Quality Inspection Results for Schott 8246 Glass Bulbs Produced under LANL Subcontract 9-LF1-J5203-1

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Abstract

Low-background glass bulbs for photomultipliers for the Sudbury Neutrino Observatory project (SNO) have been made by Schott Glaswerke, Mainz, under Los Alamos National Laboratory subcontract 9-LF1-J5203-1. The critical specifications concern a) contained radioactivity (U, Th, and K), b) light transmission, and, c) dimensions and defects. These have been subjected to quality verification independent of Schott's own controls. The results of that verification are presented herein.

1 Introduction

The Sudbury Neutrino Observatory (SNO) project makes use of thousands of photomultiplier tubes (PMT) to record the Čerenkov light emitted during

neutrino interactions in the heavy-water detection medium. Very low levels of radioactivity are required in all construction materials, in particular the PMTs. Furthermore, the PMTs operate under water at pressures up to 3.5 atmospheres.

Schott Glaswerke developed for this purpose an extremely low-background glass, Type 8246, which meets the requirements. Hamamatsu Photonics KK was awarded subcontract 9-LF1-M7719-1 by Los Alamos National Laboratory (LANL) to produce PMTs using Schott 8246 glass bulbs.

The specifications for the Schott bulbs are included as attachments to this document, "Appendix A", and "Appendix B".

The quality verification program consisted of 3 main aspects:

1. Measurement of radioactivity of samples of raw materials and glass cullet throughout the production.
2. Measurement of optical transmission of glass samples as a function of wavelength.
3. Measurement of dimensions and defects of samples taken from the entire production.

Other, less critical, specifications guaranteed by Schott were not independently verified.

2 Radioactivity

Two laboratories within SNO provided radioassay services, Birkbeck College in London (J. Barton and P. Trent), and University of Guelph (P. Jagam and J.J. Simpson). Both used hyperpure Ge detectors with local shielding and modest overburden to reduce the hadronic component of cosmic rays. The Birkbeck facility also includes a low-background NaI detector which was used to check some of the early samples. As the NaI background was somewhat higher, later measurements were only made with the Ge detector. Samples provided by Schott were generally in the range 300 to 1000 g of cullet (broken

Table 1: Radioassay results

Sample	Birkbeck			Guelph			Average		
	Th	U	K	Th	U	K	Th	U	K
	ng/g	ng/g	mg/g	ng/g	ng/g	mg/g	ng/g	ng/g	mg/g
S1	116(37)	92(10)	0.001(3)	25(13)	40(5)	0.040(10)	25(17)	40(11)	0.040(10)
S2	2(20)	38(8)	0.005(2)	18(7)	40(3)	0.020(5)	18(12)	40(10)	0.020(5)
1	92(15)	130(6)	0.170(20)	59(5)	118(3)	0.160(10)	68(10)	123(8)	0.162(9)
2	12(9)	66(4)	0.037(10)	30(4)	85(6)	0.050(5)	23(10)	75(8)	0.040(4)
3	20(11)	58(3)	0.021(8)	24(6)	53(6)	0.030(5)	22(9)	56(8)	0.028(4)
4	17(9)	52(4)	0.012(9)	11(5)	46(5)	0.020(5)	13(9)	49(8)	0.018(4)
5	16(9)	34(3)	0.017(8)	8(5)	32(5)	0.020(5)	11(9)	33(8)	0.019(4)
6	6(7)	28(4)	0.006(8)	19(5)	32(5)	0.010(5)	13(8)	30(8)	0.009(4)
7	7(8)	30(6)	0.019(8)	14(8)	34(5)	0.000(5)	11(9)	32(8)	0.005(4)
8	6(8)	30(3)	0.021(8)	17(8)	30(5)	0.020(5)	12(9)	30(8)	0.020(4)
9	13(8)	23(3)	0.015(8)	22(7)	38(5)	0.020(5)	18(9)	30(8)	0.019(4)
10	14(3)	33(3)	0.022(8)	20(5)	52(4)	0.020(5)	17(8)	42(8)	0.021(4)
11	10(8)	34(3)	0.033(8)	37(8)	60(5)	0.070(5)	24(9)	46(8)	0.060(4)

glass pieces from blowing operations). As specified in the draft subcontract, SNO approval of the raw materials was required before the melt was to begin, and samples taken from the melt before and after any given production lot had to meet specifications in order for that lot to be accepted.

Schott lacked the equipment to measure U and Th in-house at the necessary levels, and SNO offered their services to Schott at no charge. The U and Th measurements by SNO therefore are the primary data, and are not checks of Schott measurements. However, Schott was able to measure K chemically, and their results agreed well with the SNO radioassay determinations of K.

Table 1 contains the raw radioassay data.

The individual measurements from the two laboratories are generally in agreement, especially later in the production, but were not entirely consistent within the statistical uncertainties. These differences can be attributed to actual variations between samples, variations in geometry, adsorption of radon from the environment during sample changes, and to different analysis procedures. To allow for these systematic effects, we added 10 ng/g in quadrature to each statistical uncertainty in the Th and U concentration, and treated that extra contribution as a random error from measurement

to measurement. The uncertainties in the averages reflect this. The potassium numbers seemed more consistent, and we have not made a correction to those uncertainties. From this fact alone, one can speculate that the main contributor of excess error is radon, as suggested by Barton.

Sample S1 (Schott number 36773) is a sample of the raw materials mixed in the Technical Batch House, after some clean-up prompted by earlier data not shown here. Sample S2 (Schott number 36774) is from the Optical Batch House. Based on the radioassay results, it was decided to use the latter, but in hindsight, the high numbers from Birkbeck on S1 seem anomalous and probably reflect ^{220}Rn contamination that was subsequently alleviated by a change in procedure (samples were allowed to wait a day after transfer to the detector housing before being counted.)

Both laboratories analyzed the ^{40}K 1461-keV line to assay potassium. Thorium was obtained from an average of the 583- and 2614-keV transitions in the ^{208}Tl decay and the 911-keV transition from ^{228}Ac decay at Guelph, whereas Birkbeck did not use the 2614-keV line, but did use the 239-keV transition from ^{212}Pb. For uranium, Guelph made use of the 609- and 1764-keV lines from ^{214}Bi, while Birkbeck analyzed the 609- and 351-keV lines from that isotope. Hence the results strictly pertain to the ends of the Th and U chains, which are most relevant to SNO, but significant disequilibrium would not be readily detected, especially in the U chain. The 911-keV line appears above a 2-year activity, and indeed Guelph reported some evidence for disequilibrium in this line, but none was evident in the Birkbeck data. The quoted concentrations for "Th" and "U" refer to the concentrations that would exist if the chains were in equilibrium.

Figure 1 summarizes the results for Th and U, and Figure 2 the results for K.

In Table 2 we summarize the sample numbers, sampling dates (all 1991), and cumulative production (of acceptable bulbs).

Before the production began, the draft specification on both U and Th was 40 ng/g maximum, but at Schott's request (and after some analysis by SNO), the U specification was relaxed to 70 ng/g to allow inclusion of the first 608 bulbs in the production. Later production all met the tighter specification.

Table 2: Sample distribution in time and production

Sample Number	Date of Sample	Cumulative Production
S1	Jan. 9	0
S2	Jan. 9	0
1	Feb. 18	0
2	Feb. 25	0
3	Feb. 28	608
4	Mar. 4	2,003
5	Mar. 11	3,128
6	Mar. 18	6,878
7	Mar. 25	10,808
8	Apr. 3	14,045
9	Apr. 8	15,099
10	Apr. 17	16,592
none	Apr. 25	16,700
11	Apr. 28	16,700

3 Optical Transmission

During the production, Schott made frequent tests (essentially daily) of the optical transmission of the 8246 glass at two wavelengths, 587 and 320 nm. The transmission is defined in the draft contract Appendix A (attached), and includes corrections for the reflectivity at both wavelengths. The light attenuation coefficient T_{320} measured at Schott for 3-mm thick polished samples is listed in Table 3, and summarized graphically in Fig. 3.

As the draft contract called for, Schott sent optical samples to Chalk River Laboratories (CRL) at the same frequency as the radioassay samples (approximately every week). The results of the CRL measurements are summarized in a document, "Evaluation of the optical transmission of Schott glass", which is appended.

Some additional data were sent separately to LANL from CRL. These concerned two 3-mm and two 1-mm samples prepared on Mar. 6 and Mar. 13. The comparison between the Chalk River (E. Bonvin and E. D. Earle) and Schott results for these two samples is shown in Table 4. The identification

Table 3: Light attenuation data from Schott

Date	T_{320}, cm^{-1}	Date	T_{320}, cm^{-1}
Feb. 18	0.35	Mar. 3	0.42
Feb. 19	0.33	Mar. 21	0.42
Feb. 21	0.30	Mar. 22	0.41
Feb. 22	0.27	Mar. 23	0.41
Feb. 23	0.27	Mar. 24	0.41
Feb. 24	0.31	Mar. 25	0.42
Feb. 25	0.31	Mar. 26	0.43
Feb. 26	0.30	Mar. 27	0.46
Feb. 27	0.30	Mar. 28	0.43
Feb. 28	0.30	Mar. 29	0.41
Mar. 1	0.29	Mar. 30	0.41
Mar. 2	0.28	Apr. 1	0.39
Mar. 3	0.27	Apr. 3	0.40
Mar. 4	0.26	Apr. 4	0.39
Mar. 5	0.26	Apr. 5	0.38
Mar. 6	0.26	Apr. 6	0.40
Mar. 7	0.27	Apr. 7	0.39
Mar. 8	0.28	Apr. 8	0.40
Mar. 9	0.26	Apr. 9	0.41
Mar. 10	0.33	Apr. 10	0.43
Mar. 11	0.35	Apr. 11	0.42
Mar. 13	0.37	Apr. 12	0.42
Mar. 14	0.38	Apr. 13	0.43
Mar. 15	0.39	Apr. 14	0.45
Mar. 16	0.41	Apr. 15	0.44
Mar. 18	0.43	Apr. 16	0.44
Mar. 19	0.42	Apr. 17	0.43

Table 4: Comparison of Light attenuation data from Schott and Chalk River.

Sample	T_{320}, cm^{-1}	
	Schott	CRL
Mar. 6	0.26	0.26
Mar. 13	0.37	0.34

of the samples was incorrect at first, and has (we believe) been corrected in the table.

These data are in reasonable agreement. For the transmission at 587 nm (essentially the same for all samples), Schott measures 92.2%, and Chalk River 91.4-91.8%. The value expected for glass of this refractive index (1.507) and no significant absorption is 92.2%.

Table 5 shows the complete Chalk River spectral transmission data between 300 and 600 nm for the 4 samples of Mar. 6 and 13.

4 Dimensions and Defects

Being handblown, the bulbs are subject to variability in dimensions, and to defects. Schott airshipped 80 bulbs from each week's production (a total of 480) to Hamamatsu to allow Hamamatsu's inspectors an opportunity to assess on a sampling basis the overall quality of the production with respect to these parameters. The inspection reports were returned to Schott, who, in turn passed them on to SNO. Although Schott evidently intended to forward all 6 reports, in fact only reports 1, 2, 3, and 6 were received, and are appended.

The dimensions and tolerances required are shown on Schott drawing number A5349-00-02e, attached. At the Schott plant, the major dimensions were checked against preset gauges, and the wall thickness measured by means of a small iron ball placed inside the bulb and magnetically attracted to an external sensor. Wall thicknesses were measured at 6 places azimuthally on three diameters. Hamamatsu's inspection reports are appended. Of the 480 bulbs, none was rejected for dimensional errors, and only 2 were rejected for defects. This was viewed by Schott (and by SNO) as an

Table 5: Chalk River transmittance data (%) for 4 samples.

Wavelength	Mar. 13		Mar. 6	
nm	1 mm.	3 mm.	1 mm.	3 mm.
300	79.7	61.9	82.8	68.6
320	87.9	82.1	89.0	84.2
340	89.9	88.4	90.6	88.8
360	90.9	90.3	91.2	90.2
380	90.9	90.7	91.2	90.3
400	91.1	90.9	91.4	90.6
420	91.1	90.9	91.4	90.6
440	90.9	90.7	91.3	90.3
460	91.3	91.1	91.5	90.7
480	91.3	91.2	91.7	90.8
500	91.2	91.2	91.5	90.8
520	91.2	91.1	91.5	90.7
540	91.4	91.2	91.6	90.9
560	91.4	91.4	91.7	91.0
580	91.8	91.9	92.1	91.5
600	91.7	91.6	91.9	91.3

excellent outcome, virtually assuring that the bulk of the production meets specifications with respect to dimensions and defects.

5 Conclusions

Tests of critical specifications for the Schott 8246 glass PMT bulbs for the SNO project showed compliance with the final specifications of LANL subcontract 9-LF1-J5203-1. The tests included radioassay of Th, U and K, measurements of optical transmittance, dimensional checks, and inspection for defects.

Attachments

1. Appendices A and B to LANL subcontract 9-LF1-J5203-1.
2. SNO radioassay results for Th and U.
3. SNO radioassay results for K.
4. Schott data on light attenuation coefficient at 320 nm.
5. "Evaluation of the optical transmission of Schott glass", E. Bonvin, E. D. Earle, and A. Plagemann.
6. Schott drawing A5349-00-02e.
7. Hamamatsu Inspection Reports 1, 2, 3, and 6.

APPENDIX A

SPECIFICATIONS FOR SCHOTT 8246 GLASS
July 16, 1991

The following specifications shall apply to glass produced for photomultiplier tubes (PMT) to be used in the Sudbury Neutrino Observatory (SNO). The glass shall seal satisfactorily to Kovar glass types. Glass produced under this subcontract shall also meet the following specifications:

1. Contained radioactivity:	Uranium	< 70 ng/g
	Thorium	< 40 ng/g
	Potassium	< 0.2 mg/g

Specifications on contained radioactivity shall be deemed to be met if the measured values do not exceed the values listed by more than two standard deviations. The standard deviation of the measurement shall consist of Gaussian statistical and systematic standard deviations added in quadrature.

2. Coefficient of Expansion $\alpha_{20/30}$	$5.4(2)\times10^{-6}\ K^{-1}$
3. Specific Gravity	2.50(10)
4. Temperature for viscosity of $10^{7.6}$ dPa-s	760(10) C
5. Modulus of Elasticity	70(7) GPa
6. Poisson's Ratio	0.21(2)
7. Refractive Index	1.507(30)
8. Hydrolytic Resistance (per DIN 12111; ISO 719):	Class 1
9. Minimum light transmission at normal incidence of plate sample of 1 mm thickness at 586.7 nm:	0.90

APPENDIX A

SPECIFICATIONS FOR SCHOTT 8246 GLASS
July 16, 1991

10. Light attenuation coefficient at 320 nm $T_{320} < 0.50\ cm^{-1}$

T_{320} is defined for a plate sample of thickness t cm by:

$$T_{320} = [ln(I_d - 0.005) - ln(I_{320})]\ t^{-1},$$

where I_d is the transmission at 586.7 nm and I_{320} the transmission at 320 nm.

(The allowable range in a specified parameter is expressed by a quantity in parentheses, which is the allowable variation in the last digit of the number.)

APPENDIX B
PRODUCTION CONDITIONS AND INSPECTION
July 16, 1991

1. The subcontractor shall not begin the melt without written approval from the University in respect of the radiopurity of the raw materials and the suitability of the packing.

2. All samples made from the melt (Deliverables No. 1 and 2) must meet the specifications of Appendix A in order for the conditions of the subcontract to be met. If a sample is determined by the University not to be in compliance with Appendix A, then the subcontractor shall furnish additional data demonstrating that all bulbs *delivered to the University under this subcontract* meet the specifications of Appendix A. In the event of a discrepancy between the University's conclusions and the subcontractor's conclusions, data and conclusions from a third party mutually agreed upon shall be used to determine compliance. All costs of the third-party analysis shall be borne by the party whose findings were negated by the third party. If the third party substantively negates findings of both the University and the subcontractor, the third-party costs shall be shared equally between the University and the subcontractor.

