

SPETM05

LIGO-T990176-00-D

BLANK

T 970017
FE 09

LIGO-M960129-A-P

LIGO DETECTOR OPTICS
Incoming Inspection Check-off Sheet
Core Optics Blank Material

Page ___ of ___

The purpose of this sheet is to verify material physical dimensions, perform visual inspection, and to facilitate material traceability of LIGO Detector optics. This sheet is to be included in the LIGO Quality Assurance traceability file. Complete a check-off sheet for each optic blank received and inspected.

LIGO Contract No.: PP207573 Glass Mfg./Order No.: Corning/QD106248
Core optic Material: (BS) (FM) (ITM) (ETM) (RM) Glass Mfg. Part No.: F855306
LIGO Drawing No.: D960794-A-D Manufacturer's Boule No.: 24622G / FE09
Optical Glass Spec. MIL-G-174-B Date Received at Caltech: 01-21-97

- Verify glass manufacturer's Certification against LIGO Component Specification No. E960097-A-D
- Attach a copy of the glass manufacturer's Certification to check-off sheet.
- Attach the glass manufacturer's optical ~~phase~~ ^{homogeneity} maps supplied by vendor per above Component Specifications.
- Visually inspect for shipping container damage. If applicable, describe damage on attached sheet and notify the Cognizant Engineer. Date Notified: NA
- Visually inspect the blanks for damage, for chips on surfaces and edges, or for other defects. If applicable, describe damage/defects on attached sheet and notify Cognizant Engineer. Date Notified: _____
- Verify core optic blank physical dimensions per applicable LIGO drawing.
 - Inspection of material diameter. Diameter 10.105 in ~~108~~ 256.71 mm
 - Inspection of material thickness. Thickness 4.2890 in 108.96 mm
- Verify that the Registration Mark is present as required by LIGO Component Specification.
- Verify receipt of 25mm X 25mm cylinder Witness Sample(s) required by the LIGO Component Specification and visually inspect for damage. If applicable, describe damage on attached sheet and notify the Cognizant Engineer. Date Notified: NA
- Sign and date original packing slip (shipper) and distribute per paragraph 3.P.

Inspect By: [Signature] Date Inspected: 1-21-97

Reviewed and/or accepted by:
Cognizant Engineer: [Signature] Date: 2-24-97
LIGO QA Officer or Designee: _____ Date: _____

FM300

Figure 1

LIGO DETECTOR OPTICS
Incoming Inspection Check-off Sheet

Core Optics Blank Material

COMMENTS/DISCREPANCIES: (Disposition damage/discrepancies per LIGO Quality Assurance Plan (LIGO M960076-00-P) paragraphs 5.12 and 5.12.1.) _____

SKETCHES:

DISPOSITIONS: _____

CORNING

334 County Route 16
Canton, New York 13617-9703

Canton Plant . . .



...WHERE QUALITY MIRRORS PRIDE

CERTIFICATE OF COMPLIANCE

Customer: <u>California Institute of Technology</u>	Item: <u>001</u>
Customer Order No.: <u>PP207573</u>	Glass: <u>7980 Grade 0A</u>
Corning Order No.: <u>QD106248</u>	Quantity Shipped: <u>1</u>
Code No.: <u>855306</u>	Date Shipped: <u>1/16/97</u>

Registration Mark for & Serial # per LIGO
 Drawing # D960794-A-D
 Birefringence ≤ 1 nm/cm central 80 mm
 ≤ 5 nm/cm central 200 mm
 Striae per MIL-G-174 Section 4.46 method 1 or 2.

This is to certify that the above material shipped against your order is in conformance with all applicable requirements, specifications, and drawings.

Signed: Brian C. Bush
Brian C. Bush

Title: Quality Assurance Section Leader

Date: 1/16/97

FE09

SHIPPING ORDER

PACKING LIST

ST. ORD. & DATE [PP207573] 08/20/96

CNG ORD. NO. [00106248]

SOLD TO CALIFORNIA INSTITUTE OF TECHNOLOGY
 ACCOUNTS PAYABLE N/S 201-6
 1200 E CALIF BLVD
 PASADENA, CA 91125

13717
 04 056 04

SAME AS "SOLD TO" UNLESS OTHERWISE SPECIFIED
 SHIP TO CALIFORNIA INSTITUTE OF TECHNOLOGY
 ATTN: MR. LOWELL JONES
 371 S HOLLISTON
 PASADENA, CA 91105

13717
 04 056 02

SALES CODE [110 050]

DISCOUNT FACTOR []

DESIRED SHIP DATE [01/20/97]

SHIPPED TO BANTON, NY
 DATE ENTERED [08/28/96]
 DPI FOB ORIG PPD FRI INVOICED

WE EXPECT TO SHIP [01/20/97]

DATE SHIPPED		INVOICE NUMBER	
DATE SHIPPED			
ROUTING			
BEST WAY			
CAR INITIAL AND NUMBER			
THIS SHIPMENT		PREPAID	COLLECT
PARTIAL	COMPLETE		
DATE ISSUED		DATE TO SHIP	

WHSE LOC	PRODUCT CODE	DESCRIPTION	QUANTITY	
			UNITS	CASES
003	855308 7960 0000	DISC, F S, QA, WITNESS SAMPLE, .984" X .984" CYLINDRICAL YOUR PRODUCT IDENT ->> WITNESS SAMPLES WITNESS SAMPLES FOR ITEMS 1 PRICE IS INCLUDED IN ITEM 001	1 BW	PC
FE 09				

ROUTING

SHIPPING ORDER

PACKING LIST

ST. ORD. & DATE [PP207573 08/20/96]
 SOLD TO CALIFORNIA INSTITUTE OF TECHNOLOGY
 ACCOUNTS PAYABLE M/S 201-6
 1200 E CALIF BLVD
 PASADENA, CA 91125
 SAME AS "SOLD TO" UNLESS OTHERWISE SPECIFIED
 SHIP TO CALIFORNIA INSTITUTE OF TECHNOLOGY
 ATTN: MR. LOWELL JONES
 391 S HOLLISTON
 PASADENA, CA 91106
 SALES CODE [110 050] DISCOUNT FACTOR []
 SHIPPED F.O.B. [CANTON, NY] DATE ENTERED [08/28/96]
 OPI FOB ORIG PPD FRT INVOICED

CNG ORD NO. [@D106248]
 13717
 04 056 04
 13717
 04 056 02
 DESIRED SHIP DATE [01/20/97]
 WE EXPECT TO SHIP [01/20/97]

DATE SHIPPED		INVOICE NUMBER	
DATE SHIPPED			
ROUTING <u>52948</u>			
BEST WAY <u>UPS Red</u>			
CAR INITIAL AND NUMBER			
THIS SHIPMENT		PREPAID	COLLECT
PARTIAL	COMPLETE	X	
DATE ISSUED <u>7/16/97</u>		DATE TO SHIP <u>7/16/97</u>	

WHSE LOC	PRODUCT CODE	DESCRIPTION	QUANTITY	
			UNITS	CASES
		-DATA SET REQUIRED FOR EACH MIRROR BLANK		
		-WITNESS SAMPLES REQUIRED		
		-CERTIFICATE OF COMPLIANCE REQUIRED		
		-INTERFEROGRAMS REQUIRED		
		-FABRICATION INCLUDES CUTTING, FINISHING		
		MARKING		
		-320 GRIT FINISH		
		-SEE S.O.W. FROM RANDY VANBROCKLIN		
		-CALTECH RESERVES THE RIGHT TO WITNESS F		
		CERTIFICATION TESTS.		
001	855306 7980 0000	DISC. F S.O.A. 10.079"D X 4.252"T, BLANK TOLERANCES: +.040"/-.000" BOTH DIMS FOLDING MIRROR, END TEST MASSES CLEAR APERTURE = 9.252"	1 BW	PC

Rec'd complete
[Signature]
 1-21-97

ROUTING PRICE INCLUDES 13 WITNESS SAMPLES:
 SAMPLE DIMENSIONS: 884" X 884" CYLINDRICAL

DEVIATION APPROVAL FORM

Customer Name: California Inst. TECHNOLOGY

Customer P.O. Number: PP 207573

Corning Order Number: QD106 24801

Corning Part Number: F 855306

Drawing Number: E960097-A-D - LIGO - D960794

Boule Number: _____

Quantity Affected: 11 (FE 01 Thru FE 11)

Deviation Description: SBT PICs to be used in lieu of individual pieces of each piece
(attach backup information as deemed necessary)

Gari Lynn Billingsley
Customer Contact (print)

OK gfb 2-24-97

Randy V. Bazzoli
Authorizing Signature

12/12/96
Date

Send copy with shipment?
(circle Yes or No)

(Y) N

Billing Status

- Bill Now
 Bill in 30 Days
 Other _____

Deviation Number:

(sequential number) - (year)

Q704 rev. A

cc: Shipping Clerk
Customer Service

FE 09

DATA SHEET - CAL TECH LIGO MIRROR BLANKS

Cal Tech Purchase Order Number:

PP207573

Cal Tech Drawing Number:

LIGO-2960794

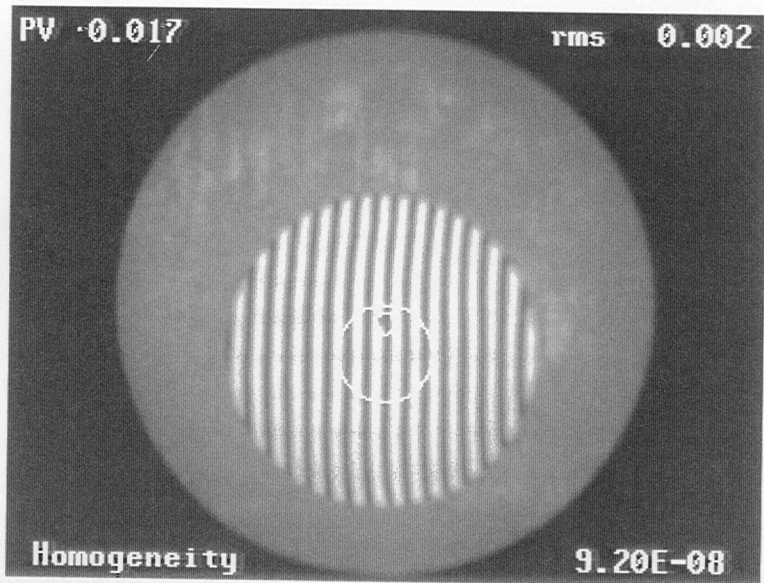
Attribute	Specification #	Requirement	Actual	Stamp	
Diameter	Per LIGO - D960097-A-D	10.079", -0.0"/+0.4"	10.105 / 10.105		QA
Thickness	Per LIGO - D960097-A-D	4.252", - 0.0" / + 0.4"	4.289 / 4.289 / 4.289 / 4.289		QA
Registration Mark	Per LIGO - D960794	Top center of optic	See Attached Cert.		M
Serial & Boule #	Per LIGO - D960794	Boule and Serial No.	246226-EE09		M
Material	Fused Silica 7980		See Attached Cert.		M
Witness Sample Map			See Attached Map		M
Defects		< 0.5 mm	See Attached Map		QA
Inclusions		< 0.1 mm; < 0.03 mm ² /100cm ² ; < 0.06 mm disregard	See Attached Map		QA
Homogeneity - central		Peak To Valley < 1.0 x 10E-6	9.20 x 10E-8		M
Homogeneity - outside		Peak To Valley < 2.5 x 10E-6	9.09 x 10E-7		M
Interferograms		To be provided	Attached		M
Birefringence	MIL G-174 Section 4.4.5	< 1nm/cm (central 3.150") < 5 nm/cm (central 7.874")	See Attached Cert.		QA
Striae	MIL G-174 Section 4.4.6, Method 1 or 2	Grade <u>A</u>	Inspection Report		M
Absorption		< 20 ppm / cm @ λ = 1.06 μm	See attached Cert.		M

Comments:

Inspected by:

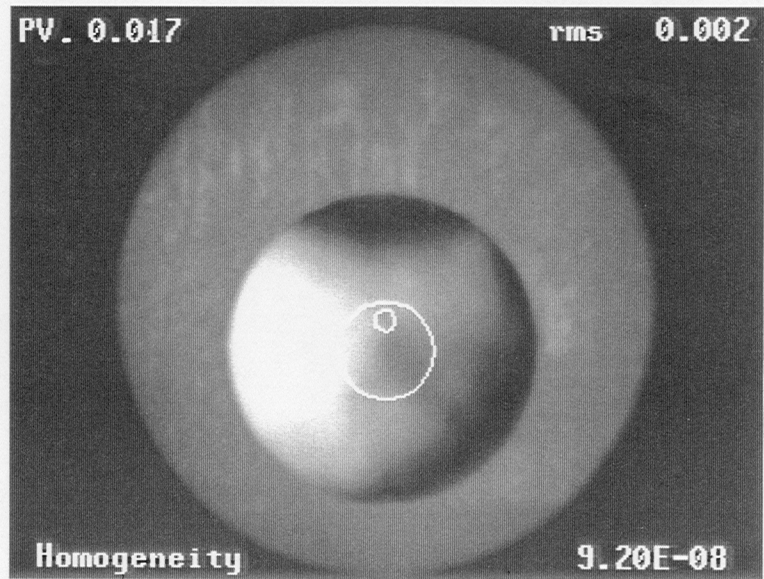
Garland Andrews

Date: 1-13-97



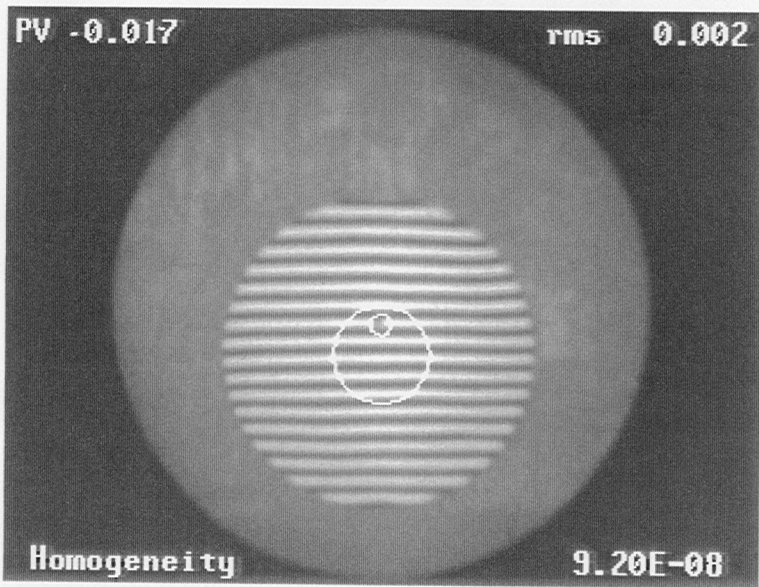
24622G

SN-FE09



24622G

SN-FE09



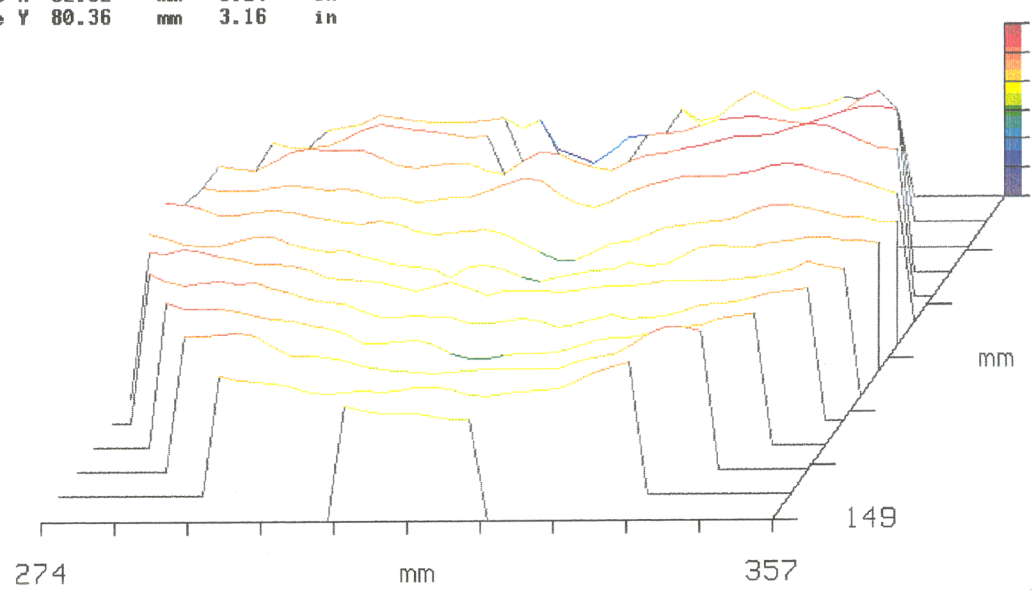
24622G

SN-FE09

Lg Aperture
 PV 0.017 wave
 rms 0.002 wave
 Power 0.006 wave
 Homogeneity 9.20E-08
 Points 1269
 AstMag (Z) 0.008 wave

Corning Inc. Canton Plant Metrology Dept. 334 Co. Rt. 16, Canton, NY 13617 (315) 379-3283

Size X 82.32 mm 3.24 in
 Size Y 80.36 mm 3.16 in



+0.00516
 wave
 -0.01190
 229

zygo Spike
 Remove Spikes: Off (xRMS): 3.00
 Data Fill: Off Data Fill Max: 25

Removed:
 PST TLT PWR
 PST TLT PWR AST CMA SA3

Zern Terms: 36

Zernike Coefficients from 1268 data points
 Order: 10th Terms: 36 rms: 0.001

-0.197	0.035	0.022	0.003															
0.004	0.001	0.000	-0.003	-0.001														
-0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000										
-0.002	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000								
0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.001	0.000	-0.001									

