LAND SEA AIR SPACE

AEROSPACE RECOMMENDED PRACTICE

Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

ARP 1192

Issued 10-1-71
Revised

METHOD FOR CALIBRATION AND VERIFICATION OF AUTOMATIC LIQUIDBORNE PARTICLE COUNTER (LIGHT METHOD)

1. SCOPE

1.1 This Aerospace Recommended Practice covers the calibration and verification of automatic liquid-borne particle counter for the determination of the concentration by number and size distribution of particles in aerospace liquids. This method is intended for the standardization of automatic liquid-borne particle counting instrumentation.

1.2 This method deals only with automatic equipment which utilizes light to size and count particles.

1.3 Individuals performing tests in accordance with this method shall be trained in the use of the equipment and understand its operations.

1.4 The concentration and size distribution of liquidborne particulate contaminants vary widely. The choice of the sampling method will affect the results. Furthermore, the differences in optical, electronic, and sampling systems between the various particle counters, and the differences in the physical properties of the liquids being monitored may contribute to variations in test results. These differences should be recognized and minimized by a standard method of primary calibration. Such a method is outlined in Section 5.

2. SUMMARY OF METHOD

The liquid to be monitored is sampled at a known volumetric flow rate. Particles contained in the sample liquid are passed through an illuminated sensing zone in the optical chamber of the instrument. Each particle passage produces a light pulse whose amplitude can be related to the particle size. Light scattered or absorbed by individual particles is detected by a photo-detector which converts the pulses into electrical current pulses. An electronic system relates the pulse height to particle size and counts the pulses such that the number of particles in relation to particle size is registered or displayed.

3. DEFINITIONS

3.1 Particle Size: The equivalent diameter of a particle detected by an instrument using light scattering or absorption principle. The equivalent diameter is the diameter of a reference sphere generating an electrical response in the photo-detector associated with the optical system. Spherical particles are used for calibration. The response of such instruments is related to the illuminated area, shape, orientation and refractive index of particles passing through the sensing zone. In addition, the geometry of the illuminating and the collecting optics as well as the spectral sensitivity of the photo-detector, influence the apparent size of the particles.

3.1.1 The measurement of a diameter of a spherical particle for calibration purpose is not analogous with the sizing by the longest dimension in accordance to the microscope method (Aerospace Recommended Practice 598A). Aerospace Recommended Practice 1192 is based on the measurement of the equivalent diameter of a particle and Aerospace Recommended Practice 598A the longest dimension of a particle. Therefore, in comparison of data of one method to the other, one must recognize this difference.

3.2 Particle Concentration: The number of particles per unit volume of liquid.

3.3 Primary Calibration: Calibration performed using reference particles of known size and physical properties. Initially performed by the equipment manufacturer, this should be repeatable by user.

3.4 Secondary Calibration: Calibration performed using the reference system built into the counter.

3.5 Statistically Valid Sample: To insure that the statistical error is less than 10%, at least 100 particles greater than a given size (or of a given size range) should be counted.[1] Statistical error varies as 1/square root of the number of particles.

4. APPARATUS

4.1 The subject method is intended for use with an automatic liquidborne particle counter as shown in Figure 1, and may include a recorder or printer.

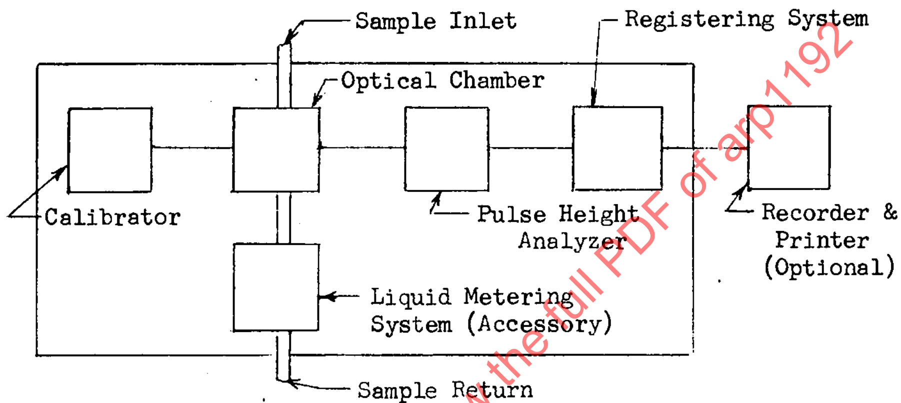

Figure 1. Block Diagram of Automatic Liquidborne Particle Sizer, Counter and Recorder

4.2 Sample Liquid Flow System: The sample liquid flow system shall consist of an inlet system, optical chamber, and liquid metering system (accessory). The inlet system shall be as short as possible so that the deposition of particles upstream of the sensing zone is minimized. Unidirectional passage of the sample liquid through the sensing zone shall be insured to prevent miscounts.

