

**DANISH METEOROLOGICAL INSTITUTE**

————— **TECHNICAL REPORT** —————

**00-7**

**Calibration of Ozone Spectrophotometers  
operating in  
Qaanaaq (Dobson #092),  
Kangerlussuaq (Brewer #053)  
and Copenhagen (Brewer #082)**

**Paul Eriksen**



**COPENHAGEN 2000**

**Calibration of Ozone Spectrophotometers  
Operating in  
Qaanaaq (Dobson #092),  
Kangerlussuaq (Brewer #053)  
and Copenhagen (Brewer #082).**

Technical Report 00-7

Author: Paul Eriksen, Middle Atmosphere Research Division

ISSN: 0906-897x

ISSN: 1399-1388 (Online)

© Danish Meteorological Institute

Danish Meteorological Institute  
Lyngbyvej 100  
DK-2100 Copenhagen  
Denmark

Phone: +45 39 15 75 00

Fax: +45 39 27 10 80

[www.dmi.dk](http://www.dmi.dk)

## Foreword.

The Danish Meteorological Institute (DMI) operates several instruments to measure the total ozone column. Three instruments are in operation on the west coast of Greenland (table 1 and figure 1) and one instrument is operated in Copenhagen. A Brewer Mk.II instrument is operated in Kangerlussuaq (Søndre Strømfjord), instrument #053, a zenith sky UV-Visible instrument (SAOZ) is operated in Pituffik (Thule Air Base) and a Dobson instrument – instrument # 092 – is operated in Qaanaaq (Thule), slightly north of Pituffik. In Copenhagen a Brewer Mk.IV is in operation.

Station name	WMO #	lat.	long.	instrument
Qaanaaq (Thule)	140*	77.5 N	69.2 W	Dobson #092
Pituffik (Thule Air Base)	140	76.5 N	68.8 W	SAOZ UV-Visible
Kangerlussuaq (Søndre Strømfjord)	267	67.0 N	50.6 W	Brewer #053 (Mk.II)
Copenhagen	309	55.7 N	12.6 E	Brewer #082 (Mk.IV)

**Table 1.** Station name, latitude, longitude and WMO station number for the DMI instruments.

\* Qaanaaq does not have a WMO identification number - we use that of Pituffik.

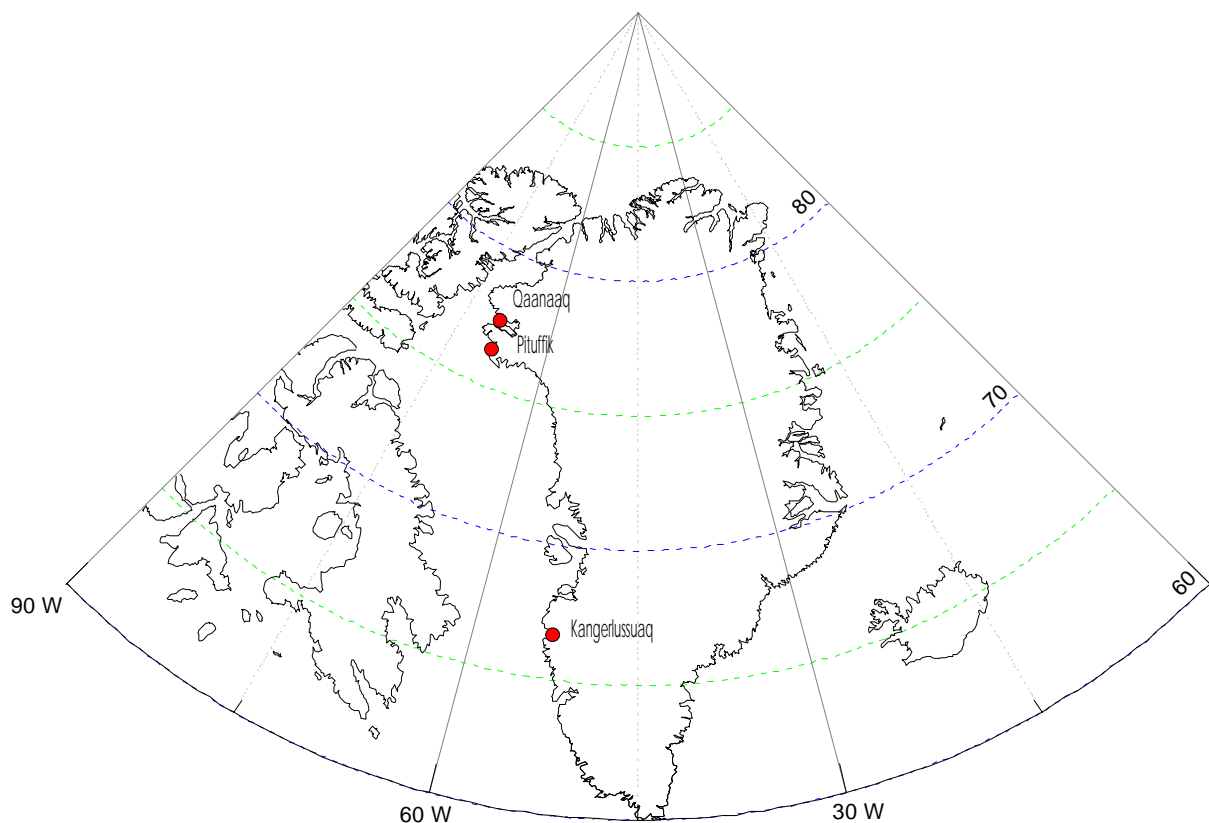


Figure 1. Location of the three Ozone Spectrophotometers in Greenland (see also table 1) operated by the DMI.