3. The University reserves the right to inspect the production of the glass bulbs at the subcontractor's plant at any time with a minimum of 24 hours notice.

4. No glassblower shall be permitted to smoke while in the act of handling or blowing glass for this subcontract.

5. Each bulb shall be checked for compliance with the dimensions and tolerances shown on Schott drawing A5349-00-02e as follows:

a) The outer diameter of the neck shall be checked at the position marked M1 on the drawing with a caliper gauge. A diameter larger than 71 mm shall be cause for rejection of the bulb.

b) The greatest outer diameter of the bulb shall be checked with ring gauges. A diameter not in the range 202 to 206 mm inclusive shall be cause for rejection of the bulb.

c) The inner diameter of the neck shall be checked with a ball gauge. A diameter smaller than 61 mm at any point in the neck shall be cause for rejection of the bulb.

d) The total length of the bulb shall be checked against preset gauges. A length not in the range 218 to 222 mm inclusive shall be cause for rejection of the bulb.

APPENDIX B
PRODUCTION CONDITIONS AND INSPECTION
July 16, 1991

6. The date of manufacture of each bulb, accurate to plus or minus 2 days, shall be shown on the outside of its packing case. A data sheet shall be packed with each bulb showing the following:

a) The actual wall thickness of the bulb at the position marked M1 on Schott drawing Number A5349-00-02e shall be measured at 6 places around the neck and recorded.

b) The actual wall thickness of the bulb at the position marked M2 on Schott drawing Number A5349-00-02e shall be measured at 6 places around the bulb and recorded.

c) The actual wall thickness of the bulb at the position marked M3 on Schott drawing Number A5349-00-02e shall be measured at 6 places around the bulb and recorded.

d) The date of manufacture of each bulb, accurate to plus or minus 2 days, shall be shown on the data sheet.

The claimed accuracy of measurements shall be given either on each data sheet or in a separate statement to the University.

Other information may also be included at subcontractor's option.

APPENDIX B
PRODUCTION CONDITIONS AND INSPECTION
July 16, 1991

7. Each bulb must satisfy the specifications listed in Table I. For the purpose of these specifications, the bulb is divided into two zones (A and B) as shown in Schott Drawing Number A5349-00-02e. No defect repairing process is allowed.

TABLE I

DEFECT	ZONE A	ZONE B
Blister, unbroken Seed Air Line, unbroken Seed Line	< 2 mm dia: allowed 2-4 mm dia: 0 to 3 inclusive > 4 mm dia: not allowed Size of non-circular defect is defined as (length + width)/2. Not more than 2 defects within 50 mm dia.	< 2 mm dia: allowed 2-5 mm dia: 0 to 5 inclusive > 5 mm dia: not allowed Size of non-circular defect is defined as (length + width)/2.
Lap Cord Chill Mark Mould Mark Stria Fold	To limit sample	Allowed
Stain	Allowed if removable by washing procedure acceptable to University	
Scratch	< 30 mm long, < 1 mm wide: 0 to 3 inclusive > 30 mm long: not allowed	< 30 mm long, < 5 mm wide: 0 to 3 inclusive > 30 mm long: not allowed

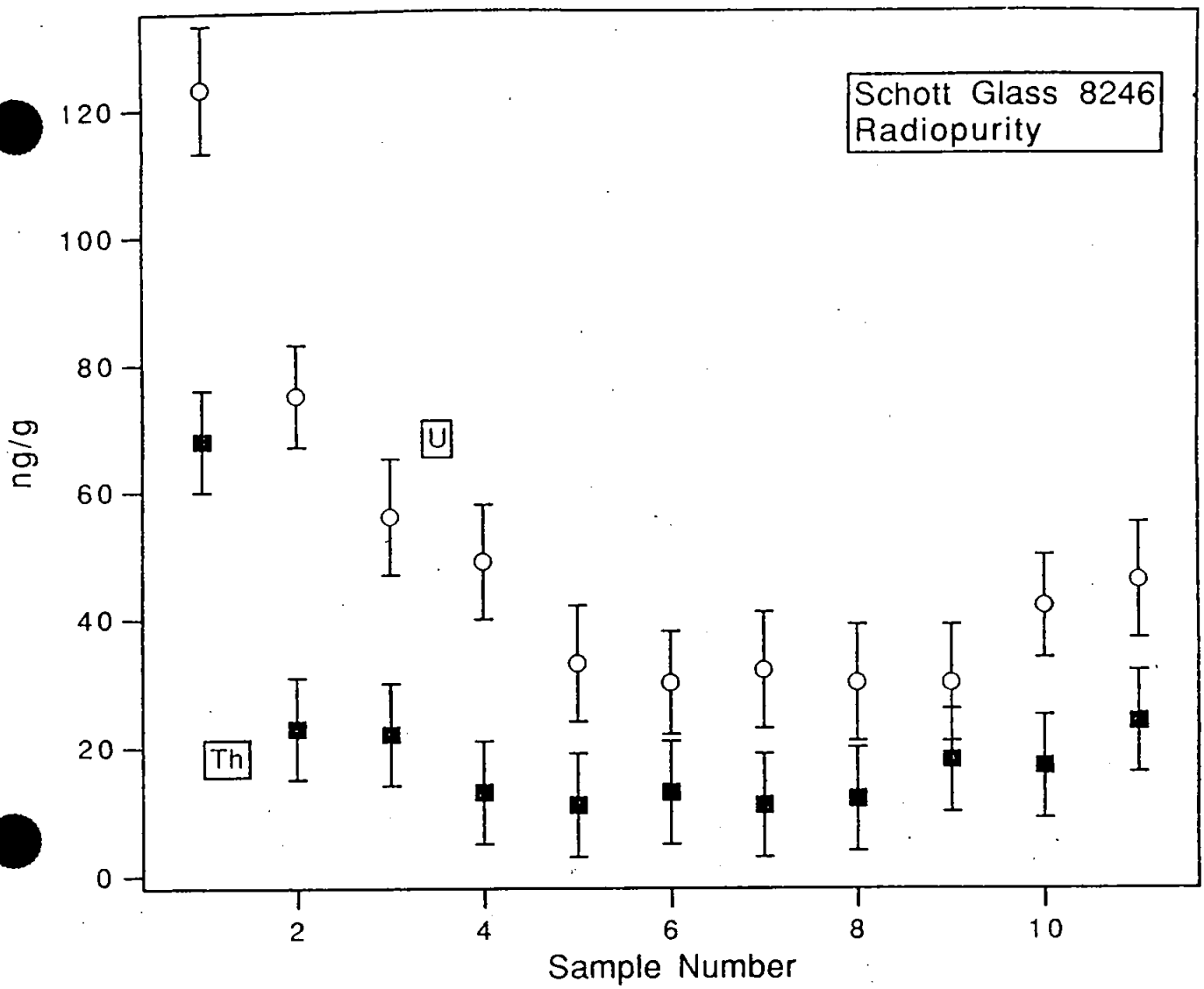
APPENDIX B
PRODUCTION CONDITIONS AND INSPECTION
July 16, 1990

TABLE I Continued

DEFECT	ZONE A	ZONE B
Stone Knot	< 0.5 mm dia: 0 to 3 inclusive > 0.5 mm dia: not allowed	< 0.5 mm dia: 0 to 3 inclusive > 0.5 mm dia: not allowed
Stress	< 150 nm/cm	< 150 nm/cm
Crack Chip Check Blister, broken Air Line, broken Metal or Iron Oxide Stone, not embedded in glass Fragment of glass adhering to surface Impact or bruises with cracking White brush mark	Not Allowed	Not Allowed

APPENDIX B
PRODUCTION CONDITIONS AND INSPECTION
July 16, 1991

8. Each bulb must comply with the dimensions and tolerances shown in Schott Drawing Number A5349-00-02e, with the specifications of Appendix A, and with the conditions of Appendix B, section 1, 4, 5, 6, and 7, collectively called "the Specifications". If a bulb is determined by the University not to be in compliance with the Specifications, then the subcontractor shall furnish additional data demonstrating that all bulbs delivered to the University under this subcontract are in compliance with the Specifications. In the event of a discrepancy between the University's conclusions and the subcontractor's conclusions, data and conclusions from a third party mutually agreed upon shall be used to determine compliance. All costs of the third-party analysis shall be borne by the party whose findings were negated by the third party. If the third party substantively negates findings of both the University and the subcontractor, the third-party costs shall be shared equally between the University and the subcontractor.


Schott Glass 8246
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ng/g
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100
80
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40
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0
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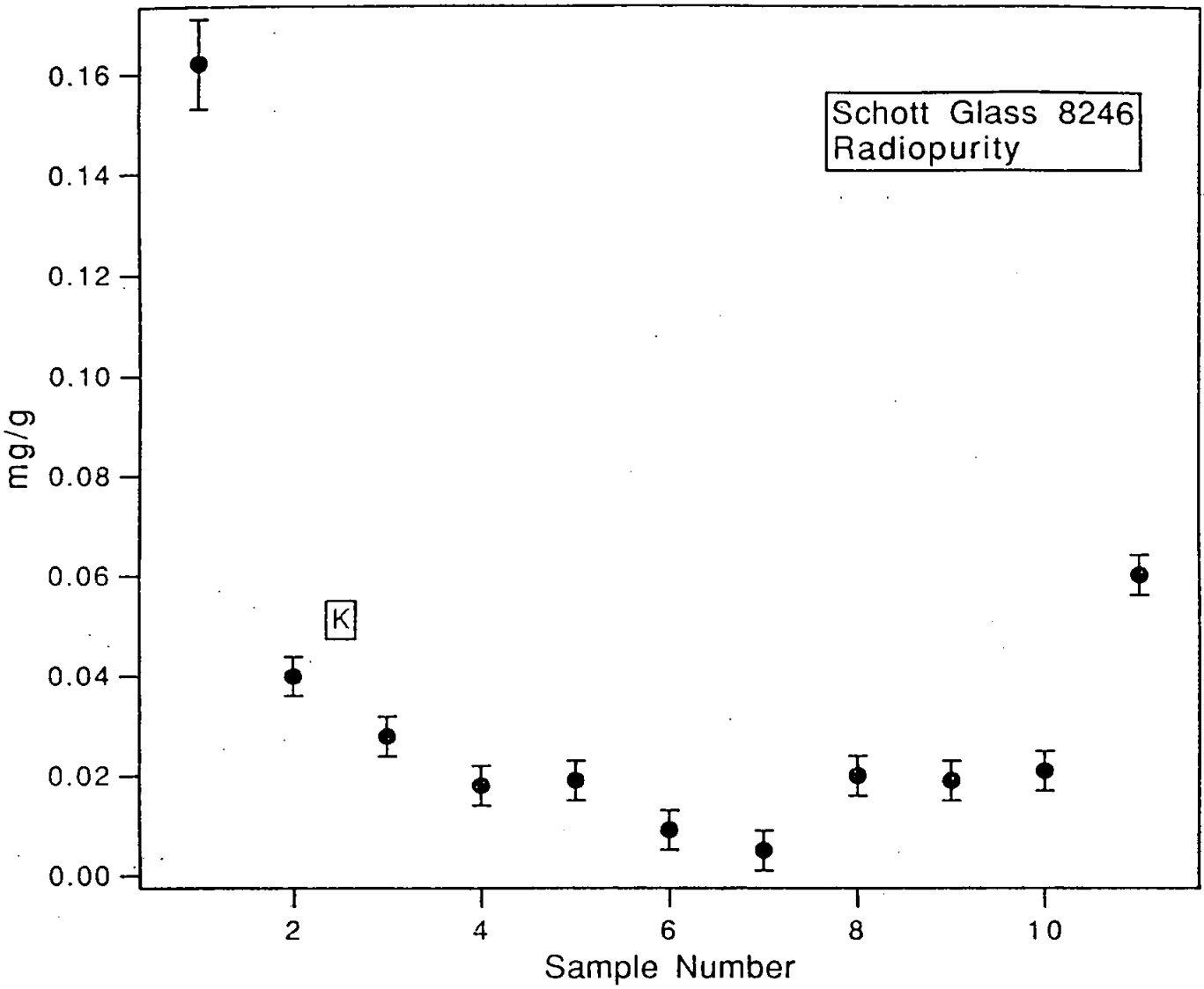
8
10
Sample Number


Schott Glass 8246
Radiopurity
K
mg/g
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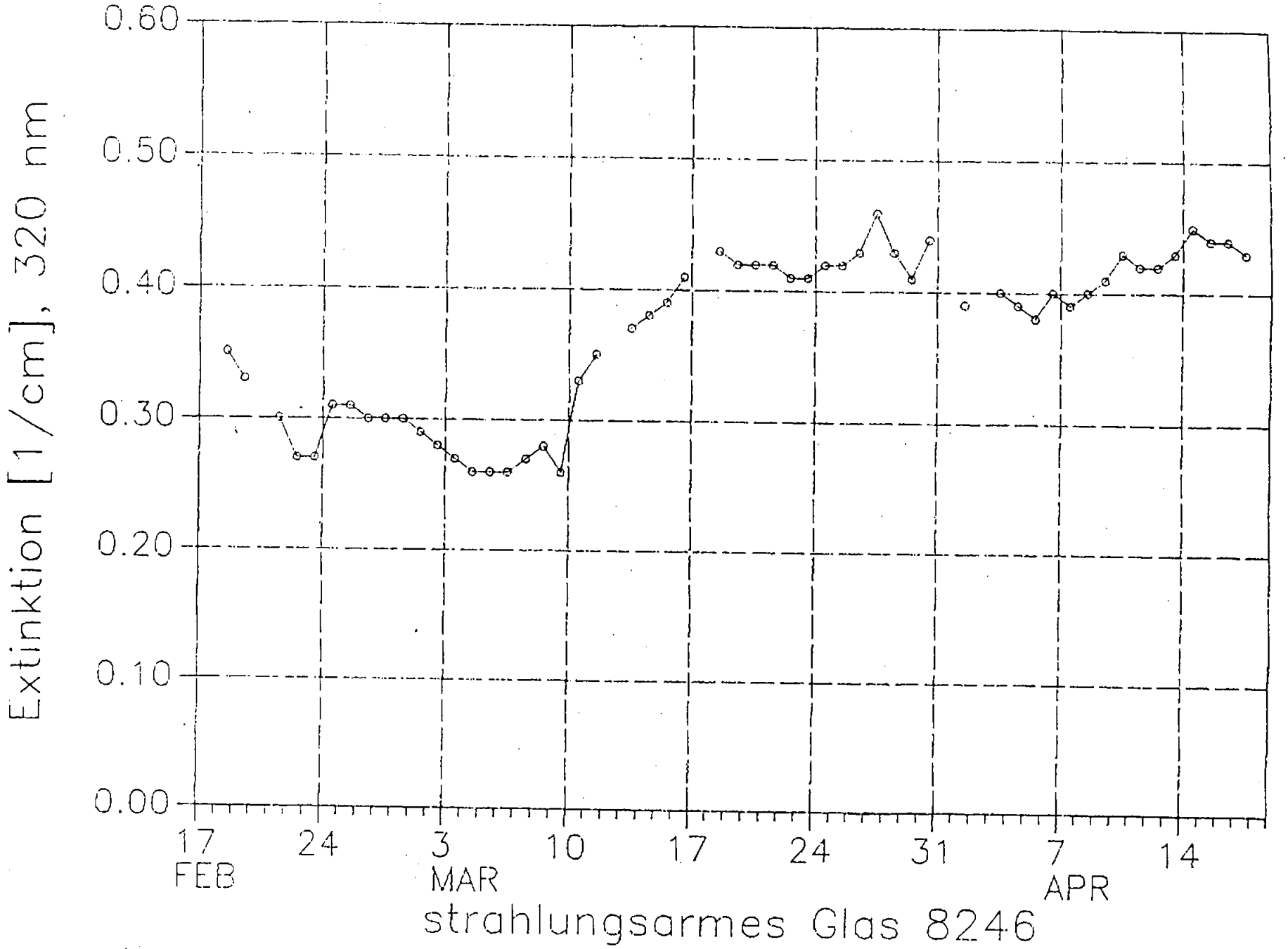
Sample Number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17
FEB
24
3
MAR
10
17
24
31
7
APR
14
strahlungsarmes Glas 8246

Evaluation of the optical transmission of Schott glass

E.Bonvin, E.D.Earle and A.Plagemann
CRL, Chalk River

June 6, 1991

1 Introduction

The Schott glass to be used by Hamamatsu for SNO PMT's must have a bulk light absorption coefficient of better than 0.5 cm^{-1} at 320 nm. This was checked by Schott during the production of the bulbs and the results of their measurements on daily extraction from the glass melt are shown in Fig. 1 & 2. Fig. 1 shows the transmission at 320 nm and 587 nm, and Fig. 2 the absorption coefficients at 320 nm. Glass samples from the melt were also sent to CRL for confirmation of this specification. The dots in Fig. 2 are the values obtained at CRL. We report here the light transmission measurements made at CRL.

