

FM02

LIGO-T990144-00-D

BLANK

T 970010
~~FM~~ FM02

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.

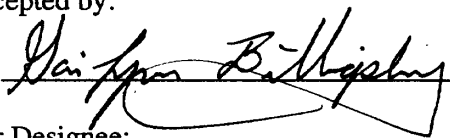
LIGO Contract No.: PP 207573
Core optic Material: (BS~~FM~~/ITM~~ETM~~/RM)
LIGO Drawing No.: D960794-A-D
Optical Glass Spec. MIL-G-174-B

Glass Mfg./Order No: Corning/QD10624801
Glass Mfg. Part No.: F855306 5N-FE02
Manufacturer's Boule No.: 34640 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: NA
- Verify core optic blank physical dimensions per applicable LIGO drawing.
 - Inspection of material diameter. Diameter 10.111" 256.87 mm
 - Inspection of material thickness. Thickness 4.2905" 109.00 mm
 - ~~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:  Date Inspected: 12-19-96

Reviewed and/or accepted by:

Cognizant Engineer:  Date: 2-25-97
LIGO QA Officer or Designee: _____ Date: _____

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.) _____

There is no large ^{aperture} data map for this substrate. However, the peak-to-valley reading in the center is small and the data sheet indicates that the large aperture was measured and is well within spec.

SKETCHES:

DISPOSITIONS:

CORNING INCORPORATED
CORNING
CORNING, NEW YORK

SHIPPING ORDER

PACKING LIST

ORD. NO. [107573] DATE [05/20/96]
 CALIFORNIA INSTITUTE OF TECHNOLOGY 13717
 ACCOUNTS PAYABLE DEPT 401-6 04 006 04
 1270 S CALIF BLVD
 PASADENA, CA 91129
 SAME AS "SOLD TO" UNLESS OTHERWISE SPECIFIED
 CALIFORNIA INSTITUTE OF TECHNOLOGY 13717
 ATTN: MR. LOWELL JONES
 201 S HOLLISTON
 PASADENA, CA 91129

DISCOUNT FACTOR [] DESIRED SHIP DATE [12/20/96]
 WAREHOUSE CODE [100054] DATE ENTERED [12/08/96]
 INVOICED

CNG ORD NO. [01100000]
 WE EXPECT TO SHIP [11/20/96]

| DATE SHIPPED | | INVOICE NUMBER | |
|-------------------------|----------|----------------|----------|
| | | | |
| DATE SHIPPED | | | |
| ROUTING <u>52637</u> | | | |
| BEST WAY <u>UPS Red</u> | | | |
| CAR INITIAL AND NUMBER | | | |
| THIS SHIPMENT | | PREPAID | COLLECT |
| PARTIAL | COMPLETE | X | |
| DATE ISSUED | 12/18/96 | DATE TO SHIP | 12/18/96 |

| WHSE. LOC. - PRODUCT CODE | DESCRIPTION | QUANTITY | |
|---------------------------|--|----------|-------|
| | | UNITS | CASES |
| 855308 7990 0000 | F.S.C.A. 4.252" T. BLANK TOLERANCES ± .040" ± .000" BOTH DIMS FOLDING MIRROR, END TEST MASSES CLEAR APERTURE = 9.052" PRICE INCLUDES 12 WITNESS SAMPLES SAMPLE DIMENSIONS .984" X .984" CYLINDRICAL WITNESS SAMPLES FROM NEARBY PORTION OF BOULE & SLABS & CORRESPONDING WITNESS SAMPLES SHALL BE SERIALIZED AS FEXX, WHERE XX INCREMENTS STARTING AT 01. #1 SPEC # LIGD-EP60097-A-D CWG# LIGD-0960794 | 3 | 1 PC |
| | DISC. F.S.OA. WITNESS SAMPLE. .984" X .984" CYLINDRICAL YOUR PRODUCT IDENT - 10 WITNESS SAMPLES WITNESS SAMPLES FOR IDENT PRICE IS INCLUDED IN ITEM 001 12-19-96 Rec'd 3 cartons in good Condition. Partial Steven Gibson FE 02 | 3 | 1 PC |

ROUTING

DATA SHEET - CAL TECH LIGO MIRROR BLANKS

Cal Tech Purchase Order Number:

PP207573

Cal Tech Drawing Number:

D960794

| Attribute | Specification # | Requirement | Actual | Stamp | |
|-----------------------|---|---|--|-------|----|
| Diameter | Per LIGO - D960097-A-D | 10.079", -0.0"/+0.4" | 10.110 ¹ 10.110 | | QA |
| Thickness | Per LIGO - D960097-A-D | 4.252", -0.0"/+0.4" | 4.290 14.2905 14.2905 14.2905 | | QA |
| Registration Mark | Per LIGO - D960794 | TOP CENTER OF OPTIC | See Attached Cert. | | M |
| Serial & Boule # | | 34640ACT-FE02 | 34640ACT-FE02 | | 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. < <u>1</u> x10E-6 | 1.95E x 10 ⁻⁷ PV - 0.034 | | M |
| Homogeneity - outside | | P.TOV. < <u>2.5</u> x10E-6 | 7.88E x 10 ⁻⁷ PV - 0.136 | | 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:

Gail Andrews

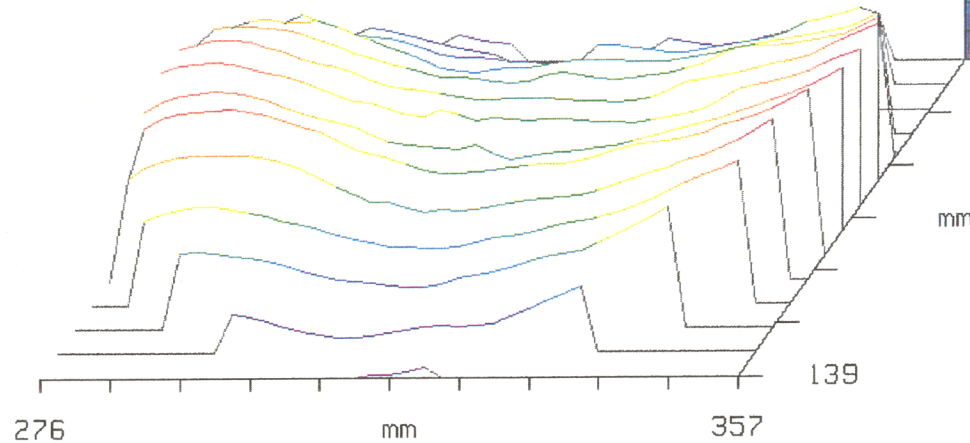
Date: 12-17-96

Homogeneity

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

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

+0.01534
wave
-0.01718
221



Save Subapt

Lg Aperture
PV 0.033 wave
rms 0.007 wave
Power 0.021 wave
Homogeneity 1.89E-07
Points 1274
AstMag (Z) 0.034 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 1273 data points

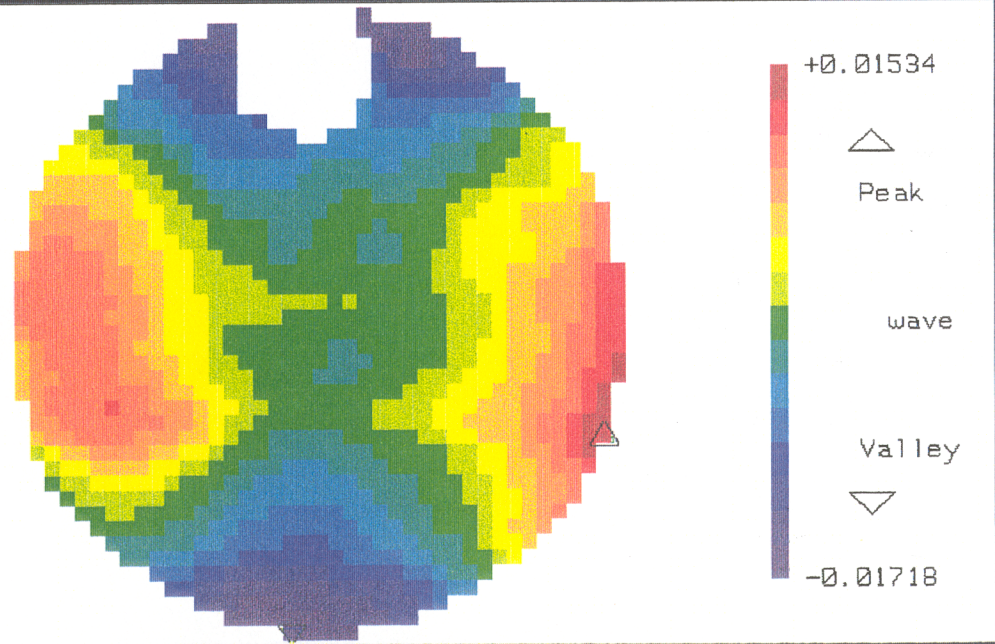
Order: 10th Terms: 36 rms: 0.001
-0.004 0.000 -0.059 0.010
0.017 -0.001 0.003 0.000 -0.001
-0.001 -0.001 -0.002 -0.002 0.001 0.001 0.000
-0.001 0.000 0.001 0.001 -0.001 0.000 0.000 0.000 0.000
0.000 0.001 0.001 0.000 0.000 -0.001 0.001 0.000 0.000

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

zygo File Data
Subtract Sys Err: On Min Mod (%): 1
Sys Err File: r111596.802 Phase Res: High
Part Thickness: 4.29 in Scale: 0.500
Boule #: 34640 AGC: Off
Suffix: ACT Light Level: 110

Comment:
CALIF INST TECH SN-FE02

Data File: 34640ACT.dat Phase Avgs: 6
Camera Res: 1.9600 mm Intens Avgs: 6
Time: Sat Dec 07 01:19:48 1996



SlopeMag TiltXY Filter AutoSeq Manipulate Metroscript
Profile VideoMon SlopeY SPC Meas Controls FileCopy Report ZernGen

DEVIATION APPROVAL FORM

Customer Name: California INST. TECHNOLOGY

Customer P.O. Number: PP 207573

Corning Order Number: QD 106 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 pics of each piece
(attach backup information as deemed necessary)

Cari Lynn Billingsley
Customer Contact (print)

OK Bob 2-24-97

Randy W. Bond
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

FE 02

cc: Shipping Clerk
Customer Service

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>3</u> |
| Code No.: <u>855306</u> | Date Shipped: <u>12/18/96</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, 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 - 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 shipper.
- 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 Panning, 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.