## History.

Dobson instrument #092 was operated for many years in Aarhus (1964-1987) but was moved to Kangerlussuaq in 1988 in response to renewed interest in the state of the ozone layer. It was operated intermittently in Kangerlussuaq until 1995 when it was moved to Copenhagen after participation in the Dobson intercomparison in Arosa. In 1999 it was decided to move the instrument to Qaanaaq/Thule to supplement the SAOZ in the spring, summer and autumn season. Regular observations in Qaanaaq/Thule were started in March 2000.

Brewer #053 and the DMI SAOZ-instrument were installed in Greenland in the autumn of 1990, and regular observations were begun immediately afterwards. Both instruments were acquired with funds made available from the Danish Environmental Protection Agency. The SAOZ instrument is a so-called UV-Visible instrument (or DOAS, Differential Optical Absorption Spectroscopy) designed to measure scattered zenith sky light at sunrise and sunset. It measures both the column ozone and the column NO<sub>2</sub>. The Brewer instrument family (Mk.II, III, IV) are operating much the same way as Dobson instruments, i.e., primarily by observations of the direct sunlight. The SAOZ instrument was therefore placed farthest north, at Pituffik (Thule Air Base), and the Brewer #053 placed at Kangerlussuaq, because they would then be able to commence operations simultaneously, by about mid February, when winter-spring ozone depletion could take place. Since the SAOZ instrument works by observing the scattered zenith light it does not provide reliable measurements during the polar summer when the sun is above the horizon all day long – in Pituffik from about May 1<sup>st</sup> to August 15<sup>th</sup>. This fact was one reason for moving Dobson #092 to Qaanaaq.

Brewer #082 was purchased and set up in Copenhagen in May 1992 in response to demands for ozone and UV measurement services in Denmark. This instrument was a main brick in the public UV service that the DMI began on June 1<sup>st</sup> 1992. It has been in operation in Copenhagen since then.

## Calibration of Brewer and Dobson instruments 1999.

The DMI's instruments for total ozone column measurements were calibrated by International Ozone Services (IOS) during the period from July 26<sup>th</sup> to August 1<sup>st</sup>. The instruments were: Brewer #082 (Copenhagen), Brewer #053 (Kangerlussuaq) and Dobson #092 and IOS's travelling Brewer #017. The calibration was carried out in Kangerlussuaq by Ken Lamb (IOS), Paul Eriksen (DMI) and Eggert Gudmundsson (DMI). The weather was nearly perfect with very few clouds. After the calibration Dobson #092 was sent to Qaanaaq, and set up there in September.

Brewer #082 and Brewer #053 were last calibrated during the NOGIC-96 campaign at Izaña, Tenerife, in October 1996. On that occasion a minor modification in Brewer #082's ETC constants was implemented while no calibration changes were made for Brewer #053. Dobson #092 was last calibrated in the summer of 1995 during the WMO Dobson Intercomparison in Arosa. An overview of the instrument calibrations is shown in the tables below.

<b>Brewer #053 (Kangerlussuaq - SFJ)</b>		
<b>Year-month</b>	<b>calibration</b>	<b>comments</b>
1990-01	received – calibrated at factory	Instrument set up in Kangerlussuaq in September 1990.
1994-08	calibrated in SFJ by IOS	General maintenance only – no changes to instrument constants.
1996-03	calibrated at factory after repair.	Instrument damaged in storm, December 1995. Considerable repair necessary. Operational again in May 1996.
1996-10	calibrated during NOGIC-96 at Izaña.	General maintenance only – no changes of instrument constants.
1999-07	calibrated in SFJ by IOS	Slight change to SO <sub>2</sub> ETC which, however, will have only marginal influence on O <sub>3</sub> measurements.

**Table 2.** Calibration history of Brewer #053.

<b>Brewer #082 (Copenhagen - CPH)</b>		
<b>Year-month</b>	<b>calibration</b>	<b>comments</b>
1992-05	received – calibrated at factory	Instrument set up in Copenhagen in May 1990 in connection with start-up of UV-Index service.
1993-11	calibrated during NOGIC-93 at Izaña.	Changes to instrument constants ETC O <sub>3</sub> /SO <sub>2</sub> . Earlier #082 O <sub>3</sub> -measurements were approx. 2% too high.
1995-09	calibrated at factory in Saskatoon after repair	Instrument repaired due to problems with detector/preamp. New instrument constants from factory calibration.
1996-10	calibrated during NOGIC-96 at Izaña.	Slight changes to ETC constants – with only marginal influence to O <sub>3</sub> -measurements.
1999-07	calibrated in SFJ by IOS	Changes to instrument constants due to change in R6/R5 from std. lamp. Periodic problem with filter 1 measurements (step in O <sub>3</sub> ) not solved. DT problem. To be solved later during post-calibration in CPH.

**Table 3.** Calibration history of Brewer #082.

<b>Dobson #092 (Kangerlussuaq, Copenhagen, Qaanaaq)</b>		
<b>Year-month</b>	<b>calibration</b>	<b>comments</b>
1986-08	calibrated at WMO intercomparison in Arosa	Small changes to N-tables and Q-tables Instrument sent to Kangerlussuaq in 1998
1990-08	calibrated at WMO intercomparison in Arosa	Thorough tests. Wedge calibration. New N-tables/Q-tables. Instrument condition is fine.
1995-08	calibrated at WMO intercomparison in Arosa	No changes. Instrument condition is fine.
1999-07	calibrated in SFJ by IOS	No changes. Calibrated against Brewer #017 and compared also to Brewers #053 and #082

**Table 4.** Calibration history of Brewer #082.

## **Adjustments made during and after calibration.**

### **Adjustments made to Brewer #053.**

See the individual calibration report below. In summary the following adjustments were made: 1) New Hg lamp (old type design), 2) O3-ETC up by 10 units as per Std. lamp R6/R5. 3) New software ver. 3.75a.

