# THE COUNTING AND SIZING PROCEDURES

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November 1972

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NOTES

This lecture will cover counting and sizing asbestos dust. The procedure is crucial and we must all follow the criteria right to the letter. This is necessary in order to obtain reproducible count comparisons.

First, I would like to acquaint you with the terminology a microscopist uses in respect to microscopic dust. The general word for dust is particulates. There are types of particulates: fibers and motes. A fiber is a particulate that has an aspect ratio (length: width) of 3:1 or longer. A mote is any particulate that is not a fiber. Motes can also be called particles, but greater differentiation between particulates and particles is achieved if they are termed motes.

As you may have learned earlier, asbestos is a crystalline form of magnesium silicate and it has a fibrous crystal structure. When some mechanical action such as twisting occurs, asbestos will fracture and splinter, forming airborne asbestos fibers. Depending on the type or violence of mechanical action, differing sizes and quantities of extremely fine fibers are produced. This characteristic of fiber production is, for the most part, limited to asbestos and related minerals.

When you observe the sample for counting, there will be an infinite variety of particulate shapes. You will need some basic differentiating technique for separating asbestos from the rest of the sample. To date, there is no convenient absolute method for readily identifying asbestos by phase-contrast microscopy. Therefore, since our sample was taken (hopefully) in an asbestos environment and asbestos is relatively unique because of its fibrous structure, we developed the first rule for asbestos evaluation.

#1 — Count only the fibers

By counting fibers only, we automatically eliminate nearly every other material. If the sample is collected in an area containing some other material that is fibrous by nature (i.e., fiberglass), you may need to reject from your count those fibers that obviously are not asbestos. This area can be very tricky, so you had better be very sure that the fiber you are rejecting is not asbestos.

Along the history of industrial hygiene, scientists found out that not all of the dust that is present in the air is retained in the lung. The respiratory tract of one's body acts as a size-selective sampling instrument capable of rejecting some sizes and retaining others. This brings us to rule 2:

#2 — Count only the fibers 5 μm in length

NOTES

This rule was established for two reasons. First, there is significant evidence that fibers in this size range are most important. Second, it was felt that better count comparisons could be achieved. In any case, data has been gathered to support both of these opinions.

When you look at the sample with your microscope, you will notice that the fibers are randomly scattered throughout the field of view.

Your concern will be with fibers associated with the left half of the Porton reticle. These six rectangles are to be considered as one square that has the dimension $10(L^2)$ and is called "the field area." It is not logical to think that all of the fibers in the field of view are going to be situated within the field area. It is inevitable that some percentage of the visible fibers will be either across the boundary lines or completely out of the field area. Therefore, as part of Rule 3, the microscopist selects two adjacent sides (I prefer the left and the bottom) and retains them as a permanent part of the procedure. Here is Rule 3:

> #3 — Count any fiber 5μm in length if it is entirely within the field of area or if some portion is within and the part without crosses one or both of the pre-selected adjacent sides. The intent of this rule is to exclude potentially eligible fibers that are either outside the field of view or that cross either of the remaining sides (even if the fiber also crosses one of the selected sides.)

Thus far I have covered fibers and field area, but you now need to know how many of each you must count in order to be convinced of your count accuracy. To give you an idea of how large the field area is in relation to the open area of the filter, a field area of .0056 $mm^2$ is 1/171,000 of the 855 $mm^2$ filter surface. This is not very much. Rule 4 tells us how much of the filter we need to examine.

> #4 — Count as many field as required to yield at least 100 fibers: at least 20 and at most 100.

Because of the relatively even dust distribution across the filter surface, the proper application of Rule 3 will assure you that 95% of counted samples gives a statistical counting error no greater than + 20%.

The next rule will help to eliminate some human bias. If I were permitted to examine every field area by looking through the microscope, I might tend to search for fields having a low count or high. This would produce a concentration that is lower or higher

NOTES

than the one that really exists; therefore, Rule 5 was initiated to eliminate this source of error.

