VacuLaz®
-2, -3, -4
(Monitor)
Operator's Manual

Particle Measuring Systems
5475 Airport Boulevard
Boulder, Colorado 80301
(303) 443-7100

P/N 10187-6

Laser and High Voltage Safety

This instrument is a Class I laser product.[1]

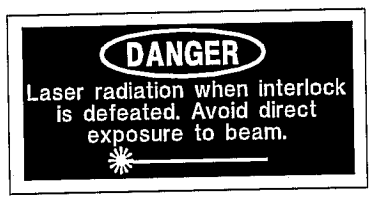
The solid state laser in this instrument is powered by a + 5, -15 volt DC power supply.

WARNING

Always look for the following labels and strictly observe cautions and warnings.

This label is displayed on the photodetector module printed circuit board and under the front cover:

This label is displayed on the interlock defeat jumper:



CAUTION

The Interlock defeat jumper should be installed only when servicing the unit.

CAUTION

Use of controls or adjustments or performance of procedure other than those specified here may result in hazardous radiation exposure.

1 National Center for Device and Radiological Health (formerly BRH).

These labels are displayed on the viewing module base plate for the heated version only:

Introduction

The VacuLaz® Sensor (PMS Models -2, -3, -4) is designed to detect particles in semiconductor process exhaust and load lock lines. The specific application of the VacuLaz® sensor is to monitor vacuum lines by means of a sample cell viewing module that is an integral part of the tool plumbing.

The VacuLaz® system analyzes and stores data in two or four size classes. Real-time data is displayed on the screen of a personal computer (PC).

The VacuLaz® utilizes laser fed illumination through a multi-element condensing system, and collects light scattered by the particles at 90° through a two-element refractive lens system or a two-element Catoptric imaging system depending on the sensor. A sample volume is defined in the center of the flow by the detector size. Sizing is accomplished in situ via light scattering and pulse height analysis.

The complete VacuLaz® system is comprised of three subsystems:

- VacuLaz® sensor attached to a viewing module
- VacuLaz® interface
- PC for data display and storage

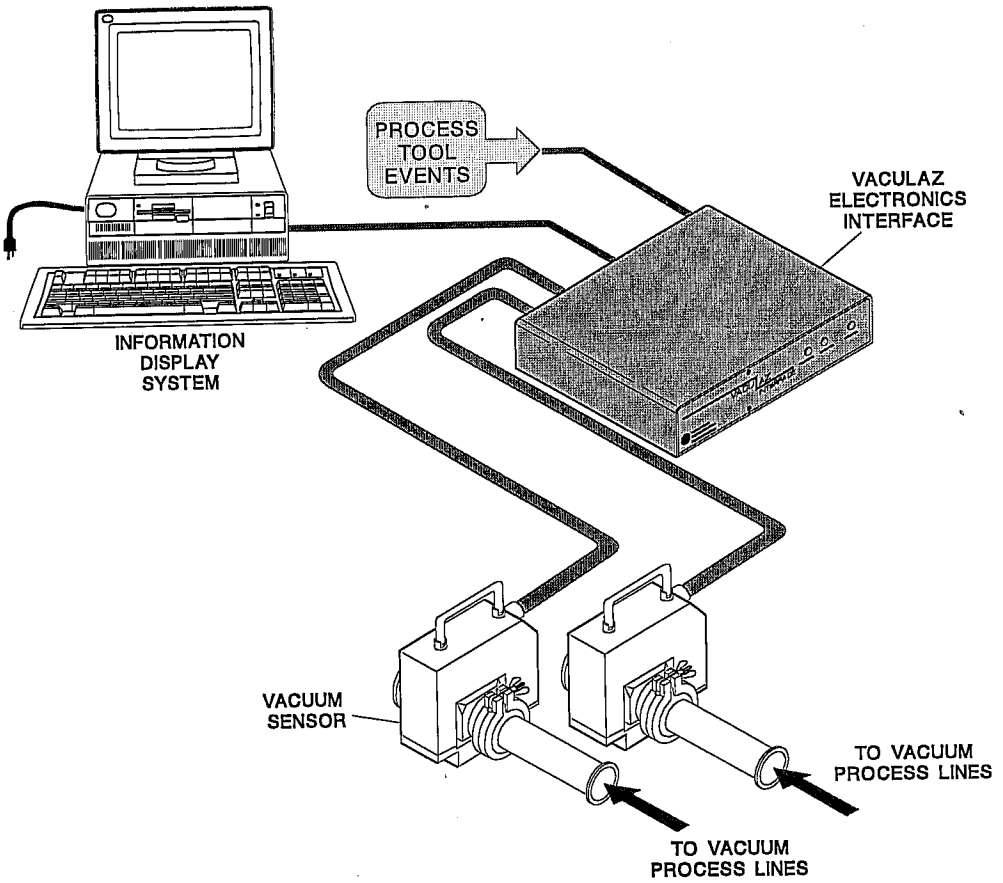


Figure 1-1. VacuLaz System Layout

Please note that different models of VacuLaz® sensors work with different models of viewing modules.