### **Adjustments made to Brewer #082.**

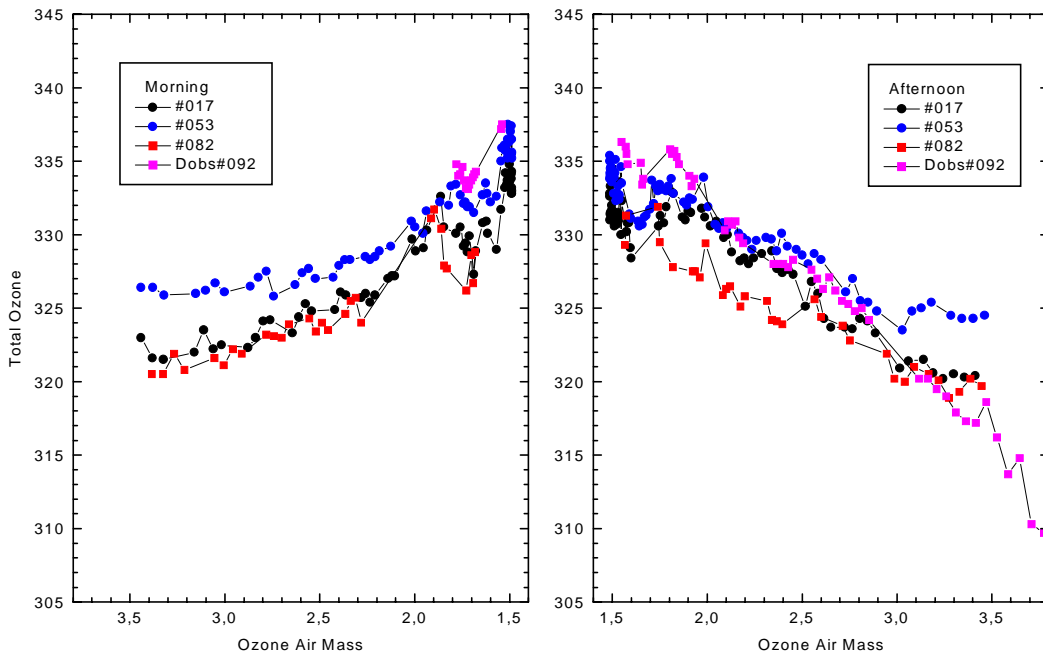
See the individual calibration report below. In summary the following adjustments were made: 1) New Hg lamp (new type design), 2) cal step to 298 (was 290 - but note that the new Hg lamp type may affect this setting because of focus changes), 3) New ETC's 2775/1800 (was 2785/1920) but the same abs. coeff's. 4) The PMT HV was increased.  
Problems not solved: filter 1 effect on some measurements.

### **Adjustments after calibration for Brewer 082 – on return from Kangerlussuaq:**

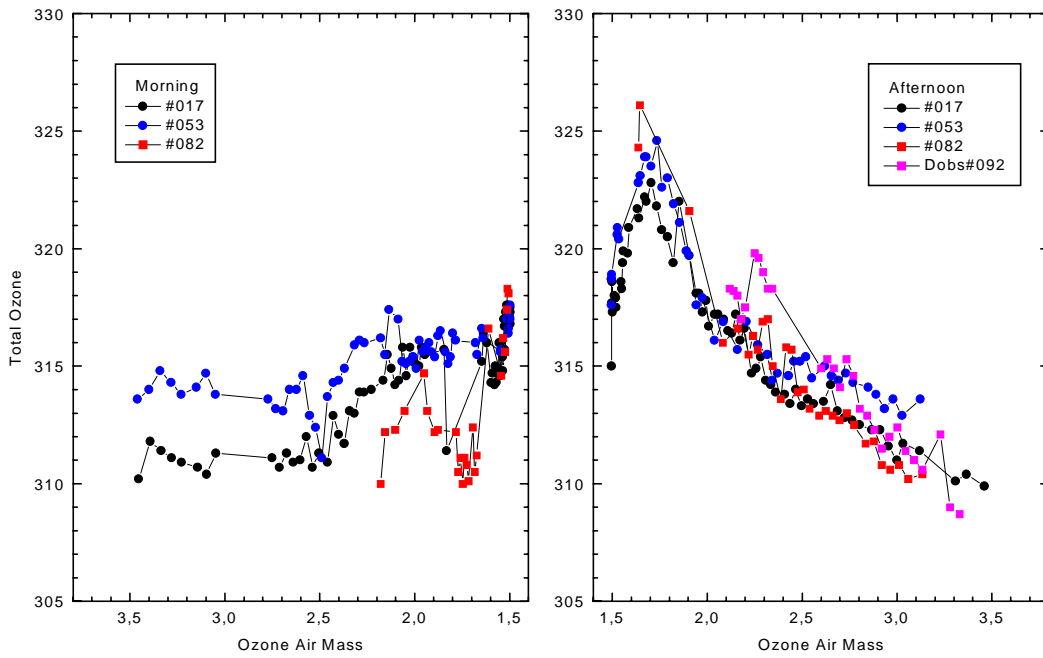
The calibration resulted in new ETC constants (O3/SO2) at 2775/1850. During the calibration the standard lamp measurements did not deviate from a similar average in the spring of 1999, where R5/R6 were  $2912 \pm 1660 \pm 4$ . Before mounting of the Brewer at DMI the PMT was dis-mounted and mounted again to learn if this had any effect on the problems with filter 1 (which were found on the last day of calibration). Apparently it had no effect, but this was not realised until later. The DT measurements (deadtime) hereafter showed about 30ns compared to earlier 40ns, which were also observed on the last day of calibration. At the same time the PMT adjustment meant a fall in R6 and R5. Consulting with IOS the O3 ETC's were adjusted from 1500/2715 (obtained at Kangerlussuaq) to 2665/1635 as a consequence of the Std. lamp R6/R5 readings. This was changed to 2685/1670 after some days of R6/R5 readings. After this, the Std. lamp readings were stable, but the DT measurements were still 30ns compared to earlier 40ns. This was to be solved on a post-calibration visit by IOS in 2000.

