PARTICULATES NOT OTHERWISE REGULATED, TOTAL 0500

DEFINITION: total aerosol mass   CAS: NONE   RTECS: NONE

METHOD: 0500, Issue 2	**EVALUATION: FULL**	**Issue 1: 15 February 1984** **Issue 2: 15 August 1994**

OSHA: 15 mg/m^3
NIOSH: no REL
ACGIH: 10 mg/m^3, total dust less than 1% quartz

PROPERTIES: contains no asbestos and quartz less than 1%

SYNONYMS: nuisance dusts; particulates not otherwise classified

SAMPLING

SAMPLER:	FILTER (tared 37-mm, 5-µm PVC filter)
FLOW RATE:	1 to 2 L/min
VOL-MIN: -MAX:	7 L @ 15 mg/m^3 133 L @ 15 mg/m^3
SHIPMENT:	routine
SAMPLE STABILITY:	indefinitely
BLANKS:	2 to 10 field blanks per set
BULK SAMPLE:	none required

ACCURACY

RANGE STUDIED:	8 to 28 mg/m^3
BIAS:	0.01%
OVERALL PRECISION ($\hat{S}_{rT}$):	0.056 [1]
ACCURACY:	±11.04%

MEASUREMENT

TECHNIQUE:	GRAVIMETRIC (FILTER WEIGHT)
ANALYTE:	airborne particulate material
BALANCE:	0.001 mg sensitivity; use same balance before and after sample collection
CALIBRATION:	National Institute of Standards and Technology Class S-1.1 weights or ASTM Class 1 weights
RANGE:	0.1 to 2 mg per sample
ESTIMATED LOD:	0.03 mg per sample
PRECISION ($\bar{S}_r$):	0.026 [2]

APPLICABILITY: The working range is 1 to 20 mg/m^3 for a 100-L air sample. This method is nonspecific and determines the total dust concentration to which a worker is exposed. It may be applied, e.g., to gravimetric determination of fibrous glass [3] in addition to the other ACGIH particulates not otherwise regulated [4].

INTERFERENCES: Organic and volatile particulate matter may be removed by dry ashing [3].

OTHER METHODS: This method is similar to the criteria document method for fibrous glass [3] and Method 5000 for carbon black. This method replaces Method S349 [5]. Impingers and direct-reading instruments may be used to collect total dust samples, but these have limitations for personal sampling.

EQUIPMENT:

1. Sampler: 37-mm PVC, 2- to 5-µm pore size membrane or equivalent hydrophobic filter and supporting pad in 37-mm cassette filter holder.
2. Personal sampling pump, 1 to 2 L/min, with flexible connecting tubing.
3. Microbalance, capable of weighing to 0.001 mg.
4. Static neutralizer: e.g., Po-210; replace nine months after the production date.
5. Forceps (preferably nylon).
6. Environmental chamber or room for balance (e.g., 20 °C ± 1 °C and 50% ± 5% RH).

SPECIAL PRECAUTIONS: None.

PREPARATION OF FILTERS BEFORE SAMPLING:

1. Equilibrate the filters in an environmentally controlled weighing area or chamber for at least 2 h.
   NOTE: An environmentally controlled chamber is desirable, but not required.
2. Number the backup pads with a ballpoint pen and place them, numbered side down, in filter cassette bottom sections.
3. Weigh the filters in an environmentally controlled area or chamber. Record the filter tare weight, W_1 (mg).
   a. Zero the balance before each weighing.
   b. Handle the filter with forceps. Pass the filter over an antistatic radiation source. Repeat this step if filter does not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.
4. Assemble the filter in the filter cassettes and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassette. Place a cellulose shrink band around the filter cassette, allow to dry and mark with the same number as the backup pad.

SAMPLING:

5. Calibrate each personal sampling pump with a representative sampler in line.
6. Sample at 1 to 2 L/min for a total sample volume of 7 to 133 L. Do not exceed a total filter loading of approximately 2 mg total dust. Take two to four replicate samples for each batch of field samples for quality assurance on the sampling procedure.

SAMPLE PREPARATION:

7. Wipe dust from the external surface of the filter cassette with a moist paper towel to minimize contamination. Discard the paper towel.
8. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 2 h in the balance room.
9. Remove the cassette band, pry open the cassette, and remove the filter gently to avoid loss of dust.
   NOTE: If the filter adheres to the underside of the cassette top, very gently lift away by using the dull side of a scalpel blade. This must be done carefully or the filter will tear.

CALIBRATION AND QUALITY CONTROL:

10. Zero the microbalance before all weighings. Use the same microbalance for weighing filters before and after sample collection. Maintain and calibrate the balance with National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights.
11. The set of replicate samples should be exposed to the same dust environment, either in a laboratory dust chamber [7] or in the field [8]. The quality control samples must be taken with the same

equipment, procedures, and personnel used in the routine field samples. The relative standard deviation calculated from these replicates should be recorded on control charts and action taken when the precision is out of control [7].

MEASUREMENT:

12. Weigh each filter, including field blanks. Record the post-sampling weight, W_2 (mg). Record anything remarkable about a filter (e.g., overload, leakage, wet, torn, etc.)

