

# Understanding your dust: Six steps to better dust collection

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**Almost every piece of process equipment in a powder and bulk solids handling plant depends on a dust collector to safely control dust or to reclaim valuable product. So why do most users treat dust collector selection as a mysterious art rather than a scientific process, without considering exactly what kind of dust they need to collect and what performance they need? This article helps take the mystery out of the process by explaining how to analyze your application needs and dust characteristics as part of choosing a dust collector. Sections detail the six steps in this process.**

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**A**re you happy with your dust collector's performance? If not, you have company: Most users are dissatisfied with how well their collectors operate.

This problem typically stems from neglecting or misunderstanding details about the unit's performance when the collector is selected. After all, in most cases a dust collector doesn't contribute to the plant's bottom line, so the user just doesn't devote the same attention to choosing a collector as to choosing a process machine.

But choosing your dust collector without doing enough research is dangerous. A poorly performing or failing dust collector can shut down your entire plant faster than any other piece of equipment. Without a dust collector, dust from process or handling machines can quickly create unsafe working conditions and the dust can't be reclaimed as product.

## The performance you should expect

You can expect the following performance from a properly selected dust collector:

- The dust collector's emissions meet your requirements.
- The dust collector's airflow is consistent to capture dust at its source.
- The filters require little maintenance at predictable intervals, and the filter media lasts reasonably long.
- The dust collector operates trouble-free with minimal maintenance.
- The captured dust is easy to handle and discard or reclaim.

## Selection factors to consider

One problem that often contributes to a poor collector choice is the dust collector manufacturer's concentration on air (or gas) flow to the exclusion of other selection factors. But to ensure the dust collector performs as it should, you need to evaluate several critical factors, including:

- What dust quantity must the unit collect — will it need to capture 2 lb/h or 2 t/h?
- What type of dust do you have? For instance, it's not enough to categorize the dust as silica. Is it sand or fume silica?
- What is the dust's particle size distribution?
- What shape are the dust particles: long skinny fibers, uniform spheres, or jagged crystals?
- Is the dust flammable?

- Is the dust hygroscopic?
- Is the clean air returned to the plant or exhausted to the atmosphere?
- What kind of requirements — such as OSHA, EPA, or plant insurance — must the dust collector meet?

By taking a close look at your dust, you'll have the information you need to choose the right dust collector. Have your dust analyzed with quantitative, scientific tests. Following these six steps will provide the data you need and help you apply the information to choosing a collector:

1. Do a site survey to gather information about your application.
2. Obtain a dust sample.
3. Send the sample to a lab for analysis.
4. Have full-scale tests run on the sample, if required.
5. Select the appropriate filter media and dust collector.
6. After installation, verify that the dust collector performs as required.

Before exploring these steps in detail, a word about the labs that can provide dust analysis: A handful of independent labs have testing experience specific to dust collection. These labs charge from about \$300 to \$1,000 for lab tests, depending on the scope of the tests you require, and up to about \$10,000 for full-scale tests.<sup>1</sup> Some dust collector manufacturers also offer test services; most offer lab tests, and several major manufacturers also provide full-scale tests. A manufacturer's testing services often are free or involve only a nominal charge. An application engineer in the independent lab or at the manufacturer's facility will test your dust and work with you to select the right collector for your needs.

## 1 Do a site survey to gather information about your application.

To gather data about your application, do a site survey. This information should accompany the dust sample (as discussed in step 2) you send for testing because the data provides a context for the tests and ensures the results will be meaningful.

Typically, you'll supply the site survey information on a data sheet, as shown in Figure 1. In addition to the information listed on the form, supply other facts to make the analysis more complete. This additional data should answer questions like these:

- Does your plant currently have dust collectors that filter this dust? If so, how well do they perform?
- Where do you intend to locate the new collector? Is headroom limited in this spot?
- How does the dust behave: Is it sticky some of the time? Does it cling to vertical surfaces or solidify after it sits in the open air?
- What service life do you want from the filter media?
- How do you want to handle the dust after it's collected? For instance, will you collect it in drums or convey it to a large silo?

## 2 Obtain a dust sample.

Even if your dust seems to be a common type, such as grain or wood dust, something in your process can cause the dust to behave differently than the norm. This is why all dusts must be sampled for testing.

Before collecting your sample, review the dust's Material Safety Data Sheet (MSDS) so you can protect yourself from any hazards associated with the dust.

Collect your sample properly. For the lab analysis, you'll need about a 1-pint sample; if you require full-scale tests as well, you'll need a much larger sample (as discussed in step 3). Be sure the sample represents the dust, with the same particle size and moisture content as the dust to be captured by the collector. For instance, a sample taken from dust swept from your plant floor isn't representative of dust that will be captured from the air by the dust collector; the floor sweepings will contain impurities and larger particles with enough mass to have fallen to the floor. If the dust comes from an existing collector's hopper, the sample won't represent the dust's true particle size distribution because it doesn't contain the particles collected on the filters.

If you have an existing dust collector, the best sample to send to the lab is a dirty filter bag or cartridge. If you don't have an existing collector, consult the lab for information about collecting a representative sample. Regardless of how you collect the sample, transport it to the lab in an airtight container to preserve the sample's moisture content.