### **POST-calibration results.**

On 8-9 June 2000 IOS visited DMI to solve the problem with DT. It was found that the reason for this discrepancy was too high a PMT HV. When the HV was set to the value it had before the calibration at Kangerlussuaq, the DT was again about 40ns. Apparently the PMT HV supply cannot sustain a sufficiently high (bleederchain-) current when the intensity is high. Comparison to Brewer #017 resulted in changing the ETC's to 2700/1900.



**Figure 2.** Calibration results on day 209, 28 July 1999.



**Figure 3.** Calibration results on day 210, 29 July 1999.

## Calibration Report: Brewer #053 - Sondrestrom, Greenland - July 27-31, 1999

### Status on Arrival:

This MKII Brewer #053 was in need of a mercury lamp, however has been working well with no serious problems. Having been maintained carefully, the instrument has been quite stable since the last calibration checks with traveling standard #017 in Izana in 1996. The standard lamp (SL) ratios R6/R5 were 1840/3600, (1830/3600 in 1996).

The Ozone constants in use were 3038/.3165 from the 1996 calibration. The initial calibration check against traveling standard #017 resulted in ozone readings which were approximately 1% higher. There were approximately 400 good direct sun observations taken together over 3.5 clear sky days. The ETC for ozone was adjusted up 10 units as per the SL ratio change and the agreement was improved as shown below.

### Mechanical and Optical Performance:

The direct sun scan test (SC) results indicated that the wavelength cal step setting of 164 was still proper. A dispersion test (DSP), scanning a series of mercury and cadmium lamp spectral lines, was completed. The resulting file (DCF21099.053) was not put into use, since the difference to existing file was a maximum of 3 steps at high wavelengths.

### Ozone Calibration Results:

<u>day</u>	<u>O<sub>3</sub></u>	<u>dev.</u>	<u>SO<sub>2</sub></u>	<u>dev</u>	<u># /</u>	<u>total</u>	<u>mu</u>	<u>hr.</u>
#053 with 96 const. 3038/3205								
20899	339.9	+1.0	-1.2	+0.2	31/	32	214	20
20999	332.7	+3.5	-1.3	+0.3	144/	152	190	16
21099	317.8	+2.8	-1.2	+0.3	103/	114	207	15
21199	312.9	+3.4	-1.1	+0.2	143/	154	195	16
#017 using ETC's 3215/3485								
20899	336.2	+1.7	-1.1	+0.5	27/	58	225	20
20999	328.7	+4.0	-0.6	+0.4	131/	149	194	16
21099	315.2	+3.1	-0.6	+0.5	129/	143	200	16
21199	311.6	+3.2	-0.4	+0.4	111/	127	187	17
#053 ETC's 3048/3205								
20899	338.5	+1.0	-0.7	+0.3	31/	32	214	20
20999	331.2	+3.2	-0.6	+0.4	144/	152	190	16
21099	316.4	+2.6	-0.6	+0.3	103/	114	207	15
21199	311.4	+3.4	-0.5	+0.3	143/	154	195	16

### UV Calibration Results:

#053's UV calibration was checked with small IOS lamp #188 and file UVR21099.053 was created and installed for use. This file is approximately 2% larger than the file (uvr296996.053) in use.

### Servicing:

The tracker wheel and micrometer gears were cleaned. The tracker levelling was improved and the step/revolution are 14680 steps now.