CALCULATIONS:

13. Calculate the concentration of total particulate, C (mg/m^3), in the air volume sampled, V (L):

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \times 10^3, \text{ mg/m}^3,$$

where: W_1 = tare weight of filter before sampling (mg),
W_2 = post-sampling weight of sample-containing filter (mg),
B_1 = mean tare weight of blank filters (mg),
B_2 = mean post-sampling weight of blank filters (mg).

EVALUATION OF METHOD:

Lab testing with blank filters and generated atmospheres of carbon black was done at 8 to 28 mg/m^3 [2,6]. Precision and accuracy data are given on page 0500-1.

REFERENCES:

[1] NIOSH Manual of Analytical Methods, 3rd ed., NMAM 5000, DHHS (NIOSH) Publication No. 84-100 (1984).
[2] Unpublished data from Non-textile Cotton Study, NIOSH/DRDS/EIB.
[3] NIOSH Criteria for a Recommended Standard … Occupational Exposure to Fibrous Glass, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-152, 119–142 (1977).
[4] 1993-1994 Threshold Limit Values and Biological Exposure Indices, Appendix D, ACGIH, Cincinnati, OH (1993).
[5] NIOSH Manual of Analytical Methods, 2nd ed., V. 3, S349, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-C (1977).
[6] Documentation of the NIOSH Validation Tests, S262 and S349, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-185 (1977).
[7] Bowman, J.D., D.L. Bartley, G.M. Breuer, L.J. Doemeny, and D.J. Murdock. Accuracy Criteria Recommended for the Certification of Gravimetric Coal Mine Dust Personal Samplers. NTIS Pub. No. PB 85-222446 (1984).
[8] Breslin, J.A., S.J. Page, and R.A. Jankowski. Precision of Personal Sampling of Respirable Dust in Coal Mines, U.S. Bureau of Mines Report of Investigations #8740 (1983).

METHOD REVISED BY:

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PARTICULATES NOT OTHERWISE REGULATED, RESPIRABLE 0600

DEFINITION: aerosol collected by sampler with 4-µm median cut point | CAS: None | RTECS: None

METHOD: 0600, Issue 3	**EVALUATION: FULL**	**Issue 1: 15 February 1984** **Issue 3: 15 January 1998**

OSHA: 5 mg/m³
NIOSH: no REL
ACGIH: 3 mg/m³

PROPERTIES: contains no asbestos and quartz less than 1%; penetrates non-ciliated portions of respiratory system

SYNONYMS: nuisance dusts; particulates not otherwise classified

SAMPLING		MEASUREMENT	
SAMPLER:	CYCLONE + FILTER (10-mm nylon cyclone, Higgins-Dewell [HD] cyclone, or aluminum cyclone + tared 5-µm PVC membrane)	**TECHNIQUE:**	GRAVIMETRIC (FILTER WEIGHT)
		ANALYTE:	mass of respirable dust fraction
FLOW RATE:	nylon cyclone: 1.7 L/min HD cyclone: 2.2 L/min Al cyclone: 2.5 L/min	**BALANCE:**	0.001 mg sensitivity; use same balance before and after sample collection
VOL-MIN: **-MAX:**	20 L @ 5 mg/m³ 400 L	**CALIBRATION:**	National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights
SHIPMENT:	routine	**RANGE:**	0.1 to 2 mg per sample
SAMPLE STABILITY:	stable	**ESTIMATED LOD:**	0.03 mg per sample
BLANKS:	2 to 10 field blanks per set	**PRECISION:**	<10 µg with 0.001 mg sensitivity balance; <70 µg with 0.01 mg sensitivity balance [3]

ACCURACY

RANGE STUDIED:	0.5 to 10 mg/m³ (lab and field)
BIAS:	dependent on dust size distribution [1]
OVERALL PRECISION ($\hat{S}_{rT}$):	dependent on size distribution [1,2]
ACCURACY:	dependent on size distribution [1]

APPLICABILITY: The working range is 0.5 to 10 mg/m³ for a 200-L air sample. The method measures the mass concentration of any non-volatile respirable dust. In addition to inert dusts [4], the method has been recommended for respirable coal dust. The method is biased in light of the recently adopted international definition of respirable dust, e.g., ≈ +7% bias for non-diesel, coal mine dust [5].

INTERFERENCES: Larger than respirable particles (over 10 µm) have been found in some cases by microscopic analysis of cyclone filters. Over-sized particles in samples are known to be caused by inverting the cyclone assembly. Heavy dust loadings, fibers, and water-saturated dusts also interfere with the cyclone's size-selective properties. The use of conductive samplers is recommended to minimize particle charge effects.

OTHER METHODS: This method is based on and replaces Sampling Data Sheet #29.02 [6].

EQUIPMENT:

1. Sampler:
   a. Filter: 5.0-µm pore size, polyvinyl chloride filter or equivalent hydrophobic membrane filter supported by a cassette filter holder (preferably conductive).
   b. Cyclone: 10-mm nylon (Mine Safety Appliance Co., Instrument Division, P. O. Box 427, Pittsburgh, PA 15230), Higgins-Dewell (BGI Inc., 58 Guinan St., Waltham, MA 02154) [7], aluminum cyclone (SKC Inc., 863 Valley View Road, Eighty Four, PA 15330), or equivalent.
2. Personal sampling pump, 1.7 L/min ± 5% for nylon cyclone, 2.2 L/min ± 5% for HD cyclone, or 2.5 L/min ± 5% for the Al cyclone with flexible connecting tubing.
   NOTE: Pulsation in the pump flow must be within ± 20% of the mean flow.
3. Balance, analytical, with sensitivity of 0.001 mg.
4. Weights, NIST Class S-1.1, or ASTM Class 1.
5. Static neutralizer, e.g., Po-210; replace nine months after the production date.
6. Forceps (preferably nylon).
7. Environmental chamber or room for balance, e.g., 20 °C ± 1 °C and 50% ± 5% RH.

