In Table 3-1 listing all test reports there is no 80-MET-5 but there is an 80-MET-8 for Union Carbide. The test report summary has a cover page using the number 80-MET-8. Also, Table 3-5 in the GCA report shows a baghouse as the control equipment. In the report the control device for the dry grinding operation is given as a scrubber.

The test point is the scrubber inlet. However, the flow to this scrubber is from cyclone vents. The cyclones are actually part of an air circuit which is used to transport ore fines. Air evacuated from the grinder is also picked up with this flow. Therefore, the test point used cannot be considered to represent uncontrolled grinder emissions only.

Screening Tests

1. CONROCK - Irwindale (ES Test) — Type Material: Sand and Gravel

Wet suppression on the crushers is used as a control measure in this plant. Tests were conducted under normal conditions (wet suppression system at crushers in use) on product screens following secondary crushing and with the wet suppression system turned off. The sample point in each case was in a duct exhausting a temporary full enclosure erected around each screen tested. Feed material was sand and gravel mined from alluvial deposits in a river wash. Moisture content of feed with wet suppression on was 1.5%. Moisture content with the wet suppression system off was essentially zero. The wet emission factor was .0063 lb/ton as compared to the dry factor of 0.118 lb/ton. In this case a moisture content well below the 4% cutoff for wet materials used for metallic minerals resulted in an emission rate of about 5% of the dry rate.

2. CONROCK - Sun Valley (ES Test) — Type of Material: Sand and Gravel

These tests were conducted under normal conditions only (wet suppression system at crushers on). Screens tested were categorized as primary recirculation, secondary product, and dust screens. Sand and gravel was mined from alluvial deposits. The dust screens (1/4 x 8 M) had an emission rate 25 times as high as the secondary product screens (0.041 lb/ton as compared to 0.0016 lb/ton).

## 5.6 AMBIENT SAMPLING ASSESSMENT PROCEDURES

No specific comments have been prepared for any of the three ambient sampling procedures for developing inferred emission factors. Only one of the procedures, the plume profiling method, which measures the mass flux through a vertical plane downwind of the source has been used to develop emission factors for use in AP-42. The most recent use has been for preparation of factors for some of the open source categories covered in Section 11.2 FUGITIVE DUST SOURCES, AP-42 Supplement 14. All of the procedures, however, sample only those particles which are suspended at the sampling point. Therefore, these data are most useful when particle size data are obtained.

# SECTION 6

# EMISSION FACTOR MATRIX DISCUSSION

## SECTION 6

## EMISSION FACTOR MATRIX DISCUSSION

In preparing a proposed matrix for construction aggregate plant emission fators it is important to understand that there are overlaps in end use of feed materials to some plants and that the process objective can be quite different depending upon end use of the product. Examples would include limestone operations that produce both aggregate and agricultural limestone and industrial sand plants which produce some construction (building) sand. In other cases, ore-bearing rocks may be similar in physical characteristics to rock used for aggregate, but the size reduction objectives can be sufficiently different so that different crusher types and reduction ratios are used. It is well known that these equipment and operating differences can significantly affect the generation of fine particles and the velocity imparted to these particles.

### Emission Factor Matrix

There are potentially a large number of material, equipment, and operating parameter factors which could be used in developing an emission factor matrix. Some of those related to crushing and grinding which are commonly mentioned in the literature and other documents bearing upon the subject are:

- Rock type
- Maximum feed size
- Feed size distribution
- Feed moisture content
- Throughput rate
- Crusher type
- Reduction ratio
- Crushing stage
- Process water use

The first five of these should be relevant to screening operations as well. Screen loading per unit area would also be important as well as the screen type and size gradation.

The use of this many parameters in a matrix would make a very large number of combinations; so large that it is unlikely that sufficient test data could be accumulated over a reasonable amount of time so that very many slots in the matrix would be filled.

The various possible parameters were assessed for importance based upon discussions with individuals and upon our interpretation of opinions voiced at the two Construction Aggregate Steering Committee meetings. As a result, the following parameters and parameter subdivisions have been selected for the recommended emission factor matrix for crushing.

<u>Recommended Parameters</u>

Material Dryness

- Wet (>1.5% moisture)*
- Dry (<1.5% moisture)

Material Class

- General Stone (granite, traprock, and other consolidated igneous or metamorphic rock)
- Limestone
- Sand and Gravel
- Miscellaneous other minerals

Crusher Classification

- Primary
  - Jaw
  - Gyratory
  - Impact
- Secondary
  - Gyratory
  - Impact
- Tertiary

* The 1.5% figure is used based upon the results from sand and gravel screening tests which showed a substantial reduction in emissions as compared to absolutely dry material. More test data are needed to support this value. A sliding scale based upon aggregate size could provide a more accurate distinction between wet and dry material.

Using this matrix there are 48 possible emission factors for crushing. These factors would apply only to the emissions arising from the actual crushing operation. This would be defined as emissions discharged from the crusher feed and discharge points. A separate category for screening operations is proposed and another for material transfer. It is suggested that transfer emission factors be based upon the empirical formulas given in AP-42, Supplement 14, Section 11.2.3.

## Classification of Test Data

Test data from the GCA report to EPA on "Particulate Emission Factors for the Construction Aggregate Industry", February 1983, GCA-TR-CH-83-02 were classified according to the matrix proposed in the previous section. Both the extractive test data and the tracer gas-receptor sampling data are shown. Emission factors for total particulate matter for the various sub-classifications are shown in Figures 2 and 3. Table 6 summarizes salient features of the sources used for the factors in Figure 2 (Extractive Test Data). Where available, data for particulate matter <10 micrometers is presented in Figures 4 and 5.

From these tables it can be seen that there is no extractive source test data for either the Stone or Sand and Gravel material categories, wet or dry. The only extractive test data for wet materials comes from ore processing facilities. The highest emission factors developed from extractive testing on dry materials involved impact type crushers which are known to produce a higher percentage of fines than do compressive type crushers (includes jaw and gyratory types). There is only one extractive test known to involve a gyratory crusher which is one of the predominant types of crushers used in the aggregate industry. This test was run at a copper ore processing facility. (Note: Data for screening are presented in the Appendix as previously discussed.)

## Discussion

It seems obvious from the data presented in the previous section that there is insufficient data to prepare a set of recommended emission factors using the proposed matrix. While such a matrix of emission factors is desirable as a longer range objective, a short-term alternative

FIGURE 2

CONSTRUCTION AGGREGATE
UNCONTROLLED EMISSION FACTORS FOR CRUSHING
FROM DIRECT SOURCE TESTING, lb/ton
(Total Particulate Matter)

| Operation | Dry Material | | | | Wet Material | | | |
|---|---|---|---|---|---|---|---|---|
| | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. |
| Primary Crushing | | | | | | | | |
| Jaw | | 0.017 (1) | | | | | | 0.038 (2) |
| Gyratory | | | | .658 (1) | | | | |
| Impact | | 0.686 (1) | | | | | | 0.0014 (1) |
| Secondary Crushing | | | | | | | | |
| Gyratory | | | | .088 (1) | | | | |
| Impact | | 1.2 (1)* | | | | 0.0006 (1)* | | |
| Tertiary Crushing | | | | 2.76 (1)** | | | | |

Numbers in parentheses are no's of plants tested
* These tests conducted on the same source. The value of 0.0006 lb/ton was obtained on a day when rain was falling.
**Material had been through dryer prior to tertiary crushing

FIGURE 3

CONSTRUCTION AGGREGATE
UNCONTROLLED EMISSION FACTORS FOR CRUSHING
FROM TRACER STUDIES, lb/ton
(Total Particulate Matter)

| Operation | Dry Material | | | | Wet Material | | | |
|---|---|---|---|---|---|---|---|---|
| | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. |
| Primary Crushing | .0015 (1) | | | | | | | |
| Jaw | | | | | | | | |
| Gyratory | | | | | | | | |
| Impact | | | | | | | | |
| Secondary Crushing | .0006 (1) | .0441 (2) | | | | | | |
| Gyratory | | | | | | | | |
| Impact | | | | | | | | |
| Tertiary Crushing | .0016 (1) | .007 (1) | | | | | | |