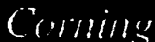
Hopefully this document addresses the current issues between CalTech -LIGO project and Corning-Canton. If there are any additional issues that need to be addressed by Corning, please do not hesitate to contact me.

Thank you for your patience in this matter.

Sincerely,

Randy VanBrocklin
Applications Engineer

Tel: 315-379-3381
Fax: 315-379-3317

The logo for Corning, featuring the word "Corning" in a stylized, serif font. The logo is set against a dark, textured background that appears to be a scan of a physical document or a stamp.

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

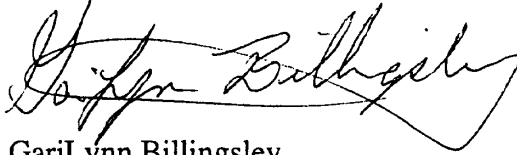
Some clarification of preferences and some discrepancies came to light during examination of the data packages for the first 9 blanks delivered to LIGO. While none of these compromise the integrity of the blanks, they can make for a confusing or misleading data package. Please let us know how you expect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

Lg Aperture

PV 0.033 wave

rms 0.007 wave

Power 0.021 wave

Homogeneity 1.89E-07

Points 1274

AstMag (Z) 0.034 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

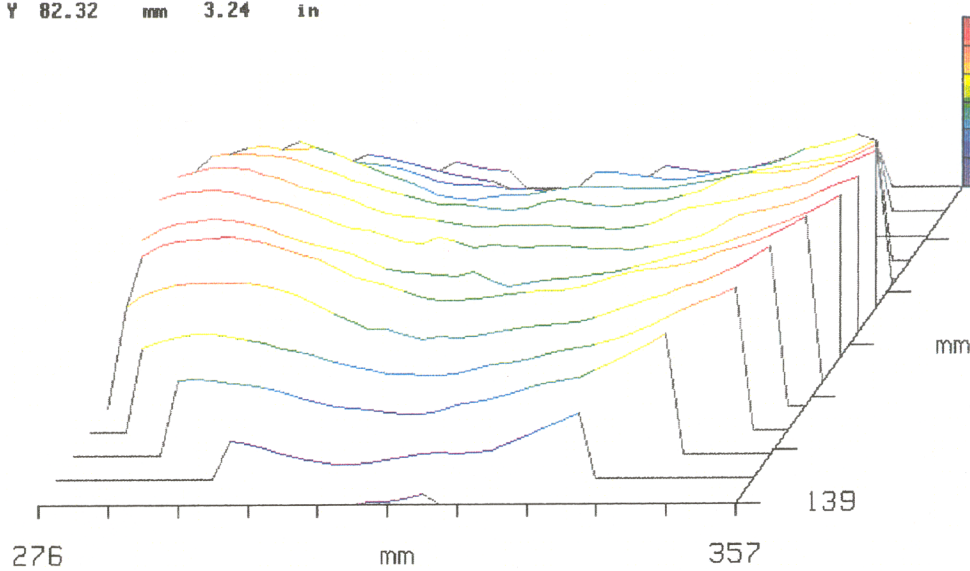
Zernike Coefficients from 1273 data points

Order: 10th Terms: 36 rms: 0.001

| | | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|-------|-------|-------|--|--|
| -0.004 | 0.000 | -0.059 | 0.010 | | | | | | | |
| 0.017 | -0.001 | 0.003 | 0.000 | -0.001 | | | | | | |
| -0.001 | -0.001 | -0.002 | -0.002 | 0.001 | 0.001 | 0.000 | | | | |
| -0.001 | 0.000 | 0.001 | 0.001 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | -0.001 | 0.001 | 0.000 | 0.000 | | |