SPECIAL PRECAUTIONS: None.

PREPARATION OF SAMPLERS BEFORE SAMPLING:

1. Equilibrate the filters in an environmentally controlled weighing area or chamber for at least 2 h.
2. Weigh the filters in an environmentally controlled area or chamber. Record the filter tare weight, W_1 (mg).
   a. Zero the balance before each weighing.
   b. Handle the filter with forceps (nylon forceps if further analyses will be done).
   c. Pass the filter over an anti-static radiation source. Repeat this step if filter does not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.
3. Assemble the filters in the filter cassettes and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassette.
4. Remove the cyclone's grit cap before use and inspect the cyclone interior. If the inside is visibly scored, discard this cyclone since the dust separation characteristics of the cyclone may be altered. Clean the interior of the cyclone to prevent reentrainment of large particles.
5. Assemble the sampler head. Check alignment of filter holder and cyclone in the sampling head to prevent leakage.

SAMPLING:

6. Calibrate each personal sampling pump to the appropriate flow rate with a representative sampler in line.
   NOTE 1: Because of their inlet designs, nylon and aluminum cyclones are calibrated within a large vessel with inlet and outlet ports. The inlet is connected to a calibrator (e.g., a bubble meter). The cyclone outlet is connected to the outlet port within the vessel, and the vessel outlet is attached to the pump. See APPENDIX for alternate calibration procedure. (The calibrator can be connected directly to the HD cyclone.)
   NOTE 2: Even if the flow rate shifts by a known amount between calibration and use, the nominal flow rates are used for concentration calculation because of a self-correction feature of the cyclones.
7. Sample 45 min to 8 h. Do not exceed 2 mg dust loading on the filter. Take 2 to 4 replicate samples for each batch of field samples for quality assurance on the sampling procedure (see Step 10).

NOTE : Do not allow the sampler assembly to be inverted at any time. Turning the cyclone to anything more than a horizontal orientation may deposit oversized material from the cyclone body onto the filter.

SAMPLE PREPARATION:

8. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 2 h in an environmentally controlled area or chamber.

CALIBRATION AND QUALITY CONTROL:

9. Zero the microbalance before all weighings. Use the same microbalance for weighing filters before and after sample collection. Calibrate the balance with National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights.
10. The set of replicate field samples should be exposed to the same dust environment, either in a laboratory dust chamber [8] or in the field [9]. The quality control samples must be taken with the same equipment, procedures, and personnel used in the routine field samples. Calculate precision from these replicates and record relative standard deviation (S_r) on control charts. Take corrective action when the precision is out of control [8].

MEASUREMENT:

11. Weigh each filter, including field blanks. Record this post-sampling weight, W_2 (mg), beside its corresponding tare weight. Record anything remarkable about a filter (e.g., visible particles, overloading, leakage, wet, torn, etc.).

CALCULATIONS:

12. Calculate the concentration of respirable particulate, C (mg/m^3), in the air volume sampled, V (L):

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \times 10^3, \text{ mg/m}^3,$$

where: W_1 = tare weight of filter before sampling (mg),
W_2 = post-sampling weight of sample-containing filter (mg),
B_1 = mean tare weight of blank filters (mg),
B_2 = mean post-sampling weight of blank filters (mg),
V = volume as sampled at the nominal flow rate (i.e., 1.7 L/min or 2.2 L/min).

EVALUATION OF METHOD:

1. Bias: In respirable dust measurements, the bias in a sample is calculated relative to the appropriate respirable dust convention. The theory for calculating bias was developed by Bartley and Breuer [10]. For this method, the bias, therefore, depends on the international convention for respirable dust, the cyclones' penetration curves, and the size distribution of the ambient dust. Based on measured penetration curves for non-pulsating flow [1], the bias in this method is shown in Figure 1.

   For dust size distributions in the shaded region, the bias in this method lies within the ± 0.10 criterion established by NIOSH for method validation. Bias larger than ± 0.10 would, therefore, be expected for some workplace aerosols. However, bias within ± 0.20 would be expected for dusts with geometric standard deviations greater than 2.0, which is the case in most workplaces.

Bias can also be caused in a cyclone by the pulsation of the personal sampling pump. Bartley, et al. [12] showed that cyclone samples with pulsating flow can have negative bias as large as –0.22 relative to samples with steady flow. The magnitude of the bias depends on the amplitude of the pulsation at the cyclone aperture and the dust size distribution. For pumps with instantaneous flow rates within 20% of the mean, the pulsation bias magnitude is less than 0.02 for most dust size distributions encountered in the workplace.

