

# 26 The Flame Photometric Detector

## General Information

Linearity

Quenching effects

PMT saturation

Optical filters

Fused silica liner

Conditions that prevent the detector from operating

Detector shutdown

Compatibility requirements

The dual wavelength FPD

## Using the Detector

Detector temperature considerations

Heater configuration

Lit offset

Procedure: Changing the Lit offset setpoint

Flame ignition sequence

Lighting the flame

Electrometer on/off

Electrometer data rates

Procedure: Using fast peaks

## Operating the FPD

Procedure: Using the FPD

## Columns and Traps

## Checkout Conditions and Chromatogram

FPD checkout conditions

Typical FPD checkout chromatograms

## Maintaining the Detector

Flame ignition problems

Changing wavelength filters

Leak testing

Parts identification

Cleaning/replacing windows, filters, and seals

Cleaning/replacing the jet

Replacing the transfer line fused silica liner

Replacing the photomultiplier tube

# The Flame Photometric Detector (FPD)

## General Information

The sample burns in a hydrogen-rich flame, where some species are reduced and excited. The gas flow moves the excited species to a cooler emission zone above the flame where they decay and emit light. A narrow bandpass filter selects light unique to one species, while a shield prevents intense carbon emission from reaching the photomultiplier tube (PMT).

The light strikes a photosensitive surface in the PMT where a light photon knocks loose an electron. The electron is amplified inside the PMT for an overall gain of up to a million.

The current from the PMT is amplified and digitized by the FPD electronics board. The signal is available either as a digital signal on the communications output or as a voltage signal on the analog output.

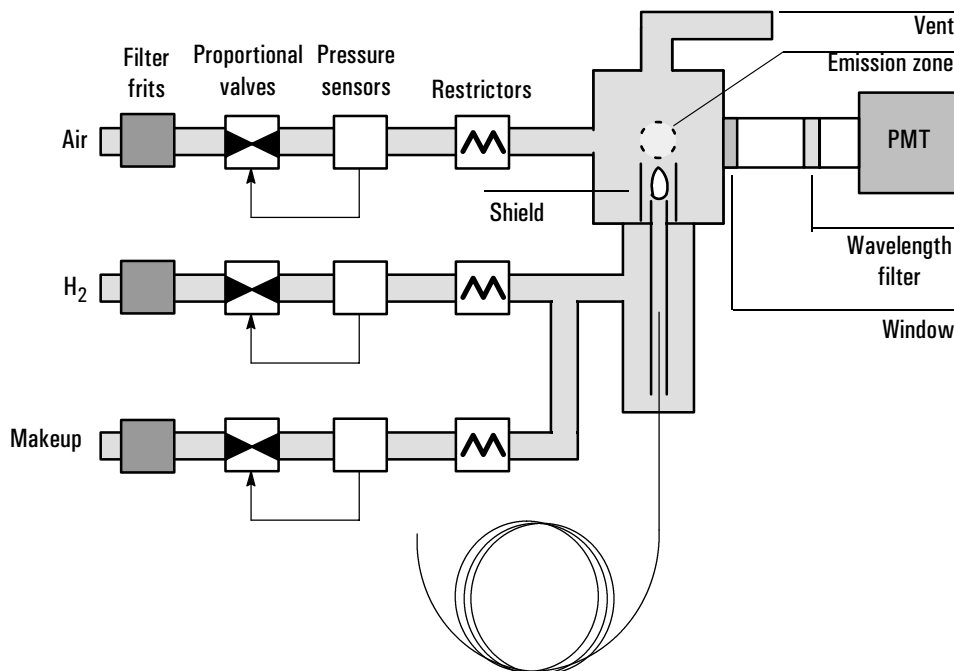
The FPD should not be stored at temperatures above 50°C, based on the original manufacturer's specifications for the PMT.

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## Linearity

Several mechanisms produce sulfur emission. The excited species is diatomic, so that emission intensity is approximately proportional to the square of the sulfur atom concentration.

The excited species in the phosphorus mode is monatomic, leading to a linear relationship between emission intensity and atom concentration.



**Figure 90. Schematic of a flame photometric detector**

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## Quenching effects

Hydrocarbon quenching occurs when a high concentration of carbon dioxide from a hydrocarbon peak is in the flame at the same time as the sulfur species. Part of the light emitted by the sulfur species is absorbed by some CO<sub>2</sub> species.

Self-quenching occurs at high concentrations of the heteroatom species. Some other ground state (unactivated) species reabsorbs the emitted photon, preventing it from reaching the PMT.

These effects are reduced by good chromatographic practices. The column should provide good separation of the compounds, those that contain sulfur or phosphorus as well as those that do not but may absorb light. A careful, multilevel calibration is well worth the investment!

Detector and gas cleanliness must be maintained to have consistent responses. Since most sulfur and phosphorus compounds contain chemically active sites, the injection and column systems must be kept very clean.

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## **PMT saturation**

The photomultiplier tube may saturate if light intensity is too high. When this happens, increasing concentration produces little or no increase in signal and peak tops are rounded or flattened. Dilute the sample to correct the problem.

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## **Optical filters**

The filters are marked on the edge with the transmission wavelength. Each filter has a mirrored side—which must face the flame when installed—and a colored surface.

The sulfur filter is blue/purple and transmits at 393 nanometers.

The phosphorus filter is yellow/green and transmits at 525 nanometers.

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## **Fused silica liner**

The FPD uses an inert fused silica insert liner in the transfer line. This allows fused silica columns up to 530  $\mu\text{m}$  ID to run right to the base of the flame, minimizing sample tailing or loss on chemically active sites. The liner is also compatible with standard packed columns.

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## **Conditions that prevent the detector from operating**

- Temperature set below 120°C
  - Air or hydrogen flow set at Off or set at 0.0
  - Ignition failure
-

## Detector shutdown

If a critical detector gas is shut down due to a pneumatics or ignition failure, your detector shuts down. This turns off everything except the detector temperature and makeup gas flow.

