FM01

LIGO-T990133-00-D

BLANK

FM Ø1

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

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.: PP 207573
Core optic Material: (BS/FM/ITM/ETM/RM)
LIGO Drawing No.: D960794-A-D
Optical Glass Spec. MIL-G-174-B

Glass Mfg./Order No: Corning / QD 10624801
Glass Mfg. Part No.: E 855306 SN-FE Ø1
Manufacturer's Boule No.: 34639 ACT
Date Received at Caltech: 12-19-96

☑ Verify glass manufacturer's Certification against LIGO Component Specification No.. E960097-A-D Folding Mirror

☑ Attach a copy of the glass manufacturer's Certification to check-off sheet.

☑ Attach the glass manufacturer's optical phase 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 10.112" 25.684 cm 256.84mm
- ☑ Inspection of material thickness. Thickness 4.294" 109.07mm
- ☑ Inspection of chamfer. NA

☑ 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: 12-19-96

Reviewed and/or accepted by:

Cognizant Engineer: [signature] Date: 2-25-97

LIGO QA Officer or Designee:_____ Date:_____

FM300

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.)

Physical dimensions are accurate to .001 in. Measurements are converted to mm using a factor of 25.4^{05} mm = 1.0 inch.

SKETCHES:

DISPOSITIONS:

H-36-R

CORNING INCORPORATED

CORNING

CORNING, NEW YORK

SHIPPING ORDER

PACKING LIST

CUST. ORD. NO & DATE: [illegible] 09/20/96

CNG ORD NO.: [illegible]

SOLD TO:
CALIFORNIA INSTITUTE OF TECHNO [illegible]
[illegible]
[illegible]
PASADENA CA [illegible]

SAME AS "SOLD TO" UNLESS OTHERWISE SPECIFIED

SHIP TO:
CALIFORNIA INSTITUTE OF TECHNO [illegible]
ATTN MR LOWELL JONES
[illegible] HOLLISTON [illegible]
[illegible]

SALES CODE: [illegible]

DISCOUNT FACTOR:

DESIRED SHIP DATE: [illegible]

SHIPPED F.O.B.: [illegible]

DATE ENTERED: [illegible]

WE EXPECT TO SHIP: 11/26/96

DATE SHIPPED	INVOICE NUMBER

DATE SHIPPED:

ROUTING: 52637

UPS Red

CAR INITIAL AND NUMBER:

THIS SHIPMENT PARTIAL	THIS SHIPMENT COMPLETE	PREPAID	COLLECT
		X	

DATE ISSUED: 12/18/96

DATE TO SHIP: 12/18/96

	WHSE. LOC. - PRODUCT CODE	DESCRIPTION	QUANTITY UNITS	QUANTITY CASES
		[illegible] S.C.A. [illegible] X [illegible] BLANK TOLERANCES [illegible] BOTH DIMS FOLDING MIRROR, END TEST MASSES CLEAR APERATURE [illegible] [illegible] INCLUDES [illegible] WITNESS SAMPLES SAMPLE DIMENSIONS [illegible] CYLINDRICAL WITNESS SAMPLES [illegible] PORTION OF BOULE [illegible] WITNESS SAMPLES SHALL BE SERIALIZED [illegible] WHERE [illegible] INCREMENTS STARTING AT [illegible] [illegible] SPEC # [illegible] DWG# [illegible]	3 ✓ BW	PC
	[illegible]	[illegible] [illegible] WITNESS SAMPLE [illegible] X [illegible] CYLINDRICAL YOUR PRODUCT [illegible] WITNESS SAMPLE WITNESS SAMPLE [illegible] [illegible] IS INCLUDED [illegible] ITEM 001	3 ✓ BW	PC

12-19-96

Rec'd 3 cartons in good Condition. Partial

Steven Elieson

FE01

ROUTING

DATA SHEET - CAL TECH LIGO MIRROR BLANKS

Cal Tech Purchase Order Number: PP 307573

Cal Tech Drawing Number: D 960794

Attribute	Specification #	Requirement	Actual	Stamp	
Diameter	Per LIGO - D960097-A-D	10.079", -0.0"/+0.4"	10.111 / 10.111		QA
Thickness	Per LIGO - D960097-A-D	4.252";-0.0/+0.4"	4.288 / 4.288 / 4.288 / 4.288		QA
Registration Mark	Per LIGO - D960794	TOP CENTER OF OPTIC	See Attached Cert.		M
Serial & Boule #	Per LIGO-D960794	Boule & Serial NO.	34639AST-FE01		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		P.TOV.<---1---x10E-6	1.26E X 10^{-7} PV-0.027		M
Homogeneity - outside		P.TOV.<-2.5-x10E-6	7.29E X 10^{-7} PV - 0.156		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 A	Inspection Report		M
Absorption		< 20 ppm / cm @ λ = 1.06 µm	SEE ATTACHED CERT.		M

Comments:

Inspected by: Gail Andrews Date: 12-17-96

CORNING INCORPORATED

zygo — Homogeneity

Lg Aperture

PV 0.027 wave

rms 0.004 wave

Power 0.012 wave

Homogeneity 1.26E-07

Points 1358

AstMag (Z) 0.006 wave

zygo — Spike

Remove Spikes: Off | (xRMS): 3.00

Data Fill: Off | Data Fill Max: 25

Removed:

PST TLT PWR

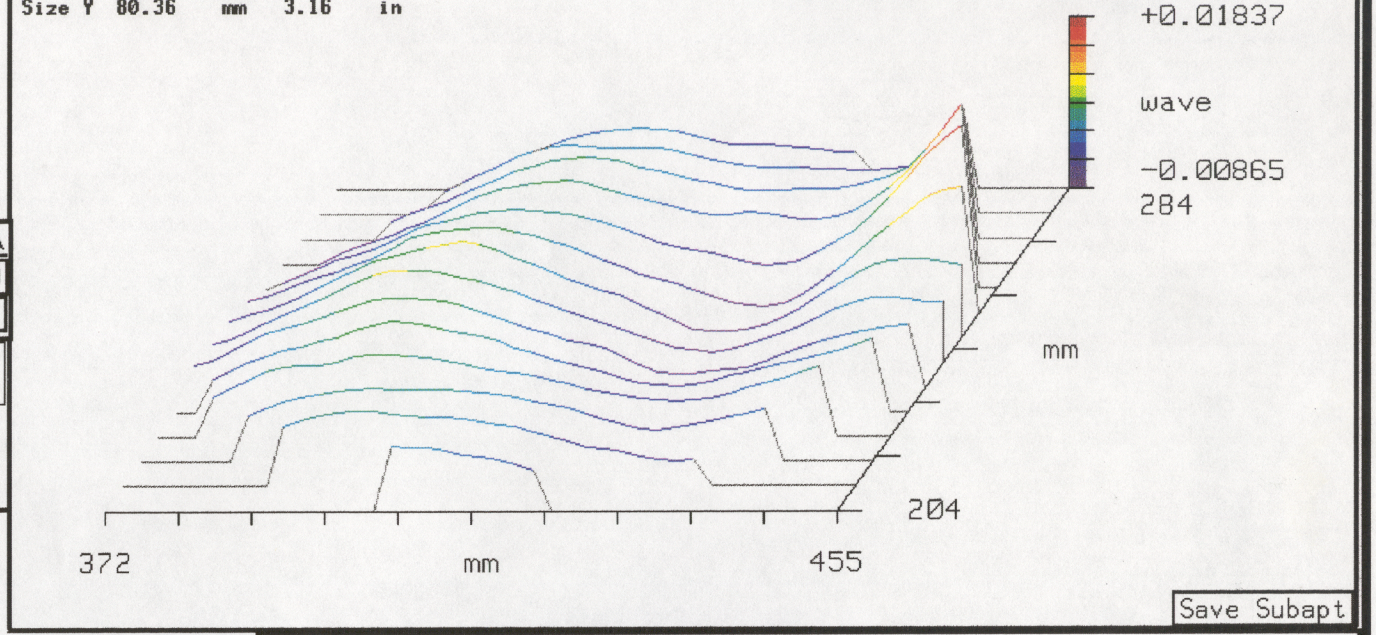
PST | TLT | PWR | AST | CMA | SA3

Zern Terms: 36

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



Save Subapt

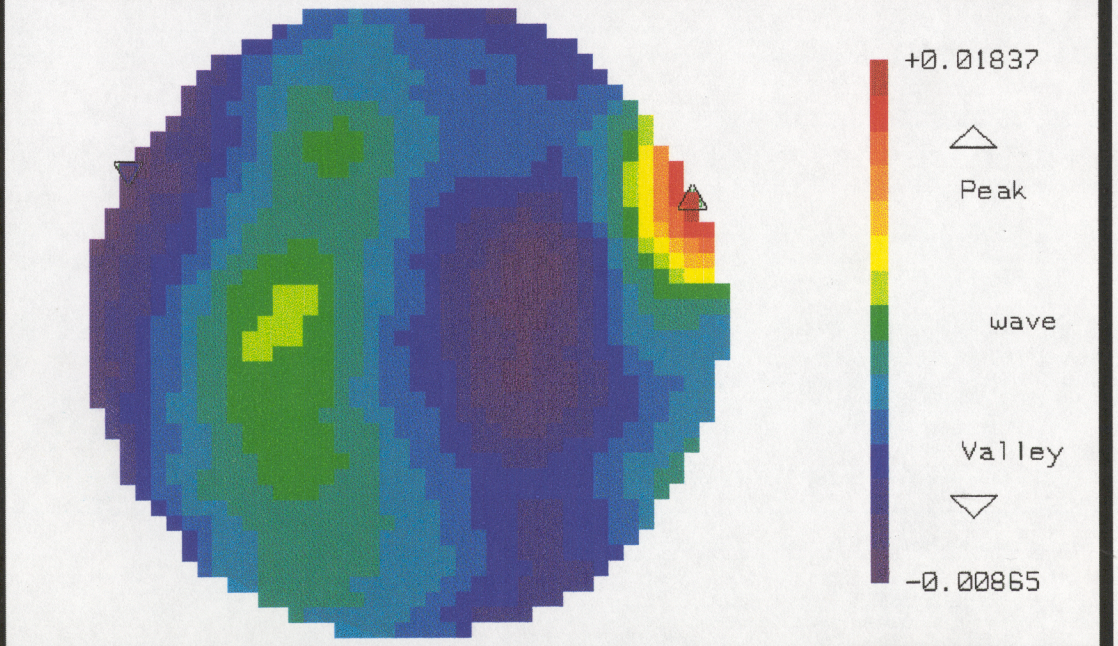
Zernike Coefficients from 1357 data points

Order: 10th Terms: 36 rms: 0.001

-0.076	0.007	-0.008	0.006					
0.000	0.003	0.008	0.000	-0.001				
0.004	0.001	0.002	0.001	-0.003	0.000	0.000		
0.000	0.002	-0.001	0.001	-0.001	0.000	0.001	0.000	0.000
-0.003	0.002	-0.001	0.000	-0.001	-0.001	0.000	0.000	0.000