Sensor	Viewing Module
VacuLaz®-2[1]	KF16,KF25 KF40,KF50
VacuLaz®-3	MF80
VacuLaz®-4	MF100

WARNING

If the viewing module is exposed to any corrosive or toxic gases it is imperative that the user accept responsibility for disassembly and detoxification of the viewing module and exposed surfaces as detailed in Chapter 7. Initial delivery and servicing of the instrument will be contingent upon the customer's agreement to abide by these terms.

[1] Special adjustment may be required. Refer to the section on Sensor installation.

Specifications

VacuLaz® -2,-3,-4 General Sensor Specifications

	VacuLaz® -2	VacuLaz® -3	VacuLaz® -4
Sensor type	In-line particle sensor	Same	Same
	In situ counting and sizing	Same	Same
LASER	Solid state laser diode at 780nm TEMoo mode	Same	Same
Laser safety	Class 1 device	Same	Same
Condensing Optics	Collimator and 135mm f.l. cylinder lens	Collimator and 40mm and 20mm f.l. cylinder lens	Collimator and 40mm and 20mm f.l. cylinder lens
Effective Laser Beam Cross-section	115μm x 1300μm	75μm x 1650μm	75μm x 1750μm
Collecting Optics	2-lens refractive imaging system	2-element catoptric imaging system	2-element catoptric imaging system
Magnification	1/2	Same	Same
Minimum detectable size	0.17 μm	Same	Same
Numerical Aperture	0.25	.45	.50
Depth of Field	≈ 2 mm	Same	Same
Flow Velocity range Calibrated at:	0.1- 10.0 m/sec 2.5 m/sec	Same	Same
Sensing heads	Sensor head with quick-disconnect mountings.	Same	Same

	VacuLaz® -2	VacuLaz® -3	VacuLaz® -4
Sampling Area	7.5mm^2 at 0.2 µm 26mm ^{2} at ≥ 0.35 µm	05.5mm^2 at 0.2 µm 33mm ^{2} at ≥ 0.35 µm	08.0mm at 0.2mm 35.0mm ^{2} at ≥ 0.35mm
Percentage of Total Volume Sampled	TBD ___% of 16mm line TBD ___% of 25mm line 2.9% of 40mm line 1.5% of 50mm line	0.73% of 80mm line	0.43% of 100mm line
Suggested Calibration Interval	One year	Same	Same
Size Thresholds*			
2-Threshold Monitor			
First	Software selectable for 0.20, 0.22, 0.25, 0.28 or 0.30 µm	Same	Same
Second	>0.5 µm	Same	Same
4-Threshold Monitor			
First	Software selectable for 0.20, 0.22, 0.25, 0.28 or 0.30 µm	Same	Same
Second	0.35 µm	Same	Same
Third	0.50 µm	Same	Same
Fourth	>1.0 µm	Same	Same

*Threshold: Defines lower size boundary; upper size boundary is undefined.

VacuLaz® -2

Table 2-1. Viewing Area and Sampling Percentage for the VacuLaz® -2 at 0.2 µm Sensitivity

Size µm	Sample Area	Sample % with KF16*	Sample % with KF25*	Sample % with KF40*	Sample % with KF50*
0.20	8.1 mm^2	TBD	TBD	0.9%	0.46%
0.35	26.0 mm^2			2.9%	1.50%.
0.50	28.0 mm^2			3.2%	1.60%
1.00	32.0 mm^2			3.5%	1.80%

Table 2-2. Viewing Areas at other Sensitivity Selections for the VacuLaz® -2

	Size µm							
Selected Threshold	.20	.22	.25	.28	.30	.35	.50	1.00
.20	8.1mm^2					26.0mm^2	28.0mm^2	32.0mm^2
.22		8.1mm^2				23.4mm^2	25.2mm^2	28.8mm^2
.25			8.1mm^2			20.8mm^2	22.4mm^2	25.6mm^2
.28				8.1mm^2		19.5mm^2	21.0mm^2	24.0mm^2
.30					8.1mm^2	18.2mm^2	19.6mm^2	22.4mm^2

* KF-16	TBD	
* KF-25	TBD	
* KF-40	Viewing Module Area	905 mm^2
* KF-50	Viewing Module Area	1772 mm^2

VacuLaz® -3

Table 2-3. Viewing Area and Sampling Percentage for the VacuLaz® -3 at 0.2 µm Sensitivity

Size µm	Sample Area	Sample % with MF80*
0.20	5.5 mm^2	0.12%
0.35	33.0 mm^2	0.72%
0.50	36.5 mm^2	0.80%
1.00	50.0 mm^2	1.10%

Table 2-4. Viewing Areas at other Sensitivity Selections for the VacuLaz® -3

Selected Threshold	Size µm .20	.22	.25	.28	.30	.35	.50	1.00
.20	5.5mm^2					33.0mm^2	36.5mm^2	50.0mm^2
.22		5.5mm^2				28.0mm^2	33.3mm^2	42.7mm^2
.25			5.5mm^2			21.0mm^2	28.7mm^2	35.3mm^2
.28				5.5mm^2		16.0mm^2	23.5mm^2	31.4mm^2
.30					5.5mm^2	13.0mm^2	20.5mm^2	28.9mm^2

