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HW--79303

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A FIELD METHOD USING URANINE TO MEASURE
PENETRATION OF HIGH-EFFICIENCY FILTERS

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General Electric Company

Richland, Washington

October 18, 1963

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A FIELD METHOD USING URANINE TO MEASURE
PENETRATION OF HIGH-EFFICIENCY FILTERS

A method has been developed to field test high-efficiency air cleaning filters to measure their efficiency in removing aerosols from contaminated air streams. In certain instances, the efficiency of air cleaning filters may be measured prior to installation. For example, high-efficiency filters of the "absolute" type are measured for their efficiency of removal of a 0.3 micron dioctylphthalate aerosol from an air stream prior to use at AEC installations. However, defects may occur during or following the installation of the filters in process or building air streams. Therefore, methods of field testing the filters following their installation are desirable.

The efficiency of an installed filter or filters for removal of either a process or artificially produced aerosol can usually be measured. Process aerosols are in most cases difficult to measure quantitatively, however, and usually have varying particle size characteristics. Therefore, an artificial aerosol, uranine, was selected for measurement purposes.

The uranine aerosol may be generated by equipment that is light in weight, low in cost and easily transported. Its particle size distribution and generation rate is reproducible in successive tests and may be varied if desired. Uranine may be determined quantitatively in submicrogram quantities by fluorescent spectroscopy. The determinations require a minimum of time and utilize equipment available to most laboratories.

This work was performed under contract No. AT(45-1)-1350 between the U. S. Atomic Energy Commission and the General Electric Company.

The uranine aerosol is produced by the generator shown in Figure I. Air at 20 pounds per square inch pressure is discharged at a rate of 0.77 cubic feet per minute (STP) through a #60 drill hole located in the wall of a 1/4 inch copper tube that is sealed at one end. The hole is positioned approximately one-half inch below the surface of a 15 percent uranine in water solution contained in a one liter bottle. As a result, a fine mist is formed. When mixed with dry air the mist droplets dry leaving a solid aerosol. Several drops of octyl alcohol are added to the generator to prevent excessive foaming. A generation rate of 7.4 milligrams per minute of uranine aerosol is obtained. A higher generation rate may be obtained by placing the hole near the surface of the liquid; however, the liquid level must then be kept constant to obtain a constant generation rate.

Samples of the uranine aerosol were collected on electron microscopoe grids by means of a thermal precipitator. The distribution determined by sizing 614 of the particles collected is shown in Figure II. A mass mean diameter of 1.0 micron was obtained from a plot of the aerosol distribution on logarithmic probability paper. One of the electron photomicrographs obtained is shown in Figure III.

The equipment used to perform an efficiency test includes two air sampling pumps, two air sample filter holders, two airflow metering devices, a uranine generator and a pressure pump. A typical test arrangement is shown in Figure IV. The uranine aerosol is introduced into the air stream upstream of the filter or filters. The uranine in metered samples of the upstream and downstream air is collected on AA Millipore Air Sampling Filters. The uranine content of the sampling filters is determined by an analytical procedure that utilizes the fluorescent properties of uranine. The penetration of the filter or filters by the uranine aerosol is determined by the following equation:

$$P = \frac{M_d}{M_u} \times \frac{Q_u}{Q_d} \times 100$$

where

P = penetration of a filter or filters by the uranine aerosol, in percent
M_d = uranine on downstream sample filter, in grams
M_u = uranine on upstream sample filter, in grams
Q_u = airflow through upstream sample filter, in cubic feet per minute
Q_d = airflow through downstream sample filter, in cubic feet per minute

The analysis to determine the uranine content of a sample filter is relatively simple. The filter is placed sample side up in a glass beaker and ten milliliters of 8.5 pH buffer of the following composition is added:

Representative Buffer Composition:

0.1 Normal Na OH - 200 milliliters
0.1 Molar H₃BO₄ - 1000 milliliters
Distilled water - 800 milliliters
Total - 2000 milliliters

The sample filter is swirled and soaked in the buffer for approximately five minutes to dissolve the uranine. The fluorescence of a portion of the liquid is then measured in a Beckman Model DU Spectrophotometer with a fluorescence accessory. Primary and secondary blue filters are used in the spectrophotometer. One millimicrogram of uranine has been satisfactorily measured by this method.

Conclusion:

A method of field testing air cleaning filters has been developed. A uranine aerosol is utilized for test purposes. By using several uranine generators and a test time of one hour, a 0.05 percent penetration of a 150,000 cubic feet per minute filter installation could be detected. The method utilizes a minimum of equipment and time.

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FIGURE I

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URANINE PARTICLE SIZE DISTRIBUTION

FIGURE II

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FIGURE III
URANINE AEROSOL

FILTER EFFICIENCY TEST LAYOUT
SCHEMATIC

FIGURE IV

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