## Compatibility requirements

If a single wavelength FPD is to be used with an Agilent ChemStation, the ChemStation must be version 4.02 or higher.

If a dual wavelength FPD is to be used with an Agilent ChemStation, the ChemStation must be version 5.01 or higher.

## The dual wavelength FPD

This is a single burner module with two PMT housings, one with a sulfur filter and the other with a phosphorus filter. Because the optimum gas flows for these elements are quite different, performance of this detector is a compromise.

The detector mounts in the back position and is heated by the Back Det and AUX 2 heaters. The AUX 2 setpoint is automatically set by the Back Det setpoint.

Two signal channels and two electrometer boards are used, one for each PMT. The Back Det control table runs the detector, while the Front Det operates in a special "signal only" mode. Typical tables for a dual wavelength FPD are:

FRONT DET (FPD)	
Output	178 9

BACK DET (FPD)	
Temp	250 250
H2 flow	50 0 50 0
Air flow	60 0 60 0
Mode: Col+makup=const	
Combined flow	15 0
Mkup (N2)	50 0 50 0
Flame	off <
Output	119 2

If a heated zone is assigned to the Front Det position, an "F det type mismatch" will be declared. To override this, press [Config], scroll to the Instrument line and press [Enter]. Scroll to the F det line, press [Mode/Type], and select Sig only FPD.

## Using the Detector

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### Detector temperature considerations

The FPD flame produces considerable water vapor. The detector must be operated above 120°C to prevent condensation.

Unnecessarily high temperatures can cause thermal decomposition of many thermally labile phosphorus and sulfur compounds.

Detector temperature can have a significant effect on sulfur sensitivity. If analyzing compounds with high boiling points, the detector temperature should be set to 25°C above the final oven temperature—if allowed by the temperature limit of 250°C.

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### Heater configuration

The FPD burner module has two heated zones, one for the detector body and one for the transfer line.

A single wavelength FPD can be mounted in either the front or back position. In the front position, it uses the Front Det and AUX 1 heaters. In the back position, it uses the Back Det and AUX 2 heaters. A second detector—possibly another FPD—can be mounted in the unused position.

A dual wavelength FPD—simultaneous detection of sulfur and phosphorus—must be mounted in the back position, where it uses the Back Det and AUX 2 heaters. A second detector cannot be mounted.

The software automatically sets the AUX heater to the same setpoint as the Det heater. You do not have to contend with two separate entries.

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## Lit offset

Lit offset is the expected difference between the FPD output with the flame lit and the output with the flame off. It is used to determine whether an attempted ignition has succeeded and to detect a flame-out condition.

If the output with the flame on minus the output with the flame off is greater than Lit offset, the flame is considered lit.

The default setting for Lit offset is 2.0 picoamps. This is a good working value for all but very clean gases and systems. You may want to change this setpoint if:

- Your detector is attempting to reignite when the flame is still on, thus producing a shutdown.
- Your detector is not trying to reignite when the flame is out.

### Procedure: Changing the Lit offset setpoint

1. Press [Config][Front Det] or [Config][Back Det].

```
┌──────────┬──────────┬──────────┬──────────┬──────────┐
│  C O N F I G U R E  F R O N T  D E T  │
│ M k u p  g a s  t y p e           N 2  │
│ L i t  o f f s e t                2 . 0 < │
│ E l e c t r o m e t e r           O n  │
└──────────┴──────────┴──────────┴──────────┴──────────┘
```

2. Scroll to Lit offset and enter a number.  
The default is 2.0 pA.  
Enter 0 to disable the automatic reignite function.  
The setpoint range is 0 to 99.9 pA.



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## Flame ignition sequence

When either of the flame ignition methods on the next page is used, the FPD automatically performs this sequence:

1. Turns all detector gases—air, hydrogen, makeup—off. Carrier remains on.
2. Sets air flow to 200 mL/min.
3. Turns the glow plug ignitor on.
4. Ramps the hydrogen flow from 10 to 70 mL/min.
5. Resets the air flow to the air flow setpoint.
6. Resets the hydrogen flow to the hydrogen flow setpoint.
7. Turns the makeup gas on.
8. Compares the signal change with the `Lit offset` value. If the change is greater than `Lit offset`, declares the flame on (lit). If it is less, declares the flame off (not lit).

For this process to work, there must be enough air pressure to the pneumatics module to provide 200 mL/min flow. We recommend a supply pressure of 90 psi.

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## Lighting the flame

### Manual

To start the flame ignition sequence:

Press [Front Det] or [Back Det]

FRONT DET (FPD)		
Temp	250	250
H2 flow	50.0	50.0
Air flow	60.0	60.0
Mode: Col+makup=const		
Combined flow	15.0	
Mkup (N2)	50.0	50.0
Flame		off <
Output		0.0

Scroll to Flame and press [On]

### Automatic

If the FPD output with the flame on falls below the flame-off output plus the `Lit offset` value, this is interpreted as a flame-out condition. The FPD runs the flame ignition sequence to relight the flame. If this fails, it runs the sequence again. If the second attempt also fails, the detector shuts down all functions except temperature and makeup gas flow.

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## Electrometer on/off

The Configure Detector control table contains an Electrometer On/Off setpoint.

On	High voltage and signal processing circuits are on. <b>If the photomultiplier tube is exposed to room light with the electrometer on, the tube will be destroyed.</b>
Off	High voltage and signal processing circuits are off. In this condition, it is safe to expose the photomultiplier tube to room light.

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### Caution

Always turn the electrometer off before removing the PMT housing to avoid destroying the tube.

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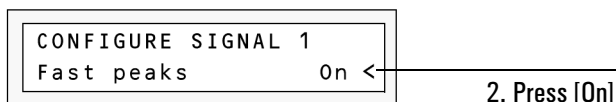
## Electrometer data rates

Analog output for the FPD can be presented at either of two speeds. The faster speed allows minimum peak widths of 0.004 minutes, while the standard speed allows peak widths of 0.01 minutes.