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

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



+0.01534
wave
-0.01718
221

Save Subapt

Measure Mask Data Save Data DBSAVE

Analyze Calibrate Load Data

zygo File Data

Subtract Sys Err: On

Min Mod (%): 1

Sys Err File: r111596.802

Phase Res: High

Part Thickness: 4.29 in

Scale: 0.500

Boule #: 34640

AGC: Off

Suffix: ACT

Light Level: 110

CALIF INST TECH *SN-FE02*

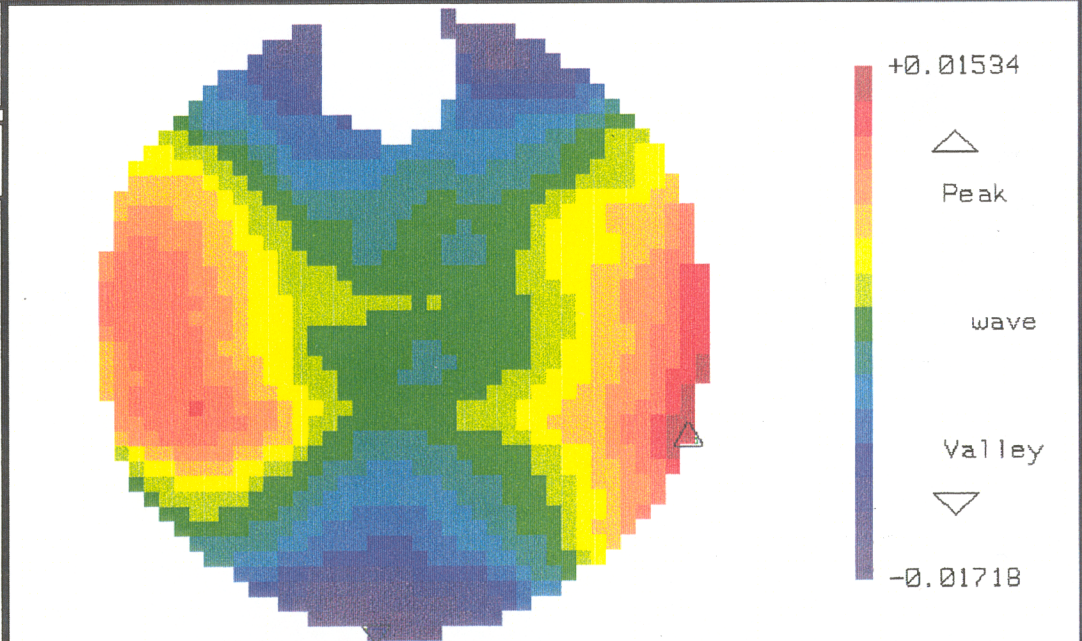
Data File: 34640ACT.dat

Phase Avgs: 6

Camera Res: 1.9600 mm

Intens Avgs: 6

Time: Sat Dec 07 01:19:48 1996

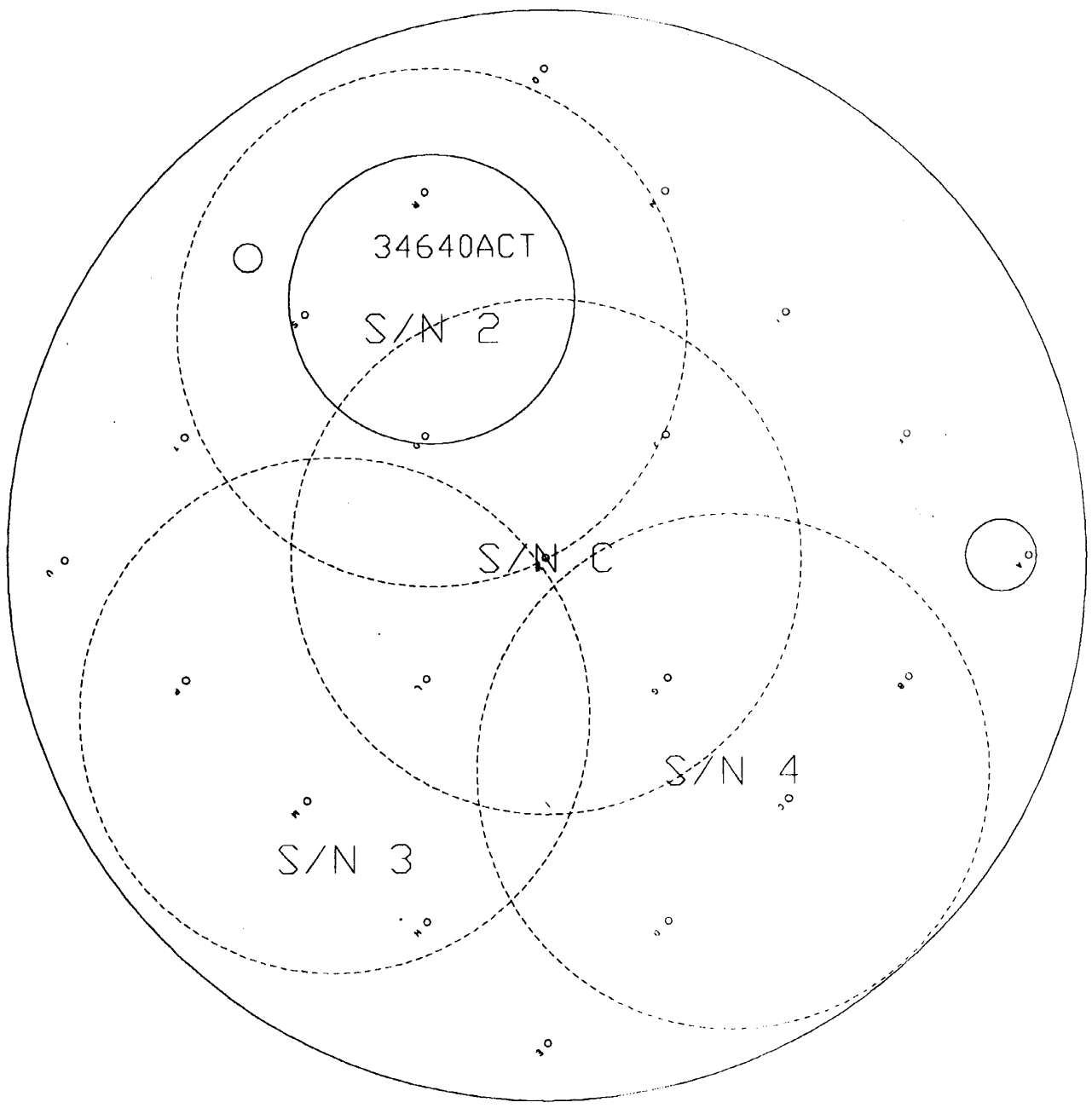


+0.01534
△ Peak
wave
▽ Valley
-0.01718

SN - FE02

180 DEG —

— 0 DEG



270 DEG

○

34640ACT

S/N 2

S/N C

S/N 3

S/N 4

○

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 : 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:

[Signature], 6/3/98
Quality Assurance

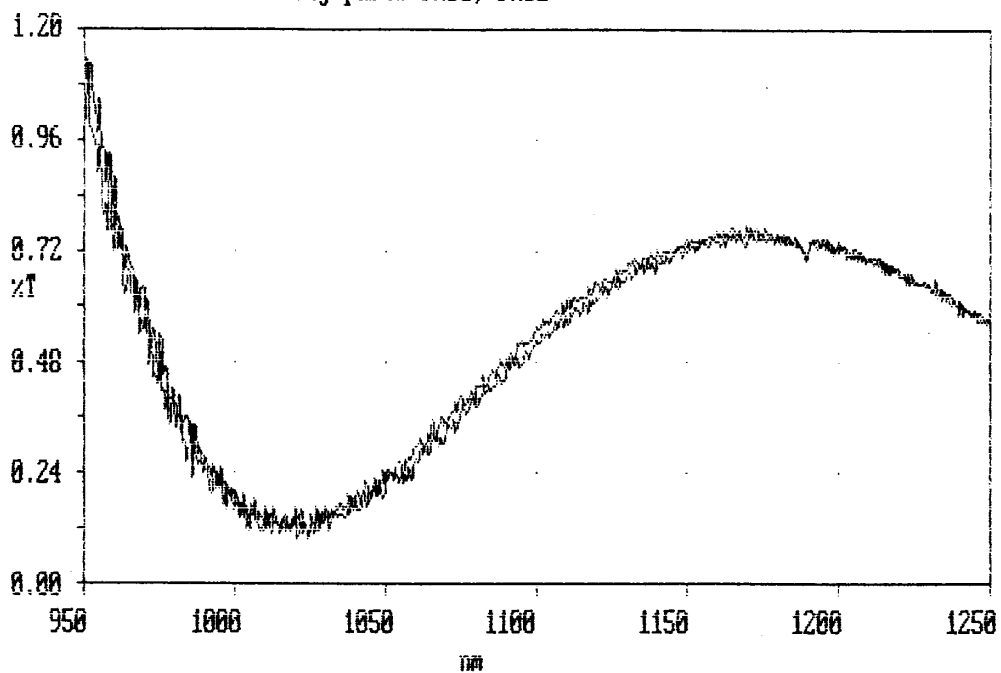
Verified by:

[Signature], 6/3/98
Engr/Tech

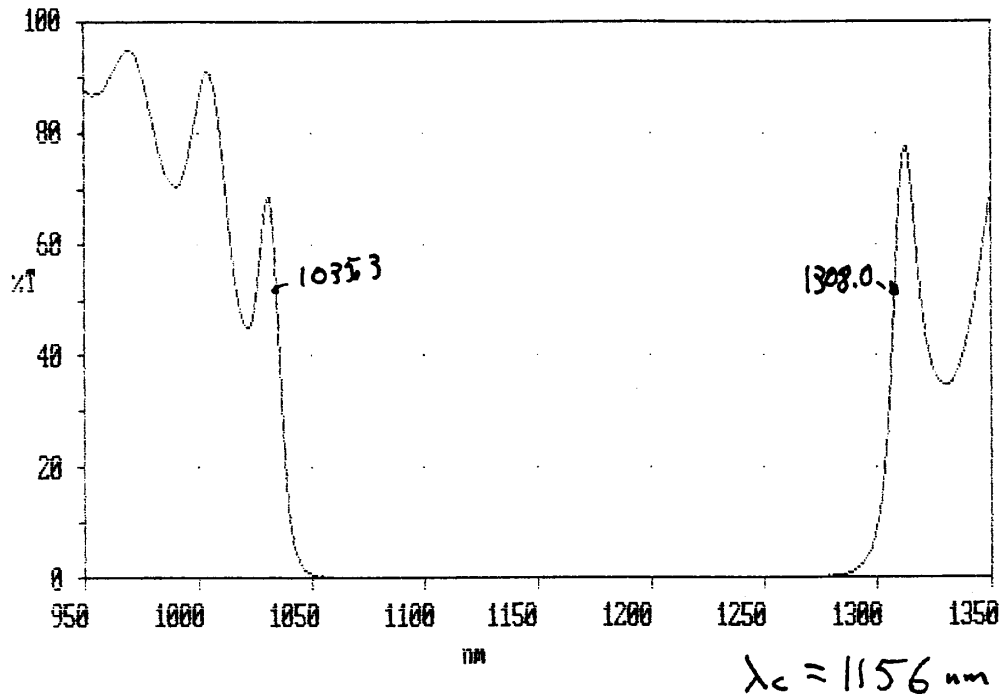
NOTE

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.