* MF-80 Viewing Module Area 4560 mm^2

VacuLaz® -4

Table 2-5. Viewing Area and Sampling Percentage for the VacuLaz® -4 at 0.2 µm Sensitivity

Size µm	Sample Area	Sample % with MF100*
0.20	8.0 mm^2	0.10%
0.35	35.0 mm^2	0.43%
0.50	38.2 mm^2	0.47%
1.00	50.0 mm^2	0.61%

Table 2-6. Viewing Areas at other Sensitivity Selections for the VacuLaz® -4

Selected Threshold	Size µm .20	.22	.25	.28	.30	.35	.50	1.00
.20	8.mm^2					35.1mm^2	38.2mm^2	50.0mm^2
.22		8.mm^2				30.8mm^2	35.1mm^2	42.8mm^2
.25			8.mm^2			25.9mm^2	31.0mm^2	36.6mm^2
.28				8.mm^2		20.6mm^2	27.2mm^2	33.8mm^2
.30					8.mm^2	15.4mm^2	23.7mm^2	31.1mm^2

* MF-100 Viewing Module Area 8188 mm^2

Viewing Module Specifications

Flange Size (ISO)	16 mm-100 mm diameter
Pressure range	10^{-8} torr to 50 psig (5000 torr A)
Length	
Unheated	
KF16	3.0 in.
KF25	3.0 in.
KF40	3.0 in.
KF50	3.5 in.
Heated	
KF16	4.0 in.
KF25	4.0 in.
KF40	4.0 in.
KF50	4.0 in.
MF80	4.5
MF100	4.5 in.
Power	
Heated	100 VAC, 115 VAC, 220/240 VAC
Wattage	
KF16	TBD
KF25	TBD
KF40	75
KF50	100
MF80	200
MF100	200
Operating Temperature	125-175° C
Wetted Surface Materials	
Cell body	Aluminum Anodized
Windows	Sapphire
Seals	Chem-rez

Information Display System (IDS) Personal Computer (PC) Requirements

- IBM (or compatible) 386DX (or better), 33 MHz
- DOS 3.3 or higher
- Microsoft Windows™ 3.1 or higher
- Mouse
- VGA Color Monitor (640 x 480 x 16 color)
- 4 MB RAM
- 40 MB Hard Disk Drive (or equivalent)
- RS-232 or RS-485 serial communications port
- Parallel printer port

Note

Significant performance improvements can be realized by increasing computer capability. The equipment listed here is the minimum for running VacuLaz® alone.

System Environmental Specifications

Temperature	10-30° C
Altitude	0-20,000 ft MSL
Humidity	0-99% RH (non-condensing)

Calibration

Table 3-1 lists particle thresholds.

Table 3-1. VacuLaz Calibration Size Ranges

	Size (microns)
2 Threshold Monitor	
First size threshold	(0.20 - 0.3)* µm
Second size threshold	>0.5 µm
4 Threshold Monitor	
First size threshold	(0.20 - 0.3)*µm
Second size threshold	0.35 µm
Third size threshold	0.50 µm
Fourth size threshold	> 1.0 µm

It is expected that the VacuLaz® sensor will remain calibrated for the duration of the suggested calibration interval. If any doubt exists as to the calibration status of the instrument, known-size particles may be used to confirm accurate calibration. Contact PMS for more details.

NOTE

The VacuLaz® sensor can be calibrated with any compatible viewing module. It is not necessary to break vacuum to check calibration.

*The first threshold is software selectable for the following sizes: 0.20, 0.22, 0.25, 0.28, 0.30µm.

Installation

Unpacking the VacuLaz®

1. Inspect the shipping container for any signs of damage or mishandling. If the container appears damaged, do not open it. Contact the shipper immediately.

2. If the shipping container appears undamaged, carefully open the container and remove the VacuLaz® instrument and accessories, inspecting each item for damage.

3. Verify that all ordered items are included:

If items are missing, contact PMS immediately.

VacuLaz ® Quick Reference Hardware

A VacuLaz® Quick Reference pamphlet is available from Particle Measuring Systems, printed on cleanroom paper, at no charge. This guide will help with the installation and system setup. It also gives helpful hints about VacuView software.

Viewing Module Installation

The viewing module is installed as an integral part of the in-house plumbing. Connections are made at the inlet and outlet by use of appropriate gaskets and flanges. It is preferable to orient the viewing module with the mounting surface as the base but any orientation is acceptable. Refer to Figure 4-2.

CAUTION

The viewing module has been cleaned and packaged in a class 100 environment. Do not open in an area where contamination could occur.

Before you begin:

Desirable Installation Practices

During installation, verify all mating parts are clean.

Ensure tubing is aligned and spacing correct so no stresses are applied to the viewing module when assembled.

Use only spectrophotometric-grade acetone or alcohol and non-abrasive wipes or cotton swabs for cleaning external optical surfaces.

Keep the viewing module optic covers in place when not in use.

Sight through the viewing module to inspect windows for contamination if DC Light level is high.