### Procedure: Using fast peaks

If you are using the *fast peaks* feature, your integrator must be fast enough to process the data coming from the GC. It is recommended that your integrator bandwidth be at least 15 Hz. To use fast peaks:

1. Press [Config][Signal 1] or [Config][Signal 2]



The fast peaks feature does not apply to digital output.

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## Operating the FPD

[Table 69](#) gives the flows for the maximum sensitivity FPD flame, which is hydrogen-rich and oxygen-poor. It is difficult to light the flame with these flows, particularly in the sulfur mode. Helium, used as carrier or makeup gas, may cool the detector gases below the ignition temperature. We recommend using nitrogen rather than helium.

**Table 69. Recommended Temperature and Flow**

	<b>Sulfur mode flows mL/min</b>	<b>Phosphorus mode flows mL/min</b>
<b>Carrier</b> (hydrogen, helium, nitrogen, argon)		
Packed columns	10 to 60	10 to 60
Capillary columns	1 to 5	1 to 5
<b>Detector gases</b>		
Hydrogen	50	150
Air	60	110
Carrier + makeup	60	60

### Supply pressure

Air supply pressure: at least 90 psi for the ignition sequence. All others: adequate to achieve desired flows.

### Detector temperature

Below 120°C, flame will not light.

Set temperature about 25°C higher than highest oven temperature—limit is 250°C.

### Lit offset [Config] [Front Det] or [Back Det]

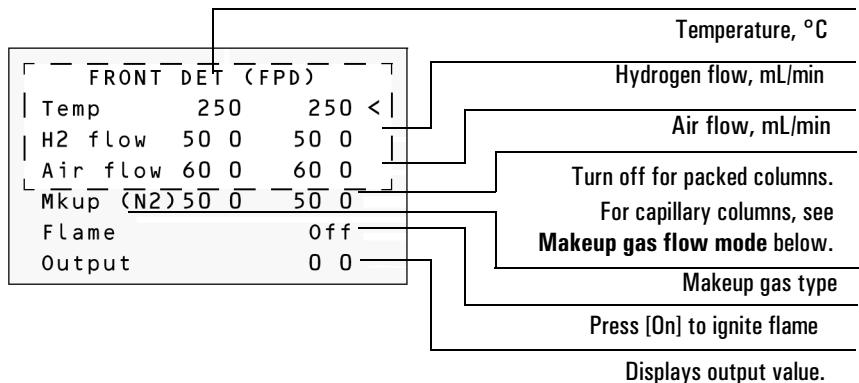
If the detector output (with the flame on) minus the output (with the flame off) falls below this value, the FPD attempts to re-ignite twice. If output does not increase by at least this much, the detector shuts down.

The recommended setting is 2.0 pA. A setting of 0 or [Off] disables autoignition.

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If the flame will not light with the sulfur mode flows shown, change to the phosphorus mode values. After the flame lights, gradually reduce the flows toward the sulfur mode values. Some experimentation will be required to find flows for your particular detector.

Press [Front Det] or [Back Det].



**Makeup gas flow mode:** If column dimensions are specified, the control table will also include one of these sets.

Mode:Const makeup <	Mode:Col+mkup=const
Mkup flow 0.0 Off	Combined flow 0.0
	Makeup flow 0.0

To **change makeup mode**, scroll to Mode: and press [Mode/Type].

Make a selection and enter the appropriate flow values.

```

┌── F DET MAKEUP MODE ──┐
│ *Const makeup flow    │
│ Col+makeup=const <  │
└────────────────────────┘
    
```

To view **makeup gas** or change **Lit offset**, press [Config][Front Det] or [Config][Back Det]:

```

┌── CONFIGURE FRONT DET ─┐
│ Mkup gas type   N2 <  │
│ Lit offset      2 0   │
│ Electrometer    0n   │
└────────────────────────┘
    
```

It is not necessary to turn the electrometer on or off unless you are performing a maintenance procedure.

To change **makeup gas type**, press [Mode/Type]:

```

┌── FRONT DET MAKEUP GAS ─┐
│ Helium           <  │
│ *Nitrogen       ────┘
└────────────────────────┘
    
```

Select the appropriate gas.

**Figure 91. FPD control table**

**Procedure: Using the FPD**

Verify that all detector gases are connected, a column is installed, and the system is free of leaks. Check the oven temperature, inlet temperature, and column flow.

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**WARNING**

Verify that a column is installed or the FPD column fitting is plugged before turning on the air or hydrogen. An explosion may occur if air and hydrogen are allowed to leak into the oven.

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1. Press [Front Det] or [Back Det] to open the FPD control table.
2. Set the detector temperature. The temperature must be greater than 120°C for the flame to light.
3. Change the hydrogen flow rate, if desired, and press [Off].
4. Change the air flow rate, if desired, and press [Off].
5. If you are using **packed columns**, turn off the makeup gas and proceed to Step 7.
6. If you are using **capillary columns**:
  - a. Verify that makeup gas type is the same as that plumbed to your instrument (next to Mkup line of control table). Change the gas type, if necessary.
  - b. If your capillary column is *defined*, choose a new flow mode, if desired, and set the makeup gas flow or combined flow.
  - c. If your capillary column is *not defined*, enter a makeup gas flow. Only constant flow is available.
7. Scroll to **F**lame and press [On]. This turns on the air and hydrogen and initiates the ignition sequence. On ignition, the signal increases. Typical levels are 4 to 40 pA in sulfur mode, 10 to 70 pA in phosphorus mode. Verify that the flame is lit by holding a cold, shiny surface, such as a mirror or chrome-plated wrench, over the vent exit. Steady condensation indicates that the flame is lit.

## Checkout Conditions and Chromatogram

This section contains typical examples of test sample chromatograms. It may be used as a general guide to instrument performance.