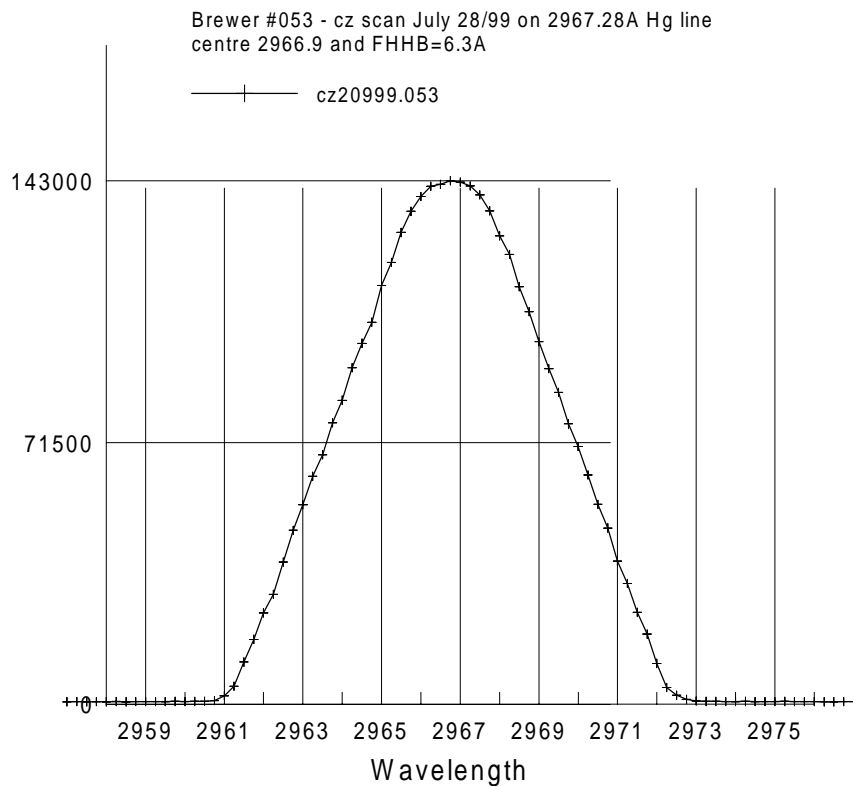
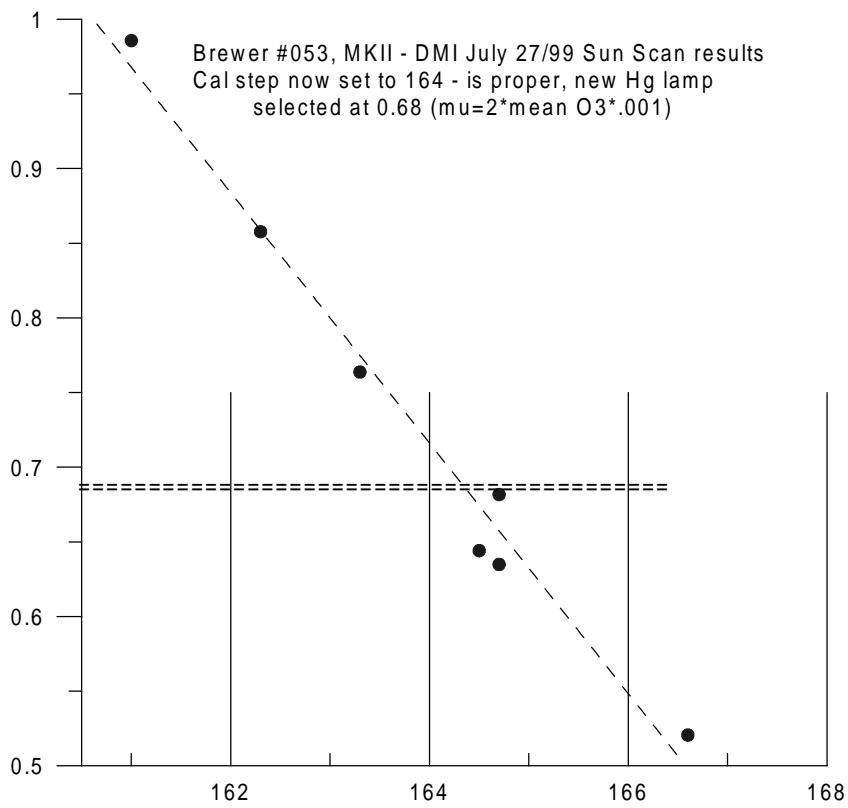
### Software:

Revised brewer software (V375a), which Y2K compliant, was installed to operate from BREW375 directory. This software has improved communications and the buffer delay is normally not needed.

Submitted by: Ken Lamb, International Ozone Services, Inc. (IOS) (053cal99.doc)



# #053 Calibration results July/1999 – Sondrestrom



## Calibration Report: Brewer #082 - Sondrestrom, Greenland - July 27-31, 1999

### Status on Arrival:

This MKIV Brewer #082 from Copenhagen had been working well with no problems. A new mercury lamp was installed at the start of this calibration. Having been maintained carefully, the instrument has been quite stable since the last calibration checks with traveling standard #017 in Izana in 1996. The standard lamp (SL) ratios R6/R5 were 1610/2930, down slightly (-10/-20) from 3 years ago.

The ETC constants in use were 2785/1920 from the 1995 repair/cal in Canada. The initial calibration check against traveling standard #017 resulted in ozone readings which were approximately 1% lower, however there were periods of higher deviation for a few measurements. There were approximately 300 good direct sun observations taken together over 3.5 clear sky days.

### Mechanical and Optical Performance:

The direct sun scan test (SC) results indicated that the wavelength cal step setting of 290 should be changed to step 293, note the initial Hg lamp was old style design. On the second day the new style of lamp was installed since this instrument has new lamp housing. The sun scans then showed that a cal step setting of 298 was necessary. A dispersion test (DSP), scanning a series of mercury and cadmium lamp spectral lines, was completed. The resulting file (DCF21099.082) was not put into use, since the difference to existing file was a maximum of 6 steps at high wavelengths. The new absorption coefficient of 0.3555 derived from the dispersion test was evaluated but the ozone agreement with #017 did not improve.

### Ozone Calibration Results:

Applying the standard lamp change to ETC's plus a further SO<sub>2</sub> adjustment (to make them 2775/1850) and using the existing absn. coefficient of 0.3581/1.1912 made the agreement acceptable as shown below. Note some of the results on day 209 when cal step was off after lamp change and on last day when the PMT (it is believed) had counting errors, were removed from these daily means.

day	O <sub>3</sub>	dev.	SO <sub>2</sub>	dev	# / total	mu	hr.
#017 using ETC's 3215/3485							
20899	336.2	+1.7	-1.1	+0.5	27 / 58	225	20
20999	328.7	+4.0	-0.6	+0.4	131 / 149	194	16
21099	315.2	+3.1	-0.6	+0.5	129 / 143	200	16
21199	311.6	+3.2	-0.4	+0.4	111 / 127	187	17
#082 using revised ETC's 2775/1850							
20899	334.8	+2.3	-1.6	+1.3	23 / 23	231	20
20999	324.7	+3.6	-0.6	+1.5	61 / 102	210	16
21099	316.8	+7.6	-0.4	+1.3	57 / 69	202	17
21199	313.0	+4.7	-1.5	+1.8	41 / 71	174	16

### UV Calibration Results:

#082's UV calibration was checked with small IOS lamp #188 and file UVR21199.082 was created and installed for use. This is an UV extended range response file calculated after it was determined the first n.d. filter was not required since the sensitivity has decreased. This file is approximately 2% larger than the file (uvr296996.053) in use, however the first n.d. filter is not used now. The filter is set in (icf) constants file with CF command - now 0 and was 64 steps.