Install the instrument with adequate clearance for sensor head protrusions.

Undesirable Installation Practices

Never run liquids through the view module.

Never leave unpowered sensor on a heated view module.

Never subject the sensor to mechanical shock.

Never re-use window seals.

Never attempt to remove the windows while under vacuum.

Sensor Installation

WARNING

Do not attempt to defeat the laser safety interlock! The laser safety interlock turns the Laser power off when the sensor head is removed from the viewing module base plate.

Important: VacuLaz® -2 sensors have a light blocking ring which must be correctly positioned according to the type of viewing module used. Incorrect positioning makes the sensor sensitive to external light sources.

A 1/4 inch gap is required between the light blocking ring and the lens mounting flange for the KF16, KF25 and KF40 cells. No gap is required for the KF50 cell.

Other sensors have a spring plunger detent which allows the light blocking ring to be moved up and down without any disassembly.

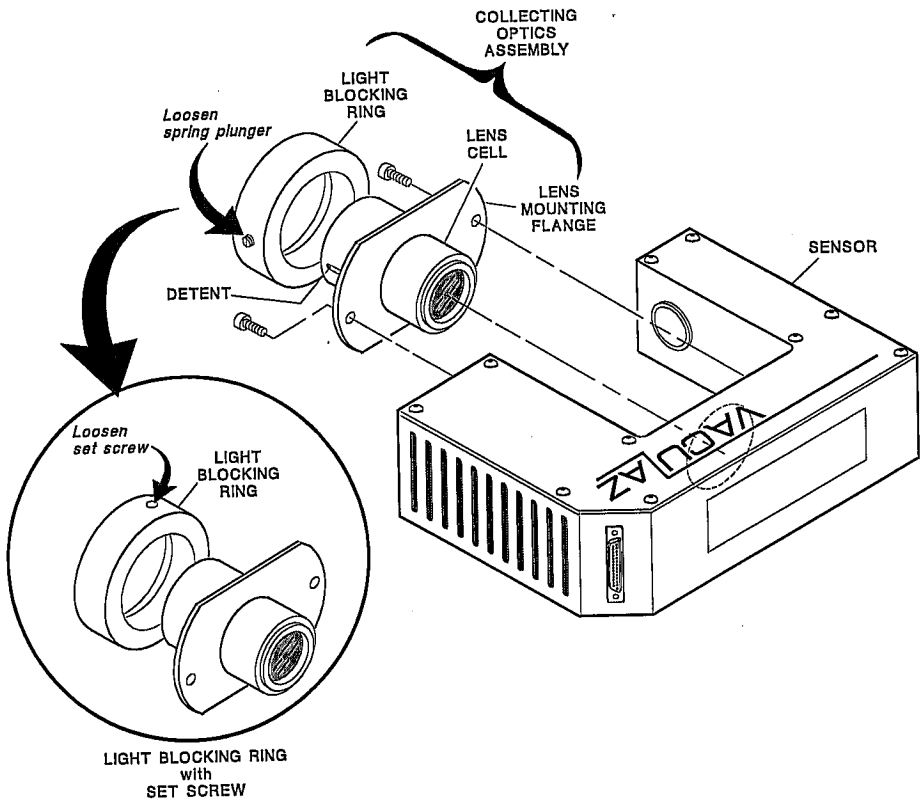


Figure 4-1. VacuLaz Collecting Optics Assembly

CAUTION

Be sure the power is off and be careful not to contaminate the optics or pinch any wires during the dissassembly or reassembly process.

Locate the laser safety interlock mounted on the base plate (Figure 4-2). Align the sensor head with the base plate so the laser safety interlock inserts into the sensor head interlock. Hand-tighten the two mounting screws.