Send a copy of the MSDS with the sample; the MSDS is important to the application engineer because it provides

information about your dust's chemical reactants and OSHA-mandated personal exposure limits.

**Figure 1**

**Typical site survey data sheet**

This form completed by \_\_\_\_\_ (name) of \_\_\_\_\_ (company) \_\_\_\_\_ (date)

**Equipment End User:** \_\_\_\_\_

**Location / Address:** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**Contact Name:** \_\_\_\_\_

**Phone Number:** \_\_\_\_\_

**SIC Code:** \_\_\_\_\_

**General Application Information**

**Operating Hours:** \_\_\_\_\_ (hrs./day) \_\_\_\_\_ (days/yr)

**Airflow @ Inlet of Collector:** \_\_\_\_\_ (ACFM) \_\_\_\_\_ (SCFM)

**Pressure Rating Required:** (+) \_\_\_\_\_ (-) \_\_\_\_\_ **Required Fan Static :** (+) \_\_\_\_\_ (-) \_\_\_\_\_

**Moisture in Air (% wt.):** \_\_\_\_\_ **Dew Point:** \_\_\_\_\_ °F or \_\_\_\_\_ °C

**Normal Operating Temp:** \_\_\_\_\_ °F or \_\_\_\_\_ °C **Max. Operating Temp:** \_\_\_\_\_ °F or \_\_\_\_\_ °C

**Electrical Requirements (NEMA):**  12  4  4X  7  9  OTHER \_\_\_\_\_  Voltage \_\_\_\_\_

**Material to be collected:** \_\_\_\_\_

**Process generating material:** \_\_\_\_\_

**Median Particle Size:** \_\_\_\_\_ microns

**Inlet Loading:** \_\_\_\_\_ (lbs/hr)

\_\_\_\_\_ (gr/ft<sup>3</sup>)

**Re-circulated Exhaust?**  yes  no

**Req'd Outlet Emissions:** \_\_\_\_\_ (gr/ft<sup>3</sup>)

\_\_\_\_\_ (mg/m<sup>3</sup>)

**Particle Size Distribution:** \_\_\_\_\_ % < 100 micron

\_\_\_\_\_ % < 10 micron

\_\_\_\_\_ % < 1.0 micron

**Bulk Density:** \_\_\_\_\_ (lb/ft<sup>3</sup>)

**General Material Characteristics (check all that apply):**

- |                                   |                                    |                                 |                                      |                                    |
|-----------------------------------|------------------------------------|---------------------------------|--------------------------------------|------------------------------------|
| <input type="checkbox"/> Abrasive | <input type="checkbox"/> Corrosive | <input type="checkbox"/> Sticky | <input type="checkbox"/> Hygroscopic | <input type="checkbox"/> Wet       |
| <input type="checkbox"/> Stringy  | <input type="checkbox"/> Chips     | <input type="checkbox"/> Toxic  | <input type="checkbox"/> Fume        | <input type="checkbox"/> Flammable |

**Explosion Venting Requirements (check or fill in blank as required)**

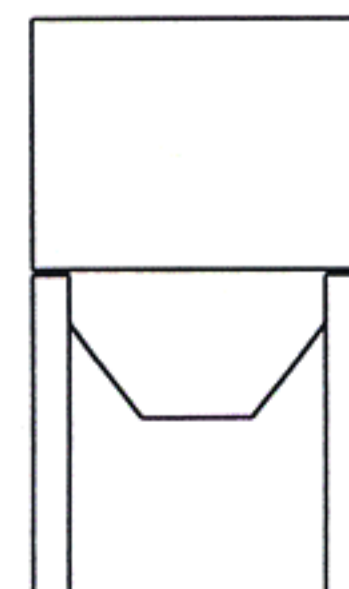
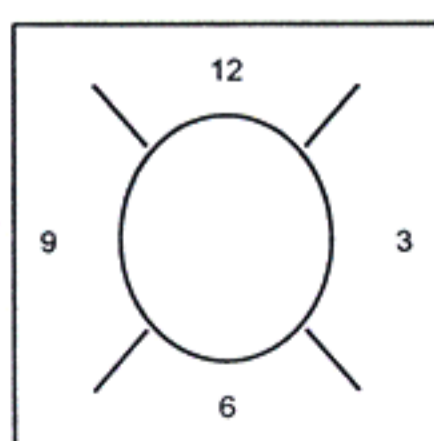
Is material to be collected explosive?  yes  no If yes, specify **K<sub>st</sub> Value** \_\_\_\_\_ **bar-m/sec**

If required, does explosion venting need to meet  **NFPA** or  **Factory Mutual** requirements?

Is equipment to be located  **inside** or  **outside?** (explosion vents must be ducted to outside)

**Below list or draw any information that is required to fully describe the intended application of the equipment:**

**Filter Orientation Required (Top View)**



### 3 Send the sample to a lab for analysis.

Testing your sample in a lab is the best way to discover important information about the dust's physical characteristics. The lab analysis includes a series of bench tests of the 1-pint sample. The tests commonly included are listed in Table I.