Numbers in parentheses are no's of plants tested

## TABLE 6

## SUMMARY OF OPERATIONAL PARAMETERS - EXTRACTIVE SOURCE TESTS

### Homestake Mining

| | |
|---|---|
| Rock Type: | Cumingtonite, quartz, other ore |
| Product: | Gold ore refining feed |
| Type of Crusher: | Jaw - Primary |
| Pick-up Point: | Pri. Crusher feed |
| Product Moisture: | Wet (4% $H_2O$) |
| Test Range: | .029 - .056 lb/ton (.041) |

### Exxon Highland

| | |
|---|---|
| Rock Type: | Tertiary Fluvial Sandstone |
| Product: | Uranium-ore refining feed |
| Feed Moisture: | Wet (5.6% $H_2O$) |
| Type of Crusher: | Impact type - Primary |
| Feed Size to Pri. Crusher: | +3" - 15" first reduced by portable jaw crusher |
| Pick-up Points: | Scrubber inlet - probably includes vibrating grizzly, primary crusher, screens and transfer points |
| Test Range: | .0008 - .0022 lb/ton (.0014) |

### Climax

| | |
|---|---|
| Rock Type: | Quartz-fluorite-molybdenite, etc. |
| Product: | Molybdenum ore process feed |
| Feed Moisture: | 4.5% $H_2O$ (wet) |
| Type of Crusher: | Primary (unknown) |
| Pick-up Points: | Crusher transfer points and crusher pit exhaust (includes railcar dump, crusher, surge bin, apron feeder |
| Test Conditions: | Sprays normally used were off |
| Test Range: | .031 - .036 lb/ton (.034) |

### Cypress Bagdad

| | |
|---|---|
| Rock Type: | Quartz-monzonite |
| Product: | Copper ore processing feed |
| Type of Crusher: | Unknown type - Secondary class |
| Product Moisture: | Dry |
| Pick-up Points: | Scrubber inlet |
| Test Range: | .061 - .139 lb/ton (.088) |

TABLE 6--Continued

J. M. Brenner

| | |
|---|---|
| Rock Type: | Limestone (low grade) |
| Product: | Aggregate |
| Feed Moisture: | Dry |
| Type of Crusher: | Jaw - Primary |
| Pick-up Point: | Crusher discharge |
| Test Range: | .015 - .018 lb/ton uncontrolled (.017) |
| Sec. Crusher: | Hammermill |
| Pick-up Points: | Scalping screen to stacking conveyor transfer point aboth hammermill feed and discharge |
| Test Range: | .0006 - 1.2 lb/ton |

Kentucky Stone

| | |
|---|---|
| Rock Type: | Limestone (high Ca) |
| Product: | Aggregate, agstone (-1/16"), stone sand |
| Feed Moisture: | Dry |
| Type of Crusher: | Single rotor impactor - Primary |
| Pick-up Points: | Beneath crusher at discharge point and at feeder to pri. belt transfer point |
| Test Range: | .558 - .793 lb/ton (.686) |

Anaconda

| | |
|---|---|
| Rock Type: | Chalcocite, chalcopyrite, other Cu ore |
| Product: | Metal refining |
| Feed Moisture: | Dry |
| Type of Crusher: | Gyratory - Primary |
| Pick-up Point: | Baghouse inlet including pickup at two grizzlies, crusher inlet, crusher discharge and transfer point from crusher to belt |
| Test Range: | .489 - .841 lb/ton (.658) |

FIGURE 4

CONSTRUCTION AGGREGATE
UNCONTROLLED EMISSION FACTORS FOR CRUSHING
FROM DIRECT SOURCE TESTING, lb/ton
(<10 um)

| Operation | Dry Material | | | | Wet Material | | | |
|---|---|---|---|---|---|---|---|---|
| | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. |
| Primary Crushing | | | | | | | | |
| Jaw | | | | | | | | .017 (2) |
| Gyratory | | | | .030 (1) | | | | |
| Impact | | | | | | | | .0012 (1) |
| Secondary Crushing | | | | | | | | |
| Gyratory | | | | .02 (1) | | | | |
| Impact | | | | | | | | |
| Tertiary Crushing | | | | | | | | |

Numbers in parentheses are no's of plants tested

FIGURE 5

CONSTRUCTION AGGREGATE
UNCONTROLLED EMISSION FACTORS FOR CRUSHING
FROM TRACER STUDIES, lb/ton
(<10 um)

| Operation | Dry Material | | | | Wet Material | | | |
|---|---|---|---|---|---|---|---|---|
| | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. | Stone (Granite, Trap Rock, etc) | Limestone | S&G | Ore & Misc. |
| Primary Crushing | 0.0008 (1) | | .0008 (1) | | | | | |
| Jaw | | | | | | | | |
| Gyratory | | | | | | | | |
| Impact | | | | | | | | |
| Secondary Crushing | .001 (1) | .032 (2) | .002 (2) | | | | | |
| Gyratory | | | | | | | | |
| Impact | | | | | | | | |
| Tertiary Crushing | .0008 (1) | .006 (1) | | | | | | |

Numbers in parentheses are no's of plants tested

appears to be necessary. In examining both the extractive test and receptor sampling categories of data there do not seem to be any discernable differences between primary, secondary, and tertiary crushing. There are at least two data points which are either suspect or otherwise not suitable for inclusion in the data base. The wide range between the two tests conducted at J. M. Brenner on a secondary crusher (.0006 - 1.2 lb/ton) suggests that that data be treated with caution. The tertiary crushing values from New Jersey Zinc involved preparing a metallic mineral for further processing which had been dried. This operation does not seem appropriate for use in a construction aggregate emission factor.

Taking into account the limited amount of data available, the lack of any demonstrated pattern, except for differences between wet and dry crushing; the lack of a consistent pattern of differences between the various crushing stages; and the needed correction factor for converting values to TSP we propose an interim single valued emission factor for all construction aggregate rock crushing. To do this we have taken the calculated average single valued emission factors for primary and secondary crushing given in Table 4-1 of the GCA report and averaged them.

However, because of the large discrepancy between tests conducted at the J. M. Brenner plant, we have taken the dry day test value only for secondary crushing (1.2 lb/ton) for use in calculating a single valued uncontrolled (dry) emission factor for construction aggregate rock and stone crushing. Table 7 shows the revised listing of data used to calculate this emission factor. The resulting emission factor for construction aggregate uncontrolled dry crushing operations is 0.28 lb/ton. Because the tests used include some ambient data where deposition of larger particles could have taken place prior to sampling and because the extractive test data show a fairly large portion of particles smaller than 10 micrometers in diameter, this value for an uncontrolled crushing emission factor should be considered as being suspended material. For comparison, the currently listed emission factors for stone crushing in AP-42, Section 8.20-1 are listed below.

TABLE 7

SELECTION OF SINGLE EMISSION FACTOR VALUES
FOR SOURCES IN THE CONSTRUCTION AGGREGATE INDUSTRY

| Source | Test Series | | | | Avg. EF for Rating Category | Calculated Single EF Value* | |
|---|---|---|---|---|---|---|---|
| | Rating | Avg. EF | EF Units | No. of Runs | | Average | Range |
| PRIMARY CRUSHING | | | | | | | |
| Uncontrolled (dry) | A | 0.017 | lb/ton | 2 | | | |
| | A | 0.686 | lb/ton | 3 | 0.508 | | |
| | A | 0.658 | lb/ton | 3 | | 0.34 | 0.0015-0.686 |
| | B | 0.0015 | lb/ton | 6 | 0.0015 | | |
| Controlled (wet) | A | 0.041 | lb/ton | 3 | | | |
| | A | 0.0014 | lb/ton | 3 | 0.0264 | 0.0264 | 0.0014-0.041 |
| | A | 0.034 | lb/ton | 3 | | | |
| SECONDARY CRUSHING | | | | | | | |
| Uncontrolled (dry) | A | 1.2 | lb/ton | 1 | 0.366 | | |
| | A | 0.088 | lb/ton | 3 | | | |
| | B | 0.0006 | lb/ton | 6 | | 0.25 | 0.0002-0.60 |
| | B | 0.0002 | lb/ton | 3 | 0.0296 | | |
| | B | 0.088 | lb/ton | 12 | | | |
| Controlled (wet) | A | 0.0006 | lb/ton | 1 | 0.0006 | 0.0054 | 0.0006 - 0.015 |
| | B | 0.015 | lb/ton | 6 | 0.015 | | |
| UNDESIGNATED CRUSHING | | | | | | | |
| Uncontrolled (dry) | B | 0.158 | lb/ton | 1 | 0.258 | 0.26 | |

* As with the GCA report, "A" rated tests were given twice the weight of "B" rated tests in calculating the single valued emission factor.