2 Measurements

Seven envelopes of glass pieces were sent to CRL in two shipments. These envelopes contained 1 mm and 3 mm thick samples. Some samples were broken in shipment and were not used. The table below lists data on the samples received. Batch # is our identification, Date is Schott production date and Contents is the thickness and number of samples in each batch.

Batch #	Date	Contents
1	Mar 5-91	1 @ 1 mm , 1 @ 3 mm
2	Mar 11	1 @ 3 mm
3	Mar 18	1 @ 1 mm , 1 @ 3 mm
4	Mar 30	3 @ 1 mm , 3 @ 3 mm
5	Apr 20	2 @ 1 mm , 2 @ 3 mm
6	Mar 13	1 @ 1 mm , 1 @ 3 mm
7	Mar 6	1 @ 1 mm , 1 @ 3 mm

The light transmission through the samples were measured from 250 to 600 nm, in 0.2 nm steps, using a spectrophotometer (Spectronic 1201, from Milton Roy Co.) with the samples placed in air. The measured transmission through two samples (1 mm & 3 mm) from batch 5 are shown in Fig. 3. Since the transmission above 400 nm is the same for different thicknesses, it is assumed that all losses above 400 nm are reflective losses at the glass-air interfaces. These losses are about 8% and are independent of wavelength. The reflective losses will be negligible when the PMTs are immersed in water because the refractive indices of glass and water are similar.

3 Absorption Coefficients

The bulk absorption coefficient $\alpha(\lambda)$ in cm^{-1} is obtained using the formula

$$\alpha(\lambda) = \frac{ln(T(587nm) - \Delta(\lambda)) - ln(T(\lambda))}{t}$$

where T is the light transmission, t is the sample thickness and $\Delta(\lambda)$ is a correction term for the dispersion ($\Delta(320nm) \approx 0.005$). The α's for the best (batch 1) and worst (batch 5) samples are shown in Fig. 4 & 5 from 250 nm to 400 nm. The best and worst samples measured are shown together in Fig. 6. All samples are better than the specification (0.5 cm^{-1} at 320 nm). Fig. 2 shows the absorption coefficients at 320 nm measured by Schott as the glass production went on. A decline of the transmission was observed after March 10, however all their data are still within the specification.

For completeness, Fig. 7 to 13 show the α's for all seven batches from 280 to 400 nm and Fig. 14 shows the actual measured transmission for the best and worst samples used to obtain the curves in Fig. 6. Also shown in Fig. 14 is the transmission expected through 5 cm of acrylic with the absorption coefficients assumed in the vessel design criteria document.

4 Relevence to SNO

To quantitatively study the consequence to SNO of the optical transmission through the various materials in SNO, a computer program has been written. It folds together the Čerenkov spectrum emitted from randomly distributed vertices inside the D_2O, the light transmissions through the D_2O, the acrylic and the H_2O and the PMT quantum efficiency. It calculates, for the different glass samples, the fraction of Čerenkov photons which finally produce photoelectrons. The PMT quantum efficiency (probability to produce a photoelectron for a photon striking the glass) is assumed to be the product of the light transmission through the glass and the internal quantum efficiency (probability to produce a photoelectron for a photon striking the photocathode). The quantum efficiency is as provided by Queen's for Tube R1408, Serial # ZW535. The water absorption coefficients are as reported in

the white book SNO-87-12, measured at NRC, and the acrylic coefficients are as in the vessel design criteria document.

The bulk of the Čerenkov light is lost at the shorter wavelengths and the acrylic has a much more severe cut-off then the glass as illustrated in Fig. 14, therefore the importance of the glass optical transmission becomes relatively insignificant for SNO. In fact, only 1% of the detectable light is lost going from the best glass sample to the worst. An additional 2% of the light is lost going from 1.5 mm thick glass to 3.5 mm thick glass, as allowed for in the specifications.

We can hope that much better acrylic will be obtained and, if so, the glass attenuation may become relatively more significant. Assuming no acrylic in the way but with the same water thicknesses, 3% of the detectable light is lost going from the best glass sample to the worst and the additional losses due to 2.5 mm thicker glass could be as high as 5%.

5 Conclusions

The bulk absorption coefficients of the Schott glass samples are within the specifications. The variations in the light transmission between samples are small, as also are the variations expected due to different glass thicknesses. Because of the other factors affecting light transmission in the SNO detector, the light absorption of the glass is unimportant. However in some other application, variations in α and thickness from tube to tube could be relevent in tube selection.

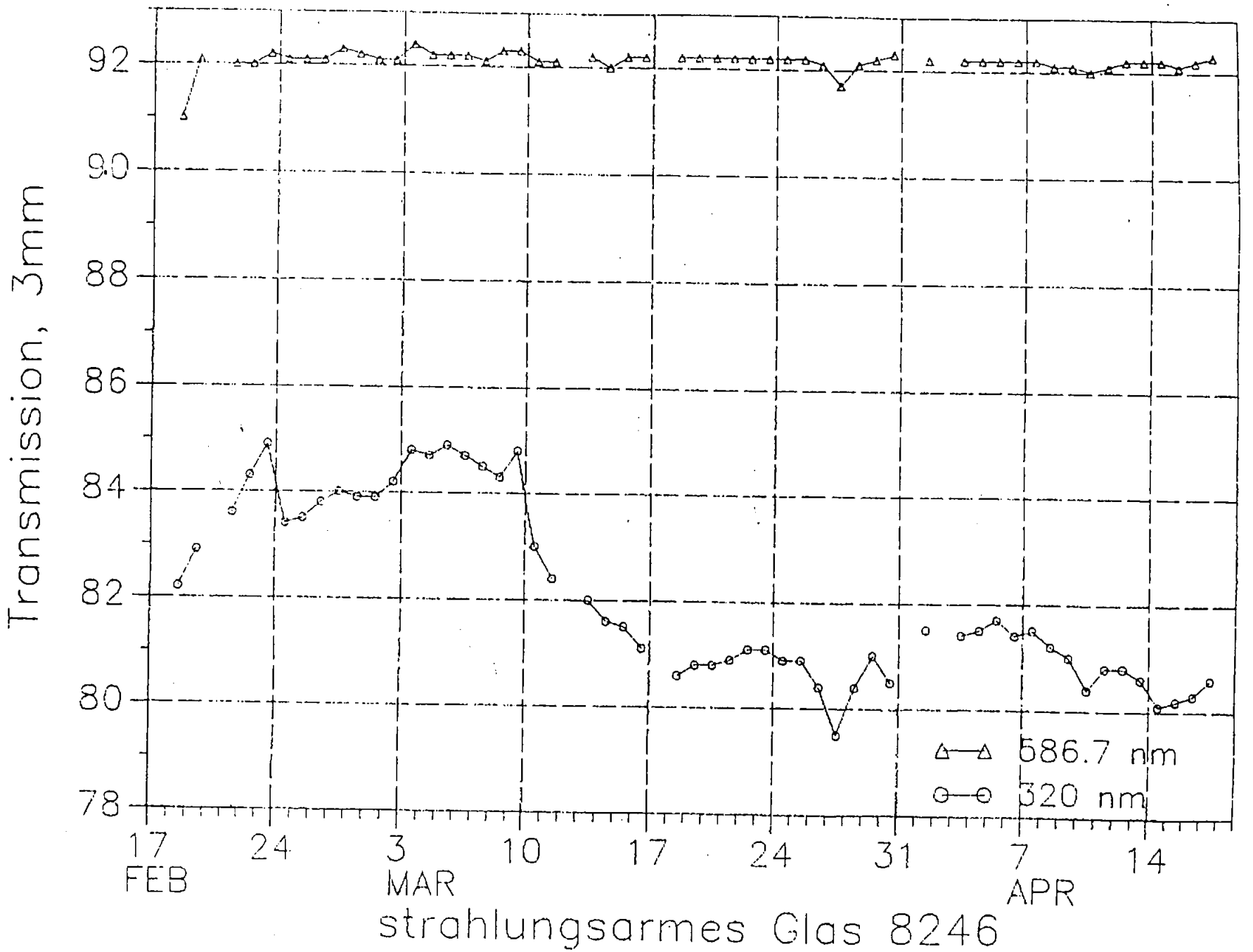
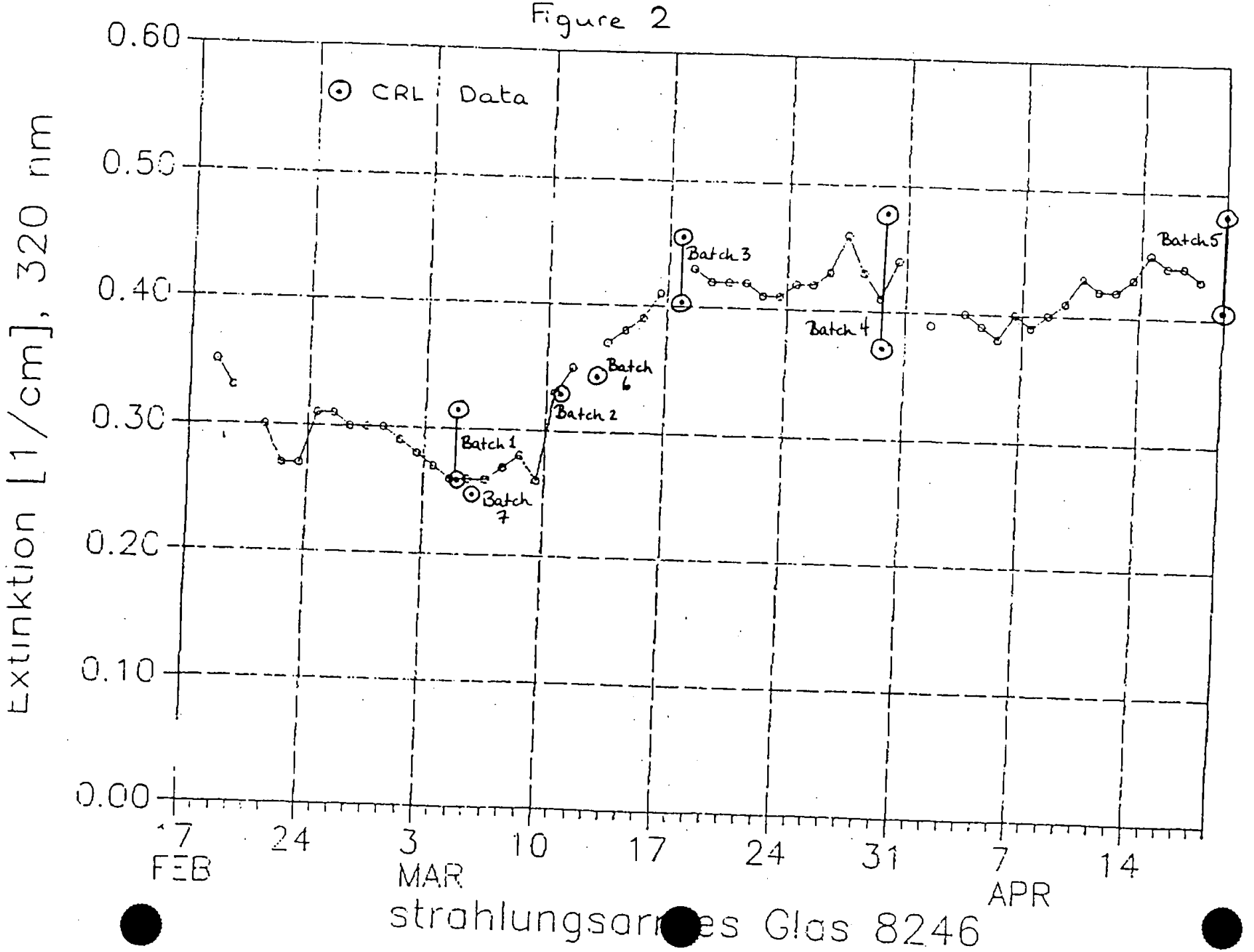

Transmission, 3mm
92
90
88
86
84
82
80
78
17
FEB
24
3
MAR
10
17
24
31
7
APR
14
586.7 nm
320 nm
strahlungsarmes Glas 8246

Figure 2


0.60
0.50
0.40
0.30
0.20
0.10
0.00
Extinktion [1/cm], 320 nm
CRL Data
Batch 1
Batch 2
Batch 3
Batch 4
Batch 5
Batch 6
Batch 7
17
24
3
10
17
24
31
7
14
FEB
MAR
APR
strahlungsarmes Glas 8246