Measure Mask Data Save Data **DBSAVE**
 Analyze Calibrate Load Data

Subtract Sys Err: On
 Sys Err File: r121396.8a2
 Part Thickness: 4.618 in

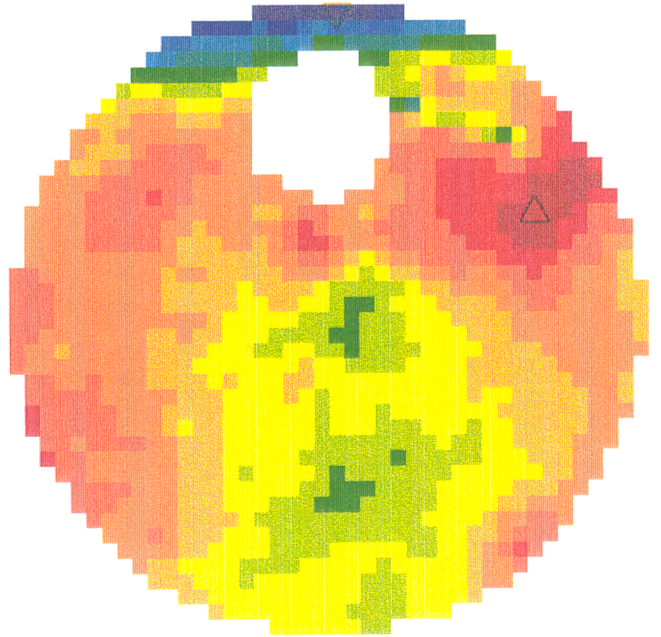
Boule #: 24622
 Suffix: G

CAL TECH *SN-FE09* Comment:

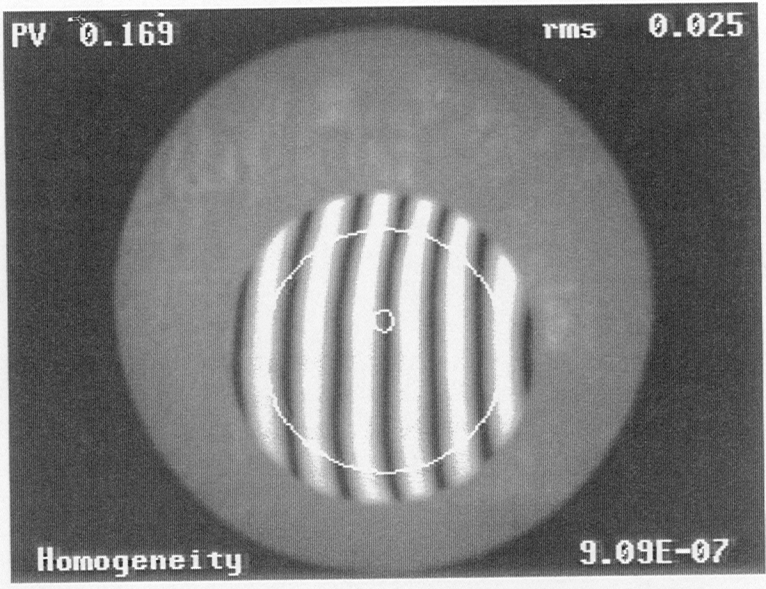
Data File: 24622G2.ct
 Camera Res: 1.9600 mm

Time: Sat Jan 04 14:25:01 1997

Save Subapt

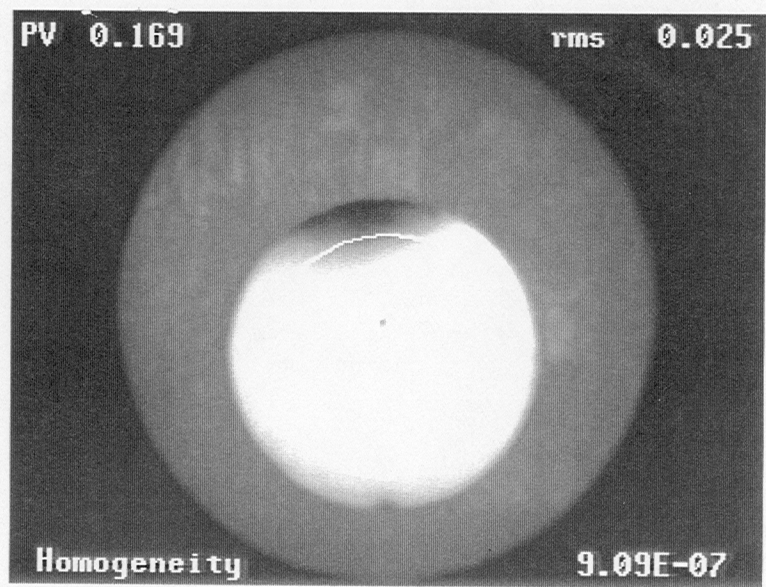


+0.00516
 Peak
 wave
 Valley
 -0.01190



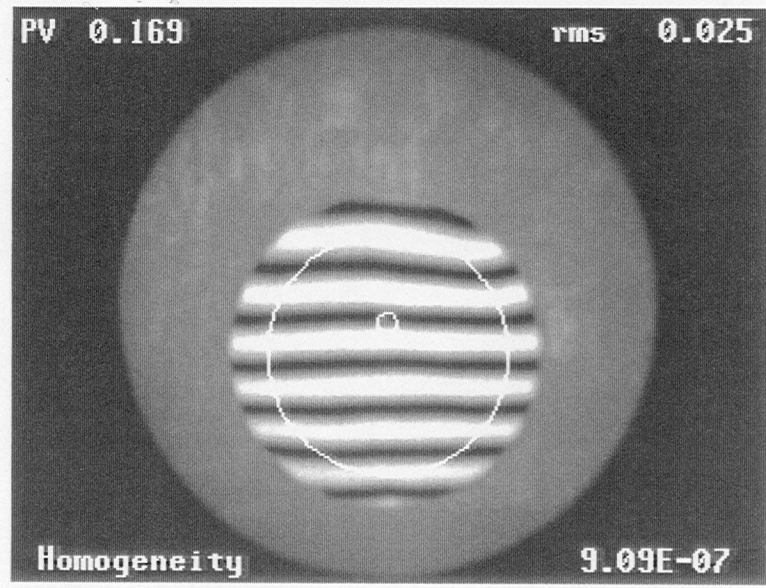
24622G

SN-FE09



24622G

SN-FE09



24622G

SN-FE09

Lg Aperture
 PV 0.169 wave
 rms 0.025 wave
 Power -0.024 wave
 Homogeneity 9.09E-07
 Points 8171
 AstMag (Z) 0.111 wave

zygo Spike
 Remove Spikes: Off (xRMS): 3.00
 Data Fill: Off Data Fill Max: 25

Removed:
 PST TLT PWR

PST TLT PWR AST CMA SA3

Zern Terms: 36

Zernike Coefficients from 8170 data points
 Order: 10th Terms: 36 rms: 0.001

-0.137	0.038	0.029	-0.013																
0.055	-0.004	0.003	-0.014	-0.007															
-0.016	0.019	0.009	0.001	0.000	0.004	0.001													
-0.016	-0.002	0.001	-0.001	-0.002	0.000	0.000	-0.001	0.000											
-0.001	-0.005	0.004	0.002	0.000	0.000	0.000	0.000	0.000											