*Particle size analysis* is probably the most important procedure of all those in the lab analysis. The results list the particle size distribution of your sample in terms of both the quantity of particles of a given size and the particle diameters. Two common sizing techniques are listed in the table: sieve analysis, for particles over 100 microns, and dual-laser (time-of-flight) particle size analysis, for particles down to submicron sizes.<sup>2</sup>

The application engineer will use this information to determine your dust collector's required filtration efficiency and pressure drop across the filter media and, from this, what type of collector and media will be most effective at a reasonable cost. In a simplified example, if the particle size analysis shows that your dust has a large quantity of extremely fine particles, a cartridge dust collector with an on-demand cleaning system may be best; if the results show that the dust contains many large particles, a baghouse dust collector with polyester felt bag filters may be best.

A thorough particle size analysis actually examines two particle size distributions: count and volume. The *count distribution* shows the number of particles in the sample

and their diameters. This distribution can help the application engineer determine, for instance, if several submicron particles are masked by larger particles in the volume distribution. The *volume distribution* (also called *mass distribution*) shows the sample's mass spread (the weight of particles of various diameters).

Let's take a closer look at the difference between the count and volume distributions. It takes 1 million 0.5-micron particles to equal the mass of one 50-micron particle. We can demonstrate the difference between the two distributions by considering a hypothetical dust containing 1 million 0.5-micron particles and 99 50-micron particles. The dust is called a *mixed dust* because its particle sizes vary widely. Based on count, 99.99 percent of the dust is submicron size, but based on volume, only 1 percent is submicron. Knowing both distributions, we would select a dust collector that captures the submicron particles and cleans them off the filters. This collector would also have a specially designed inlet to allow the much larger particles to drop out of the airstream.

Such mixed dusts are common and often result from pneumatically conveying large, fragile bulk materials such as grains and plastic pellets. An example is thermographic powder used in printing. The fragile powder has a particle size ranging from about 30 to 80 microns, but after the powder is handled and conveyed, the particles break down and generate a dust with a particle size from 0.8 to 5 microns. Another mixed dust is emitted in the exhaust from a laser cutter. This device cuts steel and generates submicron-sized carbon smoke mixed with 30- to 70-micron steel particles.

**Table I**

#### **Lab analysis tests**

<b>Test procedure</b>	<b>What it measures</b>	<b>Benefit</b>
Sieve analysis	Dust particle size over 100 microns	Helps determine filtration efficiency needed to meet emission standards
Dual-laser particle size analysis	Dust particle size distribution down to submicron range	Helps determine filtration efficiency needed to meet emission standards
Pycnometer test	Dust particles' true specific gravity (not bulk density)	Helps determine cyclone efficiency and aids in dual-laser particle size analysis calculations
Video microscope analysis	Dust particles' shape and agglomeration characteristics via visual analysis	Helps determine whether to use baghouse or cartridge dust collector
Moisture analysis	Dust particles' moisture percent by weight	Helps to prevent or troubleshoot moisture problems that can impair filter performance
Humidity chamber test	Dust particles' moisture absorption rate	Helps to prevent or troubleshoot collector problems caused by hygroscopic dust
Abrasion test	Dust particles' relative abrasiveness	Helps determine proper design of components such as inlet, valves, ductwork
Terminal velocity test	Velocity required to lift dust particles	Helps to determine collector's can velocity
Horizontal velocity test	Optimal velocity required to move dust particles horizontally	Helps determine proper ductwork design
Sliding angle and angle of repose tests	Angle that dust particles freely form	Helps determine optimal hopper design and any need for flow aids