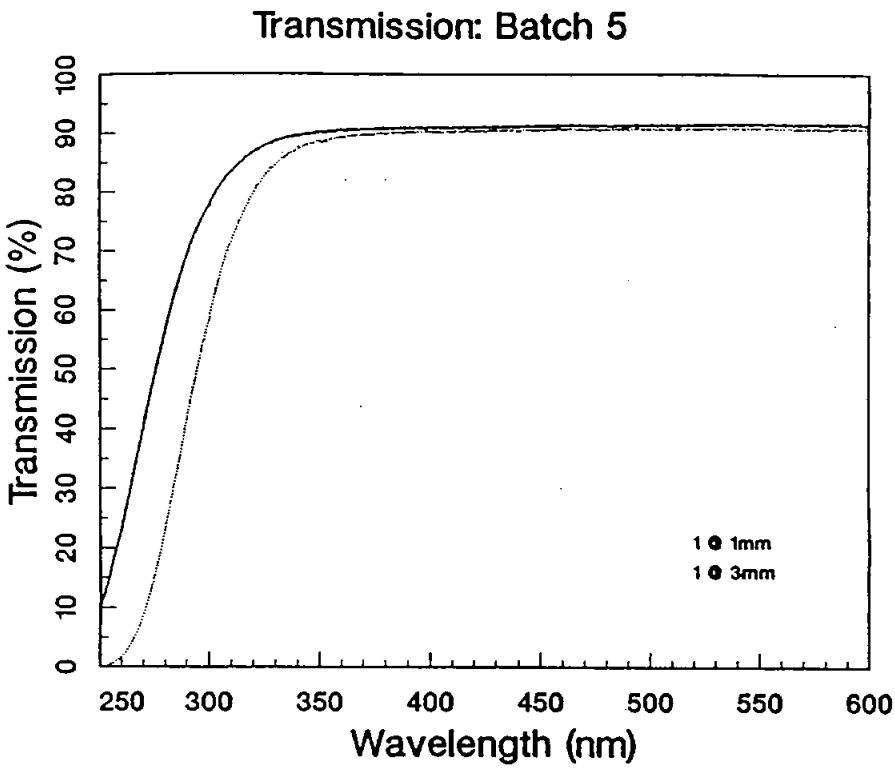


Figure 3

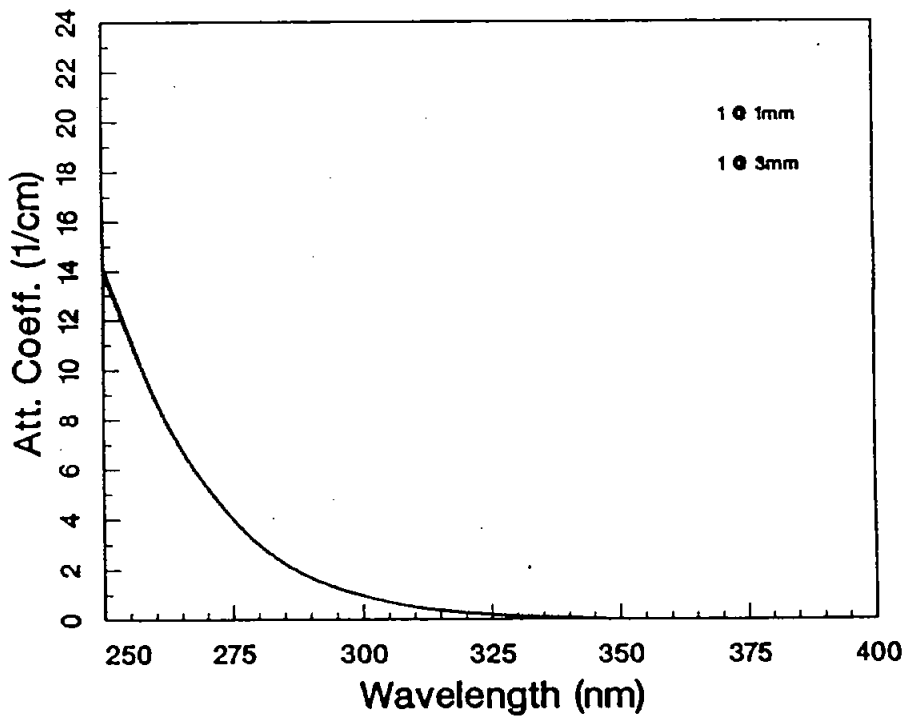


Figure 4

Batch 5

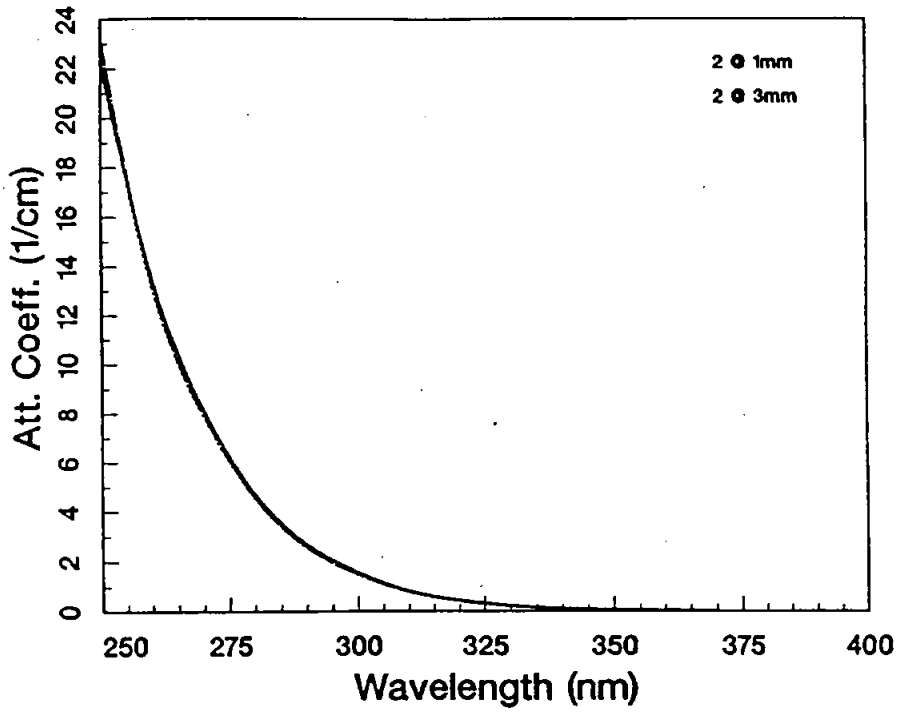


Figure 5

Best and Worst Curves

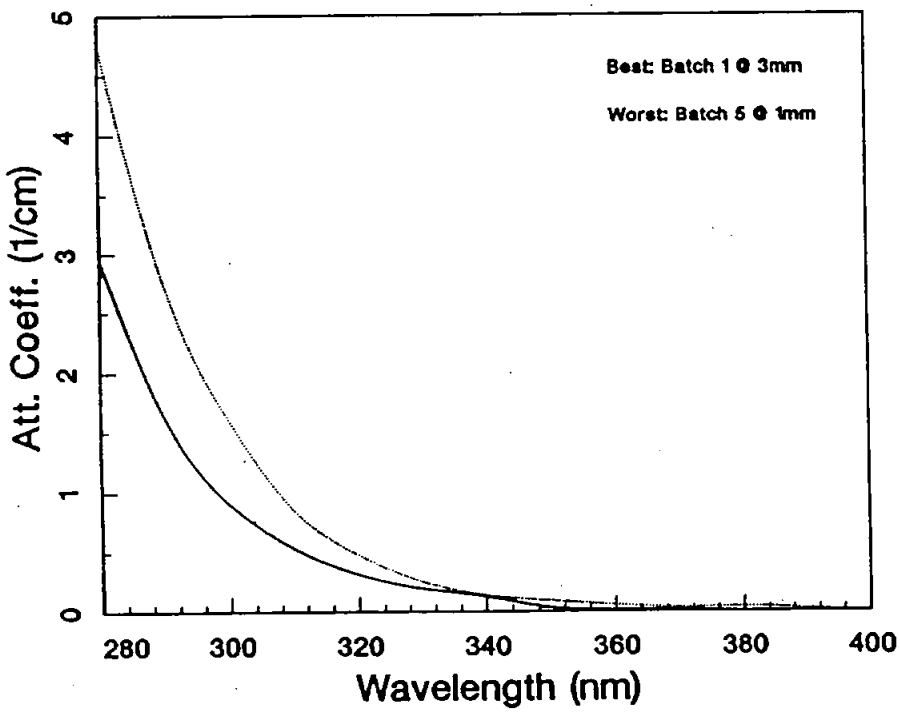


Figure 6

Batch 1

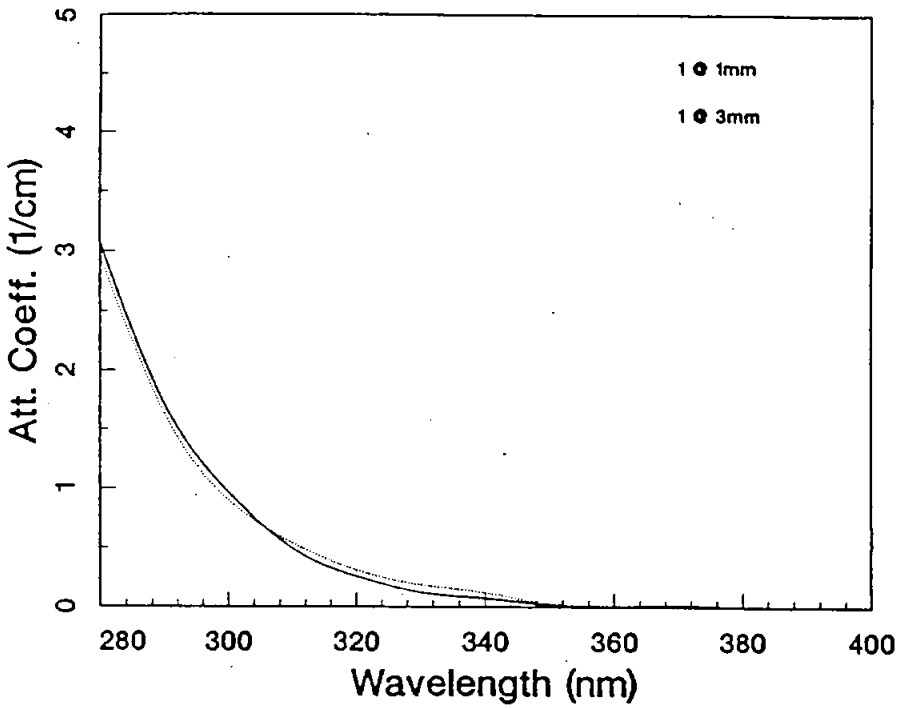


Figure 7

Batch 2

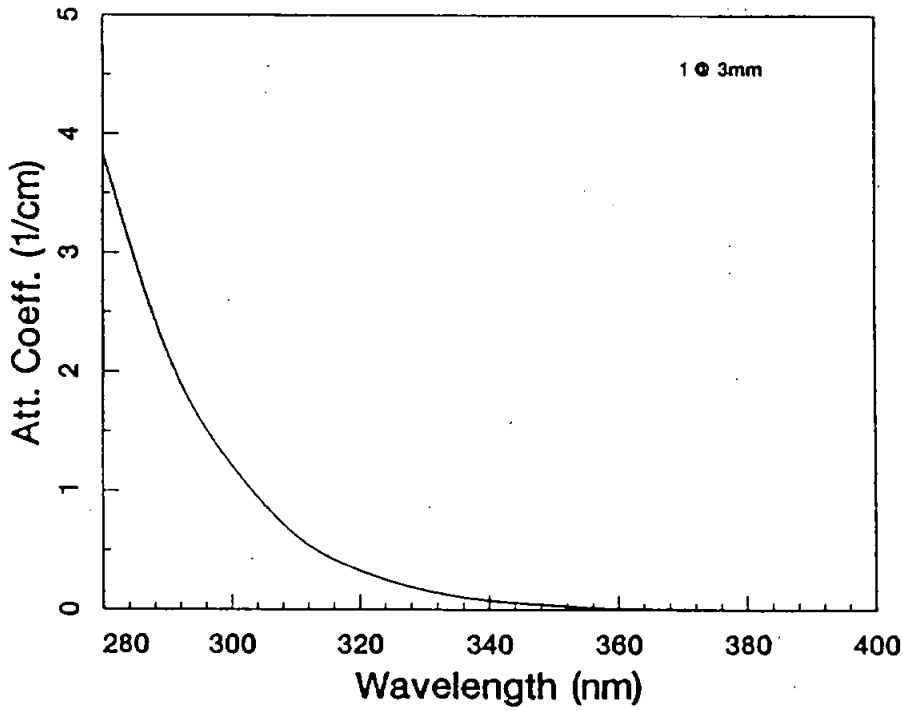


Figure 8

Batch 3

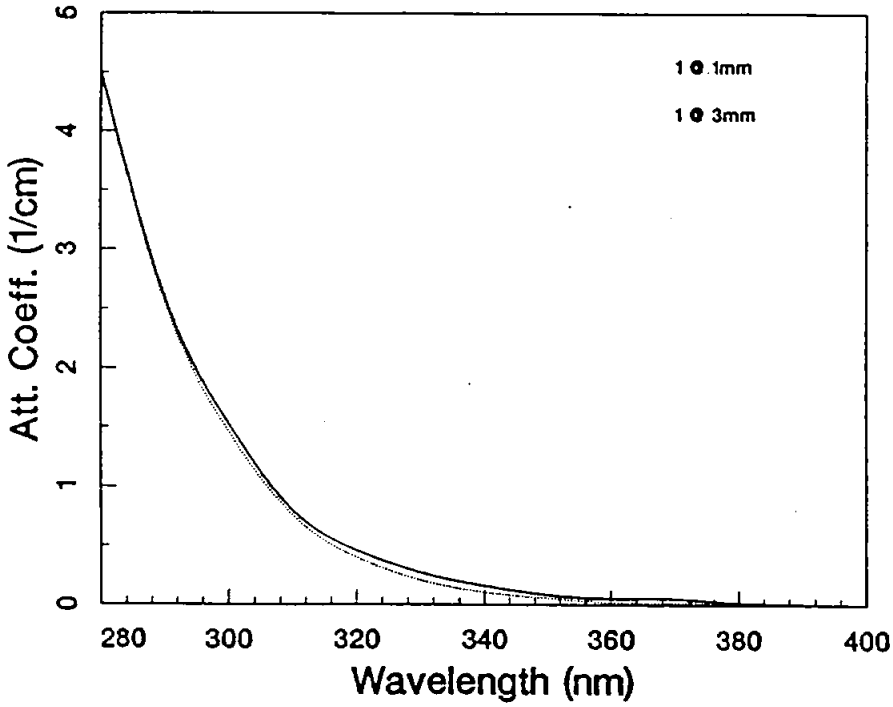


Figure 9

Batch 4

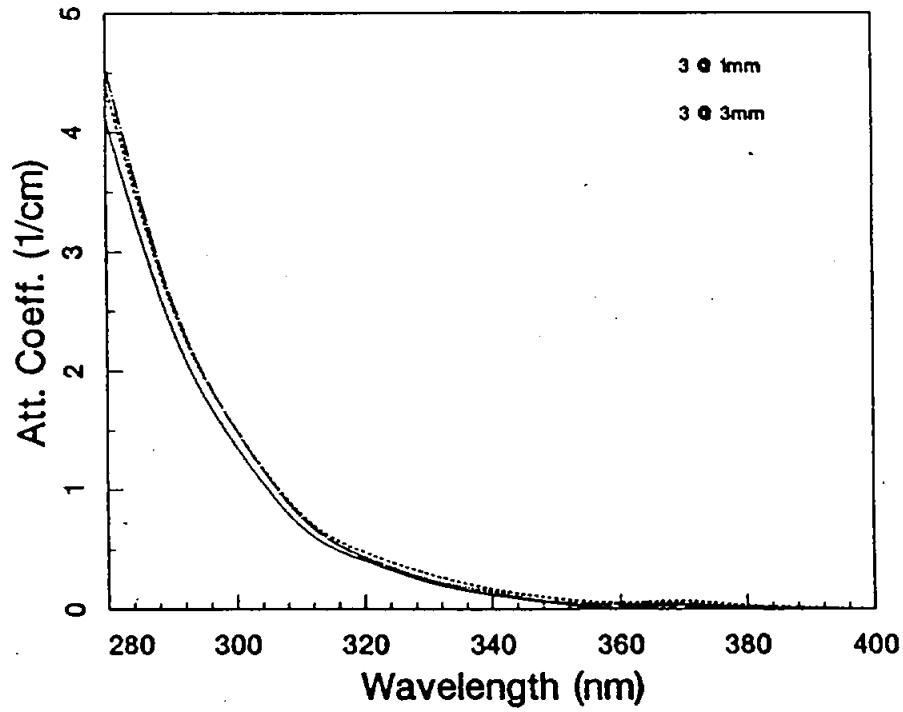


Figure 10

Batch 5

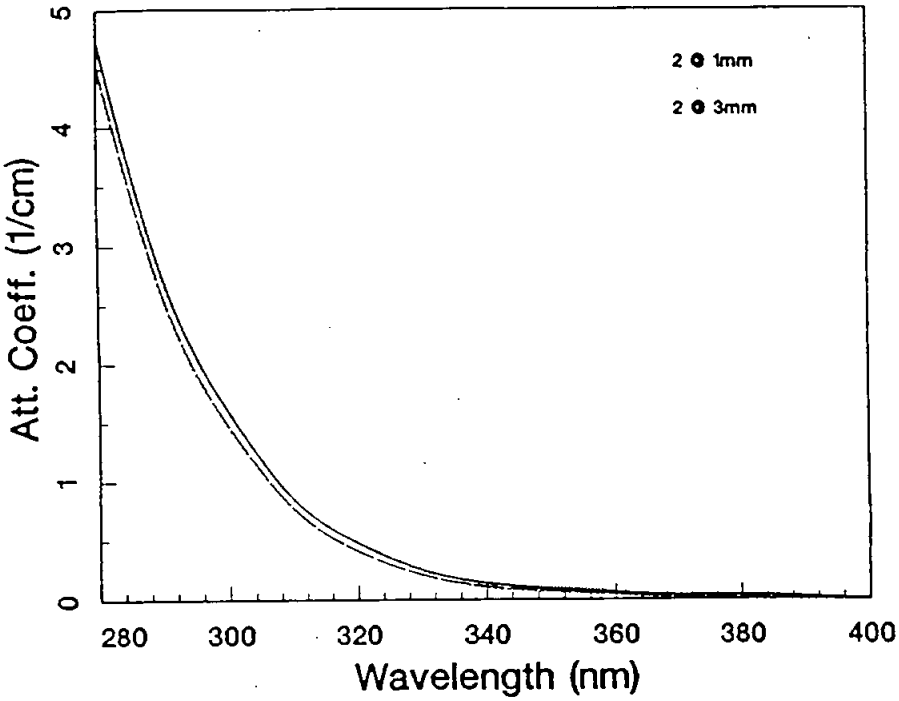


Figure 11

Batch 6

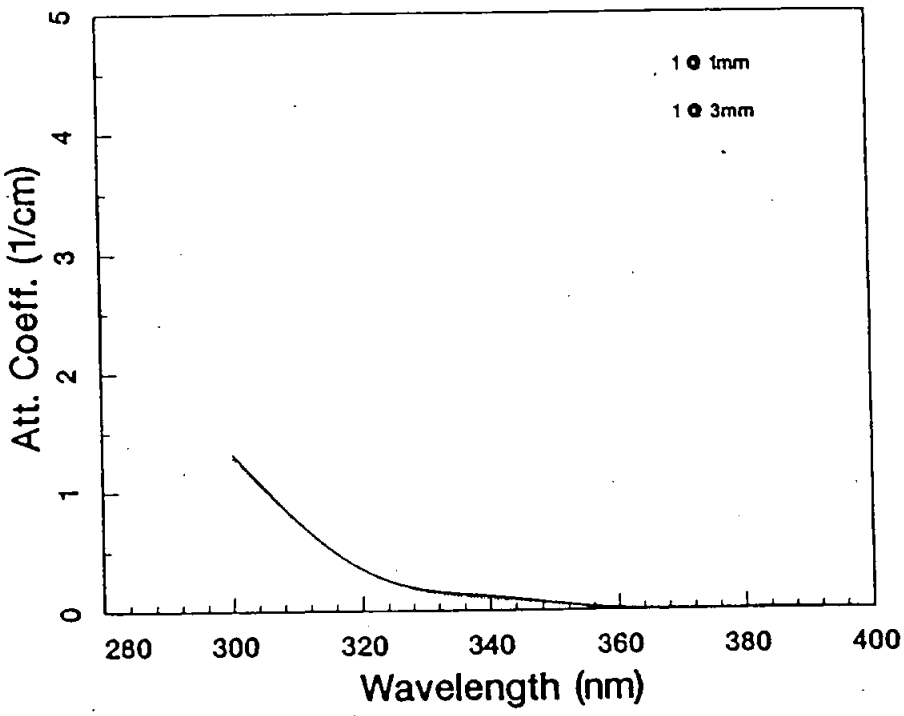


Figure 12

Batch 7

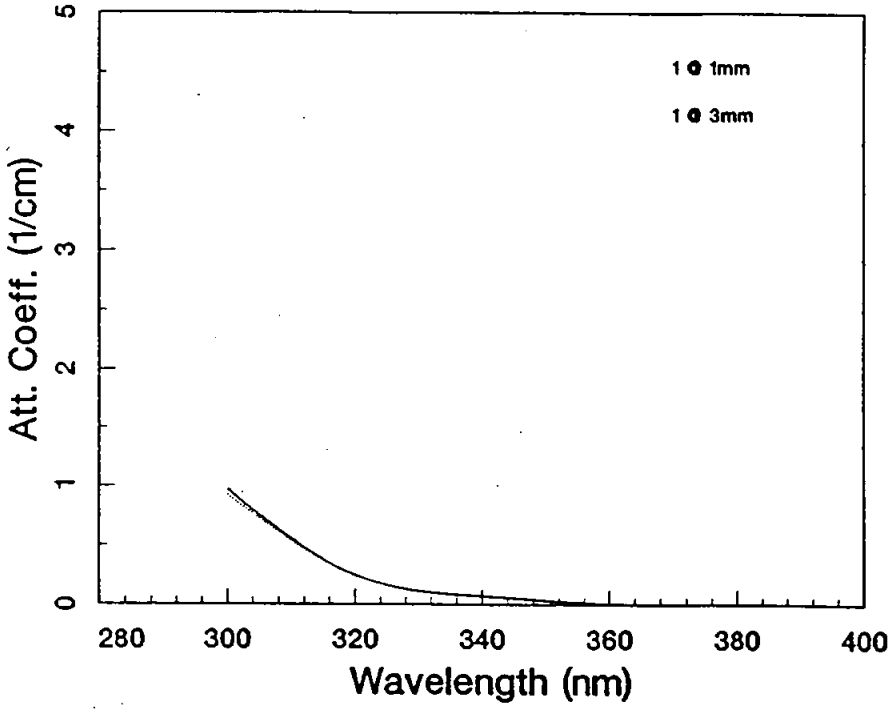


Figure 13

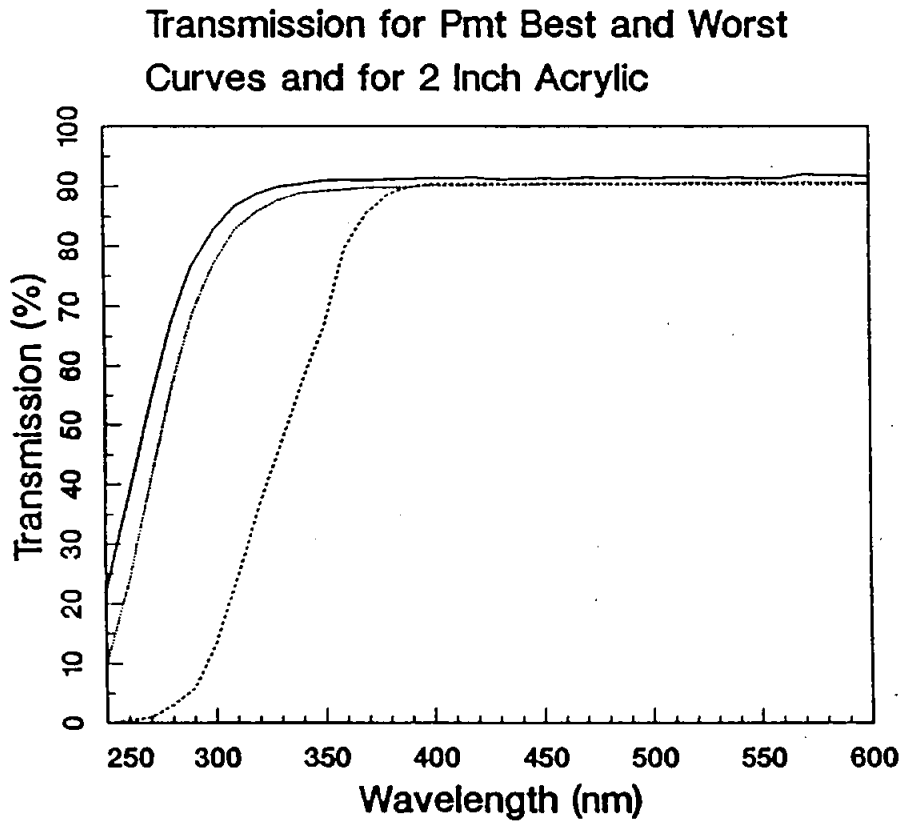


Figure 14

WD-Differenz w.t.-variation	Wanddicke wall thickness	Durchmesser diameter
max 1.0	2.0-4.0	ø70±1
		Rachenlehre 04-765 gauge
max 1.0	1.5-3.5	ø204±2
		Doppelringlehre 04-763 gauge
	1.5-3.3	

Kugellehre 04-542 min ø61 gauge

Kontrollzone
control area

≈30

M1

Zone B

M2

Zone A

M3

≈ø120

R126

abgeschmolzen
fire-cut

Konturlehre 04-743
gauge

R30

R126

R60

(90.9)

(50.91)

(50.91)

(75.09)

220±2 Höhenlehre 04-764 gauge

Index	Änderung von	Datum	Name
A5349-00-02e	≈ø120, Doppelringlehre und Höhenlehre hinzu	23-NOV-90	MGe
A5349-00-02d	ø70±1 war ø71±1, min ø61 war min ø59, WD geändert	10-SEP-90	MGe/JSch
A5349-00-02c	ø71±1 war ø64±1, min ø59 hinzu, WD + Endenbearb. geänd.	2-APR-90	MGe/JSch
A5349-00-02b	"abgesprengt" war "geschnitten Ø65 und feuerpoliert"	19-DEC-89	MGe
A5349-00-02a	"geschnitten Ø65 und feuerpoliert" war "abgeschmolzen"	13-APR-89	MGe/JSch

	Datum	Name
Bearb.	9-MAR-89	GEIER
Gepr.	10-MAR-89	JSch

zul. Abw. | Oberfläche

Werkstoff: Glasart 8246 | Stück: * | Gewicht: * | Pos: *

Benennung: Kolben für Photomultiplier
Fa. Hamamatsu, HBP-204 HE
Art.-Nr. 3289 2633 9

Maßs: 1:*

SCHOTT
SCHOTT GLASWERKE
Werk Mainz
Industrial Engineering Mtl

Form-Nr. E2633

Zeichnungsnummer: A5349-00-02e | Index: * | A3

Ers. f.: A5349-00-02d

Schutzvermerk nach DIN 34 beachten

Telefax

SCHOTT

Empfänger /To

LOS ALAMOS NATIONAL LABORATORIES,
LOS ALAMOS, NEW MEXICO/U.S.A.
Attn.: Dr. Robterson
- Physics Division -

cc: VG-AH|WH

Schott Glaswerke
Hattenbergstraße 10
D-6500 Mainz 1

Absender/From FVE San/Lutt

Telefon/Phone 06131/66-3752

Telefax/Fax 06131/66-2007

Nr./No. 57 Seiten/Pages 4

Datum/Date March 18, 1991

Sollte die angegebene Seitenzahl nicht vorliegen, bitten wir um sofortige Nachricht

If you do not receive all of these pages, please call us back as soon as possible.

YOUR TELEFAX DATED MARCH 17, 1991

1. I can recall this paragraph and therefore we will ship in the next days the second pallet with another 80 pcs. for a quality check at HAMAMATSU.

   I did not have a copy of this appendix C regarding the delivery schedule for which I thank you.

   Shall now 20 additional bulbs also be shipped to HAMAMATSU or are these the bulbs which will shortly leave for QUEEN'S UNIVERSITY?

   I received today a detailed report on the quality inspection of the first 80 pcs., copy of which I enclose to this telefax.

   On page 2, telefax of SCHOTT NIPPON there is again reference to the 27 pcs. from the pot melt which were also in detail inspected by HAMAMATSU. Among those they found a lot of rejects, but we knew this in the beginning as the quality level of a pot melt is not to compare to that of a tank melt.

   As everything looks positive you could perhaps waive the visit, but I would leave this to your decision.

2. I will pass a copy of your letter to Dr. Brix and he can send off the samples for the measuring of transmission.

   We obviously did not receive the draft subcontract of January 30, 1991 and would appreciate your sending us copies.

...

3. I thank you for your help also in this case although you are not directly involved.

Best regards,

- Electroglass Sales Dept. -

H. Stappen

Telefax

SCHOTT NIPPON
Tel: (03) 239 0851
Fax: (03) 230 1564
P.O.Box Kojimachi 64
Tokyo/Japan

SCHOTT MAINZ
Attn. Stappen-San/FVE

Fax No. E-0155/18.03.91

Lohn, Tsch
Kee, Reg
LANL

Hamamatsu Photonics - SNO Bulbs
Our FAX E-0153/15.03.91

We inform details of their income inspection result for 80 pcs as follows;

Inspection Items :

Item	Spec.	Inspection method