#5 — The fields of view are selected without looking into the eye pieces.

Earlier, I mentioned that the dust is relatively well distributed across the filter; although there is bound to be some unevenness. So we will select our fields of viewing according to the pattern described in Rule 6.

# — The fields are selected in a straight line running from the tip of the wedge (center of the filter) to the center of the arc side (circumference of the filter.)

Because the actual nature of the dust that is being sampled is unknown until you examine the filter with a microscope, you will need some common sense rules to use as guidelines when you encounter samples that are difficult to count. Consider these rules as general guidelines.

#7 — Do not count a field containing more than twenty fibers unless there is very little fiber overlap and very few background particulates.

#8 — When an agglomerate (a group of particulates that adhere to one another) covers at most 1/6 of the field area, reject the field and select another.

#9 — Since you must be able to see both ends of a fiber, ideally you must only size free fibers — that is, fibers that are unattached and you can see both ends.

At this point, let us move to a number of illustrations that will demonstrate the counting procedure:

#1 — Rule 1 tells us to count fibers only. Technically, all of the black patterns are fibers by definition.

#2 — Rule 2 tells us to count only the fibers longer than 5μm. When you compare the fiber's lengths to the 5μm circle, you may see that three are greater and would be counted. This is a very critical judgment and could be a source of error. Be as accurate as possible. At first, the judgment may require deep concentration.

NOTES

#3 — Jumping to Rule 10, we know that if a fiber is not "free" we may not be able to judge its length. In the case of this illustration, you could not easily judge fiber lengths in these agglomerates.

#4 — Part of Rule 3 requires you to count eligible fibers within the field area. Here, the field area is shaded red.

Ill. 5 — The rest of rule 5 covers eligible fibers crossing two pre-selected sides. These sides are highlighted in red in this illustration.

At this point, let us look at some illustrations and judge whether or not the fiber would be counted simply based upon its orientation around the reticle.

Ill. 6 — This fiber would be counted because part of the fiber is within the field area and it crosses one of the pre-selected sides.

Ill. 7 — This fiber would not be counted because it is not within the field area.

Ill. 8 — This fiber would be not counted because part of the fiber is within the field area and it crosses one of the pre-selected sides: but it also crosses one of the wrong sides.

Ill. 9 — This one would not be counted because no part of the fiber is within the field area.

Ill. 10 — Count this one because it crosses both pre-selected sides and has part of the fiber within the field area.

Ill. 11 — Since this fiber crosses the wrong two sides of the reticle it would not be counted.

Ill. 12 — This one is countable because it crosses one of the pre-selected sides.

Ill. 13 — Do not count this one because it crosses one of the wrong sides.

Ill. 14 — Fibers do not get any more countable than this — it is entirely within the field area.

Ill. 15 — Remember, count enough fields to accumulate a fiber total of at least 100.

Ill. 16 — Count at least twenty fields to get an accurate average of fiber distribution.

Ill. 17 — There is no need to examine more than 100 fields.

Ill. 18 — Do not count a field containing more than twenty fibers.

NOTES

Let's look at some examples of results you might obtain and see how you should handle them.

Ill. 19 — We have a total of 123 fibers for 14 fields. Is this valid? No! You must count at least twenty fields.

Ill. 20 — We have a count of 75 fibers for 20 fields. Is this valid? No! You must count at least one hundred fibers.

Ill. 21 — We now have a total of 117 fibers for 21 fields. Is this valid? Yes.

Ill. 22 — What would you do with a total of 53 fibers for only 2 fields? Reject it — the average is above twenty per field.

Just to give an idea of the interrelationships between concentration, sampling time, field area, fiber count, and examined fields, let me present to you a situation. The following data would hold true for a field area of .005 $mm^2$.

Ill. 23 — For a given sample, we are concerned with the number of fields to count in order to accumulate a total of 100 fibers.