Particulate Emission Factors
for Stone Crushing Process

| Process Operation | Uncontrolled Emission Factor (lb/ton) | |
|---|---|---|
| | Total | Suspended |
| Primary Crushing | 0.5 | 0.1 |
| Secondary Crushing & Screening | 1.5 | 0.6 |

There is a significant problem relating to emission factors for the sand and gravel category of material and for wet materials. There is essentially no new data for sand and gravel and very little data for wet material. In the AP-42 section on Sand and Gravel Processing (8.19) prior to Supplement 14, an overall plant emission factor of 0.1 lb per ton is given and a statement made that "Because these materials are generally moist when handled, emissions are generally lower than in a similar crushed stone operation." In the Supplement 14 section on Sand and Gravel Processing (8.19.1), factors are given for some uncontrolled dry operations, but no crushing factor is included. The section does state under 8.19.1.2 Emissions and Controls that - "Generally, these materials are wet or moist when handled, and process emissions are often negligible."

In the case of wet materials (>1.5% moisture), the single valued emission factor for primary crushing given in Table 4-1 of the GCA report is 0.0264 lb/ton. This is approximately 7% of the overall dry factor for primary crushing given in the table and about 5% of the value from extractive testing only. Interestingly enough, this is equivalent to the high side of the range given in 8.19.1.2 of AP-42 Supplement 14 for the control efficiency of wet suppression. A "wet" emission factor for secondary crushing can also be derived from the GCA data. The rainy day test at the J. M. Brenner Co. can be grouped with the controlled value using wet suppression from the Monsanto/TRC tracer studies at stone crushing operations. This value as shown in Table 7 is 0.0054 lb/ton. A crushing emissson factor was also developed during the plume profiling studies conducted at southern California sand and gravel plants.[4)] With the wet suppression system on the crusher turned off, the emission factor was 0.258 lb/ton. With the system on, the factor was 0.0243 lb/ton. No material moisture content data were reported. However, it could be assumed that the proper use of wet suppression at a crusher is equivalent to crushing of "wet" materials.

Emission factors for crushing wet materials can be expressed directly or on a dry basis with a control efficiency credit being given for use of wet materials or wet suppression. The latter approach is most consistent with current practice. The extractive test based emission factor for crushing wet materials (.0254 lb/ton) is nearly identical with the plume profiling based emission factor for sand and gravel using wet suppression at the crusher (0.0243 lb/ton). Using these values an emission factor for primary or secondary crushing of wet materials is calculated to be 0.025 lb/ton. If the value of 0.0054 lb/ton for secondary crushing of wet materials derived from the GCA report is included, the emission factor for primary and secondary crushing of moist materials or using wet suppression as a control measure is 0.018 lb/ton. Therefore, based upon an uncontrolled crushing emission factor of 0.28 lb/ton, wet suppression can be assigned a control efficiency of 90-95%.

One other issue which should be addressed relates to industrial sand operations. Based upon data supplied to us for this project and information obtained during a visit to the PGS plant at Berkeley Springs, West Virginia, our recommendation is that the proposed emission factor for construction aggregate rock crushing be applicable to industrial sand plant crushing taking place before wet milling and drying operations. Generally this would include primary and secondary crushing of raw material. All other operations are specifically related to the production of industrial sand products such as glass sand, abrasives, paint fillers, etc., which have been subjected to further grinding, milling, drying, and size classification. Such operations should be addressed separately.

While we have developed no suggested value for screening emissions, the recent test data reported in the Appendix for sand and gravel operations should be reviewed and considered in the preparation of a revised section on CONSTRUCTION AGGREGATES for AP-42.

# SECTION 7

# SUMMARY

## SECTION 7

## SUMMARY

Various categories of emissions test data covering crushing and grinding operations in the construction aggregates industry were reviewed and assessed for their representativeness and reliability. These data included test results from conventional extractive source testing on ventilated operations and from ambient sampling directed towards assessing source strength of open dust sources. The data were further classified as to type of operation tested and material being processed during the tests.

A matrix of suggested emission source categories covering grinding and screening was prepared. This matrix considered equipment, operational and material parameters. From the assessment of available data and the suggested matrix, data gaps were identified and uncontrolled emission factors assigned to the appropriate sub-categories in the matrix. Where available, emission factors according to particle size classes were also reviewed and included.

The analysis of the data indicated that the range of emission factors for particular material and operation categories exhibited a rather large range of values. Further, there was no consistent difference among materials handled within categories of crushing. In particular, no significant differences in emission factors between primary and secondary crushing or among limestone, granite, trap rock, and sand and gravel could be discerned. Therefore, a single valued uncontrolled emission factor for primary or secondary crushing of rock or sand and gravel was developed. This uncontrolled emission factor is for materials considered to be dry. The value developed is 0.28 lb per ton of material fed to the crushers. No value is suggested for tertiary crushing because of insufficient data. However, in many cases, there is relatively little difference between secondary and tertiary crushing equipment or in feed size.

Wet suppression appears to be very effective in reducing dust emissions if surface moisture content is high enough to prevent the dislodging of fines from larger rock fragments. From the data examined, wet suppression, when properly used, can be assigned a control efficiency of 90-95% on emissions calculated using the uncontrolled dry emission factor.

Results from recent extractive tests on screening of crushed material in two sand and gravel plants are also presented. No specific emission factor was presented.

This study showed that additional test data are required to construct a set of emission factors on an operation and material basis in the construction aggregate industry.

# REFERENCES

## REFERENCES


1. Compilation of Air Pollutant Emission Factors, AP-42 (through Supplement 14), U.S. Environmental Protection Agency, Office of Air, Noise, and Radiation, Office of Air Quality Standards, RTP, NC 27711 (May 1983).

2. Non-Metallic Mineral Processing Plants - Background Information for Proposed Standards, U.S. Environmental Protection Agency, Office of Air Quality Standards, RTP, NC 27711 (November 1982).

3. Particulate Emission Factors for the Construction Aggregate Industry, GCA-TR-CH-83-02, prepared for the U.S. Environmental Protection Agency, GCA Corporation, Chapel Hill, NC 27514 (February 1983).

4. "Assessment of Fugitive Emissions from Sand and Gravel Processing Operations," J.H. Bennett and R.J. Gordon, paper 80-12.3, Annual Meeting of the APCA, Montreal, Quebec (June 1980).

5. Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections, U.S. Environmental Protection Agency, Air Management Technology Branch, Office of Air Quality Planning and Standards, RTP, NC 27711 (April 1980).

# APPENDIX A

## CONSTRUCTION AGGREGATES INDUSTRY
## EMISSION FACTORS DATA BASE

CONSTRUCTION AGGREGATES INDUSTRY
EMISSION FACTORS DATA BASE

(EPA Supplied)

1. Metallic Minerals Emission Test Report, Union Carbide, Hot Springs, Arkansas, EMB Report 80-MET-8, May 1980 (Scott)

   Vanadium ore processing - primary crusher, coarse ore grade. Tests on vent from transfer point to primary crusher, discharge from cyclones on primary crusher transfer, discharge from wet scrubber, baghouses on coarse and fine ore storage bins. Has particle size data.

2. "Particulate Emission Factors for the Construction Aggregate Industry" Final Report GCA-TR-CH-83-02 (Draft), Feb. 1983

3. "Metallic Minerals Emission - Emission Test Report", Exxon, Casper, Wyoming, EMB 79-MET-1 (Weston)

   Primary crusher transfer point )
   Fine ore bins ) Sandstone - uranium
   Dryer )
   Multiple points served in exhaust system on crusher, scrubber outlet flow is twice inlet

4. Emission Testing at an Iron Ore Beneficiation Plant - Reserve Mining Company, Silver Bay, MN, EMB Report No. 70-10-B-5, October 1978

   Ore dump - controlled (car dump)
   Dock pellet storage - uncontrolled (silo)
   Fine crusher - controlled
   Conveyor transfer fine crusher to storage silo transfer point.