Measure | Mask Data | Save Data | DBSAVE

Analyze | Calibrate | Load Data



zygo — File Data

Subtract Sys Err: On

Sys Err File: r111596.802

Part Thickness: 5.34 in

Boule #: 34639

Suffix: SNC ACT

Min Mod (%): 1

Phase Res: High

Scale: 0.500

AGC: Off

Light Level: 110

Comment:

38" BOULE SAL-FE01

Data File: 34639sn2.sbt

Camera Res: 1.9600 mm

Time: Tue Nov 19 23:38:37 1996

Phase Avgs: 6

Intens Avgs: 6

SlopeMag | TiltXY | Filter | AutoSeq | Manipulate | Metroscript

Profile | VideoMon | SlopeY | SPC | Meas Controls | FileCopy | Report | ZernGen

zygo — Homogeneity

Lg Aperture

PV 0.156 wave

rms 0.021 wave

Power 0.062 wave

Homogeneity 7.29E-07

Points 8248

AstMag (Z) 0.076 wave

zygo — Spike

Remove Spikes: Off | (xRMS): 3.00

Data Fill: Off | Data Fill Max: 25

Removed:

PST TLT PWR

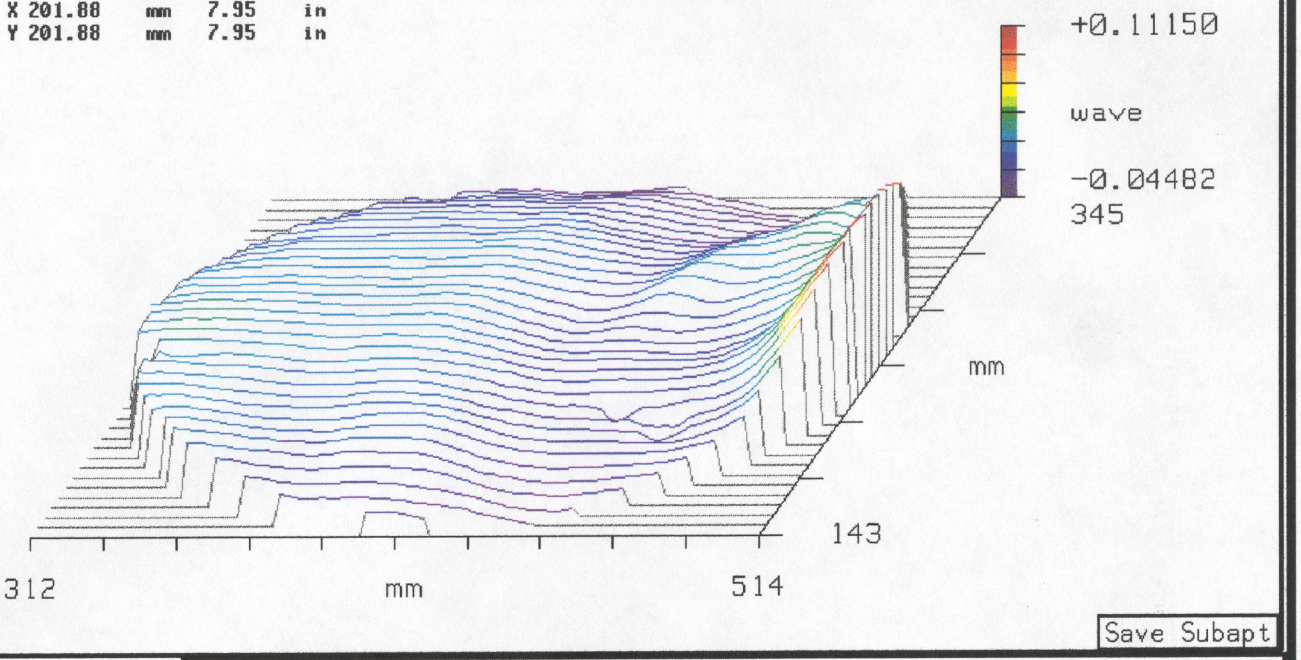
PST | TLT | PWR | AST | CMA | SA3

Zern Terms: 36

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

Size X 201.88 mm 7.95 in

Size Y 201.88 mm 7.95 in

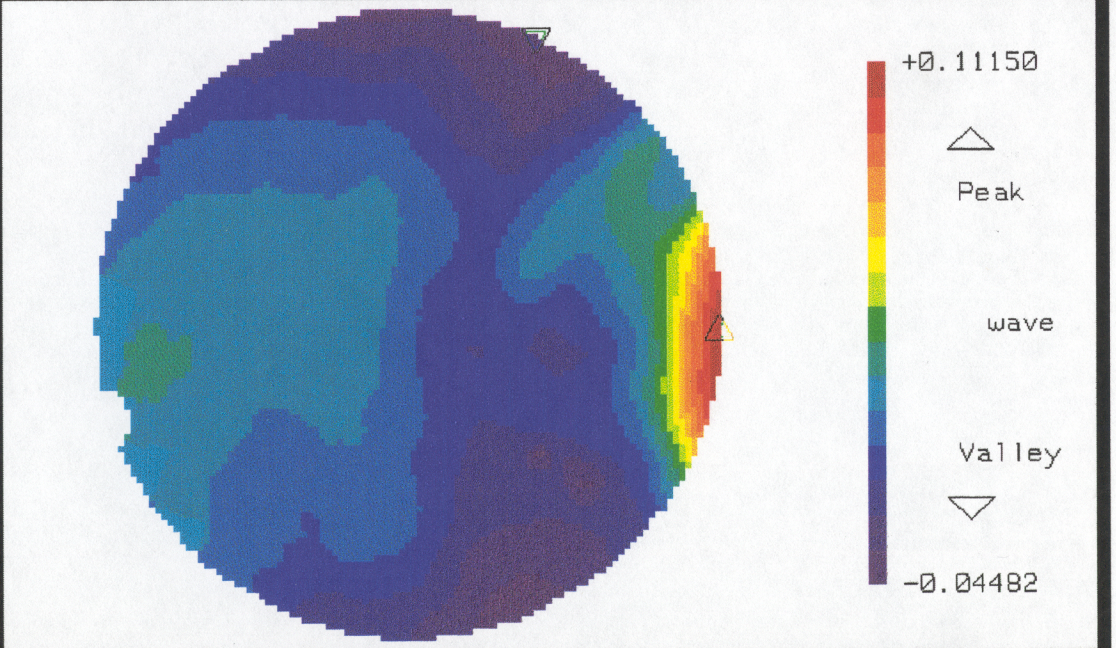


Save Subapt

Zernike Coefficients from 8247 data points

Order: 10th Terms: 36 rms: 0.004

-0.052	0.055	-0.029	0.031					
0.037	0.007	0.020	-0.006	0.002				
0.023	0.002	0.012	-0.003	0.000	0.000	0.001		
0.014	0.000	0.003	-0.008	-0.002	0.000	0.002	-0.001	-0.001
0.005	-0.004	0.000	-0.005	0.001	0.001	0.000	0.000	-0.004



Measure | Mask Data | Save Data | DBSAVE

Analyze | Calibrate | Load Data

zygo — File Data

Subtract Sys Err: On

Sys Err File: r111596.802

Part Thickness: 5.34 in

Boule #: 34639

Suffix: SNC

Comment:

38" BOULE SN-FE01

Data File: 34639sn2.sbt

Camera Res: 1.9600 mm

Time: Tue Nov 19 23:38:37 1996

Min Mod (%): 1

Phase Res: High

Scale: 0.500

AGC: Off

Light Level: 110

Phase Avgs: 6

Intens Avgs: 6

SlopeMag | TiltXY | Filter | AutoSeq | Manipulate | Metroscript

Profile | VideoMon | SlopeY | SPC | Meas Controls | FileCopy | Report | ZernGen

FAX COVER PAGE

CALIFORNIA INSTITUTE OF TECHNOLOGY

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

TO:	Brian Bush, cc:Randy VanBrocklin
ORGANIZATION:	Corning Inc.
FAX NUMBER:	(315) 379-3317
VOICE NUMBER:	(315)379-3381
DATE:	December 9, 1996

FROM:	GariLynn Billingsley
ORGANIZATION:	LIGO detector group
FAX NUMBER:	818 304-9834
VOICE NUMBER:	818 395-2184
REFER TO:	LIGO-C962562-00-D
SUBJECT:	Discrepant Material