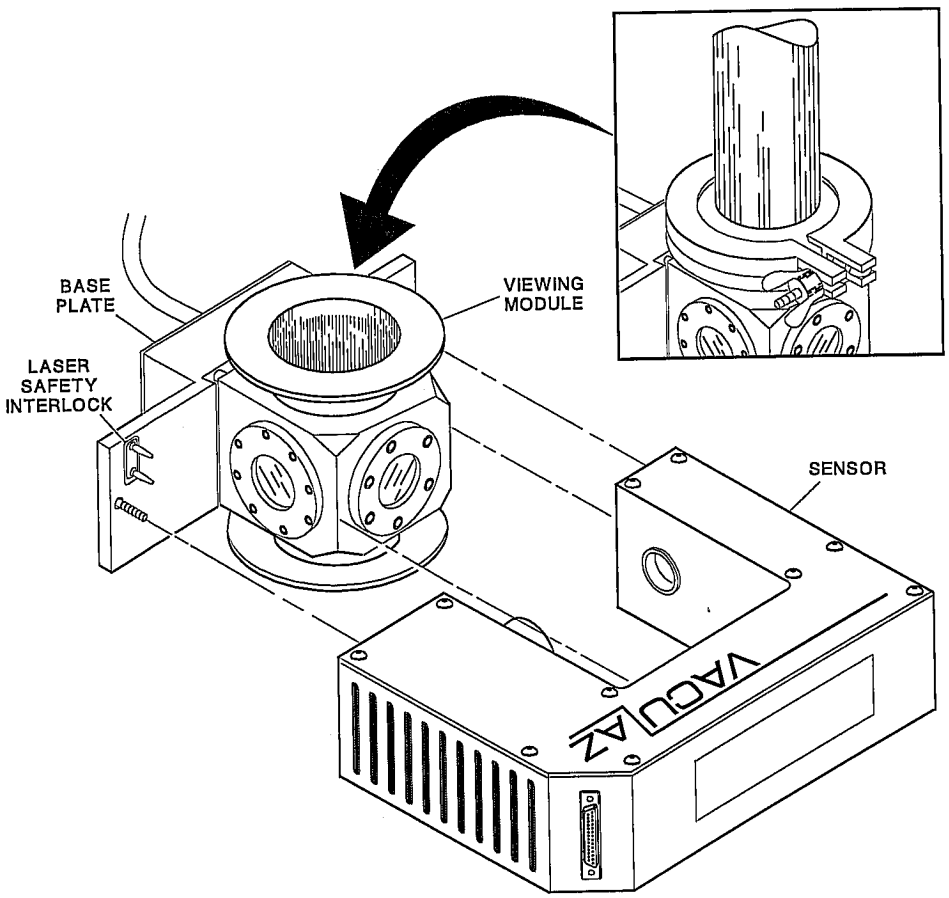


Figure 4-2. VacuLaz Sensor Installation

Optional Heated Viewing Modules

Heated viewing modules (available from PMS) have four heaters embedded in the viewing module to reduce window contamination. The heated viewing module requires power from an AC outlet.

A three-prong (grounded) cable is supplied with the 100VAC and 115VAC units. The 220/240VAC units are shipped with an unterminated cable.

CAUTION

Use cooled VacuLaz® sensors when using heated view modules. Heated view modules radiate heat to the sensor resulting in possible degradation of laser life if cooling is not introduced.

WARNING

The temperature of a heated view module may exceed 150°C (302°F).

Description and Theory of Operation

The VacuLaz® sensor operates on the principle that the amount of light scattered by a particle in a vacuum is a direct function of the size of the particle. When particles produce pulses of radiant energy during transit through a laser beam, these pulses can be collected and sensed by solid-state photodiodes. The current produced by the photodiode is converted to voltage pulses by current-to-voltage amplifiers. A pulse height analyzer measures the size of the voltage pulse and the information can then be displayed as a function of particle size.

VacuLaz® Optical System

The sensor uses a monitor technique for the identification of an effective sample area within the laser beam. The effective sample area refers to the area within the sample flow path where particles will be sized.

The laser is a 780nm wavelength solid state laser diode operating in the TEMoo mode. The condensed laser output passes through one window to enter the viewing module (Figures 5-1 and 5-2). The condensed laser output then passes through a second window before encountering the beam dump. The laser beam has a 100µm x 1.3mm (75µm x 1.65mm and 1.75 in the case of the VacuLaz® -3 and -4) cross-section at the center of the sample area in the center of the viewing module.

The collecting optics is a two lens refractive imaging system in the VacuLaz® -2, and a two element catoptric imaging system in the VacuLaz® - 3 and - 4. In both sensors, the collecting optics give a 1/2 magnification of the object and an effective depth of field of 2mm. The particle flow in Figures 5-1 and 5-3 is into the page, and with a 10 mm long detector, the effective sampling area is 26.0mm^2 for VacuLaz® -2, 33.0mm^2 for VacuLaz® -3 and 35.0mm^2 for VacuLaz® -4.

$$1/(1/2) \times 10mm \times 1.30mm = 26mm^2$$
$$1/(1/2) \times 10mm \times 1.65mm = 33mm^2$$
$$1/(1/2) \times 10mm \times 1.75mm = 35mm^2$$

Refer to Figures 5-2 and 5-4 for the VacuLaz® collecting optics ray traces.

Light scattered at a 90° angle by particles passing through the beam area is collected and refocused onto the detector. Electronic gains are used on the sensor preamplifier sections. Additional signal processing is performed by the remainder of the circuitry on the photodetector module, and the signal is then transmitted to the electronics interface.

Within the electronics interface, the signal amplitudes are compared to the threshold settings, digitized, and sent to the Information Display System.