5. Folder with comments from National Crushed Stone Task Group

6. "Suspended Particulate Emissions from the White Rocks Gravel Mine as Inferred from Air Quality Monitoring Data", prepared for Flatiron Sand and Gravel Co., Boulder, CO, 3/18/82
   George E. McVehil

7. "Air Pollution Control Techniques for Non-Metallic Minerals Industry" Draft August 1981, (incomplete, but has useful description of terminology) EPA document

8. "Industrial Sand Particulate Emission Factors for AP-42", 4/26/82
   One page results of tests on dryers, dry processing, milling.

9. Package of all items listed in Table 3-1 of the GCA report GCA-TR-CH-83-02. However, contains tables of results only - no discussions. (Note: Copy of Table 3-1 is appended.)

10. "Impact of Stone Quarry Operations on Particulate Levels", PEDCo for State of Illinois, September 1980, Revised April 1982.
Air sampling data and regression equation. No factors

11. Techniques for Evaluating and Controlling PM-10 Emissions from Fugitive Sources", PEDCo for EPA (PN3660-1-48), Sep. 1982

Gives some <PM-10 results for aggregate processing plants.

12. Anaconda Copper Company, 79-MET-3, Primary crushing - copper ore rock.

13. Papers: 80-20.2 - Selecting Measurement Techniques for Industrial Process Fugitive Emissions, Kolnsberg

80-68.7 - Fugitive Particulate Emission Development in Michigan - An Industrial Perspective, Whitehead (Ford)

80-20.5 - Regulatory Aspects of Fugitive Emissions, Westman, et al

80-12.2 - Application of Foam to Control Dust from a Rock Crushing and Handling Operation, Dowd (Nat'l. Gypsum), no actual data)

80-20.3 - Air Impacts of Fugitive Emissions, Chandler (Beak) no data

14. Reserve Mining Test - One page summary of opacity observations at crusher.

15. Bauxite Processing Test, Reynolds, Corpus Christi - Ship unloading scrubber in and out, fine storage bin baghouse exhaust

16. Lightweight Aggregate Industry (Clay, Shale and Slate) Emission Test Report - Texas Industries, Inc., EMB Report No. 80-LWA-3, May 1981

This report covers clay calcining for lightweight aggregate products. Only rotary kiln exhaust - scrubber and clinker cooler baghouse tested.

17. Visible Emissions Observations and Observations of EPA Testing - Crushed Stone and Gravel, TRC, Feb. 1980

Covers review Methods 9 and 22 only on four crushed stone and one sand and gravel plant. No quantitative emission data

18. "Particulate Emission Factors Applicable to the Iron and Steel Industry", EPA-450/4-79-028, September 1979
Midwest Research Inc. - No really applicable data

19. "Fugitive Dust Levels from Stone Crushers", 80-68-02 (APCA 1980), R.A. Wachter

Inferred emission factors from stone crushers using $SF_6$ tracer - downwind $SF_6$ and dust sampling.

20. "Iron Ore Beneficiation - Emission Test Report, Reserve Mining Company, Silver Bay, MN, EMB Report 78-10B-5, May 1979

(1) Ore car dump baghouse exhaust, (2) dock pellet storage silo vent (uncontrolled), (3) fine crusher baghouse exhaust, (4) transfer conveyor to fine crusher silos - baghouse in-out.

21. Iron Ore Pelletizing Plant Asbestos Emissions Tests, Kaiser Steel Co., Eagle Mountain, CA, July 1978

Asbestos fibers - drying zone, windbox, grate discharge, fine crushing exhaust

22. Iron Ore Beneficiation, Hanna Mining Co., Gravel and Mine, Iron Mountain, MI (S. Test), Oct 24-25, 1975

Tests on pelletizer - not relevant
Test on rotoclone exhaust serving 5 points - screens
Conveyors, transfer point

23. Lightweight Aggregate Industry (Clay, Shale, and Slate) Emissions Test Report - Vulcan Materials Co., Bessemer, AL, EMB Report 80-LWA-4

Rotary kiln exhaust, clinker-cooler exhaust

24. Air Pollution Emission Tests - Eveleth Taconite, EMB Report No. 76-10B-3, Nov. 17-21, 1975

Pelletizing furnace grate discharge end.

25. Control Techniques for Particulate Emissions from Stationary Sources, Vol. I, July 1980 (now EPA 450/3-81-005a)

No specific emission data

26. "An Investigation of Particulate Emissions from Construction Aggregate Crushing Operations and Related New Source Performance Standards"

Contains results of Monsanto Res. Corp. tests using air samplers and tracer at a number of rock and gravel and limestone plants
Done for 4 trade associations

27. "Assessment of Fugitive Emissions from Sand and Gravel Processing Operations", John H. Bennett and Robert J. Gordon, APCA Paper 80-12.3

Covers plume profiling and reverse modeled emission factors for transfer point, crusher, screens, open loading, surge piles

28. "Methods for Assessing Exposure to Windblown Particulates", Dynamac Corp., Envir. Control Division, Rockville, MD Dec. 1982
Paper study on emissions and different models for estimating concentrations of wind eroded particulates from hazardous waste sites.
EPA Project Officer John Schaum, Office of Health and Environmental Assessment, ORD. Also EAC, James W. Falco, Director

29. "Production of Sand and Gravel", Stanton Walker, Cir 57, NSGA, Oct. 1954

General description of sand and gravel operations

30. Correspondance concerning emission factors background and opinions. Covers concern about confusing sand and gravel with crushed stone

31. Chronological Mention of Emission Factors on Sand and Gravel Operations, compiled 6/8/72.

Background document on source of early emission factors

32. "Characterization of Particulate Emissions from the Stone-Processing Industry", George Weant, III, RTI for EPA, May 1975.

Descriptive document on stone processing - materials, operations, equipment, particulate formation
Emission data are only from earlier publications

33. SS and EIS from "Quarrying and Plant Process Facilities in the Crushed and Broken Stone Industry", A.E. Vervaert and R. Jenkins, and A. Basala, EPA OAQPS, August 1975

Prior to release

Has description of processes similar to #32
Test results from about 9 sources, however, all are controlled emissions from baghouses

CONSTRUCTION AGGREGATES INDUSTRY
DATA BASE

(Industry Supplied)

1. Pollution: It's All in the Book!, April 5, 1971.

2. Midwest Research Institute letter to Renninger, March 15, 1971.

3. William E. Hole letter to Kenneth Tobin, March 21, 1972.

4. Dust emission factors for sand and gravel; consideration on particulate size and potential for becoming airborne, September 26, 1972.

5. Particulate pollutant system study volume 1 - mass emissions, May 1, 1971; excerpt from MRI report of 1971.

6. NSPS comments on draft AP-42 section, February 22, 1982, letter to Southerland; Letter gives industry comments and basis.

7. Jim Crook letter to Mike Hart indicating percentage of total plant input crushed at each crushing stage, February 16, 1982.

8. Pettinos letter to EPA with plant flow sheet, January 5, 1977; new - no data.

9. Howiler letter to EPA with plant flow sheet, January 12, 1977.

10. Newman letter to EPA with plant flow sheet, January 18, 1977.

11. Zabala letter to Morris regarding industrial sand emission rates with particulate size and moisture content data, January 19, 1983.

12. Richards letter to Davison including industrial sand stack emissions tests, August 11, 1980.

13. Air Quality Data (TSP), Fairfax County, VA.

14. Non-Metallic Mineral Processing Plants - Background Information for Proposed Standards, Draft EIS, OAQPS, November 1982.

    Has 1973 AP-42 emission factors for crushed stone. Emission tests were all on controlled sources (Table 3.5).

15. "Source Assessment: Crushed Stone", EPA-600/2-78-004L, May 1978.

16. "Air Pollution Control Techniques for Non-Metallic Minerals Industry", Draft, OAQPS, August 1981

17. "Fugitive Dust Emission Factor Update for AP-42", MRI Project 4862-L (7) for EPA, December 8, 1982.