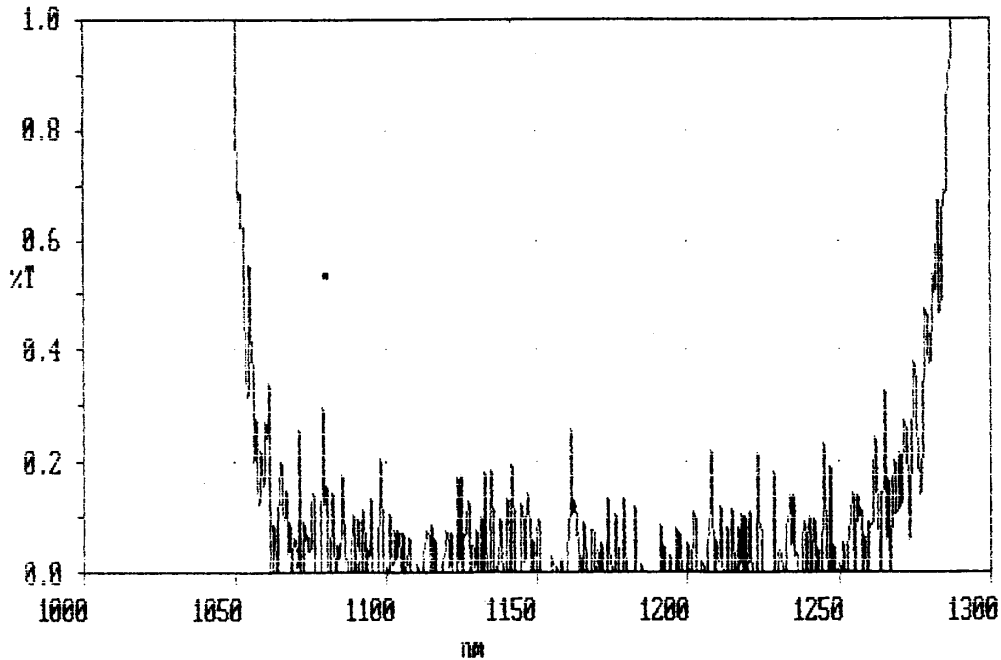
Y: user002; 1250.0 - 950.0 nm; pts 601; int 0.50; ord 0.1020 - 1.1515 %T
Inf: ox748 AR01064nm 045 deg part# FM01, FM02



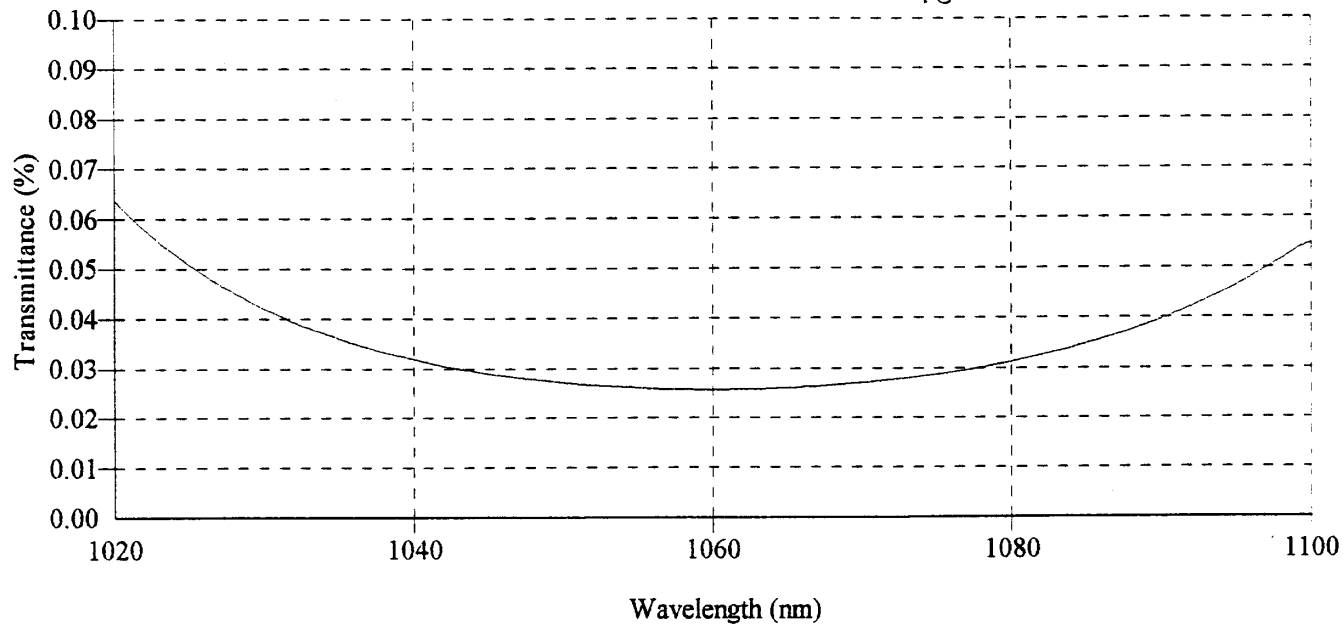
X: user002; 1350.0 - 950.0 nm; pts 801; int 0.50; ord -0.385 - 95.000 %T
Inf: #0X744, HR @ 1064nm @ 45 deg. normal incidence scan, FM01, FM02. Baked