Electric charges on the dust and the cyclone will also cause bias. Briant and Moss [13] have found electrostatic biases as large as –50%, and show that cyclones made with graphite-filled nylon eliminate the problem. Use of conductive samplers and filter cassettes (Omega Specialty Instrument Co., 4 Kidder Road, Chelmsford, MA 01824) is recommended.

2. Precision: The figure 0.068 mg quoted above for the precision is based on a study [3] of weighing procedures employed in the past by the Mine Safety and Health Administration (MSHA) in which filters are pre-weighed by the filter manufacturer and post-weighed by MSHA using balances readable to 0.010 mg. MSHA [14] has recently completed a study using a 0.001 mg balance for the post-weighing, indicating imprecision equal to 0.006 mg.

   Imprecision equal to 0.010 mg was used for estimating the LOD and is based on specific suggestions [8] regarding filter weighing using a single 0.001 mg balance. This value is consistent with another study [15] of repeat filter weighings, although the actual attainable precision may depend strongly on the specific environment to which the filters are exposed between the two weighings.

REFERENCES:

[1] Bartley DL, Chen CC, Song R, Fischbach TJ [1994]. Respirable aerosol sampler performance testing. Am Ind Hyg Assoc J, *55*(11): 1036–1046.
[2] Bowman JD, Bartley DL, Breuer GM, Shulman SA [1985]. The precision of coal mine dust sampling. Cincinnati, OH: National Institute for Occupational Safety and Health, DHEW (NIOSH) Pub. No. 85-220721.
[3] Parobeck P, Tomb TF, Ku H, Cameron J [1981]. Measurement assurance program for the weighings of respirable coal mine dust samples. J Qual Tech *13*:157.
[4] ACGIH [1996]. 1996 Threshold limit values (TLVs™) for chemical substances and physical agents and biological exposure indices (BEIs™). Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
[5] American Conference of Governmental Industrial Hygienists [1991]. Notice of intended change—appendix D—particle size-selective sampling criteria for airborne particulate matter. Appl Occup Env Hyg *6*(9): 817–818.
[6] NIOSH [1977]. NIOSH Manual of sampling data sheets. Cincinnati, OH: National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-159.
[7] Higgins RI, Dewell P [1967]. A gravimetric size selecting personal dust sampler. In: Davies CN, Ed. Inhaled particles and vapors II. Oxford: Pergammon Press, pp. 575–586.
[8] Bowman JD, Bartley DL, Breuer GM, Doemeny LJ, Murdock DJ [1984]. Accuracy criteria recommended for the certification of gravimetric coal mine dust personal samplers. NTIS Pub. No. PB 85-222446 (1984).
[9] Breslin, JA, Page SJ, Jankowski RA [1983]. Precision of personal sampling of respirable dust in coal mines. U.S. Bureau of Mines Report of Investigations #8740.
[10] Bartley DL, Breuer GM [1982]. Analysis and optimization of the performance of the 10-mm cyclone. Am Ind Hyg Assoc J *43*: 520–528.
[11] Caplan KJ, Doemeny LJ, Sorenson S [1973]. Evaluation of coal mine dust personal sampler performance, Final Report. NIOSH Contract No. PH CPE-r-70-0036.

[12] Bartley DL, Breuer GM, Baron PA, Bowman JD [1984]. Pump fluctuations and their effect on cyclone performance. Am Ind Hyg Assoc J *45*(1): 10–18.

[13] Briant JK, Moss OR [1983]. The influence of electrostatic charge on the performance of 10-mm nylon cyclones. Unpublished paper presented at the American Industrial Hygiene Conference, Philadelphia, PA, May 1983.

[14] Koqut J [1994]. Private Communication from MSHA, May 12, 1994.

[15] Vaughn NP, Chalmers CP, Botham [1990]. Field comparison of personal samplers for inhalable dust. Ann Occup Hyg *34*: 553–573.

METHOD REVISED BY:

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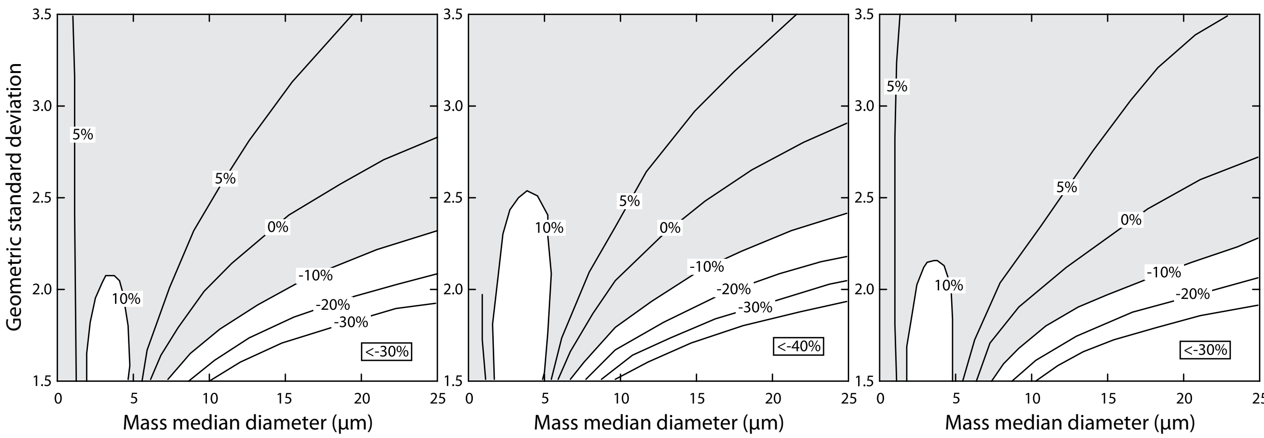

10-mm Nylon cyclone at 1.7 L/min | Higgins-Dewell cyclone at 2.2 L/min | Aluminum cyclone at 2.5 L/min

Figure 1. Bias of three cyclone types relative to the international respirable dust sampling convention.