NUMBER OF PAGES FAXED INCLUDING THIS COVER SHEET:	1

Randy

I have discussed the problem of the witness samples with our management and QA. Due to schedule pressures we are willing to accept an initial shipment of two Blanks per LIGO specification E960097-A-D without the location and orientation of the witness samples and blanks with respect to the boule. We would like to note that this is a one time discrepancy and all other shipments will be expected to conform with the specification.

very truly yours,

GariLynn Billingsley

cc:

DCC, Whitcomb, Petrac, Camp, Tyler

FE Ø1

CORNING
334 County Route 16
Canton, New York 13617-9703

Canton Plant . . .

...WHERE QUALITY MIRRORS PRIDE

CERTIFICATE OF COMPLIANCE

Customer: California Institute of Technology

Item: 001

Customer Order No.: PP207573

Glass: 7980 Grade 0A

Corning Order No.: QD106248

Quantity Shipped: 3

Code No.: 855306

Date Shipped: 12/18/96

Registration Mark for & Serial # per LIGO
Drawing # D960794-A-D
Biregringence ≤ 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, except parts approved for shipment in Deviation report.

FE Ø1
FE Ø2
FE Ø3

Signed: Brian C Bush

Brian C. Bush

Title: Quality Assurance Section Leader

Date: 12/18/96

pertains to serial numbers
FE01 — FE09 - GB

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 shipper.

10) Specification revision number referenced on Data Pack.
    QA Inspectors aware of requirement. Will be done on next shipment of parts.

CC:
Petrac
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

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,

GariLynn Billingsley
Technical Representative

DEVIATION APPROVAL FORM

Customer Name: California Inst. Technology

Customer P.O. Number: PP 207573

Corning Order Number: QD106 94801

Corning Part Number: F 855306

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

Boule Number:

Quantity Affected: 11 (FE01 Thru FE 11)

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

Gari Lynn Billingsley
Customer Contact (print)

2-24-97

Randy VanBoard
Authorizing Signature

12/12/96
Date

Send copy with shipment? (Y) N
(circle Yes or No)

Billing Status

- ☐ Bill Now
- ☐ Bill in 30 Days
- ☐ Other

Deviation Number: FE Ø1
(sequential number) - *(year)*

cc: Shipping Clerk
Customer Service

Q704 rev. A


MIRROR

Research Electro-Optics Inc.