Ill. 24 — This sample was collected for 10 min. at 2 liters per minute.

Ill. 25 — At a concentration of 0.2 fibers per cubic centimeter, one would need to count 4350 fields.

Ill. 26 — At a concentration of 2.0 fibers per cubic centimeter, one would need to count 435 fields.

Ill. 27 — At a concentration of 10 fibers per cubic centimeter, one would need to count 91 fields.

Using the same data, but changing the sample time to 30 minutes, the following results can be expected.

Ill. 28 — This sample was collected for 30 minutes at 2 liters per minute.

Ill. 29 — At a concentration 0.2 fibers per cubic centimeter, 1430 fields would be counted.

Ill. 30 — At a concentration of 2.0 fibers per cubic centimeter, 143 fields would be counted.

Ill. 31 — At a concentration of 10.0 fibers per cubic centimeter, 29 fields would be counted.

NOTES

This set of visuals was used to illustrate to you how sample time, concentration and flow rate are inter-related. Therefore, in the range of concentrations between 2 and 10 fibers per cubic centimeter, if the sample was collected for about 60 minutes at 2 L/M, you should get a countable concentration.

So far I have discussed the theory of asbestos counting and I have said little about really doing it. So let me give you a few minutes describing the procedure.

Position yourself in front of the microscope in such a manner that you can easily see through the eyepieces. Be sure both eyepieces are in proper focus. Clamp your prepared sample into the mechanical stage. If you temporarily move the objective out of the way, you may see the spot of light that comes from the condenser where it passes through the slide. Move the filter wedge until the spot is near the center of the arc side.

You will select the fields for counting by following a straight line in either direction between the tip and arc side. Never look through the eyepieces while selecting the fields. A slight turn of the mechanical stage knob will move the sample an equivalent of many field areas.

After you have selected your first field of view, you are ready to count it. You will need to develop your own counting pattern for examining the field. The pattern is necessary to hinder the possibility of counting the same fiber more than once. My own technique is counting all fibers in each subdivision working left to right and top to bottom. The pattern you choose is your perogative.

Just be sure to count a fiber only once.

Now, let's move to recording counts. A count sheet such as the one in the illustration (on p. 13) may be useful. This one contains spaces for all the necessary information that is needed for calculating the concentration. This sheet, once completed, can be filed as a permanent record.

There may be some of you who do not want to record the count field by field. You may want two counters — one to tally the number of fields counted and one to tally the number of fibers counted. This is possible — just do not lose track of either one or you've had it.

As you are counting your samples, you may reject some fields as unrepresentative. These may have

agglomerates (or other reasons) that make fiber counting and sizing impossible.

NOTES

Finally, you will need to accumulate a total fiber count at least of 100 fibers. You will never count less than twenty fields and never count more than one-hundred fields. You are not required to count any field containing more than twenty fibers — discard the sample, but indicate the reason why on the count ticket.

When the count is completed, you will need to calculate the concentration. This is accomplished with the following formula:

$$\text{Concentration} = \frac{(\text{Av. Fiber Cnt.})(\text{filter area})}{(\text{field area})(\text{Sample volume})(1000)}$$