18. Source Assessment - Crushed Sandstone, Quartz, and Quartzite -- State of the Art, EPA-600/2-78-004n, May 1978.

p. 5 - describes respirable as less than 7 micrometers. Performed literature survey. Found that literature generally states that emission factors are related to (1) Material properties, and (2) Operation. The former includes moisture content density and dustiness index.

p. 10 - mean emission factor for a representative plant operating at 454 metric tons/hour was found to be 1.63 kg/hr respirable particulate and 15.7 kg/hr total particulates.

Respirable particulates were collected on a GCA respirable dust monitor that collects 10 micrometers with a cyclone separator and 50 micrometers witout the cyclone. Their statement is that the hi-vol collects particles under 100 micrometers.

Crushing data was ot collected at the site listed but instead came from primary crushing at a crushed stone plant.

The evaluation procedure used was reverse modeling.

19. Emissions from the Crushed Granite Industry: State of the Art, EPA-600/2-78-021, February 1978.

Conducted sampling at two granite plants using hi-vols and GCA samples. Gives factors for ops. given below:

TABLE B-5. EMISSION FACTORS AND R/T RATIOS FOR PARTICULATE

| Source | Total kg/metric ton | R/T | Respirable kg/metric ton |
|---|---|---|---|
| Blasting | $7.96 \times 10^{-2}$ | 0.169 | $1.35 \times 10^{-2}$ |
| Drilling | $3.99 \times 10^{-4}$ | 0.10 | $3.99 \times 10^{-5}$ |
| Secondary crushing and screening | $2.2 \times 10^{-2}$ | 0.036 | $8.58 \times 10^{-4}$ |
| Dumping to primary crusher | $2.1 \times 10^{-4}$ | 0.036 | $7.56 \times 10^{-6}$ |
| Vehicular movement on unpaved roads | $4.91 \times 10^{-3}$ | 0.176 | $8.64 \times 10^{-4}$ |
| TOTAL | $1.07 \times 10^{-1}$ | 0.143 | $1.53 \times 10^{-2}$ |

20. Memo from Jack M. Pryor to Richard A. Morris 7/7/83 with summaries from sixteen tests made at industrial sand plants.

# APPENDIX B

## SUMMARIES OF TEST RESULTS USED IN GCA-TR-CH-83-02

TABLE 3-2. PRIMARY CRUSHING OPERATION UNCONTROLLED EMISSION TESTS

| | Average emission rate (lb/ton) | Test rating | Range of test data (lb/ton) | Emissions <2.5 microns (lb/ton) | Emissions <10 microns (lb/ton) | Company name/data source | Location of measurement device | Number of runs | Process Conditions: Average production (tons/hr) | Process Conditions: Average moisture content | Process Conditions: Type of rock | Average flow rate (acfm) | Particle size-D50[a] (microns) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 0.017 | A | 0.015-0.018 | | | J.M. Brenner (75-STN-7) | Baghouse Inlet | 2 | 123 | 0.6 | Limestone | 1,105 | -- |
| 2. | 0.686 | A | 0.550-0.793 | | | Kentucky Stone (75-STN-8) | Baghouse Inlet | 3 | 353 | 0.8 | Limestone | 4,687 | -- |
| 3. | 0.658 | A | 0.489-0.841 | 0.003 | 0.030 | Anaconda (79-MET-3) | Baghouse Inlet | 3 | 2,118 | 1.5 | Chalcocite Chalcopyrite Enargite Borxite | 87,167 | >10 |
| 4. | 0.041 | A | 0.029-0.056 | | 0.019 | Homestake Mining (80-MET-7) | Baghouse Inlet | 3 | 124 | 4.0 | Cummingtonite Sideroplesite Vein Quartz Minor Sulfides | 2,314 | >10 |
| 5. | 0.0014 | A | 0.0008-0.0022 | 0.0007 | 0.0012 | Exxon Highland (79-MET-1) | Scrubber Inlet | 3 | 391 | 5.6 | Tertiary Fluvial Sandstones | 8,893 | 1.1 |
| 6. | 0.034 | A | 0.031-0.036 | 0.003 | 0.015 | Climax Co. (79-MET-2) | Scrubber Inlet | 3 | 1,080 | 4.0 | Fine- and coarse grained quartz-fluorite-molybdenite; quartz-sericite-pyrite; quartz-fluorite-sphalerite-galena-rhodochrosite | 55,688 | >10 |
| 7. | 0.0011 | C | -- | -- | 0.0003 | Crushed Limestone (EPA 600/2-78-004E) | 50 Feet Downwind | | 209 | -- | Limestone | | -- |
| 8. | -- | C | -- | -- | 0.003 | Crushed Stone (EPA 600/2-78-004L) | 328 Feet Downwind | | 529 | -- | Traprock | | -- |

CONTINUED

## TABLE 3-2. (continued)

| | Average emission rate (lb/ton) | Test rating | Range of test data (lb/ton) | Emissions <2.5 microns (lb/ton) | Emissions <10 microns (lb/ton) | Company name/data source | Location of measurement device | Number of runs | Process Conditions: Average production (tons/hr) | Process Conditions: Average moisture content | Process Conditions: Type of rock | Average flow rate (acfm) | Particle size-$D_{50}$* (microns) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9. | 0.0015 | B | -- | | 0.0008 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 6 | -- | -- | Traprock | | -- |
| | -- | B | -- | | 0.01 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 6 | -- | -- | Granite | | -- |
| | -- | B | -- | | 0.0006 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 9 | -- | -- | Sand & Gravel (1) | | -- |
| | -- | B | -- | | 0.001 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 10 | -- | -- | Sand & Gravel (2) | | -- |

*$D_{50}$ is the calculated particulate diameter in microns for which 50 percent by weight of the collected particulates have a smaller diameter and 50 percent by weight have a larger diameter.

## TABLE 3-3. SECONDARY CRUSHING OPERATION UNCONTROLLED EMISSION TESTS

| Average emission rate (lb/ton) | Test rating | Range of test data (lb/ton) | Emissions <2.5 microns (lb/ton) | Emissions <10 microns (lb/ton) | Company name/data source | Location of measurement device | Number of runs | Process Conditions: Average production (tons/hr) | Process Conditions: Average moisture content | Process Conditions: Type of rock | Average flow rate (acfm) | Particle size-D50* (microns) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. 0.60 | A | 0.0006-1.2 | | | J.M. Brenner (75-STN-7) | Baghouse Inlet | 2 | 123 | 0.5 | Limestone | 7,540 | -- |
| 2. 0.088 | A | 0.061-0.139 | 0.002 | 0.02 | Cypress Bagdad (79-MET-4) | Scrubber Inlet | 3 | 210 | -- | Quartz-monzonite rock | 2,113 | >10 |
| 3. 0.0003 | C | -- | | 0.0002 | Crushed Limestone (EPA 600/2-78-004E) | 60 Feet Downwind | 1 | 364 | -- | Limestone | -- | -- |
| 4. 0.0014 | C | | | 0.0006 | Crushed Stone (EPA 600/2-78-004L) | 400 Feet Downwind | 1 | 590 | -- | Traprock | -- | -- |
| 0.0011 | C | 0.0008-0.0014 | | 0.0007 | Crushed Stone (EPA 600/2-78-004L) | 230 Feet Downwind | 2 | 695 | -- | Traprock | -- | -- |
| 5. 0.045 | C | 0.031-0.065 | | | Crushed Granite (EPA 600/2-78-021) | 240 to 1,280 Feet Downwind | 8 | 475 | -- | Granite | -- | -- |
| | C | | | 0.001 | Crushed Granite (EPA 600/2-78-021) | 200 to 525 Feet Downwind | 8 | 650 | -- | Granite | -- | -- |
| 6. 0.0006 | B | | | 0.001 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 6 | -- | -- | Traprock | | -- |
| 0.0002 | B | | | 0.0001 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 13 | -- | -- | Limestone (1) | | -- |
| 0.088 | B | | | 0.064 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 12 | -- | -- | Limestone (3) | | -- |
| -- | B | | | 0.02 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 11 | -- | -- | Granite | | -- |
| -- | B | | | 0.002 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 15 | -- | -- | Sand and Gravel (1) | | -- |
| -- | B | | | 0.002 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet | 12 | -- | -- | Sand and Gravel (2) | | -- |