CERTIFICATE OF CONFORMANCE

Section3.14/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 : JUNE 3, 1998
- Customer Name, Purchase Order No. : LIGO PO# PC162519/CONO5
- Customer Part Number & Revision : LIGOE980065
- Part Description : FM01,FM02; HR@1064NM
- REO Job No. : OPT05831-20 Run No.: OX744, OX748
- Qty. Shipped/Lot No. : 2 PCS

☑ **Test data (included)**

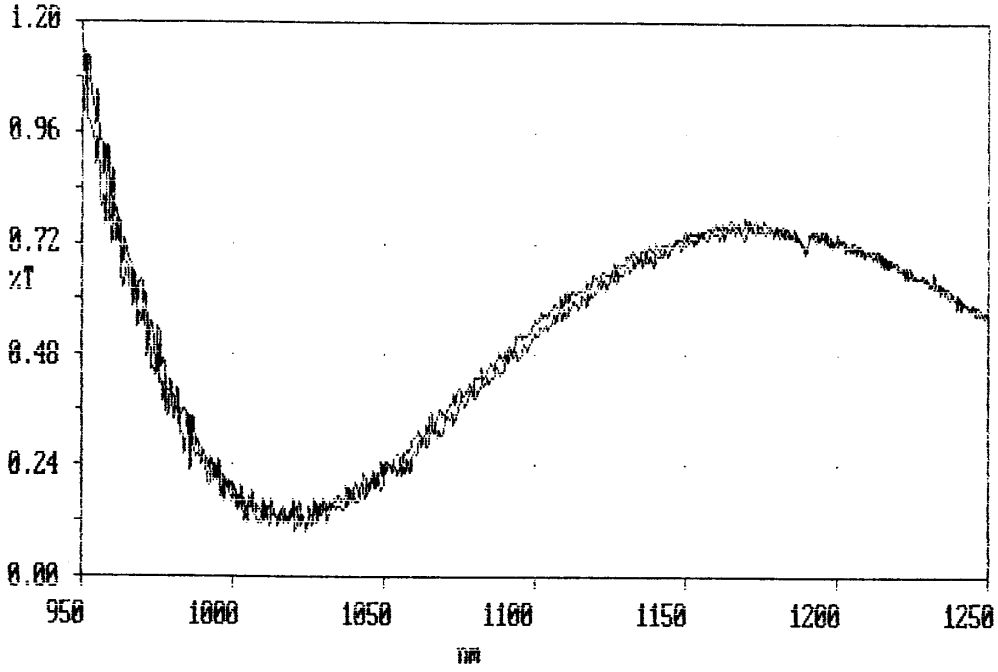
Comment:

Certified by: _____, 6/3/98
Quality Assurance

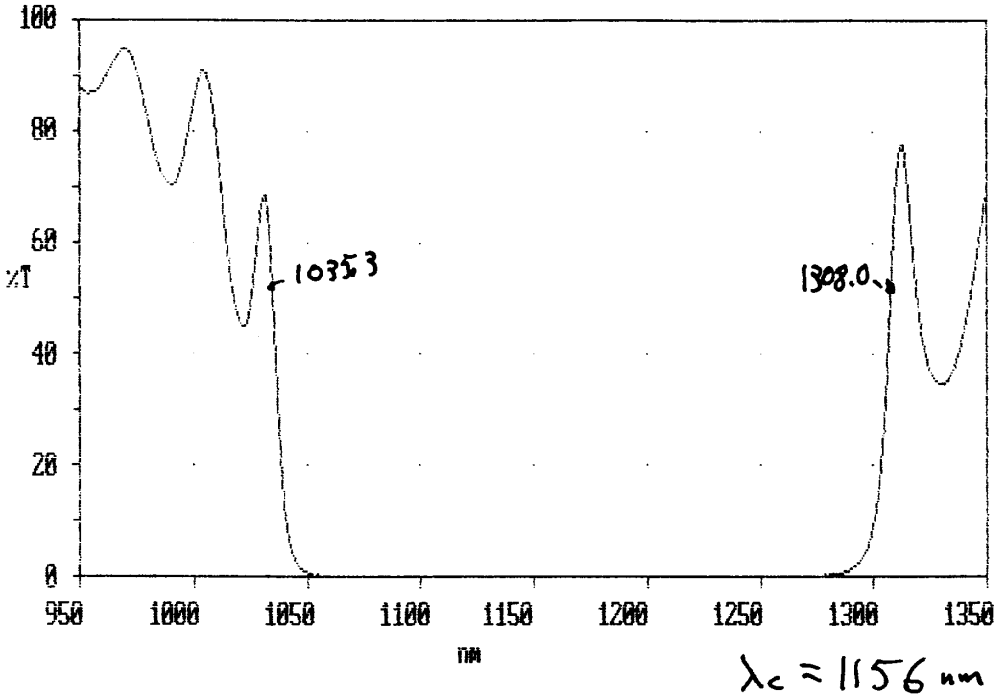
Verified by: _____, 6/3/98
Engr/Tech

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.