APPENDIX: Jarless Method for Calibration of Cyclone Assemblies

This procedure may be used in the field to calibrate an air sampling pump and a cyclone assembly without using the one-liter "calibration jar".

1. Connect the pump to a pressure gauge or water manometer and a light load (adjustable valve or 5-µm filter) equal to 2" to 5" H_2O with a "TEE" connector and flexible tubing. Connect other end of valve to an electronic bubble meter or standard bubble tube with flexible tubing (See Fig. 2.1).
   NOTE: A light load can be a 5-µm filter and/or an adjustable valve. A heavy load can be several 0.8-µm filters and/or adjustable valve.
2. Adjust the pump to 1.7 L/min, as indicated on the bubble meter/tube, under the light load conditions (2" to 5" H_2O) as indicated on the pressure gauge or manometer.
3. Increase the load until the pressure gauge or water manometer indicates between 25" and 35" H_2O. Check the flow rate of the pump again. The flow rate should remain at 1.7 L/min ± 5%.
4. Replace the pressure gauge or water manometer and the electronic bubble meter or standard bubble tube with the cyclone having a clean filter installed (Fig. 2.2). If the loading caused by the cyclone assembly is between 2" and 5" H_2O, the calibration is complete and the pump and cyclone are ready for sampling.

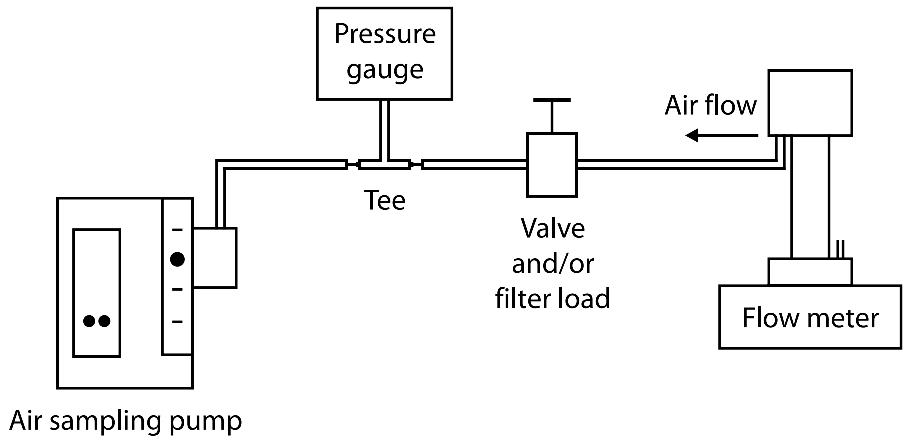

Figure 2.1. Block diagram of pump/load/flow meter set-up.

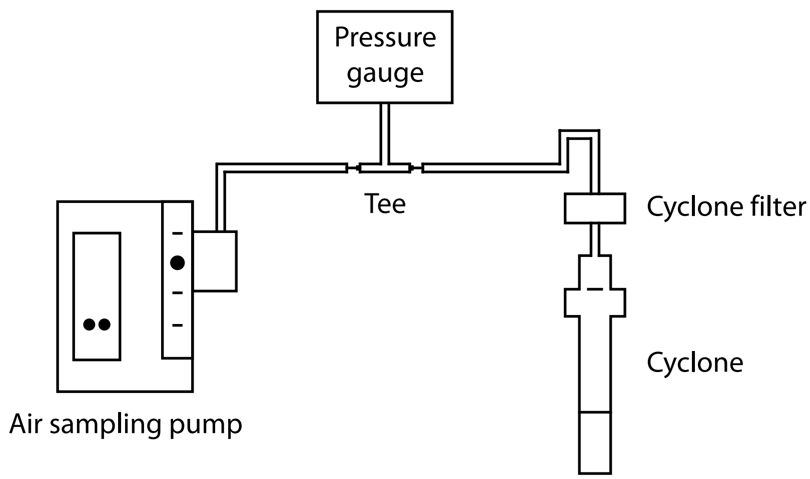

Figure 2.2. Block diagram with cyclone as the test load.

APPENDIX

A

Glossary

Basic Descriptors

Descriptors are the terms used for measurements. *NoisePro* provides two types of descriptor systems: Basic and IEC/ISO. Basic descriptors are the most common measurement terms used for noise dosimetry in the United States. For information about IEC/ISO Descriptors, including a table that identifies descriptor differences, see "IEC/ISO Descriptors,"below.

Criterion Level (CL)

The Criterion Level is the maximum allowable exposure to accumulated noise. It gives the conditions that result in a 100% doses. The Criterion Level is typically set by a regulating agency, such as OSHA, and is not usually applicable for community noise monitoring.