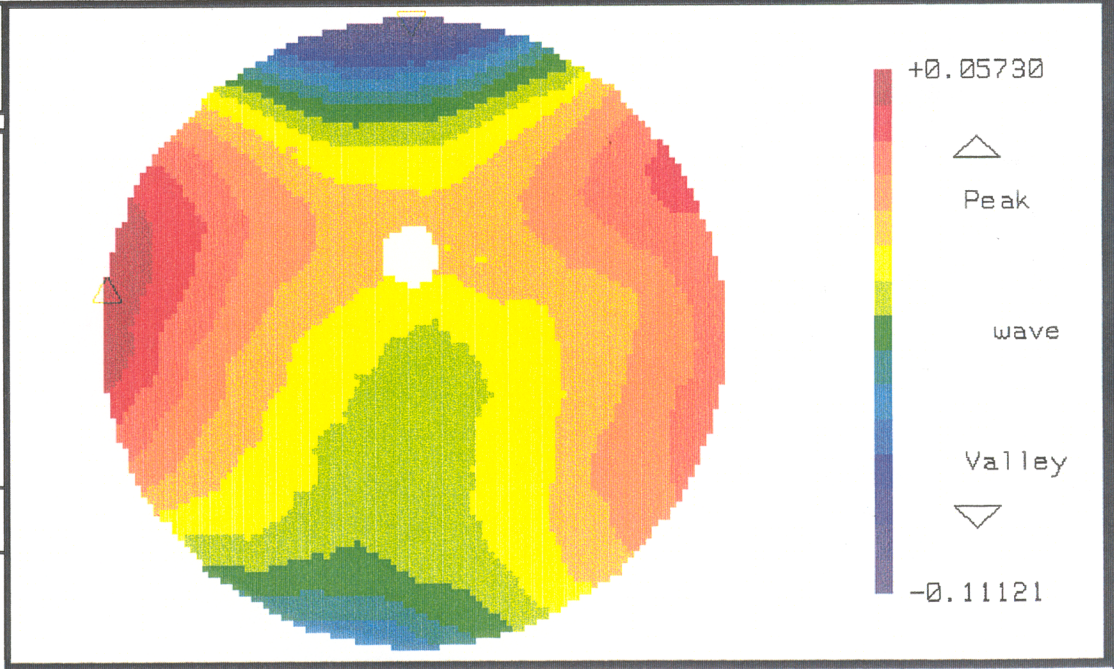
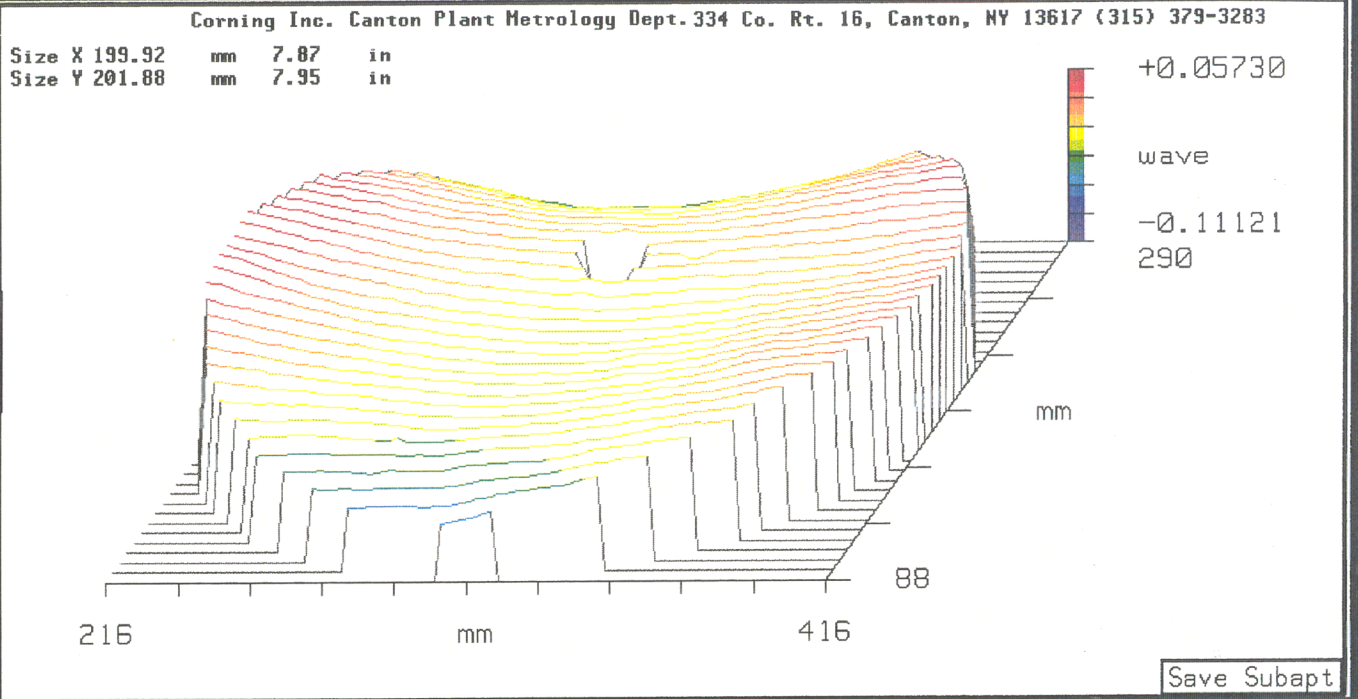
Measure Mask Data Save Data DBSAVE
 Analyze Calibrate Load Data

Subtract Sys Err: On
 Sys Err File: r121396.8a2
 Part Thickness: 4.618 in

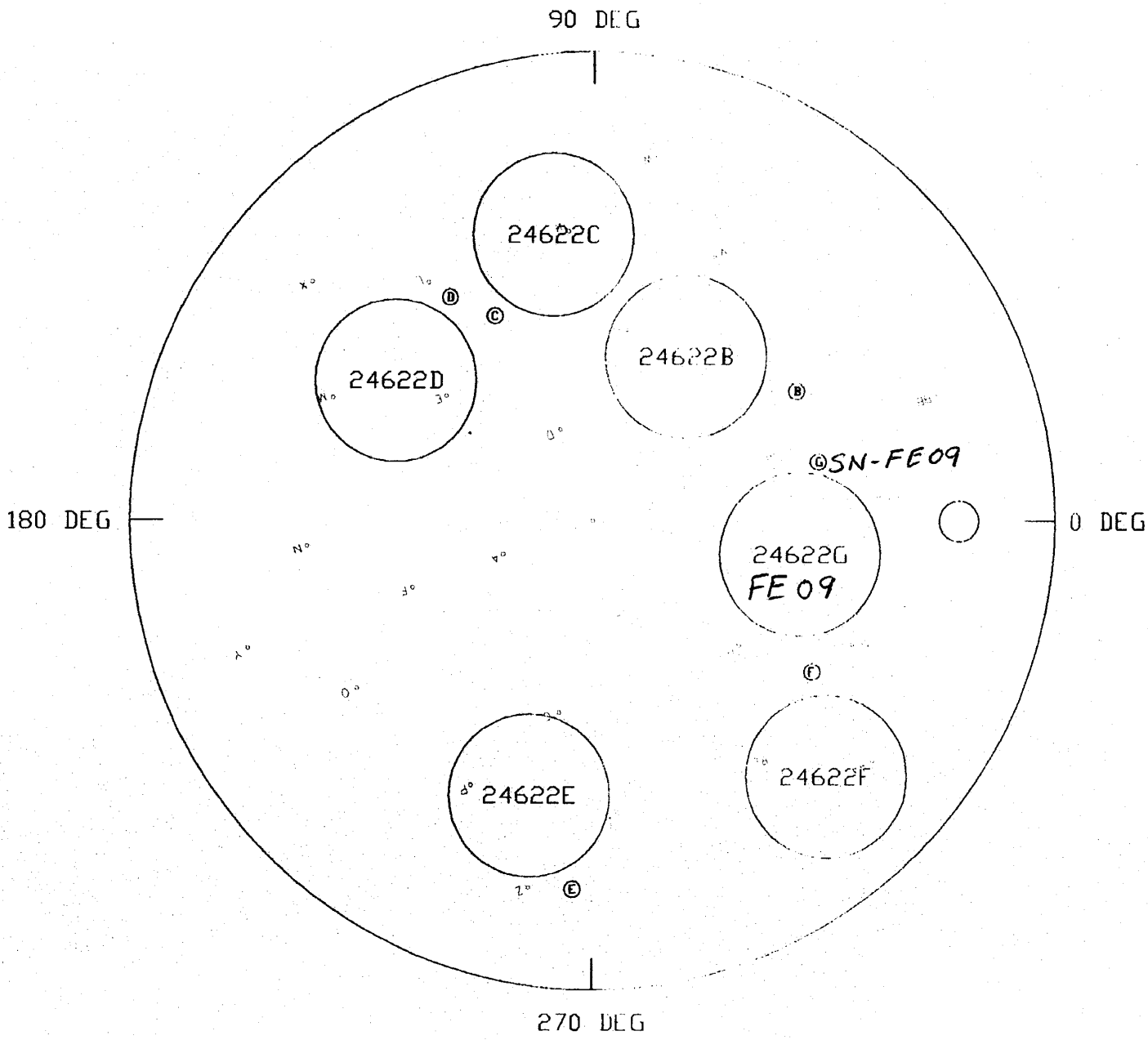
Boule #: 24622
 Suffix: G

CAL TECH SN-FE09 Comment:

Data File: 24622G1.ct
 Camera Res: 1.9600 mm
 Time: Sat Jan 04 14:10:35 1997



24622G
SN-FE09



:
: pertains to serial numbers
: FE01 - FE09 - JB
:

Canton Plant
334 County Rt 16
Canton, New York 13617

Corning Incorporated

February 17, 1997

California Institute of Technology
LIGO Project
51-33 East Bridge Laboratory
Pasadena, CA 91125

Dear Ms. GariLynn Billingsley:

This letter is in response to concerns indicated in your reference to: Review of Data Packages for first 9 Pieces.

- 1) Diameter and thickness to reference drawing # D960794-A-D.
QA Inspectors are aware of this requirement. Change will be made on shipment of next parts.
- 2) Registration Mark and Serial number should reference specification E960097-A-D.
QA Inspectors are aware of this requirement. Change will be made on shipment of next parts.
- 3) Blanks FE04, FE05, FE06 & FE08 had no arrow to point to side 1, but commenced at a surface where there was a reasonable amount of writing.
Your assumption is correct. The surface with the reasonable amount of writing is side 1.
- 4) Specification for arrow and registration mark will be followed on shipment of next parts.
- 5) Any exceptions to specifications will be noted on data pack in future. QA Inspectors are aware of this requirement.
- 6) Birefringence readings are indicated on the defect and inclusion maps. This map serves both purposes.
- 7) Absorption reading not necessary for part # E970097-A-D. This column on Data Package will be marked N/A for balance of these parts.
- 8) The Certification of Compliance applies to all pieces shipped with order. This will be noted on the C of C in the future.
- 9) Serial Numbers will be included on the shippex.
- 10) Specification revision number referenced on Data Pack.
QA Inspectors aware of requirement. Will be done on next shipment of parts.

cc:
Petrae
Camp
Elieson
Tyler

.....

- 11) Data Disk not sent with pieces of glass.
Missing information will be forwarded. QA Inspectors will double check contents of Data Packs.
- 12) Deviation Approval Form sent with initial material shipment.
Approval of first 3 pieces analyzed via Standard Boule Testing. All other parts analyzed separately.

Other:

Standard Boule Testing could be acceptable to the LIGO project given confirmation by Corning Metrology that the interferometer used for SBT is the same used to test individual pieces, and that there is no change in magnification.

