# Procedure for aligning the spectrometer mirror and shutter mask inside a Mk IV Brewer spectrophotometer

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**Introduction**
The Mk IV Brewer spectrophotometer is equipped with a movable shutter which allows wavelength selection at the spectrometer exit slits determined by the shutter position and the angle of the diffraction grating which is moved via an automated micrometer. There are eight shutter positions, five of which correspond to the ozone calculating wavelengths 306.2, 310.0, 313.5, 316.8 and 320.0 nm. There are also shutter positions for mercury (Hg) counts, dark counts and dead-time tests.

During a UV scan the instrument rotates the diffraction grating via the micrometer assembly while the shutter is set to position 2, slit 1 (306.2 nm) for the spectral region 286.5nm to 325nm. Position 6, slit 5 (320.0 nm) is used for the spectral region 325.5nm to 363nm and the micrometer is reset to near the original start position to begin the second half of the scan. During ozone scans the instrument rapidly cycles the shutter across positions 2 through 6 which correspond to the ozone calculating wavelengths.

The Run Stop (RS) test monitors the operation of the shutter position and the alignment of the mirror by taking measurements while the shutter is still and again while it is in motion using the instrument's internal lamp as a source. The "run" results are compared to the "stop" results for each slit. The ratios for positions 0 and 2 through 6 should fall in the range 1.0003 to 0.997 as stated in the Brewer's Acceptance manual.

Drifts in the RS values may indicate an alignment of the spectrometer mirror and shutter mask are needed. The NUVMC monitors the performance of the various Brewer diagnostics and performs a shutter and mirror alignment if RS values have fallen outside of tolerance range. The spectral sensitivity of the Brewer may be affected due to changes in the optical properties of the instrument. Therefore, initial and final response calibrations are always performed when making adjustments to an instrument's optics.

**Equipment**
Mk IV Brewer spectrophotometer
Hex wrench set (English sizes)
Small flashlight or head lamp

**Purpose**
This Standard Operating Procedure (SOP) outlines the NUVMC technique for checking and aligning the mirror and shutter mask in a Mk IV Brewer spectrophotometer.

**Procedure**
1. Perform an initial spectral response calibration on the instrument before adjusting the spectrometer shutter or mirror. The NUVMC has an SOP for performing a calibration.

2. If the Brewer is still running in schedule exit the schedule by pressing the Home key when the message "Press Home to abort schedule" appears on the computer screen.

3. Make sure the Brewer is in the ozone (O3) mode by giving the command "O3" at the Home screen command line.

4. Give the "PNHG" command at the Brewer Home screen command line and observe if the scan is successful. A successful scan is one at which the peak HG counts are found at step number 15 as appearing on the computer monitor. If the scan fails an error message will be printed to paper.

5. Run a series of diagnostic tests by giving the command sequence "PNFRSLRSDT" at the Home screen command line. The results from these tests will be used to monitor the effects of any adjustments that may be made to the instrument by performing an alignment. The tests in this sequence are Filter wheel Reset (FR-measures micrometer zero position), Standard Lamp (SL), Run/Stop (RS), and Dead-Time (DT) test. Information on each of these is available in the Brewer Operator's Manual for each instrument. The above diagnostic results can be conveniently viewed if they are printed to paper via the PN command, otherwise the results can be found in the data files.

6. Give the command "TT" at the Home screen command line to access the instrument's low level command environment (teletype mode). Press the "Enter" key several times until a prompt symbol appears on the computer screen. The TT commands are used to control the filter wheels (FW), zenith prism, iris, internal lamp and shutter mask. A comprehensive list of the commands can be found in Table 1.

7. Give the command "M,1,0" at the TT prompt to configure the Brewer so that the zenith prism is facing the internal lamps (zero position).

8. Give the command "M,4,128" at the TT prompt to configure the Brewer so that FW1 is at position 3.

9. Give the command "M,5,0" at the TT prompt to configure the Brewer so that FW 2 is at position 0.

10. Give the command "M,3,75" at the TT prompt to configure the Brewer so that and the iris is open.

11. Place a protective cover on the quartz dome on the top of the Brewer outer cover.

12. Remove the Brewer outer cover by loosening the four latches and lifting the cover up. Never remove the cover during inclement weather and try to pick the driest, wind free day possible. The NUVMC moves Brewers indoors for this work whenever possible.