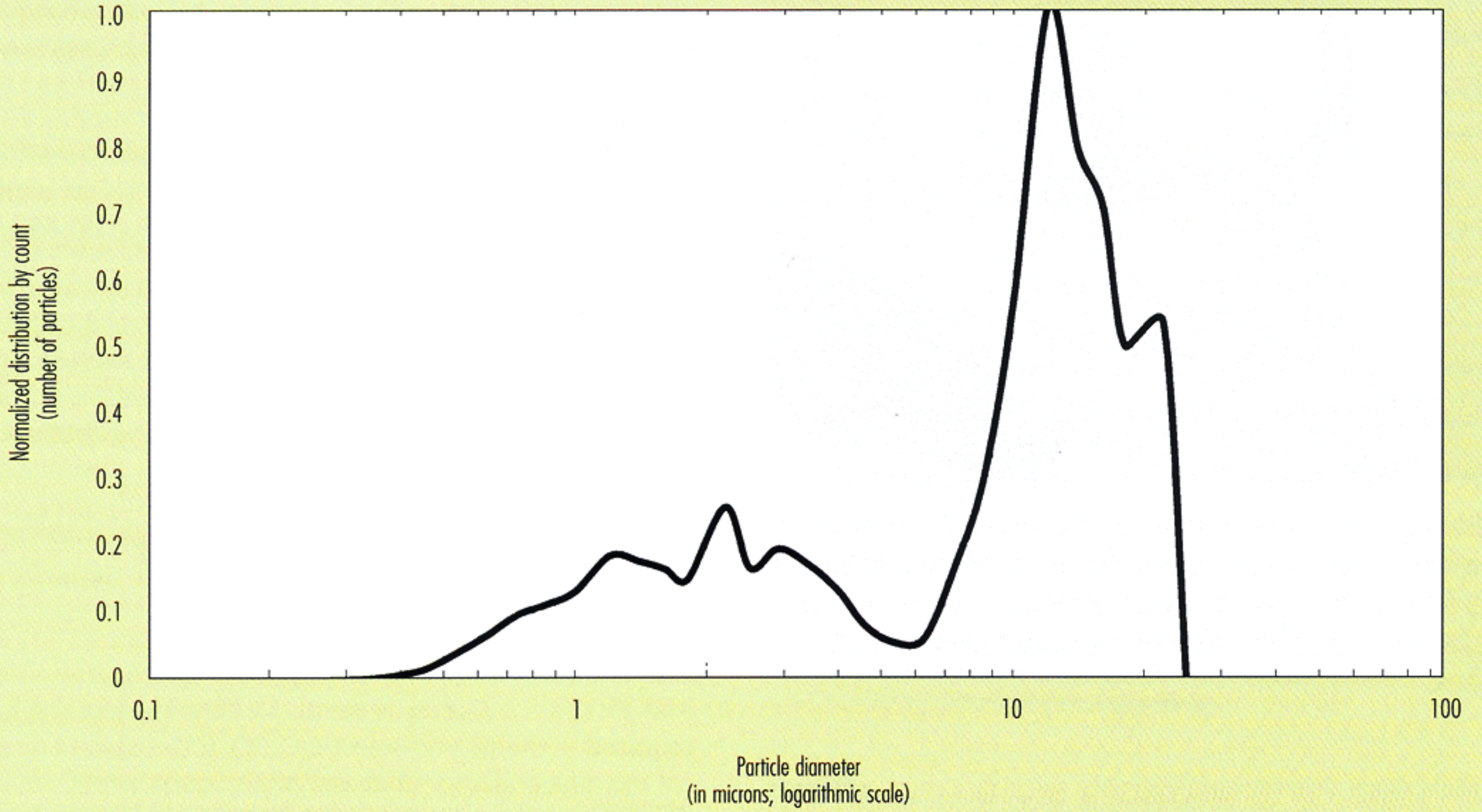
Count and volume distributions for the laser cutter dust are shown in Figures 2a and b. A magnified view of the dust is shown in Figure 3.

If you relied solely on a visual analysis — merely looking at the laser cutter dust sample in your hand — rather than a lab analysis, you would never see the submicron particles.