Y: user002; 1250.0 - 950.0 nm; pts 601; int 0.50; ord 0.1020 - 1.1515 %T
Inf: ox748 AR01064nm 045 deg part# FM01, FM02

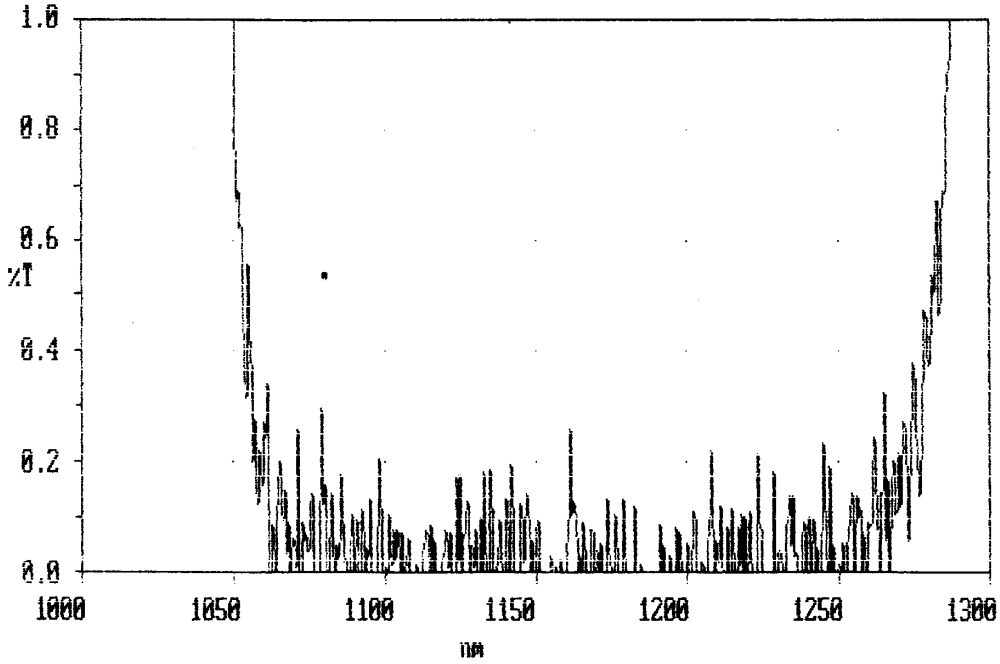


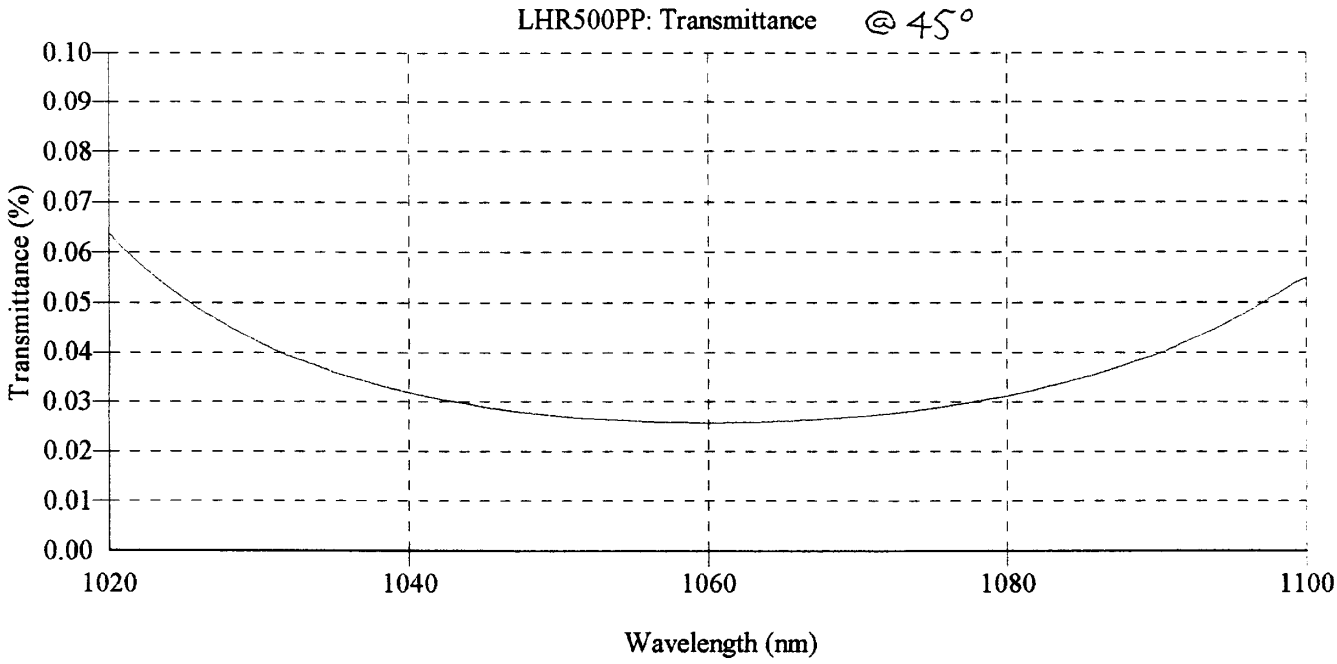
X: user002; 1350.0 - 950.0 nm; pts 801; int 0.50; ord -0.385 - 95.080 %T
Inf: #0X744, HR @ 1064nm @ 45 deg. normal incidence scan, FM01, FM02. Baked