### Servicing and problems:

When the sun scan results shifted with the new Hg lamp, then it was believed this was due to poor spectrometer focus of large mirror, however the focusing was fine and no adjustments were made. This is believed to be due to small differences in shape of 302nm line between lamps and that this instrument has a narrow slit function. The High Voltage test on the instrument showed the HV setting of 1550 volts was also still proper. The PMT housing and tube were adjusted slightly when the end cap

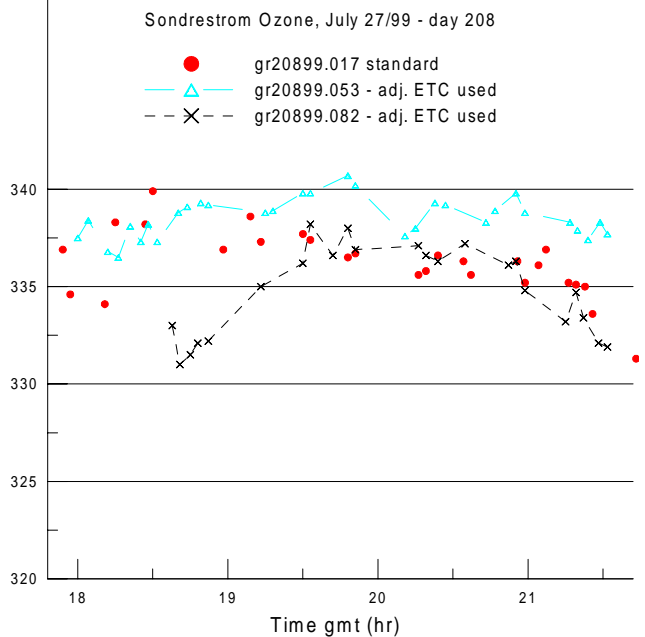
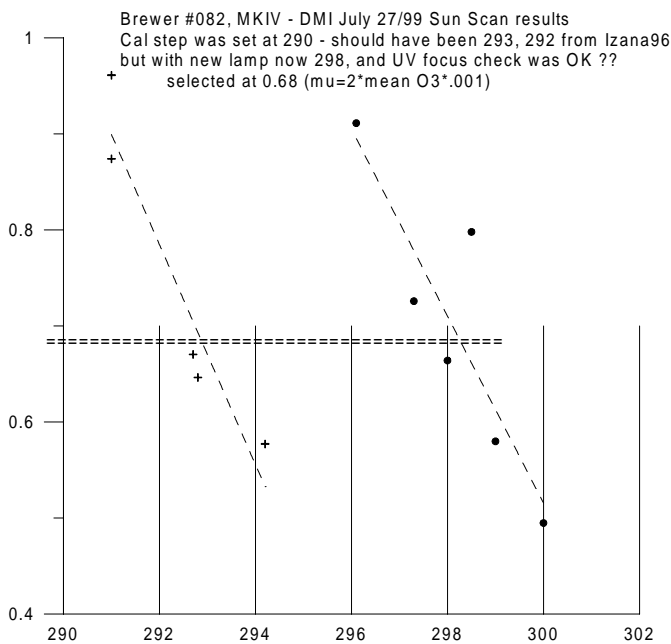
was removed. After this the DT results had went quite low and attempts to determine the reason were not successful. It is believed now that the problem is the connection(s) to the PMT. Due to time constraints the customer agreed to inspect PMT in Copenhagen and a visit by IOS may be necessary to re-check calibration. The tracker wheel and micrometer gears were cleaned and bearings lubricated in spectrometer. A new standard lamp was installed on last day since when the power to the original lamp (now 3 years old) was increased to hopefully improve DT test, it became very unstable.