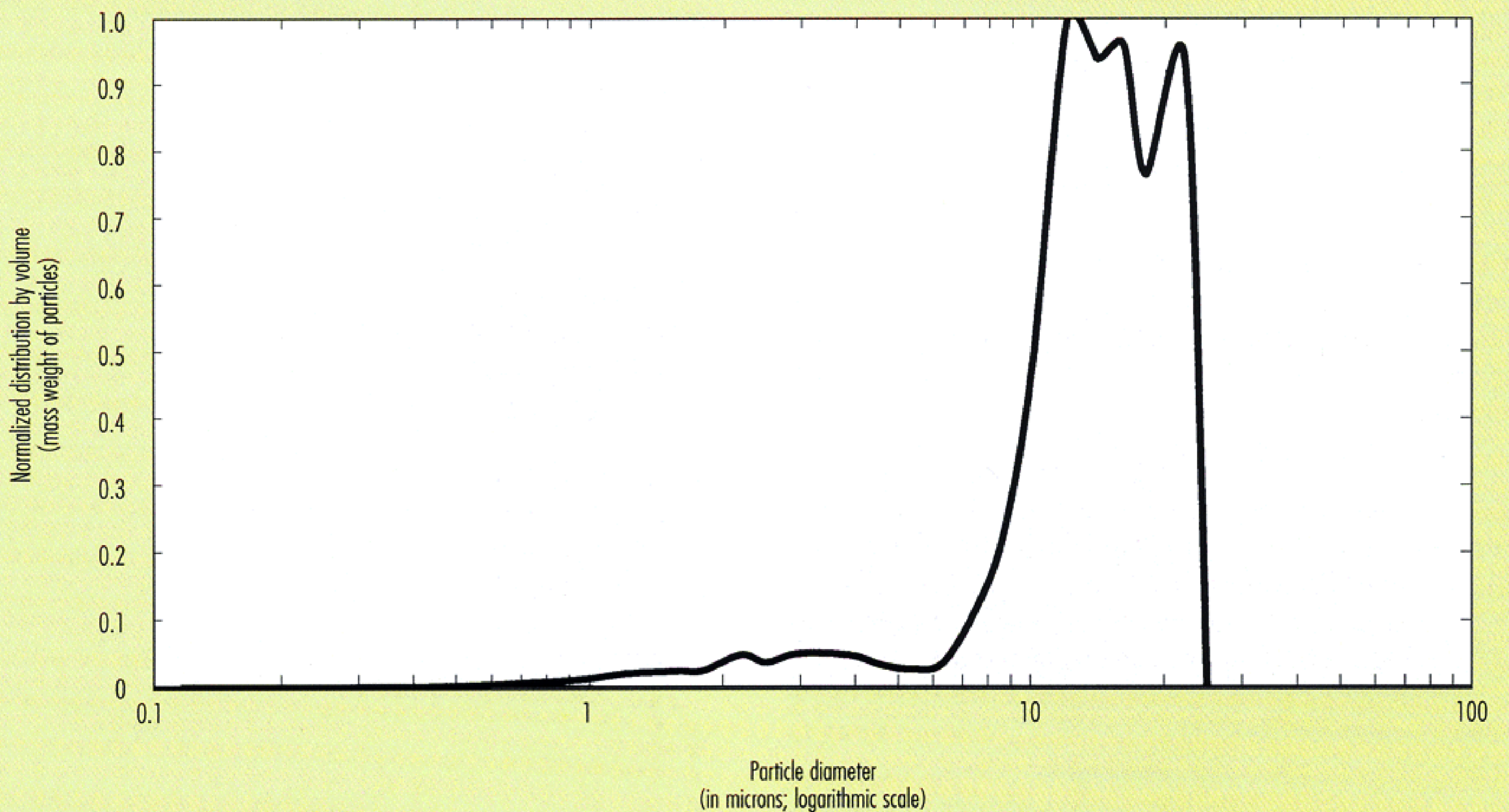
**Figure 2**

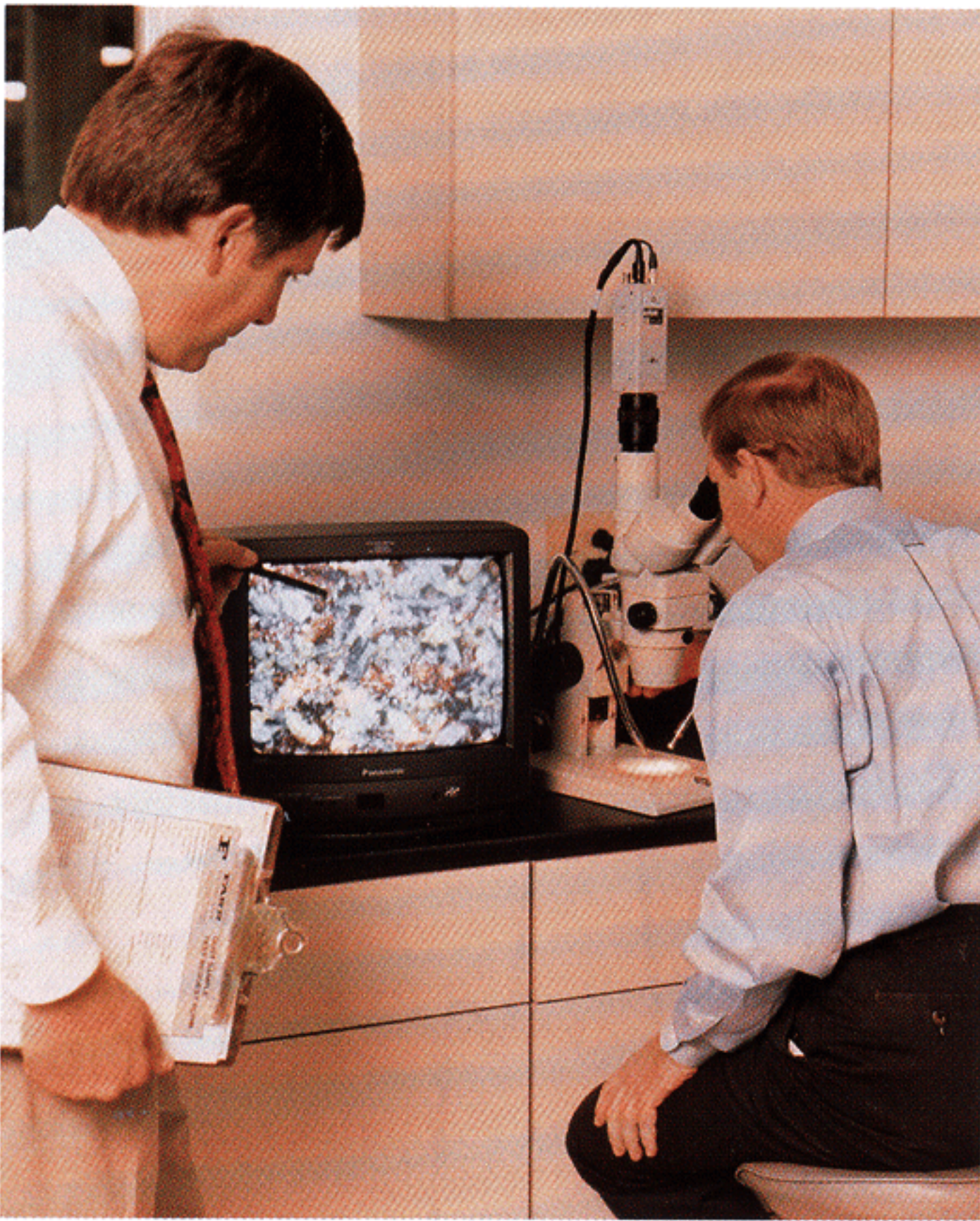
**Count and volume particle size distributions of mixed dust**

**a. Count distribution**



**b. Volume distribution**





**Having your dust sample tested in a lab reveals important information about the dust's physical characteristics. The lab analysis includes several bench tests, such as the video microscope analysis shown here.**

In this case, you would probably specify a dust collector with 12-ounce polyester felt bags to handle the large steel particles. But this collector would emit carbon smoke haze, and the filters would probably blind. On the other hand, if you performed the lab analysis with video microscope analysis, you'd clearly see the submicron particles and would choose an appropriate high-efficiency media, such as a pleated cartridge filter with cellulose or polytetrafluoroethylene (PTFE) membrane, to capture the particles.