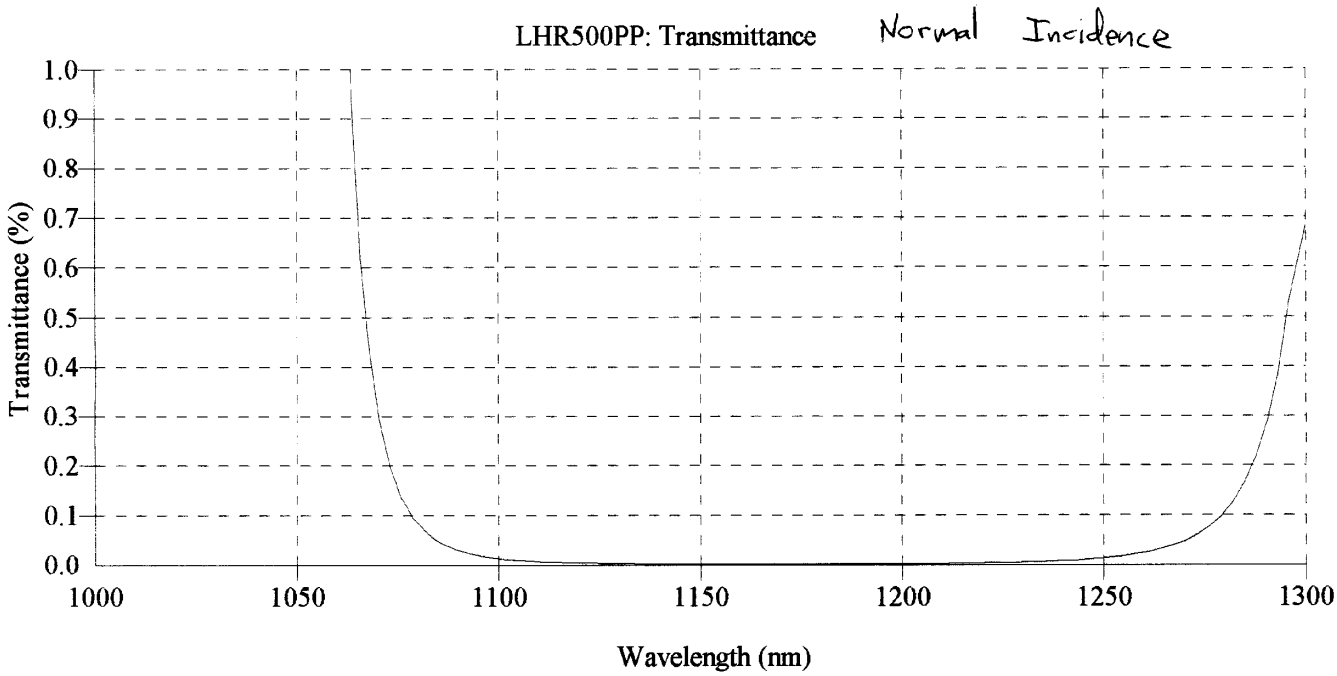


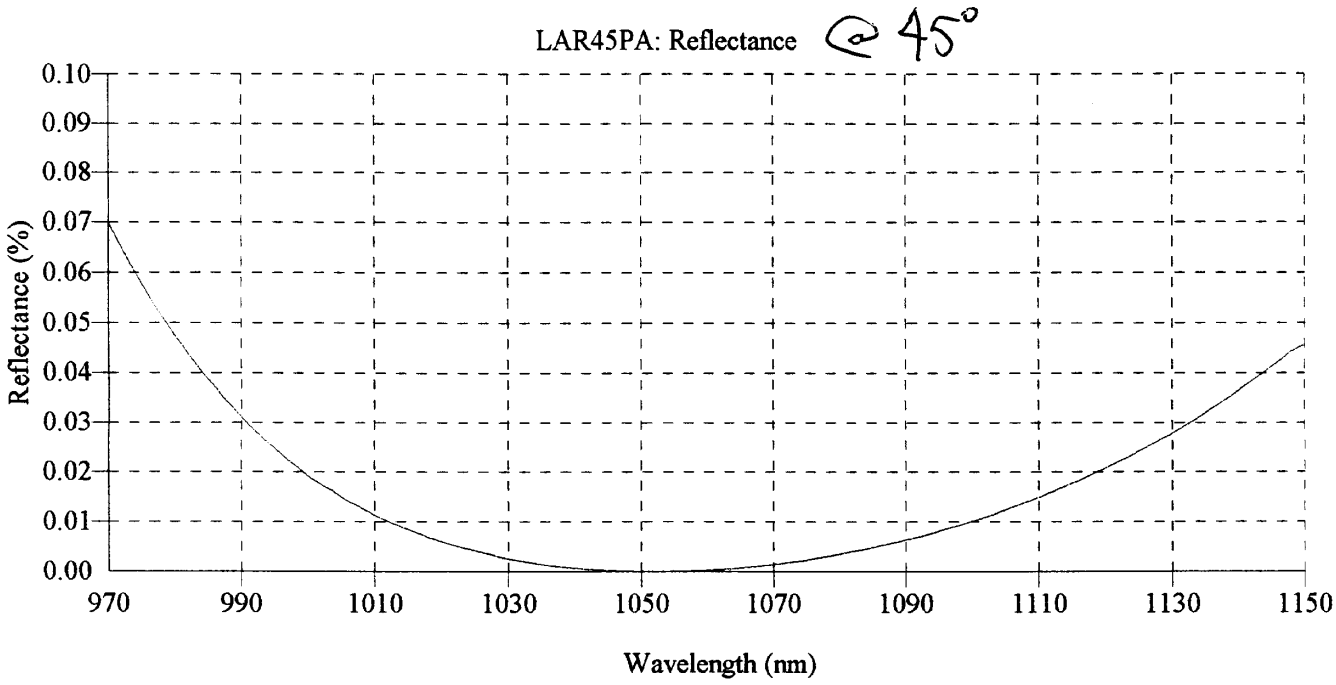
$\lambda_c \approx 1156$ nm

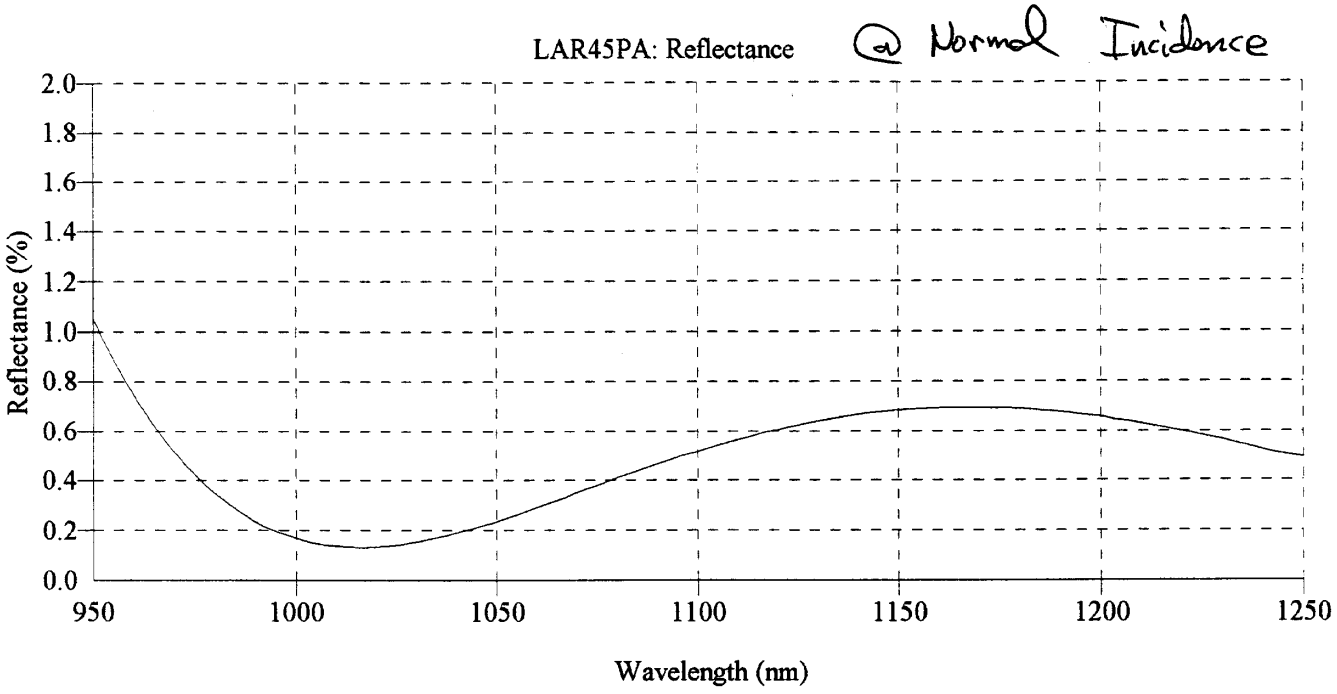
X: user002; 1350.0 - 950.0 nm; pts 801; int 0.50; ord -0.385 - 95.080 %T
Inf: #0X744, HR @ 1064nm @ 45 deg. normal incidence scan, FM01, FM02. Baked




LHR500PP: Transmittance @ 45°
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Transmittance (%)
1020
1040
1060
1080
1100
Wavelength (nm)


LHR500PP: Transmittance
Normal Incidence
Transmittance (%)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1000
1050
1100
1150
1200
1250
1300
Wavelength (nm)


LAR45PA: Reflectance @ 45°
Reflectance (%)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
970
990
1010
1030
1050
1070
1090
1110
1130
1150
Wavelength (nm)


LAR45PA: Reflectance @ Normal Incidence
Reflectance (%)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
950
1000
1050
1100
1150
1200
1250
Wavelength (nm)

Research Electro-Optics, Inc.

PAGE NO: 1

INVOICE NO: [illegible]

INVOICE DATE: 05/[illegible]/1998

INVOICE

CUSTOMER NO: [illegible]
CUSTOMER PH: [illegible]
BILL TO:

[illegible]