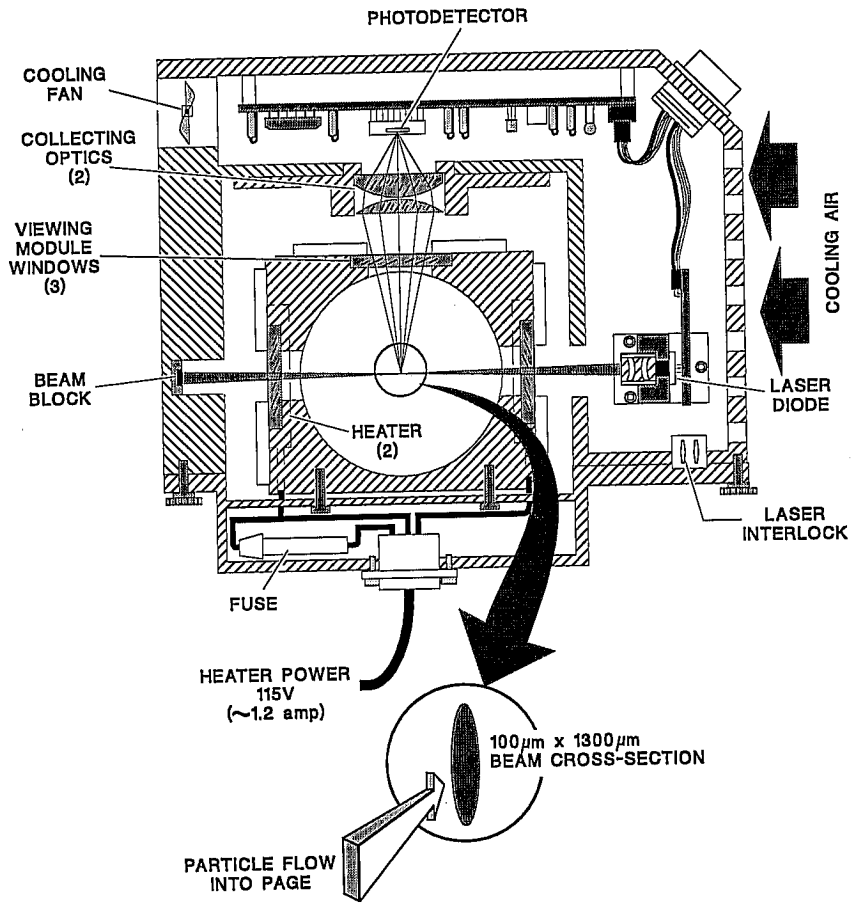


Figure 5-1. VacuLaz -2 Optics Diagram

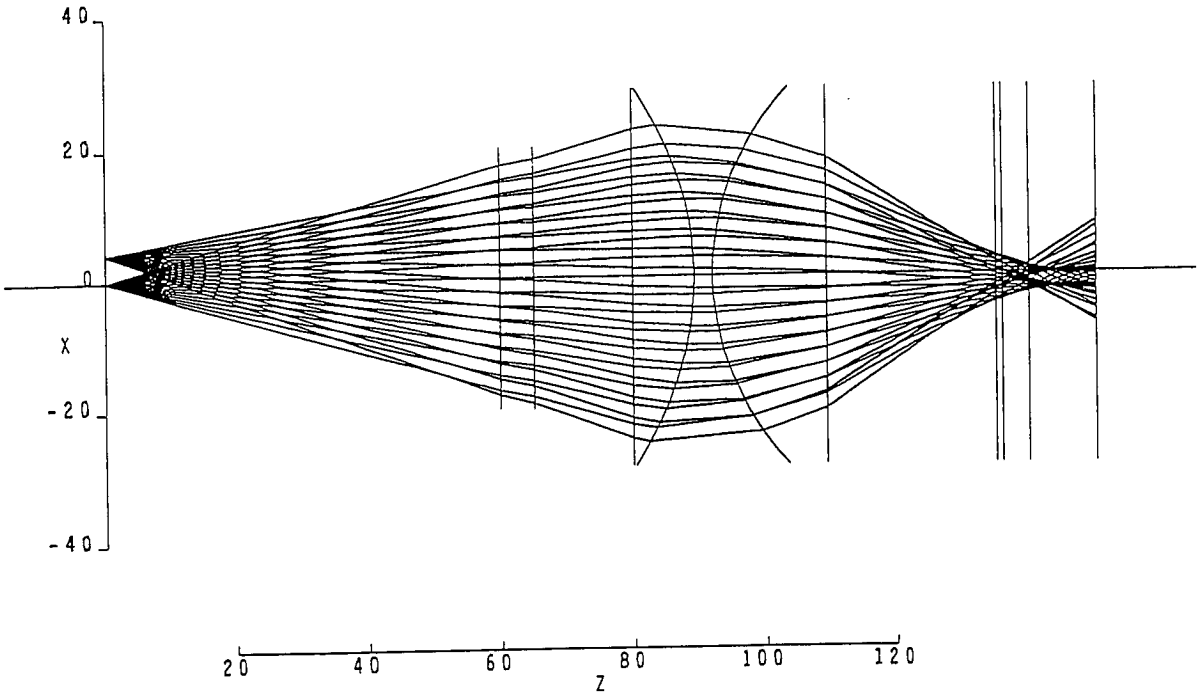


Figure 5-2. VacuLaz-2 Collecting Optics Ray Trace

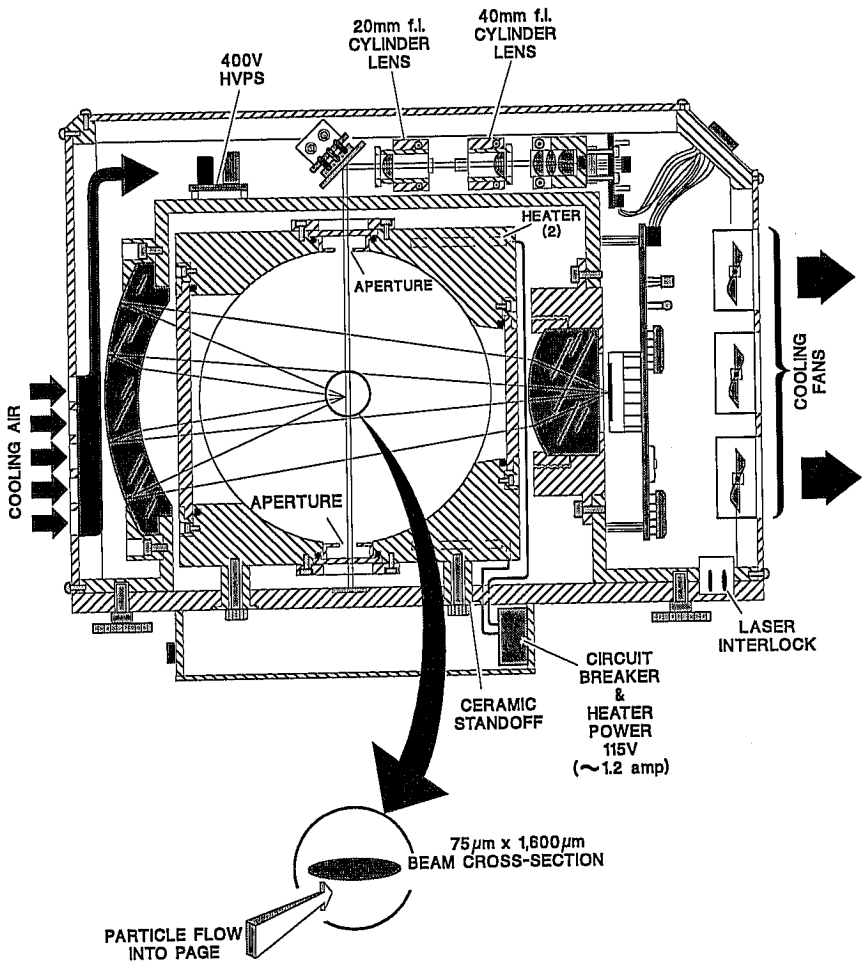


Figure 5-3. VacuLaz -3,-4 Optics Diagram

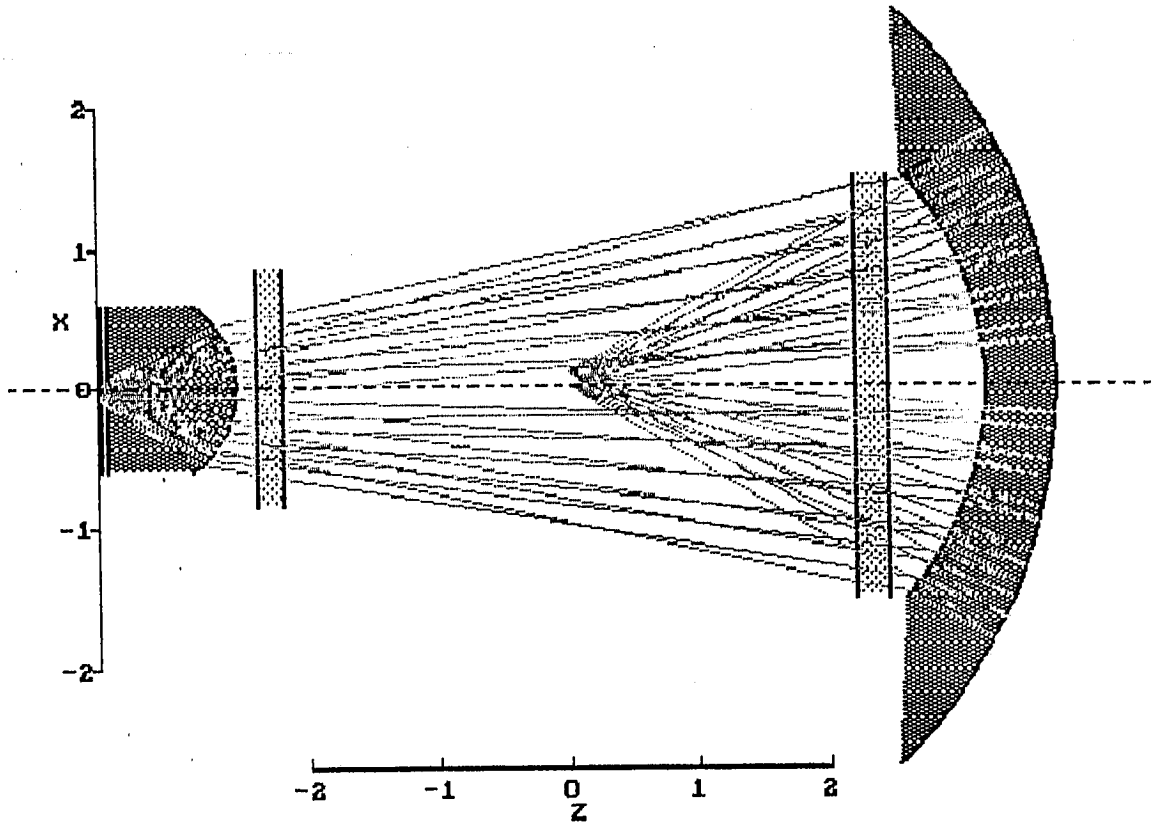


Figure 5-4.VacuLaz -3,-4 Collecting Optics Ray Trace

Sensor Electronic Signal Processing

Signals from the photodiode are fed to the noise-reduction circuit where first level noise is eliminated. The noise-reduction circuit is software-controlled for minimum sensitivity control.