This response from Mr. Andy Fanning, Corning, Canton, Metrology Dept.
"The standard process Corning-Canton uses in metrology is compliant with the CIT/LIGO fax to Randy VanBrocklin, dated January 31st, 1997. The interferometer and magnification will be the same regardless if the part is shot at it's final dimension or in boule form".

If additional clarification is required on this subject, please let me know.

Hopefully this document addresses the current issues between CalTech -LIGO project and Corning-Canton. If there are any additional issues that need to be addressed by Corning, please do not hesitate to contact me.

Thank you for your patience in this matter.

Sincerely,

Randy VanBrocklin
Applications Engineer

Tel: 315-379-3381

Fax: 315-379-3317

Corning

CALIFORNIA INSTITUTE OF TECHNOLOGY

LIGO Project, 51-33 East Bridge Laboratory, Pasadena, California 91125
818-395-2129, Fax 818-304-9834

Date: January 31, 1997

Refer to: LIGO-C970148-00-D

Corning Incorporated
Canton Plant
334 Country Route 16
Canton, New York 13617
Attention: Randy VanBrocklin, Brian Bush

Subject: Review of Data Packages for first 9 pieces

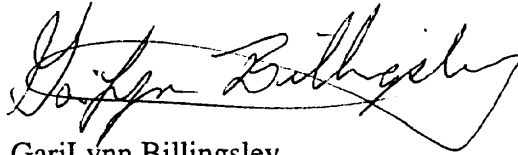
Some clarification of preferences and some discrepancies came to light during examination of the data packages for the first 9 blanks delivered to LIGO. While none of these compromise the integrity of the blanks, they can make for a confusing or misleading data package. Please let us know how you expect to address these issues for subsequent glass deliveries.

1. Data sheet; Diameter and Thickness should reference the drawing D960794-A-D
2. Data sheet; Registration Mark and Serial number should reference the Specification E960097-A-D
3. Blanks FE04, FE05, FE06 and FE08 had a registration mark which was between 12-15 mm in length and had no arrow to point to side 1, but commenced at the surface on which there was a reasonable amount of writing. We have presumed this to be side 1 but would appreciate a confirmation that this is indeed the case
4. Also, on these blanks the serial number is written immediately adjacent to the registration mark and is parallel to the (presumed) side 1, rather than as shown in the drawing. This is not a problem for us as the serial number is clear, but strictly speaking it is not in compliance with the specification.
5. We have a data package that arrived with no witness sample map, yet this item was stamped off on the data sheet, with no note of exception. An exception had been granted for this part, that exception was included in the data package. Please note the presence of an exception on the data sheet.
6. All data packages have arrived without defect or inclusion maps yet the box next to "see attached map" was stamped. How should LIGO interpret the stamp column? Please provide defect and inclusion maps.
7. Data packages arrived with the "Actual" column for Absorption reading "see attached cert", yet there was no attached certification, nor was one required for this part. There was a stamp.
8. The Certification of Compliance does not reference serial number(s) are we to assume that it applies to all pieces in the shipment?
9. Would you please include serial numbers on the shipper?

10. Would you please reference the Specification Revision number on the data sheet?
11. A data disk is required with the package, yet one piece has arrived without it. Should there be a checkoff sheet for each piece of glass stating the contents of the data package?
12. A Deviation Approval form accompanied the shipment of FE01 approving standard boule testing for 11 pieces. The form does not indicate which pieces are affected. LIGO has no record of approving this deviation. Please confirm all future Deviation Approvals in writing.

NOTE: Standard Boule Testing could be acceptable to the LIGO project given confirmation by Corning Metrology of the following information. The Interferometer used for SBT is the same interferometer which is used for single piece testing and there is no change in interferometer magnification between SBT and single piece homogeneity measurements. Deviation approval for SBT will be considered by LIGO following this clarification.

Sincerely,

A handwritten signature in black ink, appearing to read "GariLynn Billingsley". The signature is fluid and cursive, with a long horizontal flourish extending to the right.

GariLynn Billingsley
Technical Representative

SUBSTRATE



GENERAL OPTICS, INC.

PRECISION OPTICAL COMPONENTS

554 FLINN AVENUE

MOORPARK, CALIFORNIA 93021

(805) 529-3324

FAX (805) 529-4298

CERTIFICATE OF COMPLIANCE

Date: 07-07-97

To: Cal Tech

Purchase Order Number: PC203459

Part Number & Revision: D960791-A-D (w/Spec. #E950104-A-D)

Part Description: Ligo End Test Mass Substrate

Serial Numbers: SP ETM 05A

We certify that the above part was manufactured in compliance with all applicable requirements and specifications of the above purchase order and drawings except as noted below.

“Scratches” and “Point Defects” for the entire side 1 and side 2 surfaces were inspected using an high intensity white light source delivered perpendicular the surface. This was substituted for the method prescribed in specification E950104-A-D.

GENERAL OPTICS, INC.

By: _____

A. DCN: LIGO-T970017-00-D

LIGO DETECTOR OPTICS

Page 1 of 3

B. LIGO S/N: SPETM05

Incoming Inspection Check-off Sheet
Core Optics Polished Substrate

The purpose of this sheet is to verify material physical dimensions, perform visual and microscopic inspection, and to facilitate material traceability of LIGO Detector optics. This sheet is to be included in the LIGO Quality Assurance traceability file. Complete a check-off sheet for each optic blank received and inspected.

C. LIGO Contract/Purchase No.: PC 203459

D. Substrate Polisher: General Optics

E. Core optic Material: BS / FM / 2ITM / 4ITM (ETM) / RM

F. Date Received: Shipped direct to NIST

G Verify glass polisher's Certification with LIGO Component Specification No. E 950104 - A - D
Attach the completed LIGO Component Specification Verification Sheet.

H Attach a copy of the glass polisher's Certification Document and data sheet to check-off sheet.

I Verify receipt of an IBM PC compatible disc in ASCII format of all Surface Data per the applicable LIGO Component Specification sheet NA

J Attach the surface maps supplied by vendor per above Component Specifications to the check off sheet.

K Visually inspect for shipping container damage. If applicable, describe damage on attached sheet and notify the Cognizant Engineer NA

L Visually inspect the polished substrate for shipping damage, for chips on surfaces and edges, or for other defects. If applicable, describe damage/defects on attached sheet and notify Cognizant Engineer. NA

M Verify polished substrate's physical dimensions per applicable LIGO drawing.

Inspection of material diameter. Diameter 9.86 in 250.482 mm

Inspection of material thickness Thickness 3.94 in 99.977 mm

N Verify that the Serial Number is present in the proper format as required by LIGO Component Specification.

O Verify that the Registration Mark (line with arrow pointing toward surface #1) is present as required by LIGO Component Specification.

P Inspect the sides and bevels with the naked eye in normal room light and against a black background to verify that there is no gray, scuffs or scratches per the applicable LIGO Component Specification. NA

Q Use a dark field microscope at 5X magnification to inspect the polished optic for scratches and defects over the central 80 mm diameter per the applicable LIGO Component Specification. NA

R Sign and date original packing slip (shipper) and distribute per paragraph 3.R.

Inspection By: Steve Fison Date Inspected: _____

Reviewed and/or accepted by:

Cognizant Engineer: _____ Date: _____

LIGO QA Officer or Designee: _____ Date: _____

FM300

Figure 1

LIGO DETECTOR OPTICS
Incoming Inspection Check-off Sheet

Core Optics Polished Substrate

COMMENTS/DISCREPANCIES: (Disposition damage/discrepancies per LIGO Quality Assurance Plan (LIGO M960076-00-P) paragraphs 5.12 and 5.12.1.) SPETMOS

inclusion in glass noted near side 1 - small edge scratches

SKETCHES:

DISPOSITIONS:

Ligo Test Mass
Drawing Number D960791-A-D
Specification Number E950104-A-D
Serial Number SP ETM 05 A

Final Inspection report

June 7, 1997

Feature	Requirement	Actual
Side 1		
Spherical Measurement	< 1/20 Wave Concave	.022 Waves PV
Radius of Curvature	7400 M +/- 220 M	7490.11 M
Micro-Roughness	< 1.0 Angstrom	0.34 Angstroms
Surface quality	< 10 Defects Entire Surface	Verified
Side 2		
Flatness	< 1/10 Wave	0.058 Waves PV 36.7
Micro-Roughness	< 1.0 Angstrom	0.60 Angstroms
Surface quality	< 10 Defects Entire Surface	Verified
Substate Features		
Diameter of -A-	250 mm +1mm/-0 mm Dia	250.482 mm
Thickness	100 mm + 0/- .5 mm	99.977 mm Sharp Corner
Wedge, Surface 2	2 Degrees +/- 5 Min	1.983 Degrees
Chamfers, After Polish		
Side 1	2 mm +/- 0.3 mm, 2 Plc's	1.99 mm
Side 2	2 mm +/- 0.3 mm, 2 Plc's	1.89 mm