13. Remove the black spectrometer cover by loosening the two latches. **DO NOT TOUCH THE MIRROR OR DIFFRACTION GRATING WITH FINGERS OR ANY OTHER OBJECT. DO NOT ATTEMPT TO CLEAN THE MIRROR OR DIFFRACTION GRATING IF ACCIDENTALLY TOUCHED AS THIS WILL CAUSE ADDITIONAL HARM TO THE OPTICAL SURFACES.**

14. Locate the shutter, shutter motor and mount and the exit slits of the spectrometer. Gently wiggle the motor to check that it is tightly connected to its mount. If it feels loose then the screws that fasten it should be tightened down. Also check that the shutter is firmly connected to the motor and that there is some resistance to turning the shutter from position to position when the Brewer AC power is on.

15. Working in a darkened room, use a flashlight to illuminate the exit slits and shutter mask inside the spectrometer. When viewing the position of the shutter mask it is important to level your eyes as close to possible with the horizontal plane to avoid parallax error.

16. Cycle the shutter from position 0 to position 7 using the TT commands "M,11,0" and "M,11,14" to observe if the shutter mask holes are aligned with the spectrometer exit slits. Shutter position 0 has one slot while shutter position 7 has two slots. The slots in the shutter are a bit larger than the exit slits. Ideally the slot in the shutter should symmetrically frame

the exit slit. The key to this step is to avoid the parallax error associated with the lining up of the shutter mask and exit slit due to the small lateral distance that separates the two.

17. If it is observed that the shutter slits do not symmetrically frame the exit slits then an adjustment of the shutter assembly is necessary. To move the shutter up or down in the same orientation as the slits, loosen the 7/64" hex head bolt that secures the aluminum brace that the shutter stepper motor is mounted to. The brace can then be slightly adjusted to the correct position so that the shutter slits frame the exit slits. Firmly retighten the hex bolt once the correct adjustment has been made.

18. If the shutter needs an adjustment to one side or another relative to the exit slits loosen the two 0.050" hex head set-screws that secure the shutter to the stepper motor drive axel. Make the necessary adjustment to the shutter and firmly retighten the two set-screws.

19. Recheck the alignment of the shutter mask to the slits. Verify that all set-screws have been firmly retightened once the shutter is moved into the proper position.

20. Cycle the shutter from position 0 to position 7 again using the TT commands "M,11,0" and "M,11,14" to observe if the shutter mask holes are now properly aligned with the spectrometer exit slits.

21. Once the adjustment is properly made, press the "Home" key to exit teletype mode.

22. Next, check the alignment of the spectrometer mirror. The instrument's foreoptics should still be set as in steps 7 through 10.

23. Turn on the internal lamp by giving the command "B2" at the Home screen command line.

24. A rectangular spectrum of blue light from the internal lamp will appear inside the spectrometer, incident on the shutter. When the mirror is adjusted properly the spectrum should be incident horizontally across the shutter so that the exit slits are symmetrically illuminated.

25. Cycle the shutter through its various positions using the commands in Table 1 and observe the illumination on the slits. Ideally the spectrum should fall in the middle of both the shutter and exit slits. Also observe any slanting of the spectrum across the shutter, as this is an indication that the shutter is crooked.

26. If the exit slits are not properly illuminated by the spectrum, then an adjustment to the mirror should be made. Loosen the 7/64" hex head set-screw located on top of the mirror mount which locks the mirror thumb screw. Now the thumb screw which controls the angle of the mirror is free to rotate. If the lamp spectra needs to be shifted up on the shutter mask, rotate the thumb screw in the CCW direction if looking from the back of the mirror.

27. After adjusting the mirror to the proper position firmly retighten the 7/64" hex head set-screw.

28. Replace the spectrometer cover and secure both latches.

29. Replace the Brewer outer cover and secure the four latches, ensuring that the outer cover is mounted evenly all the way around the Brewer case. Remove the quartz dome protector.