The signal is buffered for noise-free transmission to the electronics interface.

Because the sensors are electronically calibrated, it is necessary to store calibration information in the sensor using a RAM device.

The sensor detector requires high voltage, supplied by the appropriate power supply.

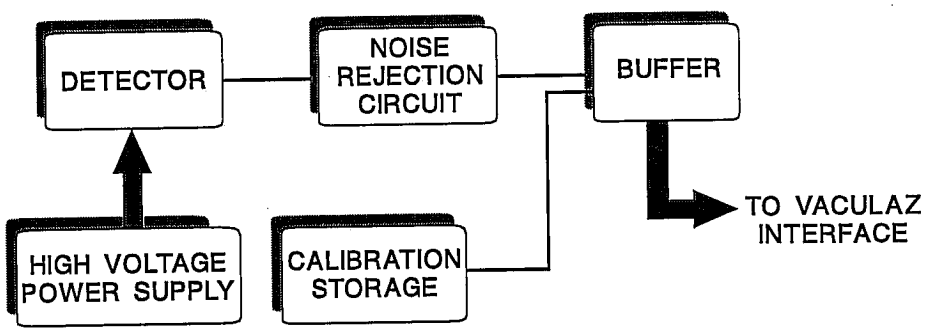


Figure 5-5. Sensor Electronics Functional Diagram

Routine Service

WARNING

Due to the toxic nature of the specialty gases used in processes, it is imperative that the viewing module be carefully removed and detoxified prior to release for service at PMS.

NOTE

Detoxification shall include purging the unit with an inert gas after removal of the viewing module from the line. All toxic or corrosive materials must be removed from the interior of the viewing module as well.

PMS will require the user to provide confirmation that the detoxification has been performed in accordance with industry guidelines before the issuance of a Return Merchandise Authorization (RMA) number for service.

The only routine service required is cleaning of the external optical surfaces of the sensor head, and the internal and external surfaces of the windows used on the viewing module. Due to the partial disassembly required (removal of the sensor from the viewing module) there is a resultant interruption of sampling.

This instrument has been designed to maintain optical alignment and calibration indefinitely under normal operating conditions.

Optics Cleaning

CAUTION

Use only spectrophotometric-grade acetone or alcohol and non-abrasive wipes or cotton swabs to clean optical surfaces.

CAUTION

Attempting to clean the condensing optics may result in misalignment and loss of calibration, and is in most cases unnecessary. Please consult PMS before attempting to clean the condensing optics.

Periodically the sensor head should be removed and the sensor head optics checked and cleaned. The viewing module windows should be checked and if the external surfaces of the windows are contaminated they should be cleaned.

If the internal surfaces of the windows are contaminated, the viewing module will need to be disconnected from the vacuum line and the windows cleaned. After the windows and optics have been cleaned, the sensor head can be reinstalled on the viewing module base plate.

There are several ways to determine the need for window cleaning:

Check for low counts in Size Channel 1 where a log-normal distribution is expected. This suggests counts are being rejected due to coincidence.

Check for excessive counts in Size Channel 1 when no particulate is present.

Monitor the DC Light level through the VACU-VIEW to establish a real-time measure of window contamination and thereby determine when window cleaning is indicated. The DC Light level reading should be correlated to coincidence loss or excessive counts in the first channel.

If the previous indications persist after the windows have been cleaned, it may be necessary to replace the windows. If this does not solve the problem, contact PMS for service.

Tips on Window Replacement and Cleaning

Optimal window cleanliness can be achieved through removal of the windows for cleaning.

When removing windows from the viewing module, be sure to wear gloves or finger cots.

Use new O-rings to ensure vacuum integrity. Verify O-rings and grooves are free of contamination before installation.

Service the windows in a cleanroom environment only.

Window Cleaning Procedure

WARNING

View Module will be hot! Allow to cool for 15 minutes before handling!

1. Unplug heated view module.
2. Remove sensor from view module.
3. Remove view module from the vacuum line.
4. Remove the window covers using a 7/64" Allen wrench. One of the windows has an aperture under the window. This aperture may fall out during window removal. It is very important to keep track of that aperture for re-installation.
5. Remove the windows. To remove the windows push from inside the view module.
6. Clean windows with de-ionized water. Follow this with a cleaning of acetone or IPA.
7. Replace windows noting aperture placement.
8. Re-install view module.

Electronic Troubleshooting

If the VacuLaz® is inoperative after cleaning of the windows and optics, contact PMS.