Note that injection volumes listed with operating conditions do not necessarily indicate total absolute volume injected. Volume given is simply the graduation (plunger position) read from a standard 10  $\mu\text{L}$  syringe. For a heated inlet, actual sample volume injected will also include an additional 0.4 to 0.7  $\mu\text{L}$ , the volume of sample volatilized from inside the syringe needle. For the dedicated, on-column inlet (unheated), the syringe plunger position more accurately reflects the true injected volume.

Also note that the following procedure and results are intended only to provide evidence of a properly functioning inlet and/or detector system; they are not necessarily suitable to test a given system against its specification limits.

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### FPD checkout conditions

#### Column and sample

Type	HP-5 30m $\times$ 0.32mm $\times$ 0.25 $\mu\text{m}$ PN 19091J-413
Sample	FPD Checkout 8500-3697
Injection volume	1 $\mu\text{L}$

#### Inlet

Temperature	250°C Purged/Packed or Split/Splitless Oven Track Cool On-Column 80°C PTV (see below)
Inlet pressure	25 psi (Constant pressure for EPC inlets, helium)

#### Split/Splitless

Mode	Splitless
Purge flow	60 mL/min
Purge time	0.75 min

**Inlet, continued**

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**PTV**

Mode	Splitless
Inlet temperature	80°C
Initial time	0.1 min
Rate 1	720°C/min
Final temp 1	350°C
Final time 1	2 min
Rate 2	100°C/min
Final temp 2	250°C
Final time 2	0 min
Inlet pressure	25 psi (constant pressure for EPV inlets)
Purge time	0.75 min
Purge flow	60 mL/min

**Detector**

Temperature	200°C
Hydrogen flow	75 ± 2 mL/min
Air flow	100 ± 2 mL/min
Makeup flow	60 ± 2 mL/min, nitrogen
Offset, flow off (O-fa)	Should be < 40 display units
Offset, flame on (O+fb)	< [(O-fa) + 85 display units]

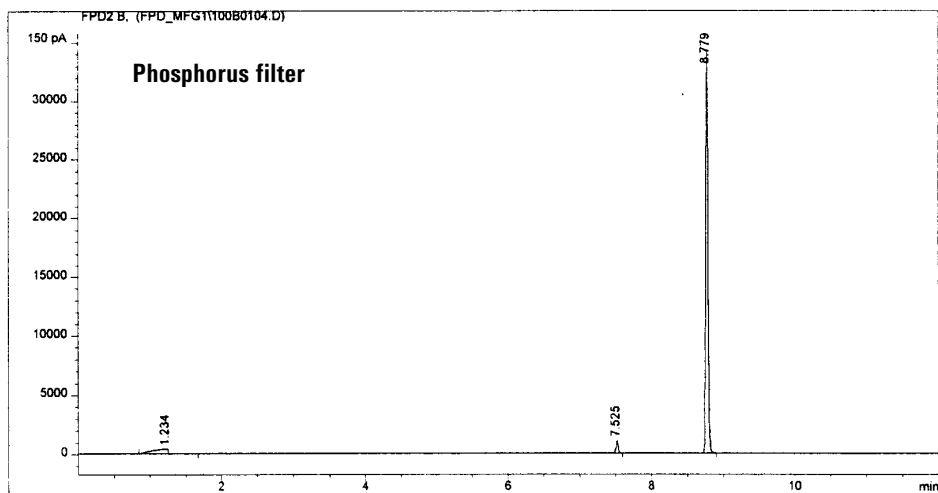
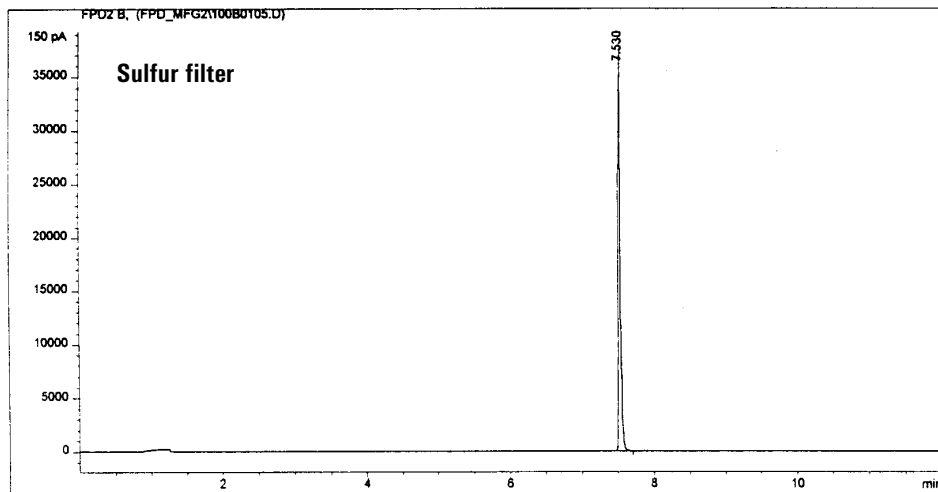
**Oven**

Initial temp	60°C
Initial time	0 min
Rate 1	25°C/min
Final temp	110°C
Final time 0 min	
Rate 2	10°C/min
Final temp 2	170°C
Final temp 1	3 min



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## Typical FPD checkout chromatograms



Your retention times will differ, but peaks should resemble this example.

# Maintaining the Detector

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**Caution** Do not store the FPD at temperatures above 50°C, since this may damage the PMT.