(A) Wall thickness of M1	2.0-4.0 mm ✓	Ultra sonic thickness measuring equipment
(B) Wall thickness of M2	2.0-4.0 mm 1,5-3,5	Ultra sonic thickness measuring equipment
(C) Wall thickness of M3	2.0-4.0 mm 1,5-3,3	Ultra sonic thickness measuring equipment
(D) Total Length	218-222 mm ✓	Inspection gauge
(E) O.D.(M2)	Dia. 202-206 mm ✓	Inspection gauge
(F) O.D.(M1)	Dia. 69-71 mm ✓	Inspection gauge
(G) I.D. of neck	Min. dia. 61 mm ✓	Inspection gauge
(H) Bubble		Visual
(I) Striae		Visual
(J) Dirt		Visual
(K) Scratch		Visual
(L) Knot/Stone		Visual

Regarding the actual data for the above, please refer to the attached sheets.

Telefax

SCHOTT NIPPON
Tel: (03) 239 0851
Fax: (03) 230 1564
P.O.Box Kojimachi 64
Tokyo/Japan

Conclusion :

All bulbs are within the spec. and problems which H-P pointed out concerning 27 pcs samples are solved.(see below comparison)

Problems to be solved in former time	This time
* Thicker wall thickness in M1 (more than 60% was over 3 mm)	Over 3 mm is 15 %
* Thicker wall thickness in fire-cut part	OK
* Bubbles in zone A	OK
* Striae	Almost nothing
* Deformed shape	Nothing (but there are circular streaks in top of dome)**
* Dirt	Nothing
* Knot/Stone	OK
* Dust/Scratch caused by packing	OK

** : Regarding circular streaks in top of dome, H-P treat as striae. (They treat bulbs which are put "X" marking on the cartons as limit sample of striae.)

If you have any unclear matters, please let us know.

Regards T. OHKUBO

T. Ohkubo

H-P / Test result of 8 inch bulb

			(A)		(B)		(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
	Lot No.	Schott (M1)	HPK	Schott (M2)	HPK	Schott (M3)	HPK	Length	O.D.	O.D.	I.D.	Bubbles	Striae	Discolorations	Scratches	Stones
		Max-Min		Max-Min		Max-Min		220	204	70	61					
1	1028	2.8-2.6	2.5	2.7-2.2	2.3	2.5-2.2	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
2	1045	3.8-3.1	3.0	2.7-2.4	2.3	2.2-1.9	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
3	1007	2.9-1.7	2.7	2.7-2.4	2.2	2.2-2.0	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
4	1014	3.3-3.0	2.6	2.6-2.3	2.3	2.1-1.9	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
5	1004	3.3-3.0	2.9	2.5-2.3	2.2	2.5-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
6	990	3.5-3.4	3.2	2.4-2.1	2.1	2.5-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
7	1020	2.8-2.7	2.6	2.5-2.2	2.2	2.5-2.2	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
8	996	3.5-3.2	3.2	2.4-2.2	2.3	2.6-2.3	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
9	998	3.4-3.2	3.2	2.4-2.1	2.4	2.5-2.1	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
10	1011	3.4-3.1	3.1	2.4-2.3	2.3	2.8-2.5	2.4	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
11	999	3.5-3.2	3.2	2.3-2.0	2.1	2.5-2.2	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
12	1009	3.5-3.3	3.1	2.7-2.5	2.3	2.3-2.1	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
13	1015	3.1-2.9	2.8	2.6-2.3	2.4	2.8-2.3	2.6	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
14	1034	3.3-3.1	2.9	2.5-2.2	2.2	3.1-2.4	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
15	1010	3.5-2.9	3.0	2.6-2.4	2.4	2.4-1.9	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
16	1023	3.5-3.4	3.2	2.3-2.1	2.1	3.0-2.0	3.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
17	1030	3.3-3.1	3.0	2.6-2.4	2.4	2.2-2.0	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
18	1063	3.5-3.2	3.1	2.5-2.2	2.2	2.2-1.9	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
19	1053	2.7-2.6	2.5	2.4-2.3	2.2	2.6-2.1	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
20	1047	3.8-3.2	3.0	3.2-2.3	2.5	2.4-1.9	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
21	1054	3.2-3.0	2.4	2.6-2.2	2.2	2.1-1.7	1.8	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
22	1051	3.4-3.2	3.1	2.5-2.3	2.3	2.7-1.9	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
23	1019	3.1-2.9	2.9	2.4-2.2	2.3	2.6-2.2	2.4	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
24	1050	2.9-2.8	2.6	2.7-2.5	2.4	2.3-1.9	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
25	1056	3.0-2.7	2.6	2.6-2.2	2.2	2.4-1.9	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
26	1048	3.2-2.9	2.8	2.6-2.3	2.3	2.7-2.2	2.6	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
27	1057	3.2-2.7	2.5	2.8-2.4	2.3	2.3-2.0	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