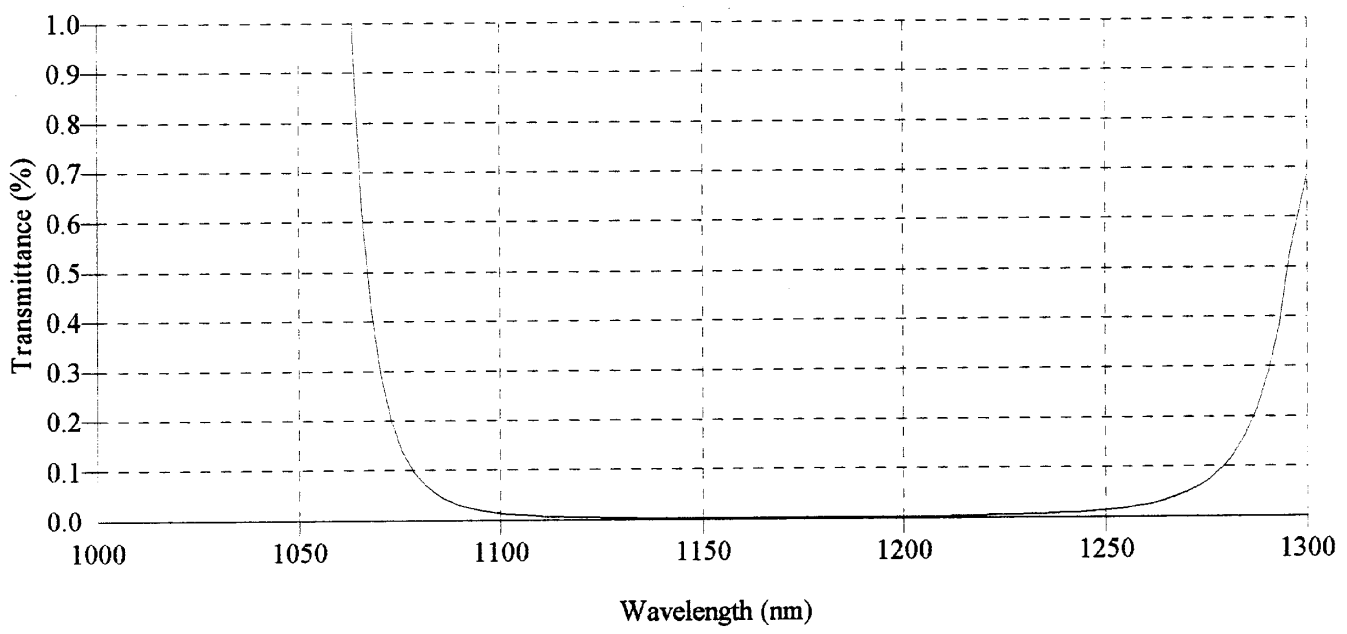
X: user002; 1350.0 - 950.0 nm; pts 801; int 0.50; ord -0.385 - 95.000 %T
Inf: #0X744, HR @ 1064nm @ 45 deg. normal incidence scan, FM01, FM02. Baked