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## Flame ignition problems

If the FPD flame won't light or stay lit, check/do the following:

1. Be sure there is a problem. Ignition is best confirmed by holding a mirror or shiny surface near the aluminum exhaust tube, with the rubber drip tube removed, and observing condensation if the flame is lit.
2. Check `Lit offset`. If it is zero, autoignition is turned off. If it is too large, the GC will not know that the flame is lit and will shut the detector down.
3. Increase the air supply pressure to the pneumatics module. This makes the flame easier to light but does not affect the air flow rate setpoint.
4. If the flame doesn't light at all, check the glow plug circuit. Observe the visual display, which will momentarily go to greater than 65500 counts when the flame lights. If the display doesn't change, check the pin connections at the printed circuit board, the lead connection on the glow plug and the appropriate 5A fuse on the GC main circuit board. If the glow plug has failed, replace it with part no. 0854-0141.
5. The flame is easier to light at higher detector temperatures.
6. Under some operating conditions, the flame may be more easily lit with the rubber drip tube removed. After lighting the flame, reinstall the drip tube.
7. If the flame still won't light, there could be a large leak in the system. This results in measured flow rates being different from actual flow rates, causing non-ideal ignition conditions. Thoroughly leak check the whole system.
8. If the analysis permits, substitute nitrogen for helium as carrier and makeup.
9. Increase hydrogen and air flow rates until ignition occurs, then reduce them toward the [Table 69](#) values. Experiment for the best values.

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## Changing wavelength filters

Install the correct optical filter, depending on the choice of Sulfur or Phosphorus mode. For Sulfur Mode, use the 393 nanometer filter (part no. 19256-80000). For Phosphorus Mode, use the 525 nanometer filter (part no. 19256-80010).

To change the filter:

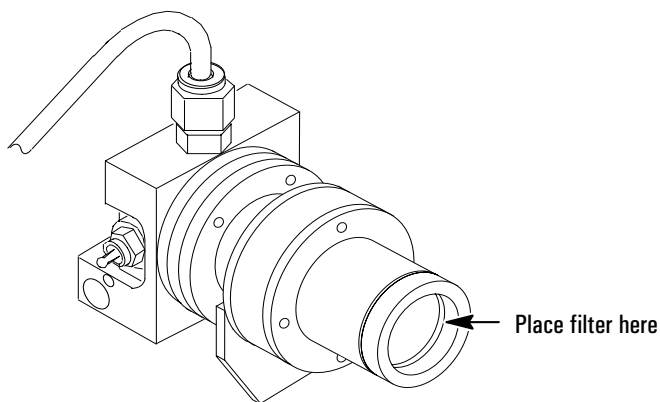
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### WARNING

Turn the main power switch—located under the left side of the oven door—off. If the photomultiplier tube is exposed to room light with the power on, it will be destroyed.

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1. Release the retaining spring around the photomultiplier housing.
2. Pull the photomultiplier housing off the detector body. A twisting motion helps.
3. Remove the old filter. Use tissue to avoid fingerprints.
4. Place the new filter in the recess so that the silvered side faces the flame.



5. Push the PMT housing as far onto the detector body as it will go.
6. Install the retaining spring around the housing.
7. Restore power.

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## Leak testing

Turn off all supply gases. Cap the detector exhaust tube with a 1/4-inch Swagelok plug (part no. 0100-0196) and a 40% graphitized Vespel ferrule (part no. 0100-1061).

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### Caution

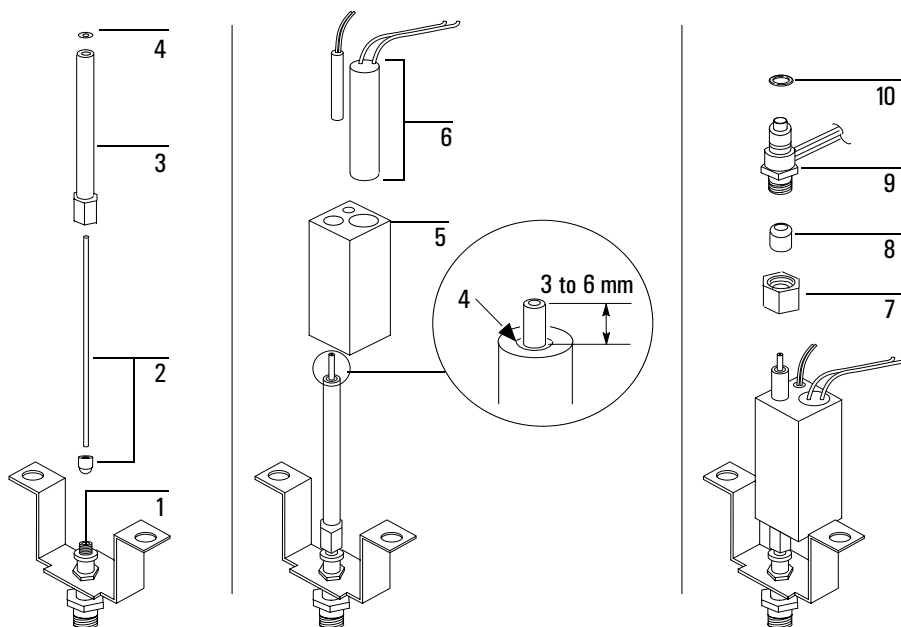
When testing the flow system under pressure, do not exceed 210 kPa (30 psig). Higher pressures may damage the detector block window or seals.

Turn one of the gases on for a few seconds and then turn it off. The indicated flow—which is really a pressure—should remain constant or drop slowly. If not, there is a leak in the system. Begin checking possible leak sources and monitor the flow number to determine when the leak has been eliminated.

