



LIQUID AUTOMATIC PARTICLE COUNTERS AND CONTAMINATION MONITORS

1. INTRODUCTION

The purpose of this report is to offer collective data on liquid automatic particle counters and contamination monitors: (a) Coulter Counter, (b) HIAC Automatic Particle Counter, (c) Millipore Micro-Scan Continuous Contamination Monitor, (d) Royco Liquidborne Particle Monitor, and (e) Sperry Liquid Contaminant Level Indicator. This Aerospace Information Report is based on information supplied by the manufacturers of the equipment described herein, and the information has not been verified experimentally by the Contamination and Filtration Panel of the Society of Automotive Engineers, Inc., Committee A-6. Additional information on the use of this equipment is shown in Section 7 of this report. As other instruments become available, this report will be amended to include information on these new instruments. The description of the equipment will encompass the following interest areas:

- Technical description
- Calibration
- Performance characteristics
- Published references

2. COULTER COUNTER

2.1 Technical Description - The Coulter Counter is a system of instruments designed to analyze sample liquid for particle count and size. Fig. 1 presents a schematic

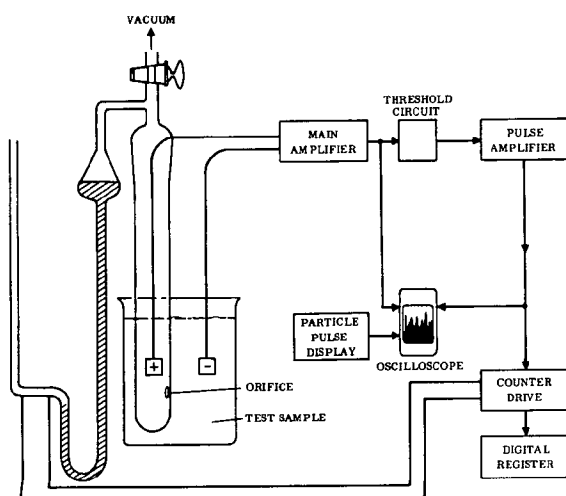


Figure 1
Schematic Diagram of the Coulter Counter

diagram of the Coulter Counter. The sample liquid is added to a beaker, and this liquid is made conductive by addition of an electrolyte. For analysis of MIL-H-5606B hydraulic oil, a mixture of 1.5 parts isopropanol (4% in ammonium thiocyanate), 1.5 parts 1, 2 - dichloroethane, and 1.5 parts MIL-H-5606B oil is recommended. Higher concentrations of hydraulic fluid are possible with alternate dielectric-solvent blends. The liquid sample is kept agitated in the beaker to assure a uniform suspension of particles in the liquid. This test sample is drawn by vacuum through a small aperture having an immersed platinum electrode on both sides of the aperture. The low dilute concentration of the particles in the test liquid permits the particles to traverse the aperture in single file. Each particle displaces a volume of conductive test liquid equal to the particle volume within the aperture. This displacement of the conductive test liquid momentarily changes the resistance between the electrodes and produces a voltage pulse of a magnitude proportional to the volume of the particle. The resultant series of pulses is electronically amplified, scaled, and counted. The voltage pulses are seen on the oscilloscope screen as vertical "spikes." The pulse pattern serves as a guide for measurement and as a monitor of instrument performance. These electrical pulses are sorted through a series of threshold discriminators having adjustable screen-out voltage levels. Each counter is set to count a specific voltage range which represents a definitive particle size range.

2.2 Calibration - The Coulter Counter is calibrated using a mono-sized system of particles such as ragweed pollen or Dow Polystyrene spheres. The size of the selected particle is measured using a microscope equipped with an ocular micrometer. The mono-sized particles are introduced into the electrolyte, and they are moved through the aperture. As the particle passes the aperture between the two electrodes, series of mono-sized pulses are produced. These pulses may be seen on the built-in oscilloscope, and they appear as a plateau. The threshold is then adjusted to coincide with this plateau. Thus, this threshold setting is calibrated to a definitive particle size value. For example, if ragweed pollen was employed for calibration purpose, the threshold setting would be calibrated to 19.5 microns diameter (or 3882 cubic microns). Since the threshold dial is linear with respect to particle volume, all other settings of the threshold may be converted to particle size. With a given aperture size and a given mono-size calibration particle, the threshold setting is stable.

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2.3 Performance Characteristics - There are two current standard Coulter Counters, Models B and C. Model B is an industrial model. This is a single channel unit. It counts one size range at a time. Depending on the nature of sample, measurement factors generally fall in the following ranges:

Aperture size, 2, 3 or more times the diameter of the largest particle in the sample (standard sizes, 11, 20, 30, 50, 70, 100, 140, 200, 280, 400, and 560 microns), and particle concentration 1, 000, 000 per milliliter and lower.