Av. Fiber Count: Average fiber count in fibers/field

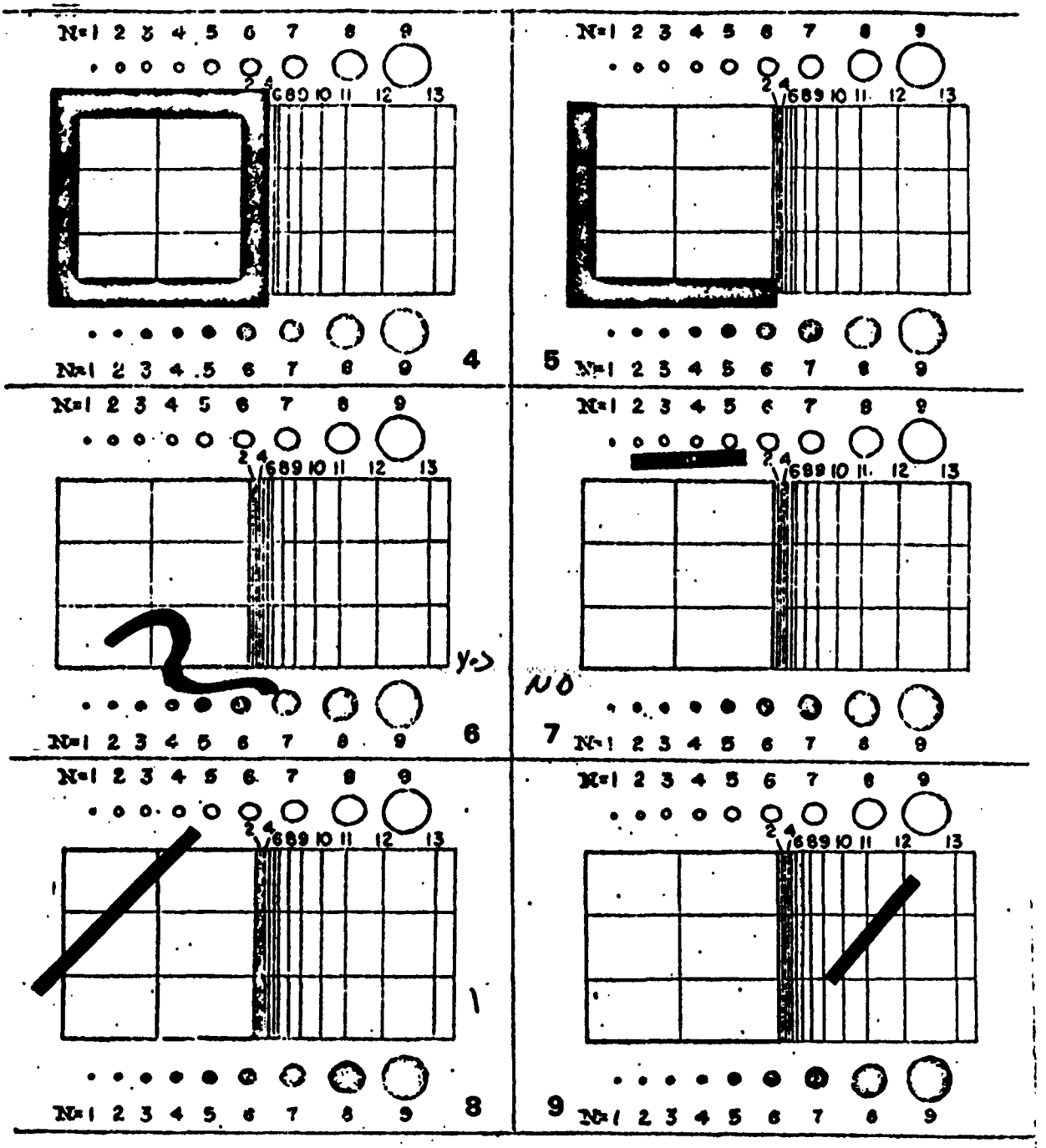
Filter area: 855 $mm^2$ for 37 mm dia. membrane filters

Counting area: Reticle calibrated in $mm^2$/field

Sample volume: Total time in minutes x flow rate in liters/minute

1000: (milliliters/liter)