## TABLE 3-4. TERTIARY CRUSHING OPERATION UNCONTROLLED EMISSION TESTS

| Average emission rate (lb/ton) | Test rating | Range of test data (lb/ton) | Emissions <2.5 microns (lb/ton) | Emissions <10 microns (lb/ton) | Company name/data source | Location of measurement device | Number of runs | Process Conditions: Average production (tons/hr) | Process Conditions: Average moisture content | Process Conditions: Type of rock | Average flow rate (acfm) | Particle size-$D_{50}$* (microns) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. 2.76 | A | 1.62-3.34 | -- | -- | New Jersey Zinc (80-MET-6) | Baghouse Inlet | 3 | 19 | 0.2 | Franklinite Willemite Zincite | 365 | -- |
| 2. 0.0007 | C | -- | -- | 0.0001 | Crushed Stone (EPA 600/2-78-004L) | 400 Feet Downwind | 1 | 695 | | Traprock | -- | -- |
| 3. 0.0016 | B | -- | -- | 0.0008 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 6 | -- | -- | Traprock | -- | -- |
| 0.0070 | B | -- | -- | 0.0060 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet | 9 | -- | -- | Limestone (3) | -- | -- |
| -- | B | -- | -- | 0.08 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet | 3 | -- | -- | Granite | -- | -- |

*$D_{50}$ is the calculated particulate diameter in microns for which 50 percent by weight of the collected particulates have a smaller diameter and 50 percent by weight have a larger diameter.

## TABLE 3-5. DRY GRINDING AND FINES CRUSHING OPERATION UNCONTROLLED EMISSION TESTS

| | Average emission rate (lb/ton) | Test rating | Range of test data (lb/ton) | Emissions <2.5 microns (lb/ton) | Emissions <10 microns (lb/ton) | Company name/data source | Location of measurement device | Number of runs | Average production (tons/hr) | Average mois-ture content | Type of rock | Average flow rate (acfm) | Particle size-D50* (microns) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 0.0003 | C | -- | -- | -- | Crushed Stone (EPA 600/2-78-004L) | 400 Feet Downwind | 1 | 600 | -- | Traprock | -- | -- |
| | 0.00008 | C | -- | -- | 0.00003 | Crushed Stone (EPA 600/2-78-004L) | 425 Feet Downwind | 1 | 695 | -- | Traprock | -- | -- |
| 2. | 0.0016 | B | -- | -- | 0.0014 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 6 | -- | -- | Traprock | -- | -- |
| | -- | B | -- | -- | 0.008 | Particulate Emissions from Stone Crushing Operations (Monsanto/TRC) | 30 Feet Downwind | 8 | -- | -- | Granite | -- | -- |
| 3. | 32.5 | A | -- | -- | 26.7 | Engelhard Minerals (78-NMM-6) | Baghouse Inlet | 1 | 3 | -- | Fuller's Earth | 2,560 | 7.0 |
| | 37.1 | A | -- | -- | 36.5 | Engelhard Minerals (78-NMM-6) | Baghouse Inlet | 1 | 0.42 | -- | Fuller's Earth | 2,060 | 1.6 |
| 4. | 17.0 | A | -- | -- | 6.5 | Union Carbide Hot Springs (80-MET-5) | Baghouse Inlet | 1 | 67 | -- | Mixture of igneous rock complexes with sedimentary (clay) intrusions | 12,900 | 10 |

*D50 is the calculated particulate diameter in microns for which 50 percent by weight of the collected particulates have a smaller diameter and 50 percent by weight have a larger diameter.

APPENDIX C

CRUSHED ROCK SCREENING SOURCE TESTS

CONROCK CORP.

Performed by
Engineering-Science

# APPENDIX C

## PROCESS DESCRIPTION

Screen emissions were evaluated at two sand and gravel plants operated by CONROCK Co. in Southern California. One plant was located in the San Gabriel Valley in an area generally identified as being in the San Gabriel River Wash. The other plant was in the San Fernando Valley and is identified as the Sun Valley plant. In both plants sand and gravel is mined from open pits. The material mined ranges in size from sand to boulders. Pit crushers (jaw type) are used for initial size reduction of boulders. This material, which is generally damp when mined, is passed over bull screens in the crusher section of the plant and under size material is conveyed to the "wet" (i.e., washed) sand and gravel section of the plant where no further crushing takes place.

The oversize material from the pit is fed to crushers and rescreened prior to further processing. While the exact configuration of each plant is somewhat different, the material either goes through additional crushing stages or is conveyed to final product screens. All crushers other than the pit crusher are cone crushers. Wet suppression is used at the crusher feed and discharge as a normal practice.

## TEST PROCEDURES

The testing was all conducted using extractive stack sampling procedures. Because no dust control equipment is installed at either plant, each screen teted was temporarily encapsulated with a temporary wood frame and heavy duty flexible plastic sheeting. These enclosures were ventilated by installation of temporary duct work and exhaust fans designed to meet ACGIH specifications for ventilating flat deck screens. The criteria used were 50 cfm/ft$^2$ screen area and 200 ft/min velocity through enclosure openings.

Sampling was conducted at test ports located in each exhaust duct. These ports were located in straight duct sections prior to entry to the exhaust fans.

Test Parameters

Tests were conducted for both total particulate matter and for particle size data. Six sampling runs were made at each location. These runs were with the wet suppression system at the crushers in operation and three runs made with the sprays off. One of the runs under each condition was made using a cascade impactor for both total and size fractionated particulate matter. Three screens were tested at the Irwindale plant. These screens are identified as follows:

Irwindale Screens

| Designation | Type | Size Gradation |
| --- | --- | --- |
| Top Screen | Symons, 5 x 16'<br>Flat Double Deck | Top Deck: 1-1/2"<br>Bottom Deck: 3/4" |
| Middle Screen | Symons, 5 x 16'<br>Flat Double Deck | Top Deck: 1/2"<br>Bottom Deck: 3/8" |
| Bottom Screen | Symons, 5 x 16' | Top Deck: 8 M |

Five screens were tested at Sun Valley. Three secondary product screens, one was a recirculating screen and one was a dust screen. Three runs each, all with the wet suppression system on were made. These screens are identified below:

Sun Valley Screens

| Designation | Type | Size Gradation |
| --- | --- | --- |
| West Product Screen | Symons, 5 x 16' | Top: 3/8"<br>Bottom: 8 M |
| Middle Product Screen | Symons, 3-1/2 x 16' | Top: 1/2"<br>Middle: 3/8"<br>Bottom: 8 M |
| East Product Screen | Symons, 4 x 16' | Top: 1/2"<br>Middle: 3/8"<br>Bottom: 8 M |
| Recirc. Screen | Symons, 5 x 16' | Top: 1-3/4"<br>Bottom: 7/8" |
| Dust Screen | Symons, 5 x 16' | Top: 1/4"<br>Bottom: 8M |

Plant operating conditions including process weight, were established and maintained by personnel from Conrock. Product sample data were obtained during the test by Conrock personnel.

Total Particulate Testing Method

For the particulate runs, the samples were collected isokinetically. The sampling train consisted of an ambient temperature Teflon probe, connected to four impingers in series. The first two impingers were charged with deionized water (100 ml each), the thrid impinger was dry, and the fourth contained 200 grams of silica gel. Between the third and fourth impinger a filter was installed and operated at ambient conditions to collect any non-condensible particulate.

The particulate samples for the laboratory analysis consisted of the probe wash, impinger contents and the filter. Moisture was determined volumetrially from the liquid gain in the impingers and gravimetrically from the silica gel. The probe wash and impinger contents were taken to dryness at a temperature of 105°C.

Particle Size Testing Method

The Andersen Stack Sampler used is an in-stack, multistage, cascade impactor which adapts to the standard EPA type sampling train and obtains the size distribution of particulate emissions in addition to total particulate mass concentration.

The Andersen Stack Sampler size cut-off points for the various stages are based upon unit density (1 g/cc) spherical particles. These cut diameters are dependent upon flow rate and gas viscosity.