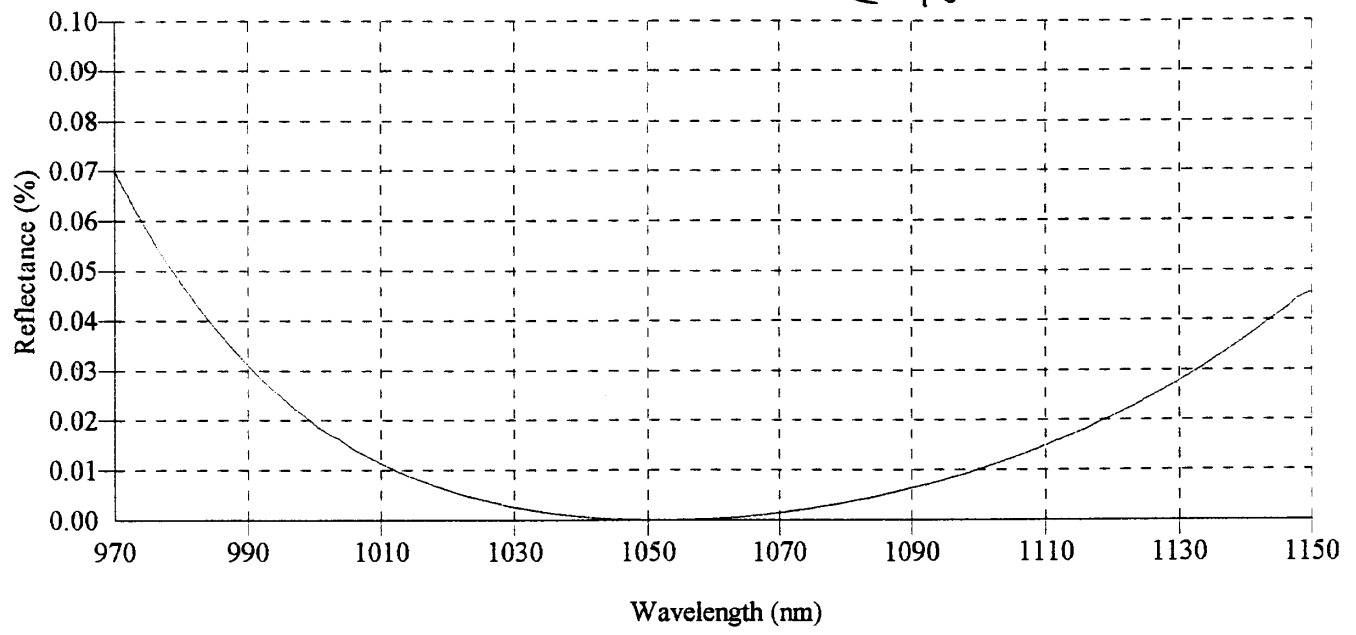
LHR500PP: Transmittance @ 45°



LHR500PP: Transmittance Normal Incidence

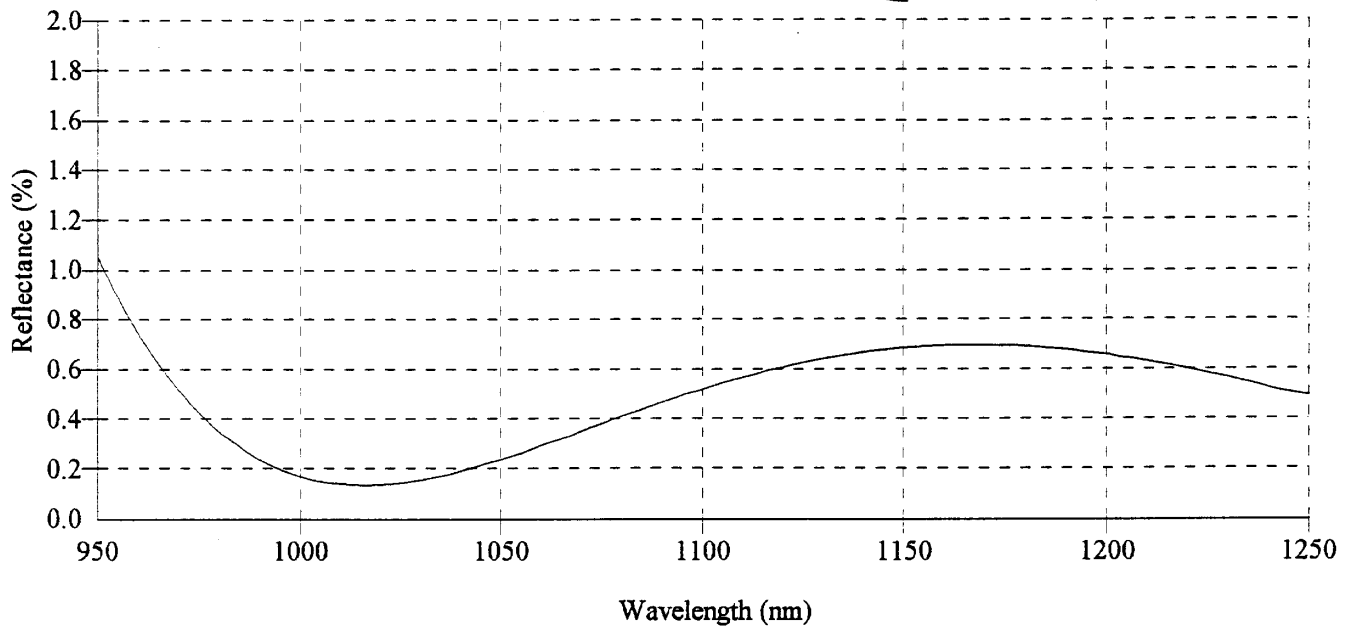


LAR45PA: Reflectance @ 45°



LAR45PA: Reflectance

ⓐ Normal Incidence





Research Electro-Optics, Inc.

PAGE NO: 1
 INVOICE NO: 828000
 INVOICE DATE: 06/29/1998

INVOICE

ORDER NUMBER: 000000
 CUSTOMER REF: 828-005 6201
 BILL TO:

YOUR ORDER NO: PC162519/LONON
 OUR ORDER NO: OPT05831-0003
 SHIP TO:

CALIFORNIA INST. OF TECHNOLOGY
 51-33 EAST BRIDGE LAB, L160
 PASADENA, CA 91125

CALIFORNIA INST. OF TECHNOLOGY
 51-33 EAST BRIDGE LAB, L160
 ATTN: HELENA ARMANDA, 18-34
 PASADENA, CA 91125

TERMS: CASH #1: DISC: SHIPPED: 05/29/1998
 CASH #2: DISC: SHIP VIA: FED-EX P1
 NET DUE DATE: 060898 F.O.B.: FACTORY
 YOUR CUSTOMER REP IS: JN 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 REFERENCE QUOTE #000000

PER QUOTES OPD-2403 & OPD-2404

REFERENCE: CALTECH L160-C98-000/L160-C98000
 L160-C950494-00-1

Technical Contact:
 Helena Armada Tel: 800-395-2070
 Mail Code 18-34

Contractual Representative:
 Irena Petrac Tel: 800-395-2975
 Mail Code 18-34

Items #001 thru #014 is per PO# PC162519

Items #015 thru #039 is per PO# PC162519
 Per REF quote #OPD-2537. No item #027 on this
 acknowledgment

Rec'd 06-08-98 *Steve Brown*

2 FOLDING MIRROR, COATED
 2 L160E 980065

CONTINUED ON REVERSE PAGE

Remit to: Accounts Receivable Department, P.O. Box 0543, Denver, CO 80256-0543
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