Examples: OSHA mandates the Criterion Level (maximum allowable accumulated noise exposure) to be 90 dB for 8 hours. For an 8 hour sample, an average level (L_{AVG}) of 90 dB will result in 100% dose.

For the OSHA HEARING CONSERVATION AMENDMENT, the "action level" is 85 dB for 8 hours. This would result in a 50% dose reading. Note that the Criterion Level has not changed. (If the Criterion Level is changed to 85 dB then an 8 hour average of 85 dB would result in 100% dose.)

Criterion Time

The time over which the Criterion Level is established, generally eight hours.

Decibel (dB)

Engineers frequently are faced with the need to compare things. One way to do that is to form a ratio of their quantities. For example, a meter is 100 times the size of a centimeter—the ratio is dimensionless. Engineers commonly determine differences in power using a special unit called a decibel. The decibel is calculated as the logarithm of the power ratio. Logarithms are used because they compress the range of very large ratios so that they're easier to display together.

Dose

Related to the Criterion Level, a dose reading of 100% is the maximum allowable exposure to accumulated noise. For OSHA, 100% dose occurs for an average sound level of 90 dB over an 8 hour period (or any equivalent exposure). By using a TWA reading rather than the average sound level, the time period is no longer explicitly needed. A TWA of 90 dB is the equivalent of 100% dose. The dose will double (halve) every time the TWA increases (decreases) by the Exchange Rate.

Example: OSHA uses an Exchange Rate of 5 dB. Suppose the TWA is 100 dB. The dose would double for each 5 dB increase over the Criterion Level of 90 dB. The resulting dose is therefore 400%. If the TWA was instead equal to 80 dB then the dose would halve for each 5 dB below the Criterion Level. The resulting dose would be 25%.

When taking noise samples less that the full workday, dose is an easy number to work with because it is linear with respect to time.

Example: If a 0.5 hour sample results in 9% dose and the workday is 7.5 hours long, then the dose for the full workday would be a 135% dose (7.5 / 0.5 x 9%). This is computed making the assumption that the sampled noise will continue at the same levels for the full 7.5 hour workday.

Exceedence Levels

An Exceedence Level is the level exceeded by the measured noise level for an identified fraction of time. Exceedence Levels may be calculated for many time fractions.

Example: An L_{40} equal to 73 dB would mean that for 40% of the run time, the decibel level was higher than 73 dB.

Exchange Rate (ER)

Also known as the Doubling Rate, this figure refers to how the sound energy is averaged over time. Using the decibel scale, every time the sound energy doubles, the measured level increases by 3 dB. This is the 3 dB Exchange Rate that most of the world uses. For every increase of 3 dB in the time weighted average, the measured dose would double.

Some organizations such as OSHA in the U.S. have argued that the human ear self compensates for changing noise levels and they felt that the 3 dB Exchange Rate should be changed to more closely match the response of the human ear. OSHA currently uses a 5 dB Exchange Rate which would mean that the reported dose would double with every 5 dB increase in the time weighted average. The Exchange Rate affects the integrated reading L_{AVG}, Dose, and TWA but does not affect the instantaneous sound level.

Hearing Conservation (HC)

A sound level established as a standard by a consensus group or a regulatory agency to be used in a hearing conservation program. The Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration (MSHA) provide regulatory standards for hearing conservation programs. In addition, the American Conference of Governmental Industrial Hygienists (ACGIH) provide industrial standards for hearing conservation programs.

Hertz (Hz)

Unit of vibration frequency, numerically equal to cycles per second.

IEC/ISO Descriptors

Descriptors are the terms used for measurements. ***NoisePro*** provides two types of descriptor systems: Basic and IEC/ISO. The IEC/ISO system is commonly used for noise dosimetry in the European Union.

Basic noise descriptors are strictly abbreviations for the measurements. In the IEC/ISO noise descriptor system, shorter abbreviations are used but are augmented by codings that identify the settings for time and frequency parameters.

Table A–1 lists Basic and corresponding IEC/ISO descriptors and explains the meanings of the codings in the IEC/ISO descriptors.

Table A–1: Basic and IEC/ISO descriptors compared

Basic	IEC/ISO	Meanings of IEC/ISO indicators
SPL	L_{CS}	Sound pressure level measured with C-weighting at slow response.
PEAK	L_{Apk}	Peak sound pressure level with A-weighting
MAX	L_{CSmx}	Maximum sound pressure level with C-weighting at slow response.
MIN	L_{CSmn}	Minimum sound pressure level with C-weighting at slow response.
L_{AVG}	L_{CSav}	Average sound pressure level with C-weighting at slow response.
EXP	E_{CS}	Noise exposure, measured in Pascal units squared multiplied by time.

L_{AVG}

L_{AVG} is the average sound level measured over the run time. This becomes a bit confusing when thresholds are used. Any sound below the threshold is not included in this average. Remember that sound is measured in the logarithmic scale of decibels therefore the average can not be computed by simply adding the levels and dividing by the number of samples. When averaging decibels, short durations of high levels can significantly contribute to the average level.