TEST RESULTS

Test results are summarized by plant in the accompanying tables.

**TABLE C.1**

**IRWINDALE SUMMARY**

Primary    Secondary    Tertiary

| Run | Comments | | Top Screen<br>Top Deck = 1-1/2 Pri.<br>Bot. Deck = 3/4<br>Rate TPH | Emissions lb/hr | E.F. lb/ton | | Middle Screen<br>Top Deck = 1/2 Second.<br>Bot. Deck = 3/8<br>Rate TPH | Emissions lb/hr | E.F. lb/ton | | Bottom Screen<br>Top Deck = 8 M<br>Rate TPH | Emissions lb/hr | E.F. lb/ton | | | | Overall Avg. E.F (lb/ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | W 4/5/84 | 1.5 | 362 | 1.38 | .0038 | ) | 151 | 2.18 | .0144 | ) | 74 | 0.16 | .0022 | ) | | | |
| 2 | W 4/5/84 | 1.5 | 363 | 0.76 | .0021 | >.0033 | 181 | 1.20 | .0066 | >.0146 | 73 | 0.37 | .0051 | >.0048 | 1649 | 9.99 | .0061 |
| 3 | W 4/9/84 | 1.5 | 285 | 1.11 | .0039 | ) | 108 | 2.42 | .0227 | ) | 52 | 0.38 | .0073 | ) | | | |
| 1 | D 4/9/84 | 0 | 285 | 7.17 | .0252 | ) | 108 | 25.39 | .2351 | ) | 52 | 4.68 | .0900 | ) | | | |
| 2 | D 4/9/84 | 0 | 285 | 13.39 | .0470 | >.0455 | 108 | 35.23 | .3262 | >.2965 | 52 | 11.09 | .2133 | >.1471 | 1335 | 157.93 | .1183 |
| 3 | D 4/9/84 | 0 | 285 | 18.34 | .0644 | ) | 108 | 35.46 | .3283 | ) | 52 | 7.18 | .1381 | ) | | | |

W = Wet suppression on
D = Wet suppression off

TABLE C.2

SUN VALLEY SUMMARY

SECONDARY PRODUCT SCREENS

| Run | Comments | | West (5 x 16) Top Deck - 3/8 Bottom Deck - 8 M | | | Middle (3-1/2 x 16) Top Deck - 1/2 Middle Deck - 3/8 Bottom Deck - 8 M | | | East (4 x 16) Top Deck - 1/2 Middle Deck - 3/8 Bottom Deck - 8 M | | | Average Values Secondary Product Screens | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rate TPH | Emissions lb/hr | E.F. lb/ton | Rate TPH | Emissions lb/hr | E.F. lb/ton | Rate TPH | Emissions lb/hr | E.F. lb/ton | Total TPH | Total Emissions lb/hr | Group E.F. (lb/ton) |
| 1 | 4/18/84 W | 1.5 | | 0.26 | | | 0.28 | | | 0.14 | | 500 | 0.78 | 0.0016 |
| 2 | 4/5/84 W | 1.5 | | 0.23 | | | 0.17 | | | 0.30 | | 500 | 0.70 | 0.0014 |
| 3 | 4/9/84 W | 1.5 | | 0.17 | | | 0.26 | | | 0.45 | | 500 | 0.88 | 0.0018 |
| | | | | | | | | | | | | Avg. E.F. = 0.0016 lb/ton | | |

TABLE C.2--Continued

"DUST" SCREEN

| Run | Comments | | Top Deck = 1/4 Bottom Deck = 8 M Rate TPH | Emissions lb/hr | E.F. lb/ton | 1.4% Moist. Avg. E.F. |
|---|---|---|---|---|---|---|
| 1 | 4/25/84 W | | 192 | 7.7 | .0401 | ) |
| 2 | 4/25/84 W | | 192 | 7.98 | .0416 | > .0411 |
| 3 | 4/25/84 W | | 192 | 8.01 | .0417 | ) SD=2.1% |

TABLE C.2--Continued

PRIMARY RECIRCULATING SCREENS

| Run | Comments | | Top Deck = 1-3/4 Bottom Deck = 7/8 | | | 1.4% Moist. |
|---|---|---|---|---|---|---|
| | | | Rate TPH | Emissions lb/hr | E.F. lb/ton | Avg. E.F. |
| 1 | 4/25/84 W | | 356 | 2.37 | .0067 | |
| 2 | 4/25/84 W | | 356 | 3.18 | .0089 | .0066 |
| 3 | 4/25/84 W | | 356 | 1.49 | .0042 | |

TABLE C.3

PARTICLE SIZE DATA
SCREENS

| Top Screen | | Middle Screen | | Bottom Screen | |
|---|---|---|---|---|---|
| Cum % | ECD (microns) | Cum % | ECD (microns) | Cum % | ECD (microns) |
| WET SUPPRESSION ON | | | | | |
| 100 | 19.0 | 100 | 18.0 | 100 | 21.0 |
| 80 | 11.6 | 92 | 11.3 | 67 | 13.0 |
| 52 | 7.8 | 87 | 7.6 | 61 | 8.8 |
| 27 | 5.4 | 81 | 5.2 | 53 | 6.0 |
| 18 | 3.6 | 71 | 3.3 | 45 | 3.9 |
| 11 | 1.8 | 57 | 1.7 | 33 | 2.0 |
| 6 | 1.1 | 25 | 1.1 | 22 | 1.3 |
| 3 | .8 | 5 | .7 | 6 | .9 |
| 1 | <.8 | 0.5 | <.7 | 2 | <.9 |
| WET SUPPRESSION OFF | | | | | |
| 100 | 19.0 | 100 | 19.0 | 100 | 19.0 |
| 93 | 11.9 | 99.8 | 11.6 | 73 | 11.6 |
| 75 | 8.0 | 97 | 7.8 | 35 | 7.8 |
| 66 | .6 | 91 | 5.4 | 33 | 5.4 |
| 55 | 3.5 | 58 | 3.6 | 25 | 3.6 |
| 32 | 1.8 | 21 | 1.8 | 20 | 1.8 |
| 14 | 1.2 | 7 | 1.1 | 17 | 1.1 |
| 6 | .8 | 2 | .8 | 14 | .8 |
| 4 | <.8 | 1 | <.8 | 12 | <.8 |

TABLE C.4

SUN VALLEY
PARTICLE SIZE DATA
SCREEN - WET SUPPRESSION ON

| Product Screens | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| East | | Middle | | Bottom | | Dust Screen | | Recirc. Screen | |
| Cum % | ECD (microns) | Cum % | ECD (microns) | Cum % | ECD (microns) | Cum % | ECD (microns) | Cum % | ECD (microns) |
| 100 | 19.0 | 100 | 19.0 | 100 | 12.9 | 100 | 19.0 | 100 | 16.7 |
| 66 | 11.6 | 86 | 12.0 | 86 | 8.0 | 91 | 11.9 | 92 | 10.5 |
| 42 | 7.8 | 70 | 9.1 | 67 | 5.4 | 81 | 8.0 | 56 | 7.0 |
| 33 | 5.4 | 50 | 5.6 | 51 | 3.7 | 72 | 5.6 | 22 | 4.8 |
| 28 | 3.6 | 31 | 3.6 | 41 | 2.4 | 58 | 3.5 | 8 | 3.2 |
| 23 | 1.8 | 22 | 1.8 | 23 | 1.2 | 36 | 1.8 | 5 | 1.6 |
| 17 | 1.1 | 18 | 1.1 | 14 | .7 | 7 | 1.1 | 3 | 1.0 |
| 14 | .8 | 13 | .8 | 5 | .5 | 1 | .8 | 1.6 | .7 |
| 9 | <.8 | 3 | <.8 | 2 | <.5 | 0.3 | <.8 | 0.1 | <.7 |

APPENDIX D

RATING FACTOR APPROACH

FROM

TECHNICAL PROCEDURES FOR
DEVELOPING AP-42 EMISSION FACTORS AND
PREPARING AP-42 SECTIONS

U.S. Environmental Protection Agency
Air Management Technology Branch
Office of Air Quality Planning and Standards
RTP, NC 27711

April 1980

## SECTION 5

## TECHNICAL SPECIFICATIONS AND RATIONALE

Because the AP-42 document consists of many sections produced at different times by different authors, uniform reporting practices are essential. This section sets forth reporting standards and reporting specifications to be followed in data collection, units, nomenclature, reporting format, and figure presentation. Technical guidance and rationale are provided for those areas of concern for which specifications cannot be described.