Model C may be obtained with six or more channels. The same aperture size is available. The counter has the capability of counting 1, 000, 000 particles per milliliter and lower.

2.4 Source - Coulter Counter, Coulter Electronics, Inc., Coulter Electronics Industrial Division, Chicago, Illinois.

3. HIAC AUTOMATIC PARTICLE COUNTER

3.1 Technical Description - In operation, a liquid sample is drawn through the liquid passage chamber windows. Fig. 2, Schematic Diagram of the HIAC Automatic Particle Counter, illustrates this instrument. The stream through the chamber window is so small that

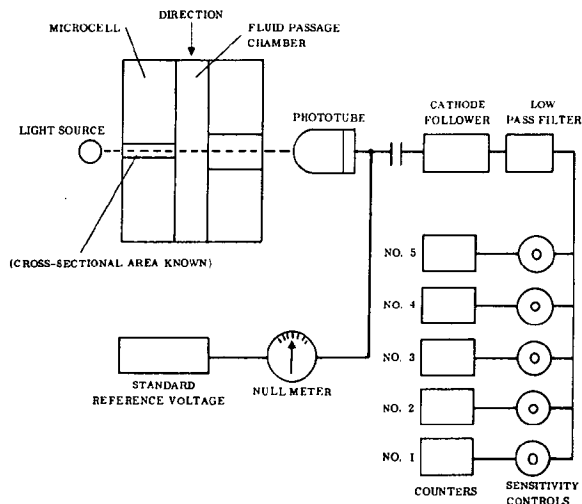


Figure 2
Schematic Diagram of the HIAC Automatic Particle Counter

foreign particles flow through one by one. Light is collimated by the long, tunnel-shaped window into a parallel beam through the chamber window. This beam of light is directed through the liquid stream onto a phototube on the opposite side. The light intensity is adjusted to create a base phototube output signal equal to a standard reference voltage as indicated when the null meter is balanced in the center scale. Whenever a foreign particle passes by the window, a fraction of the light beam is interrupted. This causes a momentary reduction in the output signal from the phototube which is proportional to the size

(projected area) of the particle passing through the light beam. This signal change is then sent to the counter sensitivity controls which have been preset to various thresholds for simultaneous counting of several size ranges through the calibration procedure. Each particle is then tallied according to its size on the electronic counters. The sample volume is metered, so that the result can be reported as the number of particles in each size range in a given liquid volume.

3.2 Calibration - The HIAC Automatic Particle Counter has a built-in calibration system as illustrated in Fig. 3. This calibration system possesses capability for producing standard signals. A table presenting various standard signals (potentiometer readings) versus particle sizes is available for each microcell. The calibration

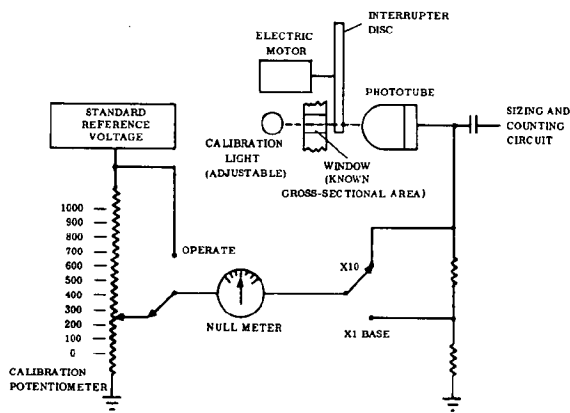


Figure 3
Schematic Diagram of the HIAC Calibration System

system is identical to the analytical system as illustrated in Fig. 2, except that the variable intensity of the calibrate light is employed to simulate different sizes of particles, and pulses are generated with the interrupter disc driven by a constant speed motor.

For calibration purposes, standard particles are considered to be circles with size designated by diameter. The window is fabricated to exact tolerances so that its area is accurately known. Thus, the percent of light that will be blocked out by any given standard particle can be precisely calculated. This, then, gives the percent change in phototube output that will be caused by a particle of a given size. The calibrate potentiometer provides one thousand increments for selecting any percent of the base operating voltage. As an example, to simulate a particle that blocks out 10% of the light, the calibrate potentiometer is set at 100 on a scale of 1000 units. The light intensity of the calibrate light is then adjusted to balance the null meter so that it is equivalent to 10% of the normal base light intensity. A transparent interrupter disc has an opaque radial line scribed on it which is slightly wider than the window through which the calibrate light passes. The sole function of the interrupter disc is to periodically break the light beam; this effect simulates a flow of particles. A constant speed motor