H-P / Test result of 8 inch bulb

	Lot No.	Schott (M1) Max-Min	(A) HPK	Schott (M2) Max-Min	(B) HPK	Schott (M3) Max-Min	(C) HPK	(D) Length	(E) O.D.	(F) O.D.	(G) I.D.	(H) Bubbles	(I) Striae	(J) Discolorations	(K) Scratches	(L) Stones
								220	204	70	61					
28	1055	3.0-3.0	2.8	2.7-2.5	2.5	2.3-2.0	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
29	1046	3.2-3.0	2.6	2.5-2.3	2.1	2.0-1.8	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
30	1049	3.0-2.7	2.6	2.4-2.2	2.2	2.4-2.1	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
31	1060	3.1-2.9	2.7	2.6-2.3	2.3	2.5-1.9	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
32	1064	2.9-2.6	2.3	2.5-2.3	2.2	2.4-2.1	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
33	1058	3.3-2.9	2.8	2.6-2.3	2.2	2.3-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
34	1033	3.2-3.0	2.7	2.5-2.3	2.3	2.7-2.3	2.6	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
35	988	2.4-2.3	2.1	2.5-2.2	2.1	2.5-2.3	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
36	1031	3.1-2.7	2.7	2.5-2.3	2.4	2.2-1.9	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
37	1061	3.3-3.0	2.6	2.5-2.3	2.4	2.5-2.2	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
38	1035	3.2-3.0	3.0	2.7-2.2	2.5	2.6-2.0	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
39	1029	3.2-2.9	2.7	3.2-2.4	2.2	2.2-2.0	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
40	1021	3.0-2.9	2.8	2.4-2.2	2.3	3.1-2.4	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
41	1052	3.2-2.8	3.0	2.6-2.4	2.3	2.5-2.1	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
42	1026	3.1-2.9	2.9	2.3-2.1	2.0	2.4-2.1	2.4	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
43	1044	3.6-3.0	2.6	2.4-2.1	2.1	2.1-1.8	1.8	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
44	1032	3.2-2.9	2.7	2.5-2.2	2.1	2.4-2.2	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
45	1059	3.4-2.9	2.7	2.6-2.4	2.3	2.4-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
46	1062	3.3-3.0	2.7	2.6-2.4	2.3	2.8-2.1	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
47	1027	3.2-3.0	2.9	2.6-2.3	2.2	2.1-1.8	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
48	1008	3.6-3.2	2.9	2.5-2.3	2.1	2.1-1.9	1.8	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
49	980	3.7-3.5	3.4	2.4-2.2	2.2	2.2-1.9	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
50	1002	3.4-3.2	2.9	2.4-2.2	1.9	2.7-2.0	2.5	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
51	1011	3.9-3.4	3.7	2.5-2.2	2.2	2.4-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
52	1043	3.0-2.8	2.6	2.7-2.3	2.3	2.2-1.9	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
53	994	3.3-3.0	2.7	2.3-2.2	2.1	2.6-2.1	2.4	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
54	996	3.7-3.2	3.1	2.7-2.4	2.4	2.0-1.8	1.7	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

H-P / Test result of 8 inch bulb

			(A)		(B)		(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
	Lot No.	Schott (M1)	HPK	Schott (M2)	HPK	Schott (M3)	HPK	Length	O.D.	O.D.	I.D.	Bubbles	Striae	Discolorations	Scratches	Stones
		Max-Min		Max-Min		Max-Min		220	204	70	61					
55	1012	3.4-3.2	2.9	2.3-2.2	2.1	2.5-2.1	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
56	1000	3.1-2.7	2.9	2.5-2.1	2.2	2.7-2.3	2.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
57	995	2.8-2.7	2.6	2.4-2.2	2.2	2.7-2.1	2.7	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
58	982	2.9-2.8	2.7	2.8-2.3	2.7	2.2-1.9	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
59	979	2.6-2.4	2.3	2.5-2.3	2.0	2.0-1.8	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
60	1022	3.2-2.9	2.7	2.4-2.1	2.1	2.2-1.9	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
61	1037	3.6-3.4	3.1	2.5-2.2	2.1	2.6-2.1	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
62	1018	3.5-3.3	3.1	2.5-2.3	2.4	2.4-2.2	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
63	992	3.5-3.2	3.1	2.7-2.3	2.4	2.2-1.8	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
64	1005	3.1-2.7	2.7	2.6-2.4	2.7	2.3-1.9	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
65	997	3.6-3.2	3.2	2.2-2.1	2.1	2.6-2.2	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
66	1008	3.5-3.2	3.1	2.6-2.3	2.4	2.3-2.0	1.9	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
67	981	3.4-3.2	3.1	2.5-2.3	2.3	2.1-1.7	1.8	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
68	989	3.6-3.2	2.9	2.4-2.1	2.3	2.3-1.8	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
69	1006	3.1-2.9	2.7	2.4-2.1	2.3	2.4-2.1	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
70	1038	3.2-2.9	2.8	2.5-2.2	2.5	2.6-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
71	1036	3.4-3.0	3.0	2.6-2.2	2.3	3.0-2.2	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
72	1039	3.3-2.9	2.7	2.5-2.3	2.4	2.8-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
73	1042	3.4-3.1	2.8	2.5-2.3	2.3	2.3-1.9	2.0	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
74	991	3.6-3.3	3.2	2.3-2.1	2.0	2.4-2.2	2.3	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
75	1001	3.9-3.4	3.2	2.3-2.1	2.0	2.6-2.1	2.4	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
76	1013	3.3-2.9	2.8	2.5-2.4	2.4	2.6-2.0	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
77	1040	3.2-2.8	2.4	2.3-2.2	2.1	2.2-1.9	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
78	1025	2.9-2.6	2.6	2.6-2.4	2.5	2.4-2.1	2.2	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
79	1017	3.1-2.9	2.9	2.4-2.3	2.3	2.5-2.3	2.4	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
80	1016	3.5-3.4	3.1	2.4-2.3	2.1	2.2-1.9	2.1	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

Telefax

SCHOTT

Empfänger /To

LOS ALAMOS NATIONAL LABORATORY,
LOS ALAMOS, NEW MEXICO/U.S.A.
Attn.: Dr. Robertson
- Physics Division -

cc: VG - AM / WM

Schott Glaswerke
Hattenbergstraße 10
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Absender/From FVE San/Lutt

Telefon/Phone 06131/66-3752

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Nr/No. 406 ~~Seiten~~/Pages 5

Datum/Date April 23, 1991

Sollte die angegebene Seitenzahl nicht vorliegen, bitten wir um sofortige Nachricht

If you do not receive all of these pages, please call us back as soon as possible.

Dear Dr. Robertson,

enclosed please find copies of HAMAMATSU'S inspection reports of airshipment no. 2 and 3.

They reject 1 piece of the second shipment and we have asked them to send us this piece.

Out of the third shipment no bulb is rejected although some show defects which, however, are all within the specification.

I'm very happy with this result which gives me confidence also for the following shipments and consequently for all the bulbs we have in stock.

We have in the meantime finished the production for you and have as a total result 16.092 good pieces in stock.

It is not intended to make any further bulbs.

We are at present making the glass for the BOREX-project and, towards the end of this production, getting into more and more troubles with bubbles. Although we do all the necessary we are not able to control and to detect the reasons for that. It was today decided that by end of this week, we will stop production of glass 8246.

With best regards,

- Electroglass Sales Dept. -

Herbert Stappen

Enclosures

Inspection Result of SNO Bulb
(2nd Shipment)

#8246　8INCH ﾊﾞﾙﾌﾞ　検査結果 (2)　　検査日 1991 /04 /09　戸塚

23 APR. 1991 FME

	LOT.	SCHOTT (M1) MAX - MIN	HPK	SCHOTT (M2) MAX - MIN	HPK	SCHOTT (M3) MAX - MIN	HPK	全長 220	外径 204	外径 70	内径 61	泡	脈理	汚れ	キズ	ｸﾞﾘ
1	5267	3.2-2.9	3.0	2.0-1.9	2.0	2.9-2.6	2.9	○	○	○	○	○	○	○	○	○
2	3509	2.8-2.4	2.5	2.4-2.2	2.3	2.3-1.9	2.0	○	○	○	○	○	○	△	○	○
3	4187	2.7-2.5	2.6	2.7-2.0	2.3	3.0-2.3	2.2	○	○	○	○	○	○	○	○	○
4	6508	2.6-2.2	2.3	2.7-2.6	2.8	2.5-2.3	2.4	○	○	○	○	○	○	○	○	○
5	2843	2.6-2.1	1.9	2.7-2.2	2.5	2.3-2.0	1.9	○	○	○	○	○	○	○	○	○
6	2587	3.5-3.2	3.1	2.5-2.2	2.2	3.1-2.6	2.6	○	○	○	○	○	○	○	○	○
7	5269	3.1-2.7	2.8	2.2-1.8	1.9	2.8-2.3	2.1	○	○	○	○	○	○	○	○	○
8	3510	3.3-2.4	2.7	2.2-2.1	2.2	2.5-2.1	2.3	○	○	○	○	○	○	○	○	○
9	6504	3.1-3.0	3.0	2.6-2.3	2.7	2.4-2.2	2.3	○	○	○	○	○	○	○	○	○
10	3512	2.6-2.3	2.6	2.3-2.1	2.3	2.7-2.4	2.3	○	○	○	○	○	○	○	△	○
11	4186	2.8-2.7	2.5	3.0-2.1	2.2	3.1-2.4	2.3	○	○	○	○	○	○	○	○	○
12	5858	3.2-3.2	2.9	2.4-2.1	2.3	2.6-2.3	2.2	○	○	○	○	○	○	○	○	○
13	5859	3.2-3.2	3.0	2.1-1.8	2.0	2.8-2.5	2.6	○	○	○	○	○	○	○	○	○
14	3723	2.9-2.6	2.5	2.4-1.9	1.9	2.6-2.3	2.4	○	○	○	○	○	○	○	○	○
15	4593	3.2-2.9	2.9	2.0-1.9	2.0	2.4-2.2	2.6	○	○	○	○	○	○	○	○	○
16	4595	2.6-2.4	2.4	2.3-2.1	2.2	2.5-2.1	2.2	○	○	○	○	○	○	○	○	○
17	3508	2.6-2.3	2.3	2.2-2.0	2.2	2.5-2.7	2.3	○	○	○	○	○	○	○	○	○
18	4932	3.4-3.2	3.1	2.5-2.4	2.5	2.5-2.4	2.0	○	○	○	○	○	○	○	○	○
19	2588	3.7-3.3	3.1	2.3-2.3	2.2	3.3-2.9	2.5	○	○	○	○	○	○	○	○	○
20	4594	3.3-2.7	3.1	2.2-2.0	2.1	2.1-1.8	1.9	○	○	○	○	○	○	○	○	○
21	2586	3.0-2.6	2.7	2.5-2.2	2.1	3.0-2.2	2.2	○	○	○	○	○	○	○	○	○
22	2584	3.6-3.3	2.9	2.7-2.3	2.5	3.1-2.6	2.5	○	○	○	○	○	○	○	○	○
23	3032	2.8-2.4	2.7	2.0-1.8	2.0	2.6-1.7	2.9	○	○	○	○	○	○	○	○	○
24	2585	3.3-3.1	2.8	2.3-2.2	2.1	3.2-2.7	2.8	○	○	○	○	○	○	○	○	○
25	3511	2.9-2.3	2.5	2.3-2.0	2.3	2.8-2.1	2.6	○	○	○	○	○	○	○	○	○
26	4933	3.4-3.1	3.0	2.5-2.3	2.5	2.7-2.2	2.5	○	○	○	○	○	○	○	○	○
27	6210	3.1-2.8	2.8	2.6-2.0	2.1	2.6-2.3	2.1	○	○	○	○	○	○	○	○	○
28	4931	3.4-3.3	3.1	2.7-2.1	2.3	2.4-2.1	2.2	○	○	○	○	○	○	○	○	○
29	5270	3.3-2.9	2.8	2.2-1.9	1.9	2.8-2.5	2.6	○	○	○	○	○	○	○	○	○
30	3727	3.1-2.5	2.0	2.9-2.3	2.2	3.2-2.6	2.5	○	○	○	○	○	○	○	○	○
31	3988	3.4-3.2	3.3	2.3-2.1	2.5	2.8-2.7	2.5	○	○	○	○	○	○	○	○	○
32	3219	3.3-3.0	2.9	2.3-2.1	2.3	2.9-2.5	2.5	○	○	○	○	○	○	○	○	○
33	3726	4.0-3.7	2.8	2.7-2.5	2.0	2.3-2.0	1.6	○	○	○	○	○	○	○	○	○
34	2842	3.4-2.7	2.5	2.3-2.1	2.3	2.4-2.0	2.0	○	○	○	○	○	○	○	○	○
35	3218	3.2-2.9	2.2	2.5-2.3	2.9	3.2-2.6	2.6	○	○	○	○	○	○	○	○	○
36	5538	3.2-2.7	2.7	2.2-2.0	2.1	2.1-1.9	2.0	○	○	○	○	○	○	○	○	○
37	3890	3.4-3.0	2.9	2.4-1.9	2.0	3.1-2.4	2.7	○	○	○	○	○	○	○	○	○
38	2844	2.6-2.4	2.4	2.5-2.3	2.0	2.8-2.3	2.2	○	○	○	○	○	○	○	○	○
39	6209	2.9-2.5	2.5	2.7-2.3	2.5	3.2-2.6	2.1	○	○	○	○	○	○	○	△	○
40	4930	2.8-2.7	2.5	2.9-2.2	2.3	2.8-2.3	2.1	○	○	○	○	○	○	○	○	○
								← Total Length (220mm)	← O.D. (204 mm)	← O.D. (70 mm)	← I.D. (61 mm)	← Bubble	← Strine	← Dirt	← Scratch	← Knot/Stone

球部の内面 (Inside of Bulb)

球部の外面 (Outside of Bulb)

口口 (End of Bulb)

○印は良品

△印は若干の問題はあるが良品域

×印は不良

良品率 99/80 (Ratio of good parts)

○ : O.K.

△ : Existing some defects but within the spec.