Example: Assume the threshold is set to 80 dB and the Exchange Rate is 5 dB (the settings of OSHA's Hearing Conservation Amendment). Consider taking a one hour noise measurement in an office where the A-weighted sound level was typically between 50 dB and 70 dB. If the sound level never exceeded the 80 dB threshold during the one hour period, then the L_{AVG} would not indicate any reading at all. If 80 dB was exceeded for only a few seconds due to a telephone ringing near the instrument, then only those seconds will contribute to the L_{AVG} resulting in a level perhaps around 40 dB (notably lower than the actual levels in the environment).

L_{DN}

Representing the Day/Night sound level, this measurement is a 24-hour average sound level where 10 dB is added to all of the readings that occur between 10pm and 7am. This is primarily used in community noise regulations where there is a 10 dB "penalty" for night time noise. Typically L_{DN}'s are measured using A weighting, a 3 dB Exchange Rate, and no Threshold.

$L_{EP,d}$

Daily personal noise exposure.

L_{EQ}

The true equivalent sound level measured over the run time. The term L_{EQ} is functionally the same as L_{AVG} except that it is only used when the Exchange Rate is set to 3 dB and the threshold is set to none.

Max Level

The highest level sampled sound level during the instrument's run time allowing for the response that the unit is set for (fast or slow).

Min Level

The lowest level sampled sound level during the instrument's run time allowing for the response that the unit is set for (fast or slow).

Peak Level

Peak is the highest instantaneous sound level that the microphone detects. Unlike the Max Level, the peak is detected independently of the slow or fast response that the unit is set for.

Example: The peak circuitry is very sensitive. Test this by simply blowing across the microphone. You will notice that the peak reading may be 120 dB or greater. When taking a long term noise sample (such as a typical 8-hour workday sample for Osha compliance), the peak level is often very high. Because brushing the microphone over a shirt collar or accidentally bumping it can cause such a high reading, the user must be careful of placing too much emphasis on the reading.

Permissible Exposure Limit (PEL)

The A-weighted sound level at which exposure for a Criterion Time, typically eight hours, accumulates a 100% noise dose.

Response

Instruments that measure time-varying signals are limited in how fast they can respond to changes in the input signal. Sound dosimeters can operate with a wide variety of response times, but the industry has chosen two particular response times to standardize measurements. These are known as the Slow and Fast response times.

Slow response

OSHA, MSHA and ACGIH all require the Slow response for sound dosimetry. The standardized time constant for the Slow response is one second. When an instrument with a one second time constant measures a signal that abruptly stops, the measurement decays at the rate of 4.35 dB per second. If an instrument with a one-second time constant responds to a tone burst, the burst must last longer than 2 seconds for the measurement to reach a steady-state value (Figure A–1).

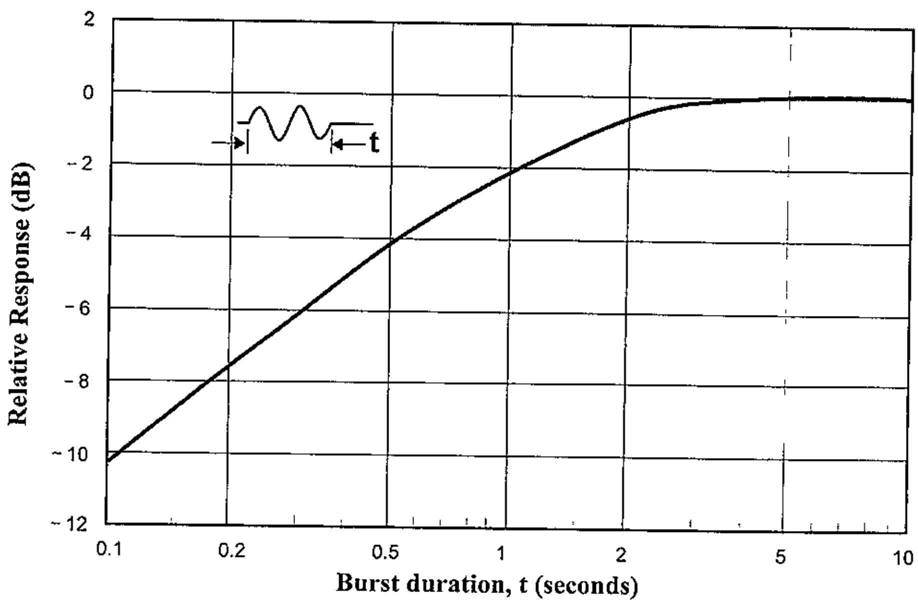

Figure A–1: Slow response to a tone burst

Fast response

NoisePro can also be set to measure using the Fast response. The standardized time constant for the Fast response is 125 milliseconds. When an instrument with a 125 ms time constant measures a signal that abruptly stops, the measurement decays at the rate of 34.7 dB per second. If an instrument with a 125 ms time constant responds to a tone burst, the burst must last longer than 500 ms for the measurement to reach a steady-state value (Figure A–2)