30. Run another series of diagnostic tests by giving the command sequence "PNHGFRSLRSDT" at the Home screen command line. Compare the new RS values to the values recorded before the adjustment was made.

31. The RS ratios should be in the range 1.003 to 0.997 for positions 0 and 2 through 7. If the RS values are within tolerance levels, the adjustments have been successful; proceed to step 32. Otherwise go back to step 6 to recheck the shutter alignment and mirror alignment.

32. Compare the pre and post adjustment FR results and note any change to the measured micrometer zero position. Any discrepancy in this number may indicate that an adjustment to the constant value in the ICF may be required. Also a sun scan (SC) test may need to be performed in order to determine if the wavelength calibration step number is optimized for the ozone scans. More information concerning the SC test can be found in the Operator's Manual for each instrument.

33. Compare the pre and post adjustment SL results and note any change in the R5 and R6 values. Any change in these numbers will require changes to be made to the ETC constants to produce accurate ozone calculations. A new ozone calibration is preferred.

34. Compare the pre and post adjustment dead-time results and note any changes. In general, changes made to the dead-time constant in the ICF file should be carefully considered and the method for determining an adjustment is subtle. If a change is made to the dead-time constant, careful inspection of data should ensue to determine if the change adversely affected the instrument's counting rate. If the high and low dead-time standard deviations do not fall within the tolerance values given in the acceptance manual, then it may indicate that the shutter is not aligned properly.

35. Once both shutter and mirror are determined to be in proper alignment a new spectral response calibration should be performed on the instrument. The NUVMC has a written procedure for performing calibrations.

36. An ozone adjustment or calibration is required as well but the NUVMC does not perform these as the contract with the EPA Brewer network is for UV measurements only.

**Table 1: Brewer Motor Positions and Control Commands**

| Motor # and Name | Step # | Position | Command String |
|---|---|---|---|
| 1:Zenith Prism | 0 | Pointing at standard lamp | M,1,0 |
| | 1408 | Pointing at zenith sky | M,1,1408 |
| | 2112 | Pointing at UVB port | M,1,2112 |
| | | | |
| 3:Iris | 0 | Iris fully closed | M,3,0 |
| | 75 or 250 | Iris fully open | M,3,75 or M,3,250 |
| | | | |
| 4:Filterwheel #1 | 320 | 0:film polarizer (horizontal) | M,4,320 |
| | 256 | 1:quartz diffuser (translucent) | M,4,256 |
| | 192 | 2:blocked aperture (opaque) | M,4,192 |
| | 128 | 3:clear aperture | M,4,128 |
| | 64 | 4:quartz diffuser; ND of f=2.0 (translucent) | M,4,64 |
| | 0 | 5:film polarizer (vertical) | M,4,0 |

| | | | |
|---|---|---|---|
| 5:Filterwheel #2 | 0 | 0:f=0 | M,5,0 |
| | 64 | 1:f=0.5 | M,5,64 |
| | 128 | 2:f=1.0 | M,5,128 |
| | 192 | 3:f=1.5 | M,5,192 |
| | 256 | 4:f=2.0 | M,5,256 |
| | 320 | 5:f=2.5 | M,5,320 |
| | | | |
| 11:Slit Mask | 0 | 0:slit 0 (Hg; 303.2-426.4 nm) | M,11,0 |
| | 2 | 1:dark count | M,11,2 |
| | 4 | 2:slit 1 (306.3-431.4 nm) | M,11,4 |
| | 6 | 3:slit 2 (310.1-437.3 nm) | M,11,6 |
| | 8 | 4:slit 3 (313.5-442.8 nm) | M,11,8 |
| | 10 | 5:slit 4 (316.8- 448.1 nm) | M,11,10 |
| | 12 | 6:slit 5 (320.1-453.2) | M,11,12 |
| | 14 | 7:dead time | M,11,14 |

**For further information or advice concerning this SOP please contact the NUVMC at the University of Georgia at http://oz.physast.uga.edu**