[illegible]
[illegible]
[illegible]

YOUR ORDER NO: PC162519/LIGO
OUR ORDER NO: OP105831-0003
SHIP TO:

CALIFORNIA INST. OF TECHNOLOGY
51-33 EAST BRIDGE LAB, LIGO
ATTN: HELENA ARMANDA, 18-34
PASADENA, CA 91125

TERMS: CASH #1: DISC:
CASH #2: DISC:
NET DUE DATE: 06/28/98

YOUR CUSTOMER REP IS: JM

SHIPPED: 05/29/1998
SHIP VIA: FED-EX P1
F.O.B.: FACTORY
SHIPMENT NO: 005105 REF:
PRO NO:

QTY ORDERED	QTY SHIPPED	QTY B.O.	ITEM NUMBER	UNIT PRICE	EXTD PRICE
			THIS ORDER IS A CHANGE ORDER TO REQ TO		
			PER QUOTES OPO-2403 & OPO-24		
			REFERENCE: CALTECH LIGO-C98-00D/LIGO-C9809E LIGO-C950494-05-1		
			Technical Contact: Helena Armadula Tel: 626 395-2070 Mail Code 18-34		
			Contractual Representative: Irena Petrac Tel: 626 395-2975 Mail Code 18-34		
			Item: #001 thru' #014 is per PO# PC162519 C		
			Item: #015 thru' #039 is per PO# PC162519 C Per REO quote #OPO-2537. No Item #027 on th acknowledgment.		
			Rec'd 06-08-98 Steve Olson		
2	2	0	LIGOE980065		
FOLDING MIRROR, COATED					

CONTINUED ON NEXT PAGE

Remit to: Accounts Receivable Department, P.O. Box 0543, Denver, CO 80256-0543
(303) 938-1960 FAX (303) 447-3279