**Software:**

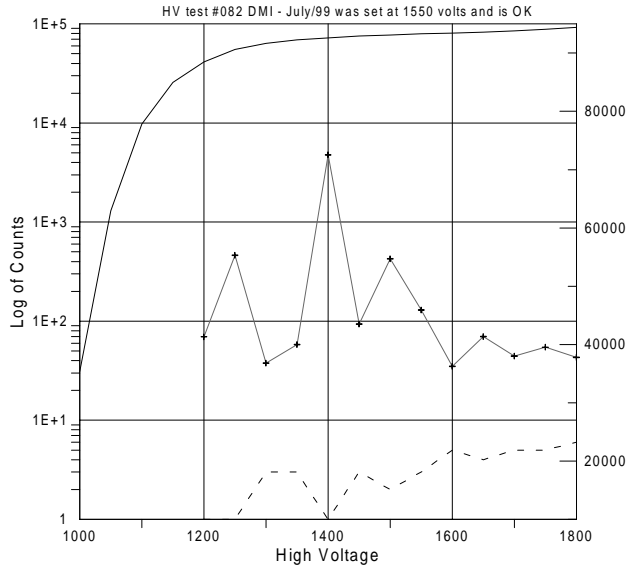
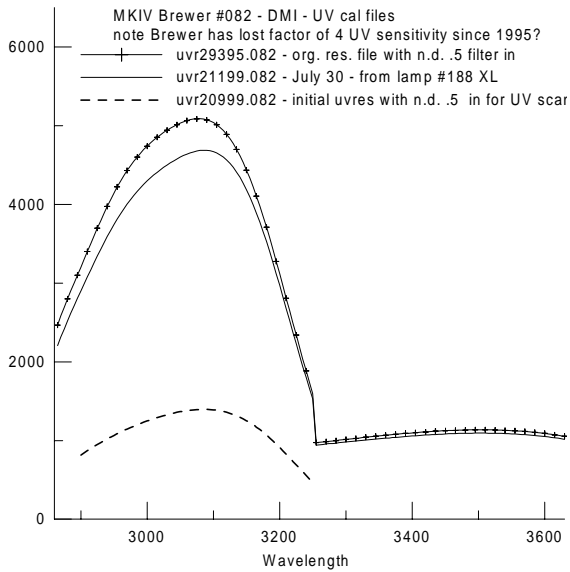
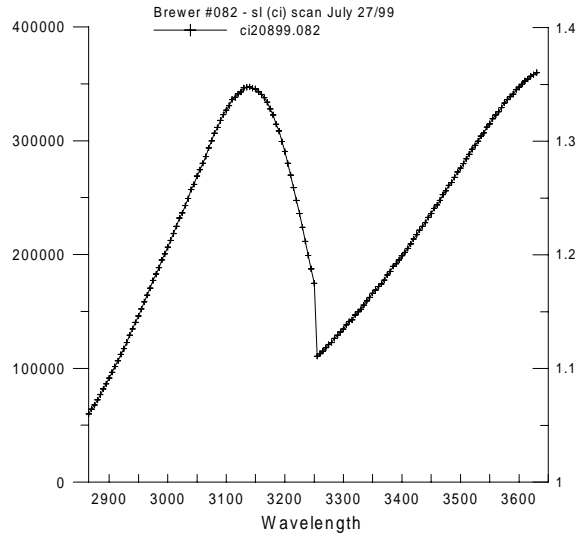
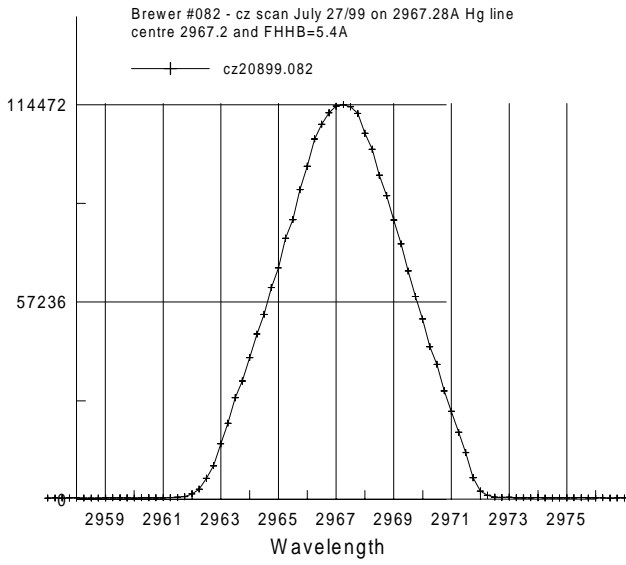
Revised brewer software (V375a), which is Y2K compliant, was installed to operate from BREW375 directory. This software has improved communications and the buffer delay is normally not needed. However this software has shown some problems with the print to disk (PD) under W95 and W98 operation. The problem is serious since program freezes and the window must be shut down and program re-started. This problem has occurred in Sondrestrom since the calibration.

**Post Calibration Operation:**

The PMT was inspected and moved in its socket about 2 mm up and down. After the DT results have been stable at 30ns but the SL ratios dropped to 1500/2715. The instrument operation has been stable and more data will be collected and compared to satellite results. The ETC constants should be adjusted to values of 2665/1635.

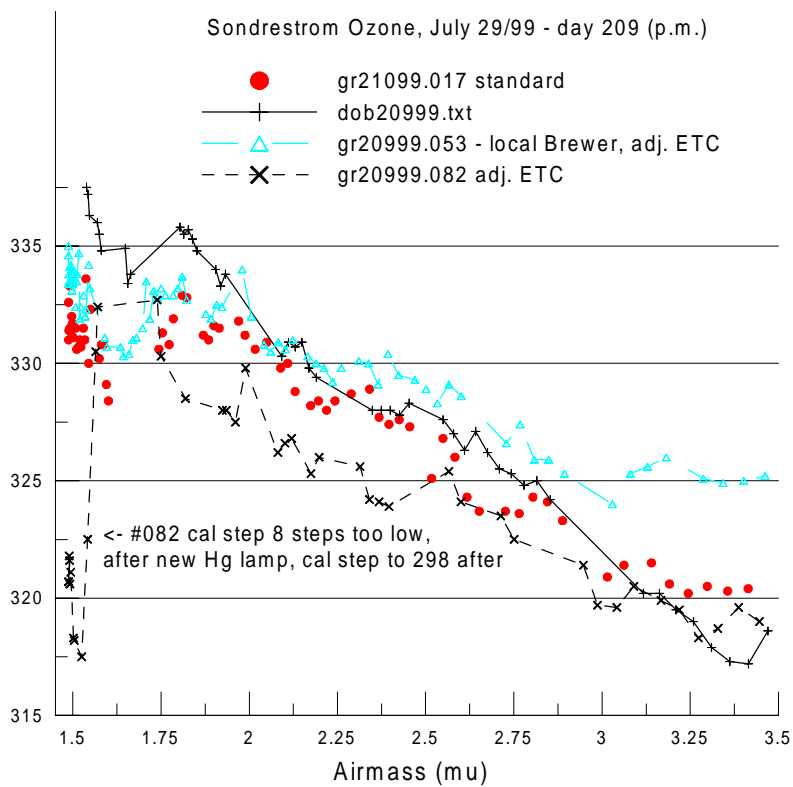
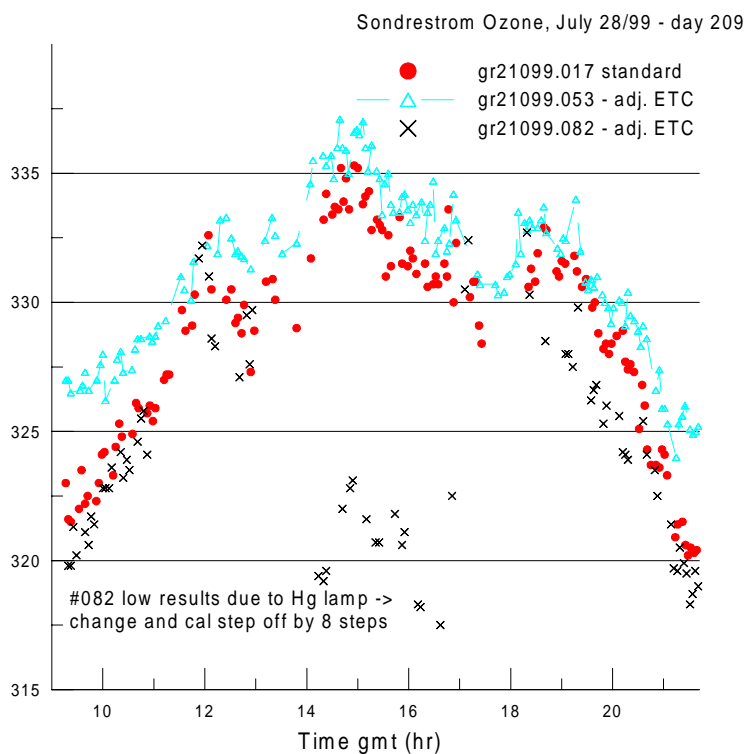