× : NG

#8246　8INCH バルブ　検査結果　(2')

	LOT. NO.	SCHOTT (M1) MAX - MIN	HPK	SCHOTT (M2) MAX - MIN	HPK	SCHOTT (M3) MAX - MIN	HPK	全長 220	外径 204	外径 79	内径 61	泡	脈理	汚れ	キズ	アバ	
41	4185	2.9-2.6	2.7	2.3-2.0	2.1	2.8-2.2	1.9	○	○	○	○	○	○	○	○	○	
42	3891	3.7-3.4	3.4	2.5-2.0	2.2	2.9-2.2	2.7	○	○	○	○	○	○	○	○	○	
43	3887	3.2-3.1	2.9	2.3-1.9	2.3	3.0-2.5	2.5	○	○	○	○	○	○	○	○	○	
44	6505	2.5-2.4	2.5	2.5-2.4	2.5	2.8-2.3	2.6	○	○	○	○	○	○	○	○	○	
45	3724	3.0-2.8	2.9	2.4-2.2	2.0	2.1-1.8	2.0	○	○	○	○	○	○	○	○	○	
46	5271	2.6-2.6	2.5	2.1-1.9	2.2	2.9-2.6	2.7	○	○	○	○	○	○	○	○	○	
47	3217	3.8-3.3	3.6	2.5-2.0	2.2	3.3-2.8	3.2	○	○	○	○	○	○	○	○	○	
48	6828	2.9-2.8	2.6	2.4-2.2	2.3	2.8-1.8	2.4	○	○	○	○	○	○	○	○	○	
49	5540	3.1-2.7	2.6	2.0-1.9	2.0	2.2-2.1	2.2	○	○	○	○	○	○	○	○	○	
50	3220	3.5-3.2	3.1	2.6-2.2	2.7	2.9-2.7	2.5	○	○	○	○	○	△	○	○	○	頂部の突起(Deformed Shape)
51	2845	2.8-2.2	2.2	2.4-2.2	2.4	2.3-2.1	2.0	○	○	○	○	○	○	○	○	○	
52	4188	2.6-2.4	2.4	2.6-2.0	2.1	2.6-2.4	2.3	○	○	○	○	○	○	○	○	○	
53	3030	2.5-2.6	2.3	2.2-2.0	2.2	2.0-1.6	1.8	○	○	○	○	○	△	○	○	○	頂部の突起(Deformed Shape)
54	3031	2.7-2.4	2.4	2.3-2.0	2.0	1.9-1.7	1.7	○	○	○	○	○	○	○	○	○	
55	5539	3.2-2.8	2.4	2.3-2.2	2.2	2.2-2.0	2.4	○	○	○	○	○	○	△	○	○	球部の内面(Inside of Bulb)
56	5860	3.1-3.1	3.0	2.5-2.1	2.2	2.7-2.3	2.3	○	○	○	○	○	○	○	○	○	
57	5268	3.0-2.9	2.7	2.3-1.9	2.0	2.8-2.5	2.8	○	○	○	○	○	○	○	○	○	
X 58	3221	3.2-3.1	2.9	2.4-2.2	2.2	3.1-2.3	2.7	○	○	○	○	○	×	○	○	○	頂部の突起 不良 (Deformed Shape)
59	2846	2.9-2.6	2.6	2.4-2.1	2.2	2.4-2.1	2.2	○	○	○	○	○	○	○	○	○	
60	6212	2.8-2.6	2.5	2.5-2.1	2.5	3.2-2.8	2.5	○	○	○	○	○	○	○	○	○	
61	3029	3.3-2.3	2.5	2.1-2.0	2.1	2.4-2.0	2.5	○	○	○	○	○	○	○	○	○	
62	3028	2.9-2.3	2.1	2.3-1.7	1.8	2.5-1.9	2.7	○	○	○	○	○	△	○	○	○	頂部の突起(Deformed Shape)
63	6211	3.2-2.9	2.7	2.4-2.2	2.4	2.9-2.6	2.3	○	○	○	○	○	○	○	○	○	
64	3725	3.9-3.2	2.5	2.4-1.7	2.1	1.9-1.6	1.6	○	○	○	○	○	○	○	○	○	
65	3889	3.4-3.3	3.2	2.3-2.1	2.1	2.9-2.7	3.0	○	○	○	○	○	○	○	○	○	
66	6827	2.8-2.7	2.6	2.4-2.3	2.3	2.8-2.2	2.1	○	○	○	○	○	○	○	○	○	
67	4596	2.3-2.1	2.1	2.1-2.0	2.0	2.3-1.9	2.0	○	○	○	○	○	○	○	○	○	
68	5541	2.7-2.5	2.2	2.5-2.3	2.4	2.3-1.9	2.2	○	○	○	○	○	○	○	○	○	
69	5542	2.9-2.3	2.3	2.2-2.1	2.1	2.5-2.0	1.9	○	○	○	○	○	○	○	○	○	
70	6507	3.0-2.8	2.8	2.6-2.5	2.5	2.7-2.3	2.4	○	○	○	○	○	○	○	○	○	
71	5861	3.5-3.1	2.7	2.3-1.9	2.0	2.7-2.2	2.6	○	○	○	○	○	○	○	○	○	
72	6829	3.1-3.0	2.8	2.5-2.3	2.3	2.6-2.5	2.4	○	○	○	○	○	○	○	○	○	
73	4597	2.5-2.4	2.4	2.1-2.0	2.0	2.3-2.0	2.1	○	○	○	○	○	○	○	○	○	
74	4929	3.2-3.0	3.0	3.2-2.4	2.4	3.3-2.2	2.3	○	○	○	○	○	○	○	○	○	
75	4189	3.0-2.8	2.8	2.7-2.2	2.0	2.9-2.5	2.3	○	○	○	○	○	○	○	○	○	
76	6826	3.4-3.2	3.0	2.7-2.5	2.6	2.4-2.0	1.7	○	○	○	○	○	○	○	○	○	
77	5862	3.7-3.3	3.0	2.3-2.1	2.2	2.6-2.4	2.2	○	○	○	○	○	○	○	○	○	
78	6825	2.9-2.6	2.5	2.5-2.2	2.3	2.4-2.0	1.8	○	○	○	○	○	○	○	○	○	
79	6506	2.5-2.1	2.0	2.5-2.4	2.3	2.5-2.2	2.2	○	○	○	○	○	○	○	○	○	
80	6208	3.0-2.8	2.7	2.1-2.0	2.0	2.9-2.6	2.4	○	○	○	○	○	○	○	○	○	

Inspection Result of SNO Bulb
(3rd Shipment)

#8246 8INCH ﾊﾞﾙﾌﾞ 検査結果 (3) 検査日 1991 /04 /15 (戸塚)

	LOT.	SCHOTT (M1) MAX - MIN	HPK	SCHOTT (M2) MAX - MIN	HPK	SCHOTT (M3) MAX - MIN	HPK	全長 220	外径 204	外径 70	内径 61	泡	加工汚れ	キズ	ブツ	
1	639	2.9-2.8	2.7	2.9-2.4	2.8	2.4-2.2	2.0	○	○	○	○	○	○	△	○	BZONE外キズ
2	78	3.3-2.3	2.5	2.6-2.2	2.0	2.5-2.0	2.0	○	○	○	○	○	○	○	○	(Outside of B Zone)
3	1615	3.0-2.8	2.5	2.5-2.2	2.5	2.3-2.1	2.2	○	○	○	○	○	○	○	○	
4	1851	3.4-3.1	3.0	2.3-2.2	2.1	2.2-2.1	2.1	○	○	○	○	○	○	○	○	
5	73	3.2-3.0	2.6	2.7-2.2	2.1	2.2-1.7	1.8	○	○	○	○	○	○	○	○	
6	2359	3.0-2.6	2.5	2.2-2.0	2.1	2.3-2.0	2.1	○	○	○	○	○	○	○	○	
7	67	3.7-3.4	3.0	2.6-2.3	2.3	2.2-1.9	2.0	○	○	○	○	○	○	○	○	
8	638	2.7-2.5	2.3	2.7-2.3	2.6	2.1-1.8	1.7	○	○	○	○	○	○	○	○	
9	1616	2.8-2.6	2.4	2.4-2.2	2.3	2.8-2.1	2.7	○	○	○	○	○	○	○	○	
10	77	2.6-2.4	2.3	2.2-2.0	1.9	2.4-2.0	2.1	○	○	○	○	○	○	○	○	
11	75	2.8-2.5	2.4	2.3-2.0	2.0	2.6-2.1	2.4	○	○	○	○	○	○	△	○	AZONE外側
12	552	3.1-2.9	2.5	2.4-2.3	2.3	2.3-2.0	2.0	○	○	○	○	○	○	○	○	(Outside of A Zone)
13	1967	3.4-2.9	3.1	2.6-2.4	2.4	2.5-2.1	2.1	○	○	○	○	○	○	○	○	
14	1612	3.0-2.7	2.6	2.5-2.2	2.3	2.4-2.1	2.4	○	○	○	○	○	△	○	○	頂部 (Top of Dome)
15	1966	3.1-2.7	2.7	2.3-2.1	2.0	2.6-2.1	2.3	○	○	○	○	○	○	○	○	
16	6	2.8-2.5	2.5	2.4-2.0	2.2	2.4-2.0	2.0	○	○	○	○	○	○	○	○	
17	1854	4.0-3.4	3.4	2.4-2.2	2.2	2.0-1.7	1.9	○	○	○	○	○	○	○	○	
18	1418	3.0-2.8	2.5	2.5-2.4	2.3	2.3-2.1	2.1	○	○	○	○	○	○	△	○	AZONEスリキズ
19	2176	3.0-2.6	2.6	3.0-2.0	2.4	2.8-2.5	2.1	○	○	○	○	○	○	○	○	(Outside of A Zone)
20	2355	3.2-2.9	2.7	2.3-2.0	2.1	2.2-1.7	2.0	○	○	○	○	○	○	○	○	
21	986	3.3-3.1	3.0	2.4-2.3	3.4	2.3-2.1	2.1	○	○	○	○	○	△	○	○	頂部 (Top of Dome)
22	80	2.7-2.5	2.3	2.5-2.1	2.1	2.5-2.4	2.3	○	○	○	○	○	○	○	○	
23	61	3.3-2.8	2.6	2.5-2.3	21.0	2.2-1.6	1.6	○	○	○	○	○	○	○	○	
24	984	3.6-3.0	3.3	2.5-2.1	2.2	2.3-1.9	2.0	○	○	○	○	○	○	○	○	
25	1192	3.5-3.3	3.2	2.2-2.1	2.1	2.4-2.2	2.0	○	○	○	○	○	○	○	○	
26	1965	3.1-2.9	2.9	3.1-2.3	2.3	2.8-2.3	2.7	○	○	○	○	○	○	○	○	
27	774	2.8-2.7	2.4	2.9-2.6	2.8	2.0-1.7	1.9	○	○	○	○	○	○	○	○	
28	771	2.8-2.6	2.6	2.3-2.1	2.2	3.0-2.5	2.6	○	○	○	○	○	○	○	○	
29	1853	3.1-2.8	2.8	2.8-2.6	2.5	1.6-1.5	1.6	○	○	○	○	○	○	○	○	
30	2358	2.8-2.5	2.3	2.4-2.1	2.3	2.4-2.0	1.9	○	○	○	○	○	○	○	○	
31	569	3.6-3.4	3.3	2.3-2.2	2.1	1.9-1.7	1.8	○	○	○	○	○	○	○	○	
32	1964	3.0-2.7	2.5	2.6-2.3	2.6	2.5-2.1	2.2	○	○	○	○	○	○	○	○	
33	2357	3.3-2.8	2.9	2.3-2.0	1.8	2.1-1.6	1.7	○	○	○	○	○	○	○	○	
34	478	2.3-2.0	2.0	2.5-2.2	2.5	2.7-2.0	2.2	○	○	○	○	○	○	○	○	
35	72	3.5-3.2	3.1	2.6-2.3	2.2	2.3-1.9	1.9	○	○	○	○	○	○	○	○	
36	1850	2.8-2.5	2.4	2.5-2.3	2.3	2.1-1.8	1.7	○	○	○	○	○	○	○	○	
37	1421	3.9-3.5	3.4	2.4-2.2	2.3	2.1-1.9	2.0	○	○	○	○	○	○	○	○	
38	480	2.5-2.2	2.1	2.4-2.2	2.3	2.2-1.9	1.9	○	○	○	○	○	○	○	○	
39	635	3.2-3.0	3.0	2.7-2.5	2.9	2.7-2.2	2.5	○	○	○	○	○	○	○	○	
40	1417	3.3-3.0	2.7	2.4-2.2	2.2	2.0-1.9	1.9	○	○	○	○	○	○	△	○	M2部 (Point M2)
								↑ Total Length (220mm)	↑ O.D. (204 mm)	↑ O.D. (70 mm)	↑ I.D. (61 mm)	↑ Bubble	↑ Striae	↑ Dirt	↑ Scratch	↑ Knot/Stone

良品率 80/80. 100%
Ratio of Good Parts

○: O.K.
△: Existing some defects but within spec.
×: NG

#8246　8INCH ﾊﾞﾙﾌﾞ　検査結果　(3')

	LOT. NO.	SCHOTT (M1) MAX - MIN	HPK	SCHOTT (M2) MAX - MIN	HPK	SCHOTT (M3) MAX - MIN	HPK	全長 220	外径 204	外径 70	内径 61	泡	脈理	汚れ	欠	ブ
41	1419	3.3-3.0	2.8	2.6-2.3	2.3	2.2-2.0	1.8	○	○	○	○	○	○	○	○	○
42	773	2.7-2.5	2.4	2.8-2.5	2.5	2.5-1.9	1.9	○	○	○	○	○	○	○	○	○
43	70	3.7-3.0	3.5	2.8-2.5	2.5	2.2-1.9	1.9	○	○	○	○	○	○	○	○	○
44	1189	3.5-3.3	3.4	2.3-2.1	2.2	2.4-2.3	2.1	○	○	○	○	○	○	○	○	○
45	2356	2.5-2.5	2.4	3.4-2.4	2.5	2.2-1.9	1.8	○	○	○	○	○	○	○	○	○
46	74	3.6-3.1	2.9	2.5-2.1	2.1	2.2-2.0	2.0	○	○	○	○	○	○	○	○	○
47	488	2.6-2.4	2.4	2.3-2.1	2.0	2.3-1.7	1.9	○	○	○	○	○	○	○	○	○
48	637	2.7-2.4	2.3	2.7-2.3	2.3	2.4-2.1	2.1	○	○	○	○	○	○	○	○	○
49	772	2.6-2.4	2.2	2.8-2.4	2.5	2.2-2.0	1.8	○	○	○	○	○	○	○	○	○
50	1963	2.7-2.4	2.4	2.4-2.3	2.3	2.6-2.1	2.2	○	○	○	○	○	○	○	○	○
51	2174	3.5-3.0	3.1	2.5-2.1	2.4	2.9-2.2	2.1	○	○	○	○	○	○	○	○	○
52	1852	3.3-2.8	2.9	2.6-2.5	2.4	2.1-1.9	2.0	○	○	○	○	○	○	○	○	○
53	1188	3.5-3.1	2.8	2.3-2.0	2.1	2.7-2.1	2.1	○	○	○	○	○	○	○	○	○
54	562	2.8-2.6	2.5	2.5-2.3	2.0	2.1-1.7	1.7	○	○	○	○	○	○	○	○	○
55	983	3.0-2.7	2.6	2.5-2.2	2.4	2.7-2.4	2.2	○	○	○	○	○	○	○	○	○
56	63	3.3-2.9	2.9	2.7-2.3	2.4	2.1-1.7	2.0	○	○	○	○	○	○	○	○	○
57	2175	3.7-3.3	3.1	2.2-2.1	2.0	2.9-2.2	2.1	○	○	○	○	○	○	○	○	○
58	66	2.7-2.6	2.5	2.4-2.2	2.3	2.9-2.2	2.1	○	○	○	○	○	○	○	○	○
59	987	3.0-2.8	2.6	2.5-2.2	2.3	2.3-1.9	2.1	○	○	○	○	○	○	○	○	○
60	479	3.2-2.9	2.8	2.4-2.0	2.2	2.2-2.1	2.0	○	○	○	○	○	○	○	○	○
61	1613	2.8-2.6	2.6	2.5-2.3	2.5	2.6-2.5	2.3	○	○	○	○	○	△	○	○	○
62	1420	3.1-3.0	2.8	2.3-2.2	2.3	2.3-2.0	2.1	○	○	○	○	○	○	○	○	○
63	44	3.1-2.6	2.4	2.5-2.3	2.4	2.5-2.2	2.2	○	○	○	○	○	○	○	○	○
64	1614	2.8-2.6	2.5	2.3-2.1	2.3	2.6-2.3	2.5	○	○	○	○	○	○	○	○	○
65	2178	3.7-3.3	3.3	2.3-2.1	2.2	2.6-2.3	2.1	○	○	○	○	○	○	○	○	○
66	64	3.7-3.0	2.9	2.4-2.1	2.2	2.1-1.7	1.8	○	○	○	○	○	○	○	○	○
67	68	3.3-3.0	2.8	2.4-2.1	2.2	2.8-1.7	2.0	○	○	○	○	○	○	○	○	○
68	71	3.3-2.9	2.8	2.5-2.3	2.2	2.0-1.5	2.1	○	○	○	○	○	○	○	○	○
69	775	2.6-2.4	2.2	2.3-2.2	2.2	2.3-2.1	1.9	○	○	○	○	○	○	○	○	○
70	2177	3.0-2.7	2.7	2.4-1.9	1.9	2.3-2.2	2.0	○	○	○	○	○	○	○	○	○
71	65	3.0-2.8	2.6	2.8-2.6	2.5	2.1-1.5	1.7	○	○	○	○	○	○	○	○	○
72	1191	3.0-2.7	2.7	2.1-2.0	2.0	2.4-2.0	1.8	○	○	○	○	○	○	○	○	○
73	79	2.5-2.2	2.1	2.1-1.9	1.9	2.1-1.8	2.0	○	○	○	○	○	○	○	○	○
74	570	2.9-2.8	2.6	2.6-2.4	2.5	2.2-1.9	2.0	○	○	○	○	○	○	○	○	○
75	641	3.6-3.1	3.0	2.7-2.3	2.4	2.2-2.0	1.6	○	○	○	○	○	○	○	○	○
76	553	3.6-2.6	2.8	2.4-2.2	2.3	2.2-1.9	2.0	○	○	○	○	○	○	○	○	○
77	1190	3.5-3.0	3.0	2.1-2.0	2.1	2.3-2.1	2.0	○	○	○	○	○	○	○	○	○
78	985	3.5-2.5	2.4	2.3-2.1	2.2	2.8-2.3	2.5	○	○	○	○	○	○	○	○	○
79	38	2.9-2.2	2.0	2.2-2.0	2.1	2.2-1.9	1.7	○	○	○	○	○	○	○	○	○
80	481	3.1-2.8	2.7	2.3-2.0	1.9	2.7-2.4	2.5	○	○	○	○	○	○	○	○	○