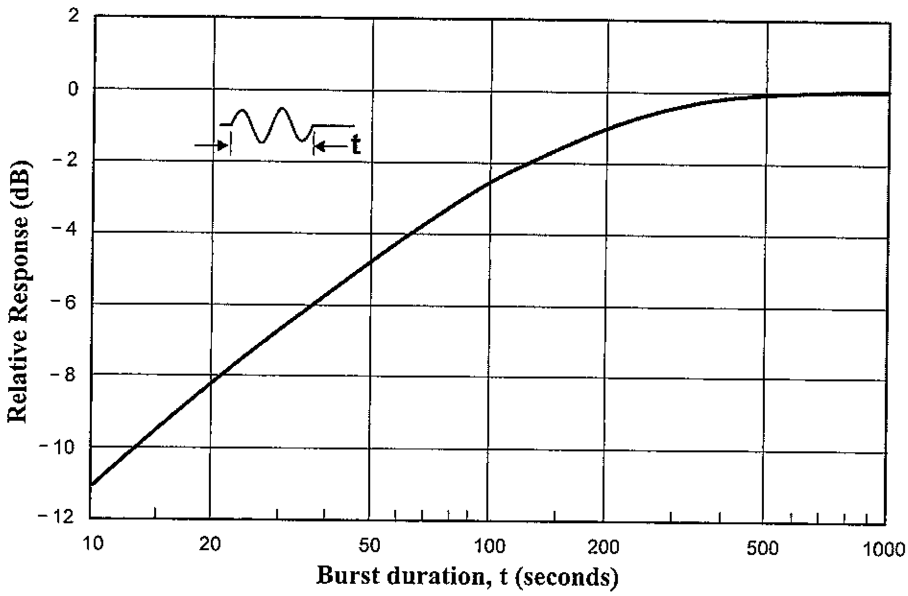

Figure A–2: Fast response to a tone burst

Sound Exposure Level (SEL)

The sound exposure level averages the sampled sound over a one second period. Assuming the sampled run time to be greater than one second, SEL is the equivalent one second noise that would be equal in energy to the noise that was sampled. SEL is typically measured using a 3 dB Exchange Rate without a threshold. (SEL is not used by OSHA).

Example: Suppose you wanted to measure in a location next to railroad tracks which also happened to be in the takeoff path of an airport. A train passes by taking 10 minutes with an average sound level of 82 dB. A jet passes overhead taking 45 seconds with an average level of 96 dB. Which of these events results in more sound energy? **Answer**: You can answer the question by comparing their SEL readings which compress each event into an equivalent one second occurrence. The SEL for the train is 109.7 dB; the SEL for the jet = 112.5 dB.

Threshold

Also known as the Cut Off, the Threshold affects the L_{AVG}, TWA, and Dose measurements. All sound below the Threshold is considered nonexisting noise for the averaging and integrating functions. The Threshold does not affect measurements in the sound level mode.

OSHA uses two different thresholds. The original Occupational Noise Exposure Standard (1971) used a 90 dB threshold and called for engineering controls to reduce the noise levels if the eight hour TWA was greater than 90 dB. The Hearing Conservation Amendment (1983) uses an 80 dB threshold and calls for a hearing conservation program to be put in place if the eight hour TWA exceeds 85 dB (50% dose). The Hearing Conservation Amendment is the more stringent of the two rulings and is what most US industrial users are concerned with.

Example: With an 80 dB threshold, suppose you placed a 79 dB calibrator on the unit for a period of time. Because all of the noise is below the threshold, there would be no average (you can think of it as an average of 0 dB). If the calibrator were 80 dB instead, then the average would be 80 dB. On histogram printouts, typically 1 minute (or other specified increment) averages are printed. Because real noise fluctuates, it is quite possible to have an average level below the threshold. This also applies for the overall L_{AVG}.

Time Weighted Average (TWA)

The Time Weighted Average represents a constant sound level lasting eight hours that would result in the equivalent sound energy as the noise that was sampled. TWA always averages the sampled sound over an 8-hour period. This average starts at zero and grows. It is less than the L_{AVG} for a duration of less than eight hours, exactly equal to the L_{AVG} at eight hours, and grows higher than L_{AVG} after eight hours.

Example: Think of TWA as having a large 8-hour container that stores sound energy. If you run a dosimeter for two hours, your L_{AVG} is the average level for those two hours - consider this a smaller 2-hour container filled with sound energy. For TWA, take the smaller 2 hour container and pour that energy into the larger 8-hour TWA container. The TWA level will be lower. Again, TWA is always based on the 8-hour container. When measuring using OSHA's guidelines, TWA is the proper number to report if the full workshift was measured.

Example: If the workshift is 6.5 hours long, then measure for the entire 6.5 hours. TWA is the correct level to report to OSHA. It does not have to be modified.

Upper Limit (UL)

This is a feature available on many of the Quest dosimeters. The user can select a certain decibel level. The dosimeter will then record the amount of time that the sound level was at or greater than the preset level. This time is then recorded as "UL TIME".

NOTE: The Upper Limit is a measurement parameter. Setting it does not affect the operating range of the instrument.

Weighting

Input sound signals are generally scaled, or weighted, so that the instrument's frequency response follows characteristic curves. There are three such standardized weighting curves in common use, and all are implemented in *NoisePro.*

A-weighting is said to best fit the frequency response of the human ear. When a sound dosimeter is set to A-weighting, it responds to the frequency components of sound much like your ear responds. Sound dosimeters sometimes use C-weighting and Z-weighting (zero or no weighting) to make measurements. Curves showing the scaling over the range of human hearing are shown in Figure A–3.