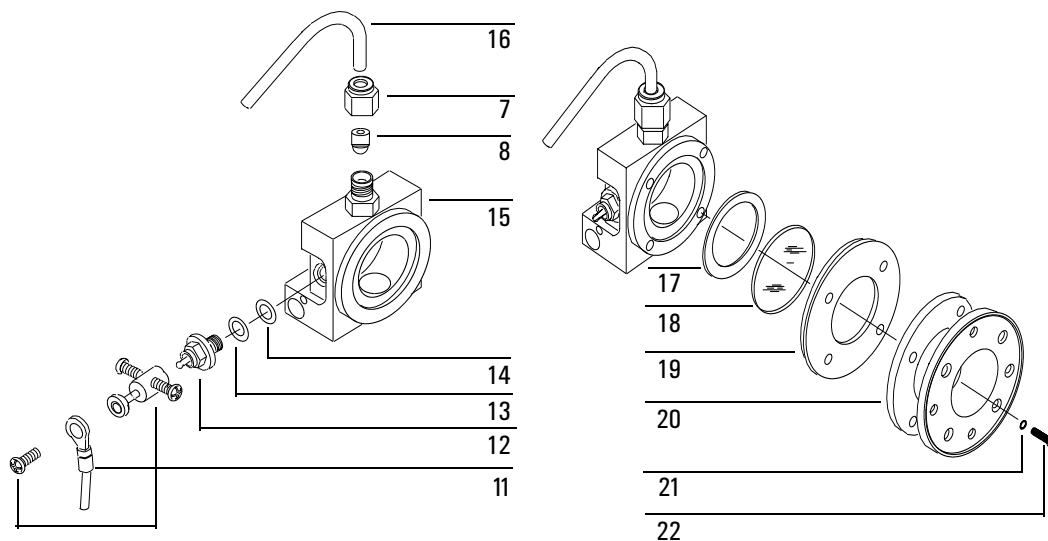
Possible leak sources, in order of decreasing probability, are:

1. Septum
2. Column fittings
3. Supply line swage-type plumbing connections
4. Detector block O-ring or Vespel seals
5. Other system plumbing

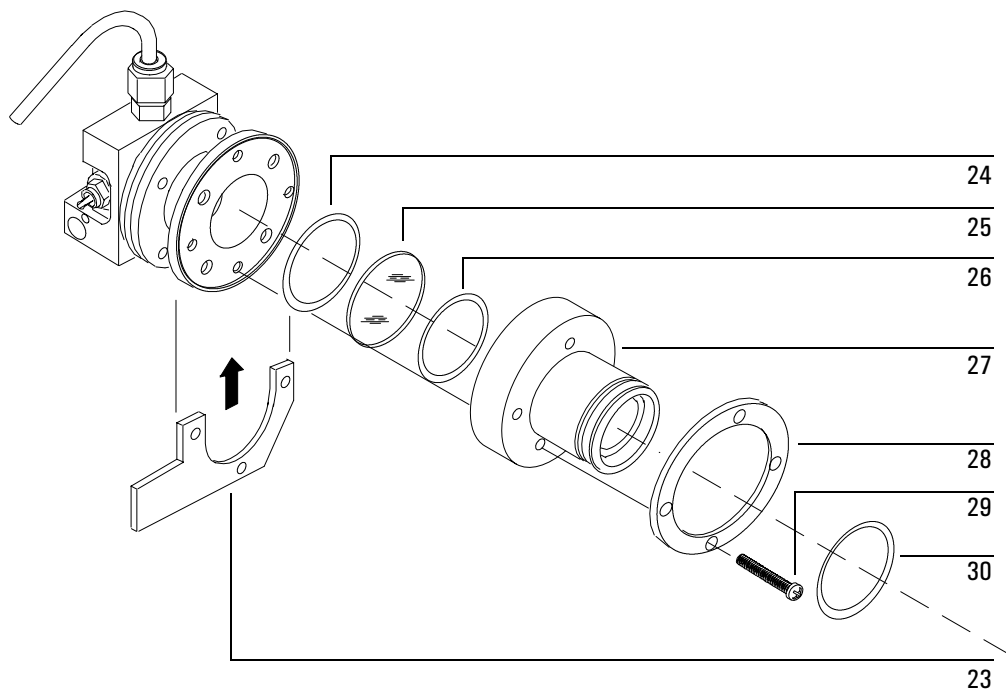
## Parts identification



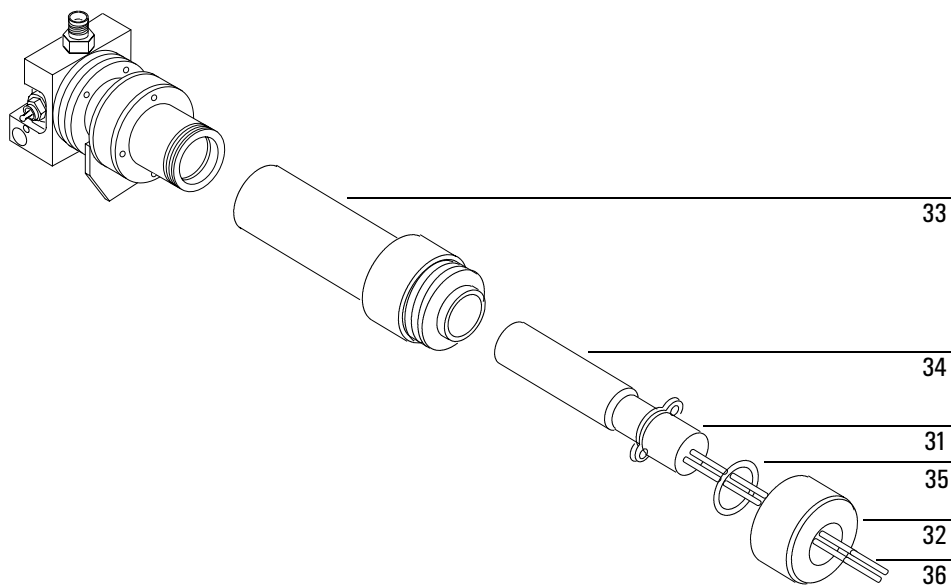
Item	Description	Part no.
1	Base assembly weldment	
2	Gigabore liner/ferrule assembly	19256-60590
3	Transfer tube	19256-80550
4	O-ring, Kalrez, transfer tube	0905-1101
5	Lower heater block	
6	Heater/sensor assembly	
7	Nut, brass, 1/4-inch	0100-0056
8	Ferrule, Vespel, 1/4-inch ID	5080-8774
9	Jet cartridge	G1535-80500
10	O-ring, Kalrez, jet cartridge	0905-1103