If blanks are used, subtract the average blank count of the same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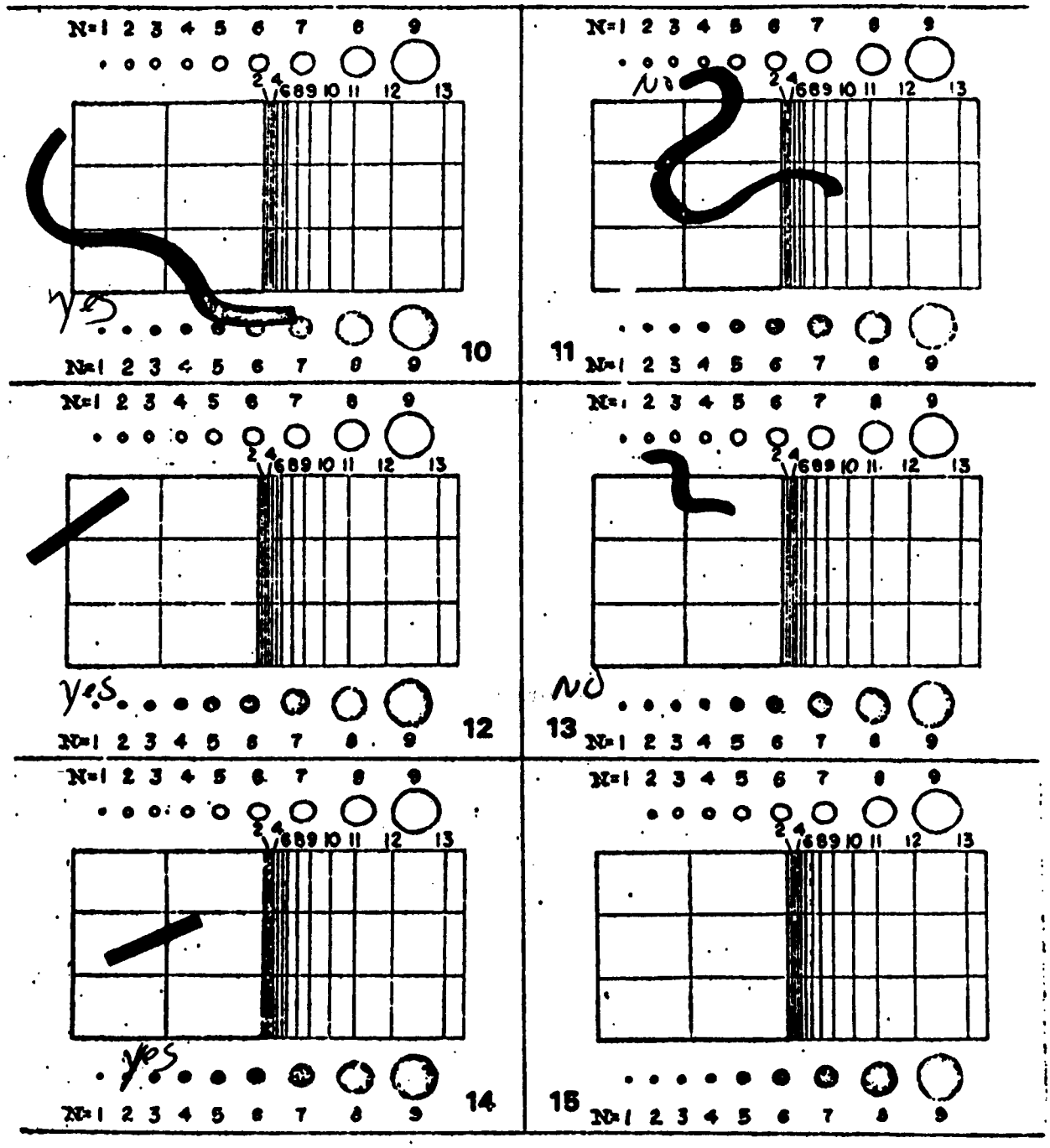
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2 4 6 8 9 10 11 12 13
yes
10
11
yes
12
NO
13
yes
14
15

ASBESTOS COUNT RECORD SHEET

SAMPLE# _____ OPERATION _____

FLOW _____ TIME _____ VOLUME _____ DATE / /

INITIALS _____ F.AREA _____ BLK.CNT.AV. _____

AV. COUNT _____ CONCENTRATION _____

COMMENTS _____