頂部(Top of Dome)

Telefax

SCHOTT

Empfänger /To

LOS ALAMOS NATIONAL LABORATORY,
LOS ALAMOS, NEW MEXICO/U.S.A.
Attn.: Dr. Robertson
---
cc: VG-AM/WM

Schott Glaswerke
Hattenbergstraße 10
D-6500 Mainz 1

Absender/From *FVE San/Lutt*

Telefon/Phone *06131/66-3752*

Telefax/Fax *06131/66-2007*

~~Nr~~/No. 35 ~~Seiten~~/Pages 3

Datum/Date *June 24, 1991*

Sollte die angegebene Seitenzahl nicht vorliegen, bitten wir um sofortige Nachricht

If you do not receive all of these pages, please call us back as soon as possible.

Dear Dr. Robertson,

Enclosed please find HAMAMATSU'S inspection result of the sixth and last representative sample shipment.

From those 80 pieces nothing was rejected, so that we now have a total of 2 rejected bulbs out of 480 pcs. which is really an excellent result and gives me trust and confidence that the balance of bulbs in stock are okay.

Please inform Spencer Hill that the audit is in the last stage of completion and will be hopefully send out still this week.

Would you, after having a final agreement, give me an update on how the bulbs should be supplied to Japan?

Best regards,

- Electroglass Sales Dept. -

Herbert Stappen

Enclosure

#8246　8INCH ﾊﾞﾙｸﾞ　検査結果 (6)　　検査日 1991 /06 /10

戸塚

	LOT.	SCHOTT (M1) MAX - MIN	HPK	SCHOTT (M2) MAX - MIN	HPK	SCHOTT (M3) MAX - MIN	HPK	全長 220	外径 204	外径 70	内径 61	泡	脈理	ストレ	キズ	ゴミ
1	14501	2.9-2.7	2.6	2.7-2.3	2.6	3.0-2.3	2.4	○	○	○	○	○	○	○	○	○
2	14439	2.8-2.6	2.5	2.7-2.5	2.3	2.2-1.8	2.1	○	○	○	○	○	○	○	○	○
3	14502	2.6-2.5	2.4	2.5 2.0	2.3	2.6-2.2	2.5	○	○	○	○	○	○	○	○	○
4	14440	2.9-2.7	2.5	2.8-2.7	2.5	2.1-2.0	2.0	○	○	○	○	○	○	○	○	○
5	14443	3.5-3.2	3.2	2.2-2.1	2.0	2.6-2.4	3.5	○	○	○	○	○	○	○	○	○
6	14442	2.8-2.6	2.5	2.9-2.8	2.7	1.9-1.8	1.9	○	○	○	○	○	○	○	○	○
7	14441	3.2-2.9	2.7	2.5-2.4	2.2	2.4-2.2	2.4	○	○	○	○	○	○	○	○	○
8	14598	3.2-2.9	2.7	2.7-2.6	2.2	2.1-1.7	1.7	○	○	○	○	○	○	○	○	○
9	14379	3.3-3.0	3.0	2.0-2.0	1.8	2.7-1.9	2.0	○	○	○	○	○	○	○	○	○
10	14599	2.8-2.6	2.6	2.7-2.5	2.5	2.7-2.0	2.2	○	○	○	○	○	○	○	○	○
11	14503	2.9-2.8	2.6	2.7-2.3	2.5	2.7-2.1	2.2	○	○	○	○	○	○	○	○	○
12	14378	3.5-3.1	2.8	2.5-2.3	2.4	2.3-2.2	1.7	○	○	○	○	○	○	○	○	○
13	14505	2.5-2.4	2.2	2.7-2.5	2.5	2.8-2.3	2.3	○	○	○	○	○	○	○	○	○
14	14504	2.6-2.5	2.5	2.7-2.2	2.5	2.8-2.5	2.5	○	○	○	○	○	○	○	○	○
15	14601	2.8-2.7	2.5	2.9-2.6	2.3	2.7-1.7	1.7	○	○	○	○	○	○	○	○	○
16	14597	2.9-2.3	2.3	2.2-2.7	2.0	2.2-2.0	1.8	○	○	○	○	○	○	○	○	○
17	14600	3.1-2.4	2.6	2.6-2.3	2.5	2.5-2.1	2.1	○	○	○	○	○	○	○	○	○
18	14380	3.5-3.0	2.8	2.5-2.3	2.3	2.5-2.0	1.7	○	○	○	○	○	○	○	○	○
19	14327	2.9-2.7	2.7	2.3-2.1	2.2	3.0-2.4	2.3	○	○	○	○	○	○	○	○	○
20	15382	3.1-3.0	2.7	2.6-2.4	2.5	2.3-1.9	1.5	○	○	○	○	○	○	○	○	○
21	14381	3.2-3.0	2.9	2.6 2.2	1.9	2.1-1.9	1.6	○	○	○	○	○	○	○	○	○
22	14328	3.0-2.7	2.5	2.7-2.3	2.2	2.0 1.5	1.5	○	○	○	○	○	○	○	○	○
23	14326	2.5-2.3	2.4	3.0-2.6	3.0	2.5-1.8	2.3	○	○	○	○	○	○	○	○	○
24	14591	3.0 2.6	2.5	2.4-2.2	2.4	2.5-1.7	1.8	○	○	○	○	○	△	○	○	○
25	14590	2.2-2.0	2.5	2.0-1.9	2.3	1.9-1.5	1.6	○	○	○	○	○	○	○	○	○
26	14594	3.0-2.8	2.4	2.5-2.3	2.4	2.6 2.0	2.0	○	○	○	○	○	○	○	○	○
27	14592	3.0-2.9	2.8	2.6-2.3	2.3	2.3-1.9	1.6	○	○	○	○	○	○	○	○	○
28	14325	2.7-2.6	2.6	2.6-2.0	2.3	2.4 2.0	1.9	○	○	○	○	○	○	○	○	○
29	14324	3.0 2.9	2.9	2.4-2.1	2.2	1.9-1.8	2.0	○	○	○	○	○	○	○	○	○
30	14593	2.9-2.7	2.0	2.2-2.2	2.2	2.4-2.1	1.8	○	○	○	○	○	○	○	○	○
31	14585	2.2-2.0	2.4	2.2-1.7	2.5	2.2-1.9	2.6	○	○	○	○	○	○	○	○	○
32	14581	2.4-2.2	2.7	2.0-1.8	2.5	2.4-1.8	2.9	○	○	○	○	○	○	○	○	○
33	14575	3.0 2.9	2.7	2.6-2.2	2.6	3.0 2.7	2.4	○	○	○	○	○	○	○	○	○
34	14576	3.1-2.9	2.7	2.7 2.6	2.5	2.8 2.3	2.7	○	○	○	○	○	○	○	○	○
35	14579	2.2-2.0	2.5	2.1-1.9	2.5	2.1-1.9	2.7	○	○	○	○	○	○	○	○	○
36	14580	2.2-2.0	2.3	2.1 1.9	2.6	1.9 1.7	2.4	○	○	○	○	○	○	○	○	○
37	14582	2.2-2.1	2.3	1.9-1.9	2.3	2.3 1.9	2.3	○	○	○	○	○	○	○	○	○
38	14984	3.1-2.7	2.8	2.4-2.2	2.2	1.8-1.7	1.5	○	○	○	○	○	○	○	○	○
39	14574	3.0-2.9	2.7	2.8-2.6	2.5	2.7-2.3	1.6	○	○	○	○	○	○	○	○	○
40	14578	3.5-3.2	3.0	2.5-2.1	2.4	2.3-2.1	1.8	○	○	○	○	○	○	○	○	○

-- Total LG (220 mm)
-- O.D. (204 mm)
-- O.D. (70 mm)
-- I.D. (61 mm)
-- Bubble
-- Strine
-- Dirt
-- Scratch
-- Knot / Stone

○ : O.K.

△ : Existing some problem but within spec.

× : N.G.

#8246　8INCH バルブ　検査結果 (6')

	LOT. NO.	SCHOTT (M1) MAX - MIN	HPK	SCHOTT (M2) MAX - MIN	HPK	SCHOTT (M3) MAX - MIN	HPK	全長 220	外径 204	外径 70	外径 61	泡	脈理	汚れ	キズ	ゴミ
41	14980	2.6-2.5	2.5	2.3-2.2	2.2	2.2 1.9	1.9	○	○	○	○	○	○	○	○	○
42	14981	3.0-2.7	2.8	2.2-2.0	2.0	2.1-1.9	1.8	○	○	○	○	○	○	○	○	○
43	14577	3.6-3.3	2.9	2.9-2.3	2.3	2.1-2.0	1.7	○	○	○	○	○	○	○	○	○
44	14982	2.7-2.3	2.1	2.2-2.1	2.1	2.7-2.3	2.9	○	○	○	○	○	○	○	○	○
45	14983	3.0-2.8	2.7	2.2-2.0	2.0	2.4-2.1	2.4	○	○	○	○	○	○	○	○	○
46	14623	2.8-2.5	2.3	2.7-2.2	2.3	2.8-2.4	2.5	○	○	○	○	○	○	○	○	○
47	14620	2.5-2.3	2.3	2.5-2.1	1.9	2.9-2.6	2.5	○	○	○	○	○	○	○	○	○
48	15304	3.0-2.7	2.7	3.4-2.5	2.7	2.0-1.8	1.9	○	○	○	○	○	○	○	○	○
49	15711	3.3-3.1	3.0	2.1-2.0	2.1	2.0-1.7	1.7	○	○	○	○	○	○	○	○	○
50	14576	3.1-3.0	3.0	2.1-1.9	2.1	2.3-2.1	2.2	○	○	○	○	○	○	○	○	○
51	14755	2.9-2.6	2.7	2.2-2.0	2.2	2.2-1.8	1.8	○	○	○	○	○	○	○	○	○
52	14619	2.4-2.2	2.1	2.5-2.3	2.5	2.2-2.3	2.4	○	○	○	○	○	○	○	○	○
53	14621	3.1-2.6	3.7	3.7-2.5	2.4	2.8-2.5	2.5	○	○	○	○	○	○	○	○	○
54	14622	2.6-2.5	2.3	2.7-2.3	2.3	2.7-2.4	2.4	○	○	○	○	○	○	○	○	○
55	14747	3.1-2.7	2.6	2.5-2.0	2.1	2.4-2.0	2.1	○	○	○	○	○	○	○	○	○
56	14754	2.7-2.6	2.6	2.1-1.9	2.1	2.5-2.1	2.1	○	○	○	○	○	○	○	○	○
57	14748	3.2-2.9	3.2	2.1-1.9	2.1	2.2-2.0	2.1	○	○	○	○	○	○	○	○	○
58	14753	2.8-2.7	2.7	2.0-1.8	1.9	2.4-2.1	1.9	○	○	○	○	○	○	○	○	○
59	15913	2.2-2.1	2.1	2.2-1.9	1.8	2.5-2.4	2.2	○	○	○	○	○	○	○	○	○
60	14745	2.8-2.5	2.7	2.6-1.9	2.0	2.5-2.0	2.0	○	○	○	○	○	○	○	○	○
61	14746	3.7-2.8	2.6	2.2-1.9	2.2	2.5-1.9	2.2	○	○	○	○	○	○	○	○	○
62	15302	2.7-2.5	2.4	2.8-2.0	2.3	2.7-2.1	2.9	○	○	○	○	○	○	○	○	○
63	15709	2.8-2.2	2.2	2.7-2.1	2.6	3.0-2.3	1.8	○	○	○	○	○	○	○	○	○
64	19122	2.5-2.3	2.3	2.0-1.9	2.2	2.9-2.3	2.1	○	○	○	○	○	○	○	○	○
65	15914	2.3-2.3	2.2	2.1-1.8	1.9	2.6-2.6	2.7	○	○	○	○	○	○	○	○	○
66	15712	3.3-3.0	3.1	2.0-1.9	2.0	2.2-1.8	2.0	○	○	○	○	○	○	○	○	○
67	15306	2.9-2.3	2.3	3.1-2.3	2.5	2.3-1.8	1.7	○	○	○	○	○	○	○	○	○
68	15303	2.7-2.5	2.5	2.8-2.0	2.3	2.6-1.9	2.0	○	○	○	○	○	○	○	○	○
69	15710	3.2-3.0	2.9	2.1-2.1	2.1	2.2-2.0	2.0	○	○	○	○	○	○	○	○	○
70	15915	2.4 2.2	2.1	2.3-1.7	1.9	2.7-2.5	2.5	○	○	○	○	○	○	○	○	○
71	14757	2.4-3.1	3.1	2.1-1.8	2.1	1.9-1.8	1.7	○	○	○	○	○	○	○	○	○
72	15911	2.2-2.1	2.2	2.2-2.0	2.3	2.4-2.2	2.0	○	○	○	○	○	○	○	○	○
73	15713	3.6-3.2	2.6	2.0-1.9	2.0	2.1-2.0	2.0	○	○	○	○	○	○	○	○	○
74	14744	3.5-2.8	2.9	2.2-2.0	2.1	2.4-1.8	1.9	○	○	○	○	○	○	○	○	○
75	15305	2.8-2.7	2.7	2.7-2.3	2.4	2.1-1.8	1.9	○	○	○	○	○	○	○	○	○
76	15996	2.9-2.7	2.5	2.6-2.2	2.4	2.5-2.3	2.2	○	○	○	○	○	○	○	○	○
77	15995	3.0-2.9	2.6	2.5-2.2	2.3	2.5-2.2	2.0	○	○	○	○	○	○	○	○	○
78	15997	3.2-2.9	2.7	2.3-1.9	2.3	2.8-2.4	2.5	○	○	○	○	○	○	○	○	○
79	15993	3.1-2.9	2.7	2.7-2.3	2.6	2.47-2.4	2.4	○	○	○	○	○	○	○	○	○
80	15994	2.9-2.6	2.5	2.6-2.5	2.5	2.4-2.4	2.2	○	○	○	○	○	○	○	○	○
平均値			2.6		2.3		2.1	-- Total LG (220 mm)	-- O.D. (204 mm)	-- O.D. (70 mm)	-- I.D. (61 mm)	-- Bubble	-- Striae	-- Dirt	-- Scratch	-- Knot / Stone

↑ Average of wall thickness

すべて合格です。

• 100% O.K.