4.2.1 If bottle samples are employed, measures should be taken so that all of the particles in the bottle is passed into the sensing zone. This could be accomplished by repeated flushing of the sample bottle.

4.3 Sensing System: The sensing zone shall be formed by intersecting the sample flow with a beam of illuminating light in the optical chamber. The light scattered or absorbed by the particles appearing in the sensing zone shall be sensed by the photo-detector. The instrument shall be designed to maintain its stated accuracy despite variations in the line voltage and the ambient temperature. The operating line voltage and temperature ranges shall be specified.

4.4 Electronic System: The electronic system shall include a pulse height analyzer, counting circuits and a system for registering number of particles in relation to several size ranges.

4.4.1 The pulse height analyzer may operate in either one or both of the two modes: (1) to respond to all particles within a discrete size range, or (2) to respond to all particles larger than a lower size limit. Means for selecting the desired particle size ranges or limits shall be provided.

4.4.2 The counting circuits shall accumulate information generated by the pulse height analyzer in response to particles during a known time interval. Depending on the mode of operation and the design of the instrument, pulse count accumulation in one or several size ranges may be provided.

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[1] This expression relates to the procedure in this method, and not contamination analysis in general.

4.4.3 The registering system shall indicate the number of particles or concentration with respect to selected particle size ranges or size limits. The counting time interval shall be related to the flow rate of sampled liquid, or instructions shall be provided in the operating manual such that the flow rate can be related to the time in order to determine the sample volume.

4.4.4 Recorder and Printer Output (Optional): An electrical signal output for a built-in or auxiliary printer and/or for other recorders may be provided.

4.4.5 Calibrator: An internal secondary calibration system shall be incorporated in the instrument. This shall function by simulating in the sensing zone of the optical chamber the presence of known size particles. The secondary calibration system shall be validated with respect to primary calibration using particles of known physical properties in accordance with the procedure described in Section 5. The secondary calibration system will be used for checking the sizing and counting accuracy of the instrument, and to provide a stable reference for the sensitivity adjustment of the instrument.

5. PRIMARY CALIBRATION

5.1 Mechanical connections, necessary to provide liquid flow to the optical flow cell of the instrument, are made.

5.2 All power switches are turned on.

5.3 Pulse height analyzer is adjusted in accordance with the calibration curve (indicated particle diameter versus pulse height output) for the automatic liquidborne particle counter. The precise method of adjustment shall be provided by the manufacturer.

5.4 The optical flow cell is filled with the liquid to be monitored, and the liquid flow stopped. A clean liquid is essential as this will ensure a low background count when standard sized particles are placed into the flow system. The optical system should be calibrated to the refractive index of the liquid used to standardize the counter.

5.5 Appropriate amount of the standard reference particles is added into the inlet flow (see Fig. 1). Several sizes are employed to adequately calibrate the various size categories. The reference particles shall be well dispersed by vigorous agitation, stirring, or ultrasonic vibration. Microscopic examination of the dispersion will be carried out to insure that no agglomerated material is present in the reference particle suspension.

5.5.1 The calibration of an automatic liquidborne particle counter should be made with accurately sized and counted discrete size particles. If the calibration is to be valid, not only must the exact count be traceable to the Bureau of Standards but the contamination level or concentration must be in the range where the counter is to be employed. It has been experienced that the larger size particles may block the sensor and distort the count of small particles. Therefore for accurate calibration, a known distribution of discrete size particles is employed. Discrete size particles should be used to eliminate uncertainty in sizing the particles, i.e. in place of 5 to 15 microns, particles of 10 ± 0.5 microns should be used. When a counter is to be used to check a liquid at a Class 6 level, the 100 milliliters of calibrating liquid should contain 16,000 particles of 10 micron size, 2,850 particles of 20 micron size, etc. including 16 particles 100 micron size.

5.5.2 Aerospace Recommended Practice 598A: The Determination of the Particulate Contamination in Liquids by the Particle Count Method is employed to check the calibrating liquid. It should be checked before and after the liquid is passed through the illuminated sensing zone. Only in this manner can it be ascertained that the particles are properly dispersed and suspended in the liquid throughout the sizing and counting system.

5.6 The flow of liquid is started and the instrument is adjusted in accordance to the manufacturer's instruction until the pulse height readings peak in the appropriate particle size range.