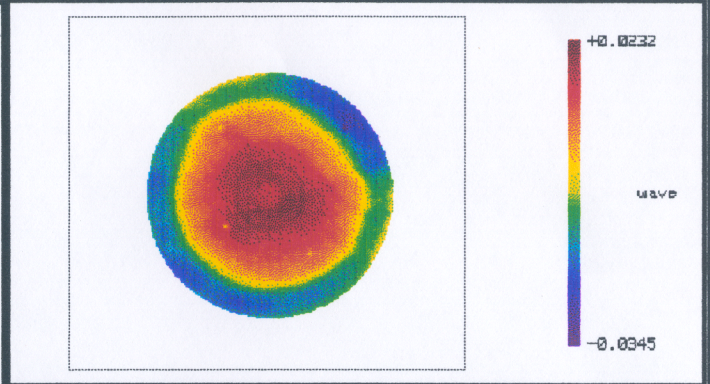
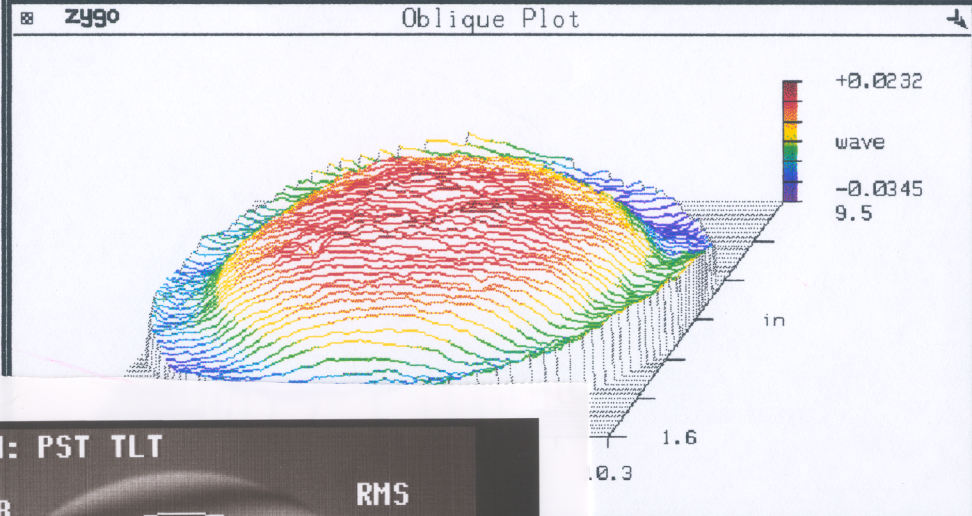
Substrate, End Test Mass	Serial Number: SP ETM Ø5 A		Specification	Reported Value	✓
	Surface 1	Surface Figure Over Central 200mm	Spherical, Concave	.022 waves PV	✓
		Absolute Radius of Curvature Tolerance	7,400m + 220m - 220m	7490.11 m	✓
		Variation of Radius of Curvature from Average	+ 111m - 111m		
		Astigmatism	< 10nm p-v		
	Surface 2	Surface Figure Over Central 200mm	Flat		
		Radius of Curvature	> 80 Km		
		Astigmatism	< 64nm p-v		
	Physical Dimensions	Substrate Diameter	250mm +1mm/-0mm	250.482 mm	✓
		Substrate Thickness	100mm +/- .5mm	99.977mm	✓
		Wedge Angle, Surface 2 Chamfers, After Polish	2° ± min	1.983°	✓
		Side 1	2mm ± 0.3mm	1.99 mm	✓
	Surface Errors Surface 1	Side 2	2mm ± 0.3mm	1.89 mm	✓
Low Spatial Frequency Band Central 80mm		≤ 4.3 cm ⁻¹ σ _{rms} < 0.8nm			
Low Spatial Frequency Band Central 200mm		≤ 4.3 cm ⁻¹ σ _{rms} < 1.6nm			
	High Spatial Frequency Band Central 80 & 200 mm	4.3 – 7,500 cm ⁻¹ σ _{rms} < 0.2nm			

Scratches, Point Defects & Polish	Side 1	Specification		Certification	✓	
		Scratches	The Total Area of scratches within the central 80mm diameter shall not exceed 25 X 10 ³ square micrometers (width x length).		Hand Sketch w/dimensions	
			The total area of scratches outside the central 80 mm diameter shall not exceed 250 x 10 ³ square micrometers.		Hand Sketch w/dimensions	
		Point Defects	There shall be no more than 10 point defects within the central 80mm diameter.		Hand Sketch w/dimensions	
			There shall be no more than 100 point defects on the entire surface. Point defects of radius greater than 25 micrometers are treated like scratches for the purpose of this specification. Point defects of radius less than 2.5 micrometers are disregarded.		Hand Sketch w/dimensions	
Side/Bevel Polish	Sides and bevels shall be polished from a three micrometer grit finish. These surfaces shall appear transparent with no gray, scuffs or scratches visible to the naked eye when viewed in normal room light against a black background.		Inspection Report			

LIGO Component Specification Verification Sheet
End Test Mass

Scratches, Point Defects & Polish Side 2	Specification		Certification	✓
	Scratches	The total area of scratches shall not exceed 1×10^6 square micrometers over the central 235 mm.	Hand Sketch w/dimensions	
	Point Defects	There shall be no more than 100 point defects within the central 80mm diameter.	Hand Sketch w/dimensions	
		There shall be no more than 300 point defects on the entire optic. Point defects of radius greater than 25 micrometers are treated like scratches for the purpose of this specification. Point defects of radius less than 2.5 micrometers are disregarded.	Hand Sketch w/dimensions	
Side/Bevel Polish	Sides and bevels shall be polished from a three micrometer grit finish. These surfaces shall appear transparent with no gray, scuffs or scratches visible to the naked eye when viewed in normal room light against a black background.	Inspection Report		

**LIGO Component Specification Verification Sheet
End Test Mass**



PV	0.058	wave	Solid Plot
rms	0.013	wave	3D Plot
Power	-0.043	wave	

Removed: PST TLT

PV 0.058 wave

RMS 0.013 wave

Pts. 21184

Power -0.043

General Optics, Inc.

7.87 in	Removed: PST TLT	Aperture(%dia.)
0.04 wave	Points 21184	

Measurement Controls

Part Number: LIGO TEST MASS - SIDE 2

Serial Number: SP ETM 05A Min Mod Pct: 3

Inspector: J. LONGO Intens Avgs: 4

Intf Scale Factor: 0.5 Phase Avgs: 4

Refractive Index: 1.500000 AGC: On Phase Res: Normal

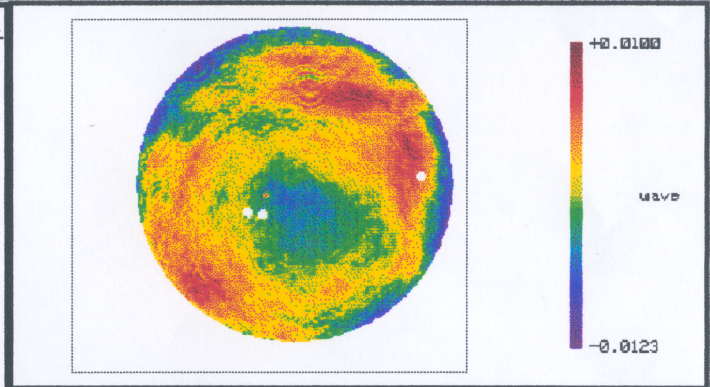
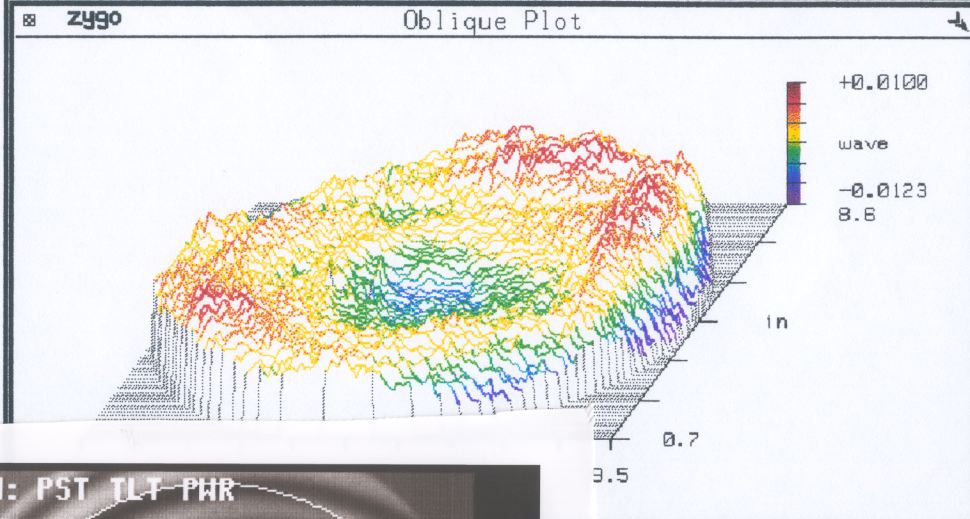
Time: Wed Jun 4 11:55:47 1997 AGC Mode: Normal Reflectivity