Item	Description	Part no.
7	Nut, brass, 1/4-inch	0100-0056
8	Ferrule, Vespel, 1/4-inch ID	5080-8774
11	Ignitor cable assembly	G1535-60600
12	Glow plug	0854-0141
13	Spacer, ignitor	19256-20590
14	O-ring, Kalrez, ignitor	0905-1102
15	Weldment, block	
16	Exit tube assembly, aluminum	19256-20700
	Exit tube assembly, stainless steel	19256-20705
17	Gasket, head shield	19256-80040
18	Window, first heat shield	19256-80030
19	Disk, heat shield	19256-20580
20	Coupling, stainless steel	19256-20550
21	Lockwasher (4 required)	2190-0108
22	Screw, M3 x 12 (4 required)	0515-0911



Item	Description	Part no.
23	Clamp	19256-00090
24	O-ring, silicone, 0.926-inch ID (orange)	0905-0955
25	Window, second heat shield	19256-80060
26	O-ring, silicone, 1.05-inch ID (orange)	0905-1104
27	Flange adapter	
28	Flange ring	19256-00200
29	Screw, M3 x 25 (4 required)	0515-0065
30	O-ring, Viton, 1.239-inch ID (brown)	0905-1100
Filters (not shown)		
	Sulfur mode	19256-80000
	Phosphorus mode	19256-80010



Item	Description	Part no.
31	Tube socket	19256-20670
32	End cap	19256-20710
33	PMT tube housing	19256-20650
34	Replacement photomultiplier tubes	
	PM tube ONLY	G1535-80050
	PM tube and housing assembly	19256-60510
35	O-ring for PM tube	0905-1099
36	Resistor network cable assembly	19256-60580



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## Cleaning/replacing windows, filters, and seals

Column bleed and/or effluent can contaminate the first quartz window (heat shield) nearest the detector module. Dust, fingerprints, atmospheric contaminants can dirty both quartz windows, the filter, and/or the photomultiplier tube window. Contamination anywhere along the light path between flame and PMT can reduce detector sensitivity.

1. Turn the electrometer off.
2. Turn hydrogen, air, and auxiliary gas supplies to the detector off. Turn the heaters off. Wait for the detector to cool.
3. Release the retaining spring around the photomultiplier housing.

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**Caution** Always turn the electrometer off before removing the PMT housing to avoid destroying the tube.

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**Caution** Keep the open end of the PMT housing covered as much as possible to avoid light damage to the tube.

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4. Pull the PMT housing off the detector and remove the filter. Use lint-free lens tissue to clean the filter on both sides. Clean the PMT window seen inside the housing. Avoid scratching surfaces; do not use a cleaning fluid that might leave a film upon drying.
5. Inspect the filter: chips, scratches, and/or cracks in the light path scatter light, reducing detector sensitivity. Replace filters as necessary.

Inspect the PMT window for damage; if necessary, replace the PMT.

- a. Remove the four screws in the PMT adapter flange and remove the flange. Use care as a quartz window is exposed and may fall out. Clean the window using lens tissue.
- b. Remove the four screws in the stainless steel coupling and carefully remove the coupling. The remaining quartz window may fall out. Clean the window using lens tissue.

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**Caution**

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This window—the one closest to the flame—may stick when the detector is cold. It is easier to remove when the detector is warm, but be careful to avoid burns.

6. Note the placement and types of seals found on the disassembled parts. Seals should be replaced with new parts on reassembly.
7. Inspect the windows: chips, scratches, cracks or fogging in the light path scatter light, reducing sensitivity. Replace windows if necessary.
8. Reassemble the parts in reverse order, making sure all seals are of the proper type and in their proper locations. Tighten screws evenly and firmly to ensure gas- and light-tight seals. If the filter has a silvered side, it should face the flame (indicator arrows > on edge of filter should point toward the PMT).

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## Cleaning/replacing the jet

If a response problem is encountered (sensitivity, noise, selectivity) the FPD jet should be inspected for deposits and, if necessary, cleaned or replaced. To properly service the jet, the detector module should be removed from the instrument, followed by appropriate service:

1. Turn off power to the gas chromatograph and disconnect the main power cord. Remove the detector covers.
2. Allow time for the heated zones to cool to safe temperatures.

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**Caution** Always turn the electrometer or the main power off before removing the PMT housing to avoid destroying the tube.

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**Caution** Keep the open end of the PMT housing covered as much as possible to avoid light damage to the tube.

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3. Remove the photomultiplier tube assembly from the detector module; also remove the filter. Set both in a safe place.
4. Remove the exhaust tubing.
5. Remove the sheet metal cover. On the single wavelength detector, it is held by two screws at the top and two at the bottom; on the dual wavelength detector it is held by two screws at the top. Loosen the screws holding the detector to the U-clamp. Use two wrenches to loosen the swage connection at the bottom of the jet assembly from the transfer line tube and carefully lift the burner module from the transfer tube so as not to damage the fused silica liner.

It is not necessary to disconnect any plumbing, ignitor leads or the heater/sensor. Leave all attached and disconnect the detector block from the transfer line at the 1/4-inch swage fitting, then gently lift the block and rotate it enough to access the jet.

6. Remove and inspect the jet assembly. Rotating it slightly helps to free it. The jet assembly slips out of the FPD block more easily if the block is still warm. Use a wire or brush to remove any deposits.
7. This is also an ideal time to inspect/clean the glow plug ([see “Flame ignition problems” on page 642](#)), and inspect/clean the quartz windows (see [”Cleaning/replacing windows, filters, and seals”](#)).
8. Use compressed air or nitrogen to blow out loose particles from the jet and/or detector module body.
9. Inspect and clean deposits from the jet bore using a suitable wire. If the jet is damaged in any way, replace it. It is good practice to replace the jet, rather than try to clean it, particularly when extremely high sensitivity is required.
10. Install a new Kalrez O-ring seal onto the jet. Do not re-use the old O-ring.