### 5.1 DATA STANDARDS/TEST METHODS

Emission factors in AP-42 are based on data obtained from several sources, including published technical papers and reports, documented emission testing results, and personal communications. Data provided by individual sources vary from single values, to ranges of minimum and maximum values, and finally to data from replicated source tests. Some data sources provide complete details about their collecting and analyzing procedures, whereas others provide only sketchy information in this regard.

The author selects data on the basis of the quantity and quality of data that are available. The following data are always excluded from consideration:

1. Test series averages reported in units that cannot be converted to the selected reporting units (see Section 5.4).

2. Test series representing incompatible test methods (i.e., comparison of EPA Method 5 front-half with EPA Method 5 front- and back-half).

3. Test series of controlled emissions for which the control device is not specified.

4. Test series in which the source process is not clearly identified and described.

5. Test series in which it is not clear whether the emissions measured were controlled or uncontrolled.

If there is no reason to exclude particular data from consideration, each data set is assigned a rating. A rating system is needed because some data are used when little other information is available, but are excluded when sufficient high-quality data exist. The data are rated as follows:

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 are certainly to be 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.

The author uses the following criteria to evaluate source test reports for sound methodology and adequate detail:

1. <u>Source operation</u>. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.

2. <u>Sampling procedures</u>. If actual procedures deviated from standard methods, the deviations are well documented. Procedural alterations are often made in testing an uncommon type of source. When this occurs, an evaluation is made of how such alternative procedures could influence the test results.

3. <u>Sampling and process data</u>. Many variations can occur without warning during testing, and sometimes without being noticed. Such variations can induce wide deviations in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and are given a lower rating.

4. <u>Analysis and calculations</u>. The test reports contain original raw data sheets. The nomenclature and equations used are compared to those specified by EPA, to establish equivalency. The depth of review of the calculations is dictated by the reviewers' confidence in the ability and conscientiousness of the tester, which in turn is based on factors such as consistency of results and completeness of other areas of the test report.

An A-rated test may be a stack test, a material balance, or some other methodology, as long as it is generally accepted as a sound method of measuring emissions from that source. In some cases (e.g., some VOC sources), a material balance calculation may be rated A and a stack test may only be rated B or C.

Because only one combined value is used to calculate the AP-42 emission factor for each facility, only the results of tests of equal rating are retained when multiple-series tests are run at the same facility.

Although the rating system described above is subjective, it provides a basis for excluding poor data when sufficient good data are available. The compiler also attempts to ascertain how representative the tested facility is of the entire industry. For example, source tests performed for the preparation of New Source Performance Standards (NSPS) may not be representative of the industry as a whole. If a substantial portion of the data used in the derivation of an emission factor comes from NSPS tests, this fact is footnoted at the bottom of the emission factor table.

When an AP-42 section is revised, the data standards are applied to the data used to calculate the current factor. Because some potentially good data may have been excluded as a result of poor documentation in the past, all new data is clearly documented and the reasons for the A through D ratings clearly stated in the background information. When data rated lower than B are used in calculating an emission factor, the table is footnoted with an explanation of any limitations the emission factor may have.

## 5.2 STATISTICAL METHODS

The AP-42 emission factors are based on data from published and unpublished reports, technical papers, and personal communications with individual investigators. Emission data extracted from the source documents may have been determined by emission source testing, material balance, or engineering analysis.

The emission factors thus represent statistical averages or single values that have been determined by engineering judgment to be representative of the available data for a specific source category.

In the ideal situation, a large number of A-rated source test sets representing a cross section of the industry are reduced to a single value for each individual source by computing the arithmetic mean of each test set. The emission factor is then computed by calculating the arithmetic mean of the individual source value. No B-, C-, or D-rated test sets are in the calculation of the emission factor because the number of A-rated tests is sufficient. This ideal method of calculating an emission factor is not always possible because of lack of A-rated data.

The number of A-rated tests needed to represent a cross section varies among industries. The following variables influence this number.

1. The total number of facilities in the Nation (sample size vs. total population)
2. The variability of emissions within the industry
3. The variability of emissions within each facility

4. The representativeness of the sample of the total industry

Because this judgment is subjective, the rationale behind the decision is documented in the background information. If possible, estimates of these variables are made. At a minimum, the author attempts to estimate the total number of facilities in the Nation.

Specific data that are included in the background document include but are not limited to the following.

1. Number of facilities tested

2. Estimate of number of facilities in the United States

3. Range of emissions in the United States (minimum, maximum)

4. Range of emissions for each facility tested (minimum, maximum, and number of tests)

5. A description of how the sample was chosen (i.e., random, tests for NSPS, etc.) and an estimate of whether this may cause bias in the data.

If the number of A-rated tests is so limited that the inclusion of B-rated tests would improve the emission factor, then B-rated test data are included in the compilation of the arithmetic mean. No C- or D-rated test data are averaged with A- or B-rated test data. The rationale for inclusion of any B-rated test data is documented in the background information. As more A-rated test data become available, the B-rated test data are dropped from the emission factor calculation. A footnote is added to the emission factor table to inform the user of the limitations on the emission factor.

If no A- or B-rated test series are available, the emission factor is the arithmetic mean of the C- and D-rated test data. When C- and D-rated test data are used, limitations on the use of the emission factor are clearly footnoted in the emission factor table. The C- and D-rated test data are used only as a last resort, to provide an order-of-magnitude value.

Throughout the statistical process, test results at an individual source are reduced to a single value by using the arithmetic mean, and individual source emission factors are combined by computing the arithmetic mean. In some industries, the median may more accurately represent an "average" value. In these cases, the more correct statistical method is used; the rationale for its use is documented in the background information and a footnote is added to the emission factor table. In the absence of such a footnote, the user can conclude that the emission factor represents an arithmetic mean.

The author attempts to reduce the data to a single emission factor rather than a range of values. Should the ranging values lend themselves to categorization, the author may present several emission factors that are based on a facility variable (e.g., age, throughput, fuel).

## 5.3 QUALITY RATING/STATISTICAL CONFIDENCE

In AP-42, emission factors for each criteria pollutant emitted from each of the emission points associated with an industrial process are grouped into a single table. The reliability of these emission factors is indicated by an overall Emission Factor Rating ranging from A (excellent) to E (poor). These ratings take into account the type and amount of data from which the factors were calculated.

The use of a statistical confidence interval may seem desirable as a more quantitative measure of the reliability of an emission factor. Because of the way an emission factor data base is generated, however, prudent application of statistical procedures precludes the use of confidence intervals unless the following conditions are met:

> The sample of sources from which the emission factor was determined is representative of the total population of such sources.

The data collected at an individual source are representative of that source (i.e., no temporal variability resulting from source operating conditions could have biased the data).

The method of measurement was properly applied at each source tested.

Because of the almost impossible task of assigning a meaningful confidence limit to the above variables and to other industry-specific variables (i.e., variability in determining fuel characteristics), the use of a statistical confidence interval for an emission factor is not practical. Therefore, some subjective quality rating is necessary. The following emission factor ratings are applied to the emission factor table.

A - Excellent. Developed only from A-rated test data taken from many randomly chosen facilities 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 facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. As in the A rating, the source category is specific enough to minimize variability within the source category population.

C - Average. Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities 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. The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there may be reason to suspect that these facilities 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 are footnoted in the emission factor table.

*Source category: A category in the emission factor table for which an emission factor has been calculated; generally a single process.

E - Poor. The emission factor was developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested 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 these factors are always footnoted.

Because the application of these factors is subjective, the reasons for each rating is documented in the background information. The ratings of A through E no longer represent the 0- to 40-point system previously applied to the entire emission factor table.

The calculation of individual confidence limits for all variables associated with an emission factor for use as the basis of the A to E ratings is encouraged if the author wants to do so. Documentation for this determination is presented in the background information.