Instrument: Mark IVxp Id 0 SN 4532 SB 0 Phase Avg Pause: Off

Wavelength-In: 6328.0 A Wavelength-Out: 6328.0 A

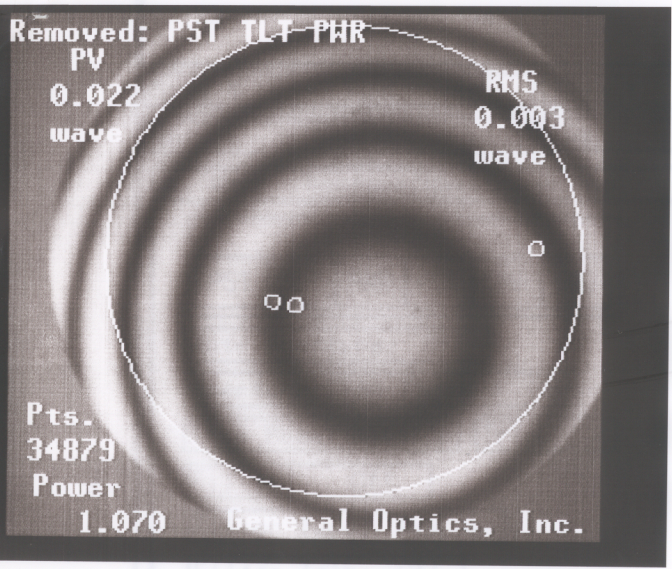
Subtract Sys Err: Off Sys Err File: SysErr.dat

Discon Action: Ignore Discon Filter: 45 Light Level: 48



PV	0.022	wave	Solid Plot
rms	0.003	wave	3D Plot
Power	1.070	wave	

7.88	in	Removed: PST TLT PWR	Aperture(%dia.)
-1.07	wave	Points	34879



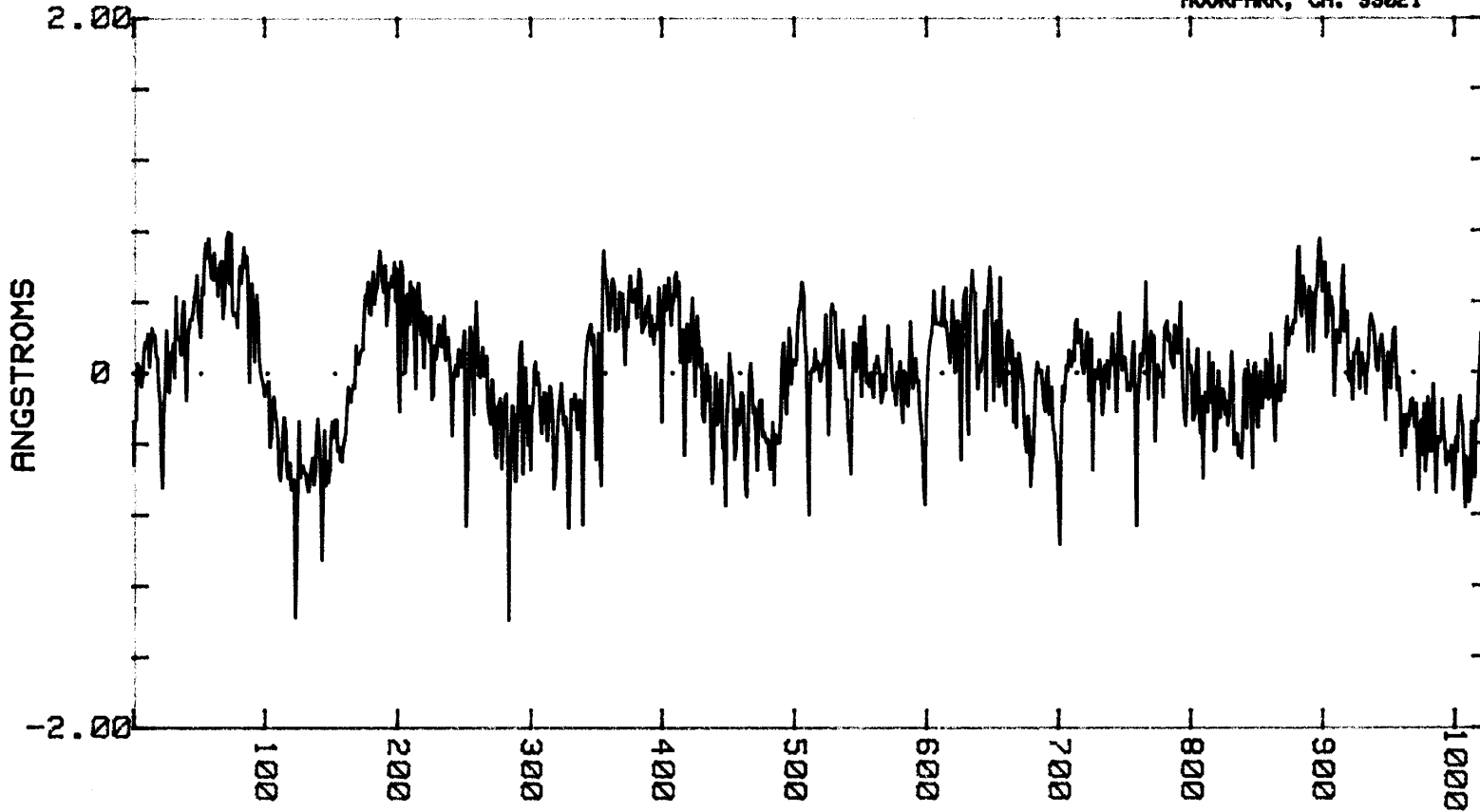
Measurement Controls

Part Number: LIGO TEST MASS - SIDE 1	
Serial Number: SP ETM 05A	Min Mod Pct: 3
Inspector: S. RILES	Intens Avgs: 4
Intf Scale Factor: 0.5	Phase Avgs: 4
Refractive Index: 1.500000	AGC: On Phase Res: Normal
Time: Mon Jun 2 08:08:33 1997	AGC Mode: Normal Reflectivity
Instrument: Mark IVxp Id 0 SN 4532 SB 0	Phase Avg Pause: Off
Wavelength-In: 6328.0 A	Wavelength-Out: 6328.0 A
Subtract Sys Err: Off	Sys Err File: SysErr.dat
Discon Action: Ignore	Discon Filter: 45 Light Level: 17

J-6108 LIGO TEST MASS SPETM 05A S-1

Processed
RMS 0.34 angstroms
P-V 2.19
1024 points

4 Jun 1997 10:43:21
GENERAL OPTICS, INC.
(805) 529-3324
554 FLINN AVENUE
MOORPARK, CA. 93021



J-6108 LIGO TEST MASS SPETM 05A S-2

Processed

RMS 0.60 angstroms

P-V 4.64

1024 points

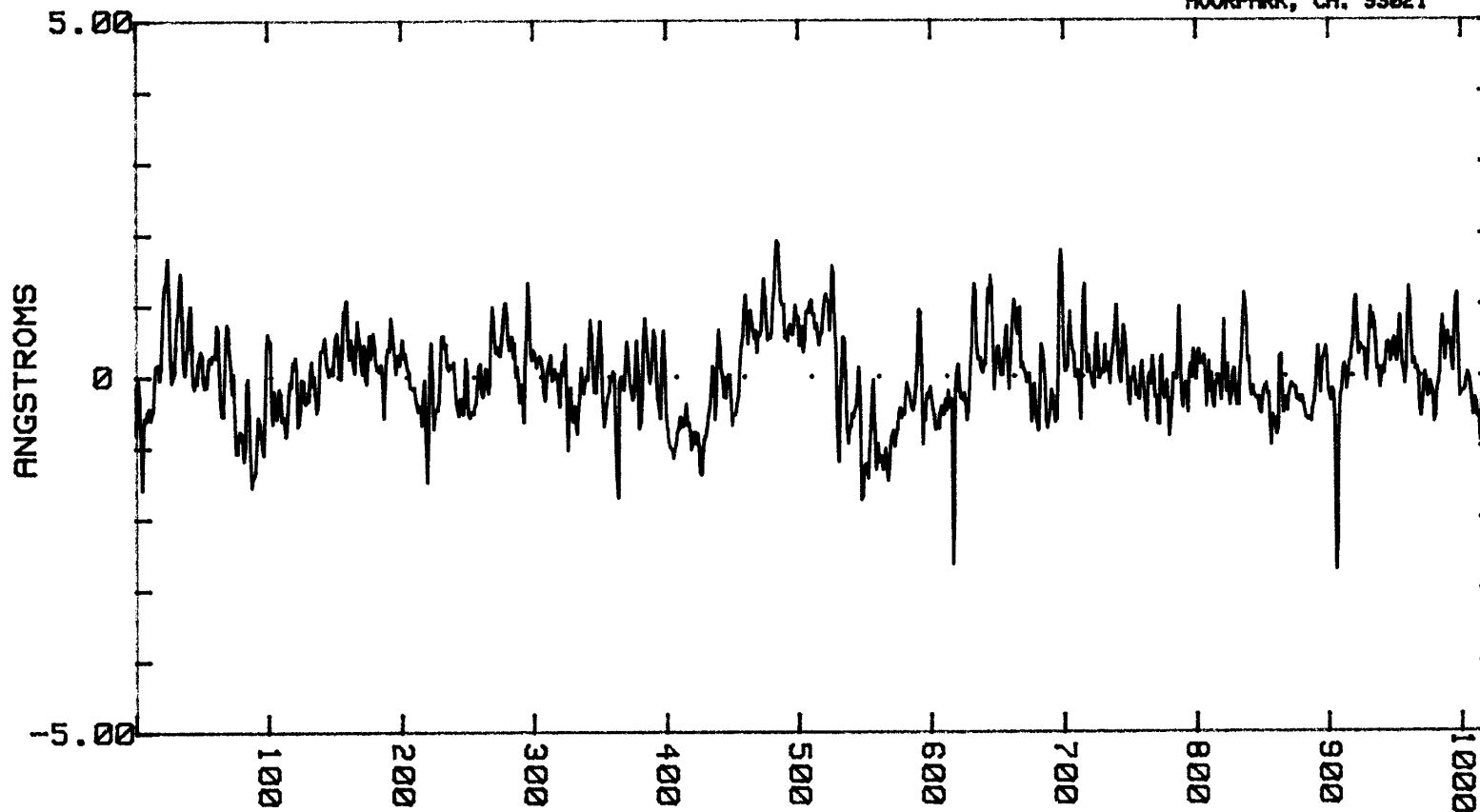
4 Jun 1997 10:52:01

GENERAL OPTICS, INC.