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**Caution**

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Be careful not to crush or side-load the fused silica liner when reinstalling the detector.

11. Reassemble all parts of the detector module; reassemble the module onto the instrument. Use a new Vespel ferrule to seal the detector module to the transfer line.
12. Reinstall the PMT assembly on the detector module; restore instrument gases and power.

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## Replacing the transfer line fused silica liner

Occasionally the transfer line fused silica liner between the column and FPD module must be inspected, cleaned, and/or replaced.

1. Turn off power to the gas chromatograph and disconnect the main power cord. Remove the detector covers.
2. Allow time for heated zones to cool to safe temperatures.
3. Inside the oven, remove the column to the FPD.

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**Caution** Always turn the electrometer or the main power off before removing the PMT housing to avoid destroying the tube.

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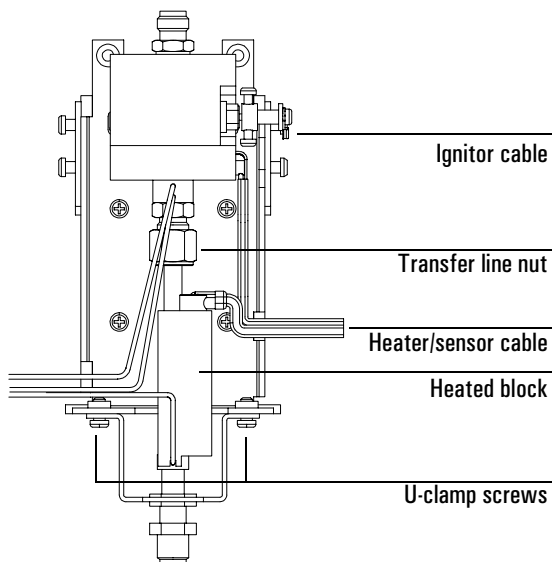
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**Caution** In the next step, keep the open end of the PMT housing covered as much as possible to avoid light damage to the tube.

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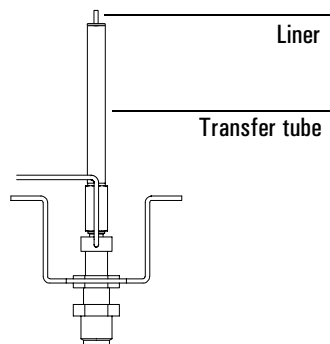
4. Remove the photomultiplier tube assembly—or assemblies—from the detector module; also remove the filter(s). Set them in a safe place.

5. Locate the ignitor cable attached to the side of the detector. Trace the cable back to the printed circuit board and disconnect it there.



6. Remove the exhaust tubing and the sheet metal cover—on the single wavelength detector, it is held by two screws on the top and two at the bottom; on the dual wavelength detector, it is held by two screws at the top.
7. Remove the four screws that attach the detector to the top of the oven (one at each corner). Remove the detector from the GC.
8. Loosen the transfer line nut. Remove the two screws that secure the U-clamp to the detector frame. Remove the U-clamp and the attached parts from the bottom of the detector.

9. Remove the transfer line nut and its ferrule, the heater/sensor cable assembly, and the heated block.



10. With an open end wrench, unscrew the transfer tube from the detector base. Lift the transfer tube—containing the fused silica liner—vertically off the instrument. Remove the fused silica liner and the 1/16-inch Vespel ferrule by pulling the liner and ferrule out from the bottom. Inspect for damage.
11. If necessary, install a new fused silica liner and Vespel ferrule. When doing so, carefully feed the fused silica liner through the Kalrez O-ring at the top of the transfer line so as not to damage the O-ring.
12. Carefully replace the fused silica liner, ferrule and tube onto the detector base. The fused silica liner should be positioned so that it protrudes 6 to 7 mm (1/4-inch) above the top of the transfer tube weldment. With a wrench, firmly tighten the transfer tube (1/2-turn past finger tight).
13. Reinstall the heated block, the heater/sensor cable assembly, the nut, and the ferrule. The notch in the bottom of the block fits over the tubing coming from the detector fitting.
14. Tighten the U-clamp screws, then tighten the nut on the transfer tube.
15. Place the detector on top of the instrument, orient it properly, and install the four screws to hold it. Install the top cover and the exhaust tubing.
16. Connect the ignitor cable to the printed circuit board.
17. Install the PMT assembly (or assemblies).
18. Restore normal operating conditions.

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## Replacing the photomultiplier tube

If the PMT is defective (high voltage on and the flame lit: low or no signal and/or high noise not attributed to any other source such as bad cables, light leaks, high temperature, defective signal board, etc.), it must be replaced.

1. Turn off power to the gas chromatograph and disconnect the main power cord.

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**Caution**

Turn the electrometer or main power off before opening the PMT housing to avoid destroying the tube.

2. Free the cables to the PMT from the clip on the support. Pull a few inches of the cables through the cable tie toward the end cap. Unscrew the end cap from the PMT assembly. Slide the cap away from the assembly.
3. Slide the resistor network cable assembly and the photomultiplier tube and socket out of the housing until about 1 inch of the tube is exposed.

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**Caution**

Protect the new PMT from light as much as possible to avoid damage to the tube.

4. Pull the socket off the PMT. Remove the PMT and replace with a new tube.
5. When seating the socket on the new tube, be certain that the missing pin on the tube base is lined up with the gap in the socket contacts.
6. Reassemble in reverse order. Make sure grease, fingerprints, dust, etc. are removed from the PMT window facing the detector module. Be sure that the O-ring is in place on the PMT/resistor bridge network assembly, as this is a critical light seal. If the O-ring is damaged, replace it.
7. Screw the end cap onto the PMT assembly. Pull the cables through the cable tie to eliminate slack at the end of the assembly. Place the cables in the clip on the side of the PMT housing support.