The *pycnometer test* measures the particles' true specific gravity (rather than bulk density). This can help the application engineer calculate the efficiency of a cyclone and determine what gravity data to input for the dual-laser particle size analysis test.

The *video microscope analysis* provides a close-up view of the dust so the application engineer can determine the dust's particle shape and other characteristics important to dust collector selection. For instance, submicron, spherical dry particles such as polystyrene latex beads are hard to capture and require surface filter media such as P-84, PTFE membrane, pleated cellulose, or spun-bond polyester. Long fibrous particles such as fiberglass, grain dust, or wood dust can require wide bag filter spacing or wide pleat spacing on cartridge filters to avoid media bridging and packing. An

oily dust such as chili powder can require filter media with an oleophobic (oil- and water-resistant) coating.

The video microscope analysis also reveals particle agglomeration. The dual-laser particle size analysis can indicate that the sample contains large particles, but the microscope can show thousands of particles stuck together in a ball. Once you see agglomerated particles, you need to know whether the particles agglomerate *before* or *after* they reach the dust collector. The site survey information you gathered in step 1 can help you answer this question. If the dust collector is very dry and subsequent moisture causes the particles to stick together, you know you can treat the dust as tiny submicron particles that won't agglomerate in the operating environment. Conversely, if the site survey reveals that the collector will be exposed to moisture, you need to select a collector with an effective cleaning system to prevent caking on the filters.

Other tests provide additional information about your dust. The *moisture analysis* measures the particles' moisture content by weight and helps you choose filter media, such as polypropylene or a Teflon-treated type, that can release wet particles during the cleaning cycle. The *humidity chamber test* indicates whether the dust is hygroscopic (absorbs moisture). If the dust is hygroscopic, bag filters or widely pleated cartridge filters rather than tightly pleated cartridge filters would be best.

The *abrasion test* reveals the dust's abrasiveness and — if required — helps you select an abrasion-resistant design for the dust collector inlet and other components, such as valves and ductwork. The *terminal velocity test* (also called the *lift velocity test*) helps you determine the right dust collector size and bag or cartridge filter size by pinpointing the air velocity needed to lift the dust. (Together, the dust collector size and filter size create the collector's can velocity, the upward airflow through the dust collector housing.) The *horizontal velocity test* reveals the optimal velocity for moving your dust horizontally and helps you design the collector's ductwork.

The *sliding angle test* and the *angle of repose test* determine the angle at which dust freely forms and help you determine the dust collector's hopper angle and any need for flow-aid devices, such as air pads that inject air into the hopper to assist discharge. Along with video microscope analysis, the sliding angle test helps to identify the dust's adhesive and cohesive properties — for instance, whether the dust is likely to stick to dissimilar surfaces or agglomerate.

## **4 Have full-scale tests run on the sample, if required.**

Although the site survey and the lab analysis typically provide enough data, in some cases you'll need to have full-

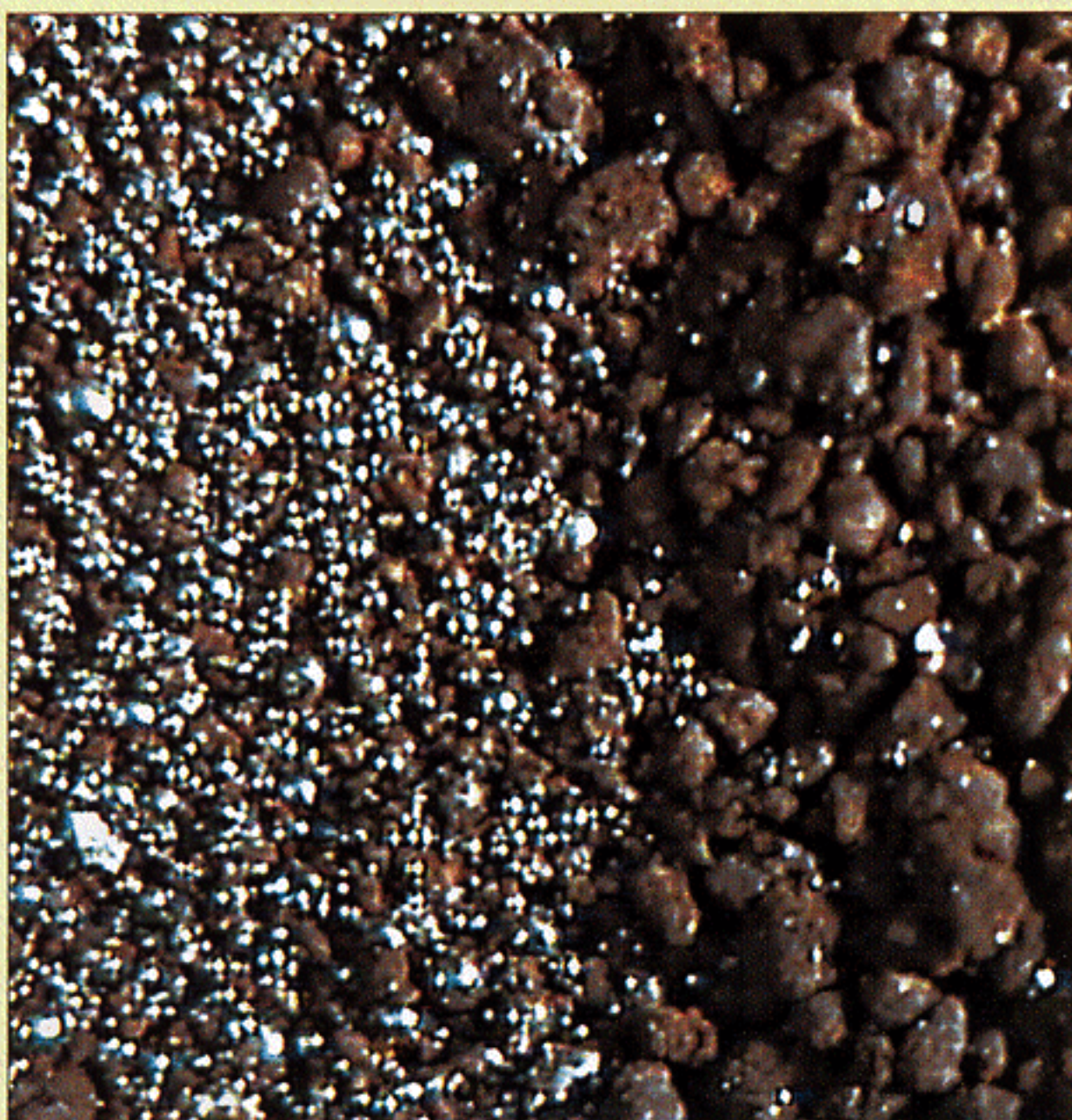
scale dust collector tests run on your dust. You may need to do these tests if:

- Your dust collector has never operated properly and you want to diagnose and correct the problem.
- You want to predict how your sticky or hard-to-handle dust will behave in the collector.
- You want to know how your moist or hot process airstream will affect dust collection.
- Your plant must meet stringent emission requirements.
- Your dust has a history of causing collector “upsets.” These can be caused by plugging (either from plugged filters that increase the pressure drop until airflow through the filters stops or from a plugged hopper discharge that causes dust to build up until it touches the filters) or filters that leak or break due to excessive airflow.

The full-scale tests typically require a dust sample large enough to fill a 55-gallon drum. The test apparatus includes various dust collectors, so the application engineer can run the dust through any of them to determine which unit is best for a given application. A portable version of such a test apparatus is shown in Figure 4.

**Figure 3**

**Magnified video microscope view of mixed dust**



The application engineer can perform each test using different air-to-cloth ratios (ACRs), dust loads, can velocities, and inlet velocities and compare the performances of different filter media, inlets, and housing designs. Emissions, pressure drop, and many other variables can be controlled and monitored during testing. When the tests are done, the engineer can determine the optimal collector type, filter media, ACR, cleaning frequency, and collection efficiency for your application.

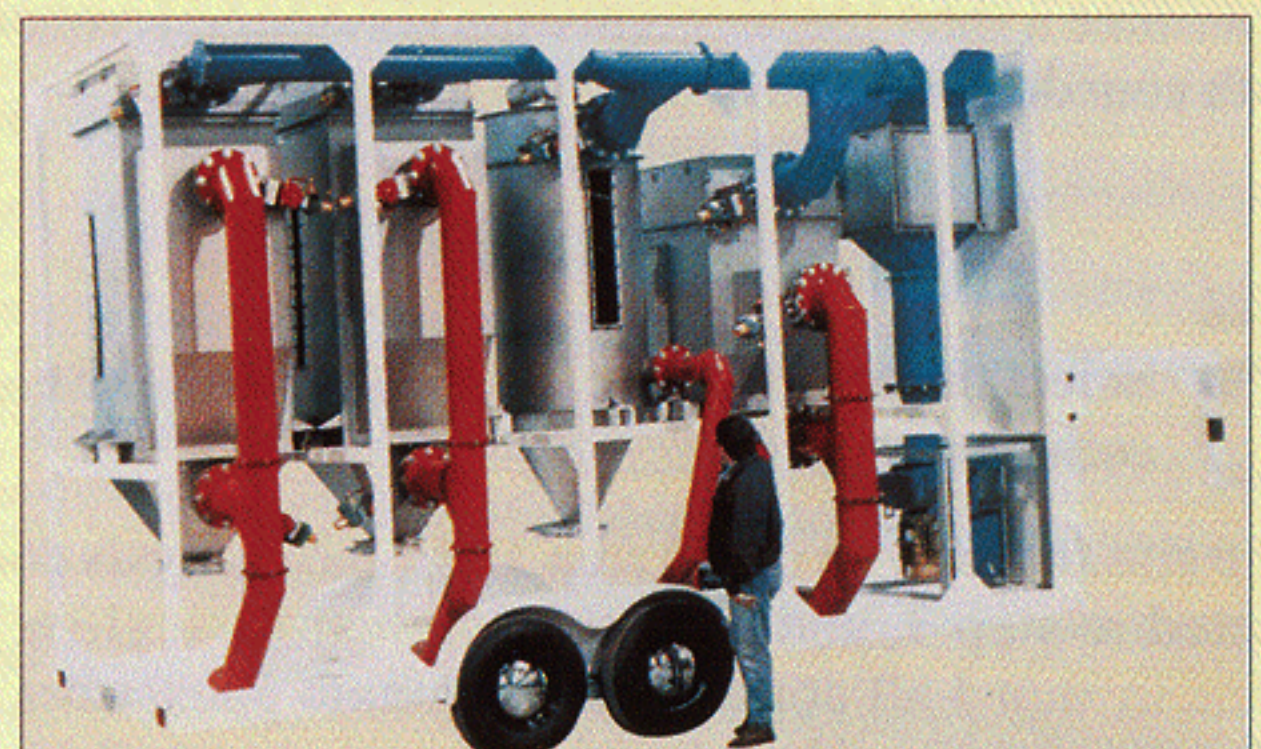
Important test parameters include the ACR, dust load, can velocity, inlet velocity, and filter media. The ACR, which determines the airflow velocity through the filter media, is one of the most important parameters in selecting filter media. If the air velocity through the filter is too high, the dust will be forced deep into the media and won't be removed during the cleaning cycle. This will blind the filter and cause it to fail. A high ACR also re-entrains more dust on the filter. Conversely, a lower ACR requires a larger, more expensive filter. By optimizing your dust collector's ACR, you can get the best performance and economy out of your filter.