(805) 529-3324

554 FLINN AVENUE

MOORPARK, CA. 93021





GENERAL OPTICS, INC.

554 FLINN AVE.

MOORPARK, CA 93021

PHONE: (805) 529-3324 • FAX: (805) 529-4298

INVOICE NUMBER	24692
INVOICE DATE	6/11/97

CUSTOMER ORDER NO.	DATE ORDERED	DATE DUE	SHIP VIA	DATE SHIPPED
PC203459	10/18/96		Fed-X SOS Prepay & Bill	6/11/97
F.O.B.	TERMS OF PAYMENT		TAXABLE	BUYER'S NAME
Moorkpark	Net 30 Days		No	Tina Lowenthal (818) 395-2758

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CALTECH
Accounts Payable 201-6
Pasadena, CA 91125

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National Institute of Standards & Technology
Route 124 and Clopper Road
Gaithersburg, MD 20899

Attn: Chris Evans

ITEM	ITEM DESCRIPTION	QUANTITY ORDERED	QUANTITY PREVIOUS SHIPMENT	QUANTITY BACK-ORDERED	QUANTITY THIS SHIPMENT	UNIT PRICE	AMOUNT
1	Polish LIGO Test Mass Optics per Specification E950104-A-D and per Drawing D960791-A-D. Note: All work to be performed on a best-effort basis. Serial Numbers: SPETM01A SPETM02A SPETM03A SPETM04A SPETM05A	8	0	3	5	7500.00	37,500.00
2	Non-recurring set-up charge <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p><i>These items were visually inspected by me at General Optics, and were drop shipped to NIST per my instructions.</i></p> <p><i>Gan Lynn Billingsley</i> 6-11-97 Gan Lynn Billingsley, CALTECH Date</p> </div>	1 Lot	0	0	1 Lot	5000.00 Lot	5000.00

A late charge of 1% per month will be charged on past due balances.

We are an Equal Opportunity Employer M/F

We hereby certify these goods were produced in compliance with all applicable requirements of Sections 6, 7 and 12 of the Fair Labor Standards Act, as amended and of regulations and orders of the United States Department of Labor issued under Section 14 thereof.

J-6108, 6118

SUBTOTAL	42,500.00
SALES TAX	0.00
SHIPPING CHARGES	0.00
TOTAL	\$42,500.00

MIRROR



Research Electro-Optics Inc.

CERTIFICATE OF CONFORMANCE

Section 3.14/REO QC Manual, Q-001, Doc. No. V:QA:REO 014, Rev. "B", 09/13/96

Certificate of Conformance from: Research Electro-Optics (REO) Inc.
1855 South 57th. Court
Boulder, Colorado 80301
(303) 938-1960, Fax (303) 447-3279

Research Electro-Optics (REO), Inc. hereby certifies that the items listed below have been inspected and tested to the extent necessary to conform with all the requirements of the noted Purchase Order, drawing, and applicable specification(s). Inspection and test data are on file at our facility and will be furnished to customer upon request.

- Date of Shipment 06/21/99
- Customer Name California Inst. of Tech / PC162519/C0N05
Purchase Order No.
- Customer Part LIGOE980068
Number & Revision
- Part Description END TEST MASS, COATED
- REO Job No. OPT05831-28 Run No: OX987/OX991
- Qty. Shipped/Lot No. 2 PCS / M1001-01

Test data (included)

Comments:

SPETM05

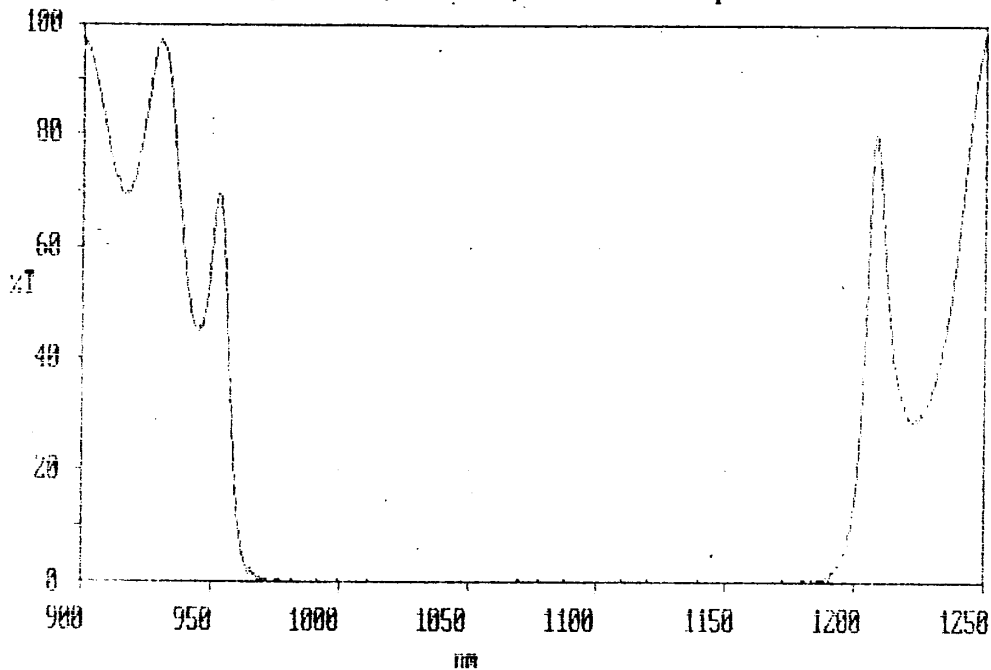
SPETM07

Certified by: Jesus Pineda 6/21/99 Date
Quality Assurance
 Verified by: Dale C. Hess 21 June 99 Date
Engr/Tech

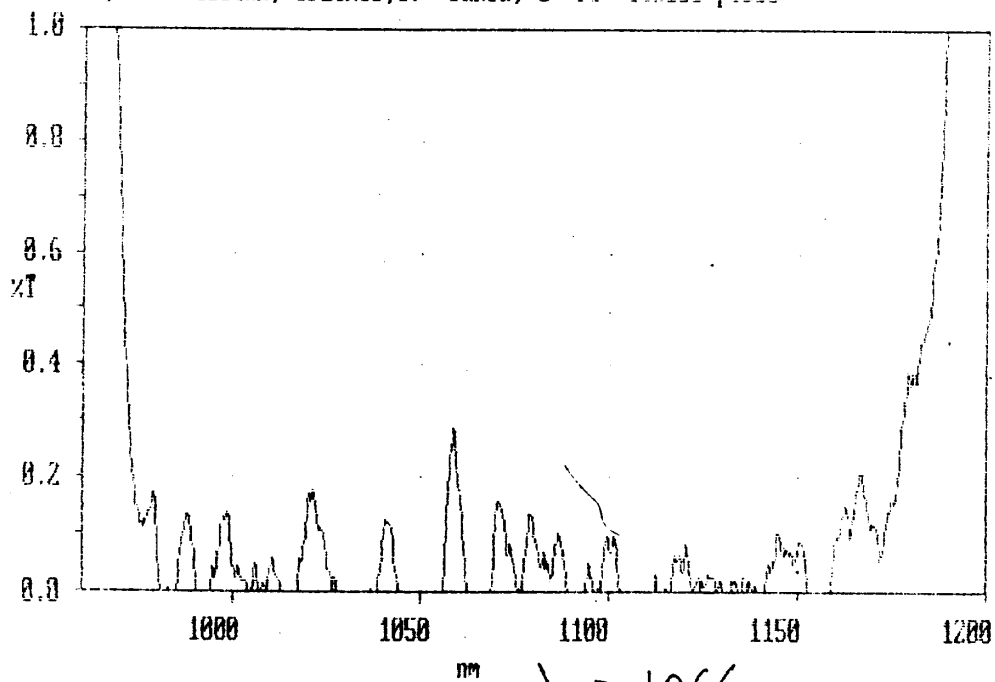
NOTE

Certificate must accompany the package to be shipped or attached to the outside of the same box to which the "Packing Slip" envelope is attached.

X: user003: 1250.0 - 900.0 nm; pts 1751; int 0.20; ord -0.449 - 98.191 %T
Inf: 0X987, HR @ 1064nm, SPETM05,07 baked, 1" FS witness piece



X: user003: 1250.0 - 900.0 nm; pts 1751; int 0.20; ord -0.217 - 97.268 %T
Inf: 0X987, HR @ 1064nm, SPETM05,07 baked, 1" FS witness piece



Y: user002; 1100.0 - 1000.0 nm; pts 1001; int 0.10; ord -0.007 - 0.1762 %T
Inf: 0X991, AR @ 1064nm, SPETM05,07 baked, 1" fs witness