# #082 Calibration results July/1999 - Sondrestrom

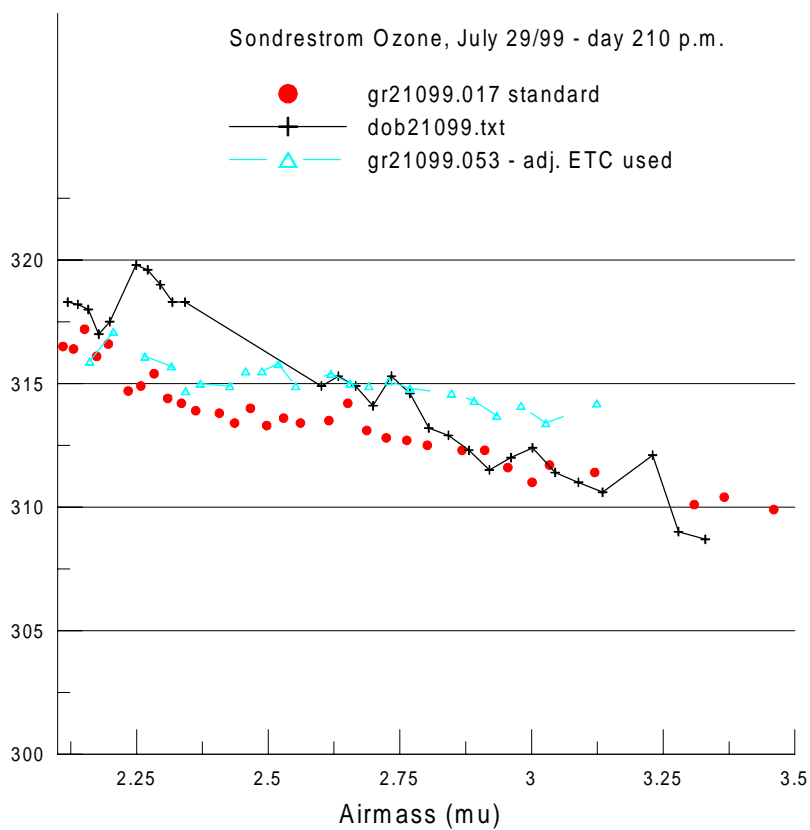
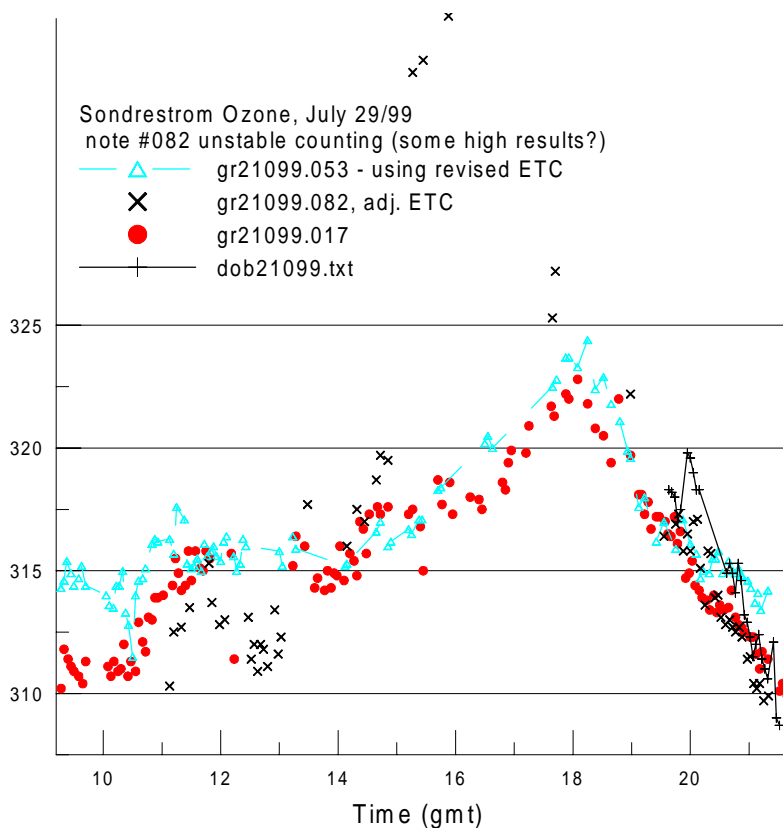


Submitted by: Ken Lamb, International Ozone Services, Inc. (IOS) (082cal99.doc)

Sondrestrom 99 Ozone Calibration Results:  
(082cal99.doc)



Sondrestrom 99 Ozone Calibration Results:  
(082cal99.doc)



Sondrestrom 99 Ozone Calibration Results:  
(082cal99.doc)