By varying the *dust load*, the application engineer can observe how a filter will perform at expected and extreme dust loads. In many applications, the ACR must be reduced as the dust load increases. For this reason, it's important to know the maximum dust load a given filter can handle while still meeting emission requirements and maintaining a steady pressure drop.

The *can velocity* is as important as ACR, although it's sometimes overlooked. Another related parameter is the *interstitial velocity* — the upward airflow through the interstices (spaces) in the dust collector's filter compartment. Both can and interstitial velocity are proportional to the ACR and the dust collector's total airflow capacity.

**Figure 4**

**Portable full-scale test apparatus**



To better understand the influence of can velocity, consider this example: A dust collector with 12-foot-long bag filters can have the same filter surface area and ACR as a collector with 8-foot-long bag filters. However, the can velocity in the first collector is 30 percent higher, which can cause bag failure. A high can velocity tends to prevent dust from falling into the collector's hopper and promotes dust recirculation in the filters, which has the same effect as increasing the dust load at the inlet. The second dust collector will operate at a lower pressure drop with reduced emissions (because the dust load is effectively lower) and with longer filter service life.

The application engineer can also test the *inlet velocity* to predict how it can affect the dust collector's performance. With an abrasive dust, it's important to maintain a low inlet velocity. A high inlet velocity tends to increase dust re-entrainment on the filters and abrade the filters or cause them to swing inside the filter compartment, any of which can reduce filter life.

*Filter media* are available in dozens of types, ranging from standard polyester felt bags to more exotic ceramic bags and polyamide cartridges. The latter specialty media can cost as much as ten times more than polyester felt. So it's important to compare the performance of different media. Full-scale testing that compares filter media can help you select the best-performing, most cost-effective media for your application.

Different types of filter media also differ in their ability to control emissions. As you know, EPA and OSHA continue to tighten air quality control regulations. To obtain an EPA permit, you must know what your stack emissions are. Many plants find it easier to deal with OSHA, which is concerned with regulating indoor air quality, than with EPA. So they return filtered air to the plant and accept responsibility for ensuring air quality inside the workplace, thus avoiding EPA's time-consuming form-completion and permitting process. [*Author's note:* Air quality regulations differ from state to state, so check with your state authorities before deciding whether or not to recirculate dust collector exhaust to the plant.] But whether you try to meet EPA or OSHA requirements, use full-scale tests to determine a filter media's emission control performance with your dust

## 5 Select the appropriate filter media and dust collector.

The site survey you did in step 1, the lab analysis completed in step 3, and, if required, the full-scale tests done in step 4 all combine to eliminate guesswork in selecting a dust collector and help you choose the best filter media with confidence.

Keep in mind your site survey and test results when considering these factors in selecting a dust collector and filter media:

- Choose the appropriate filter element (bag or pleated cartridge) and filter media.
- Determine the optimal ACR for your filter media.
- Calculate the proper can velocity, which determines the dust collector size.
- Select the appropriate inlet design.
- Design the collector hopper to quickly discharge the dust.

## 6 After installation, verify that the dust collector performs as required.

Once your dust collector is installed and running, make sure its operating parameters, such as pressure drop and filter service life, meet your requirements.

Because processing technology continues to evolve, finer, hotter, and wetter dusts are created everyday and pose greater challenges to filter media. The dust control industry is responding with its own technology developments. To continue to achieve optimal dust collector performance, maintain a close relationship with your dust collector manufacturer and keep up with the latest developments in collectors and filter media. **PBE**

### References

1. Contact the authors for more information on independent test labs.
2. Find more information on particle sizing techniques in articles listed under "Particle analysis," pages 103-104, in *Powder and Bulk Engineering's* comprehensive "Index to articles," December 1997.

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