JPL PUBLICATION 78-15, VOLUME V

# Characterization of Solar Cells for Space Applications

## Volume V. Electrical Characteristics of OCLI 225-Micron MLAR Wraparound Cells as a Function of Intensity, Temperature, and Irradiation

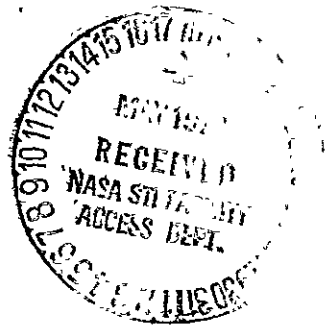
B. E. Anspaugh
T. F. Miyahira
R. S. Weiss



April 1, 1979

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California



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The research described in this publication was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract No. NAS7-100.

## ABSTRACT

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CONTENTS



Figures

Figures (contd)

Figures (contd)



Tables

## SECTION I

## INTRODUCTION

A series of reports is being generated to present parametric characterization data on both state-of-the-art and developmental solar cells of interest to the photovoltaic community. These data consist of the electrical characteristics of the candidate solar cell under a wide range of temperature and illumination intensity combinations of the type encountered in typical space applications. This series (JPL Publication 78-15) will consist of a number of reports, each report being devoted to a particular type of solar cell and identified by a volume number. Previously published reports with their associated solar cell descriptions are listed in the bibliography to this document. Each report consists primarily of working graphs and tables and does not address itself to interpretive conclusions. The formatting of this series of reports will be relatively invariant to facilitate comparisons between the characteristics of any of the cell types considered in the series. This report contains a set of parametric data on the OCLI 2 x 4-cm wraparound cell which was produced in limited quantity as a possible candidate for the Solar Electric Propulsion Mission. Parametric data are presented for the cells both before and after irradiation with $1 \times 10^{14}$ e/cm$^2$ of 1 MeV electrons.

## SECTION II

## CELL DESCRIPTION

The cells reported here were manufactured by OCLI in pilot line quantities and are not yet space-qualified. These cells are fabricated from crucible grown, P-type silicon, boron-doped to a resistivity of 1-3 ohm-cm (2 ohm-cm nominal). The cell dimensions are 2 x 4 x 0.023 cm (9 mils) thick. The electrical contacts on both the front and back surfaces are evaporated Ti-Pd-Ag. The contact pattern on the front surface consists of 12 fingers running the long dimension of the cell. The fingers terminate in contacts deposited on the cell edges. These cell edge contacts wrap around to the rear of the cell and terminate in pads measuring approximately 0.31 x 0.46 cm. The wraparound contacts and pads are insulated from the silicon by a dielectric oxide material deposited prior to contact deposition. The cells are not textured and have a 2-layer antireflection coating, giving the cells a green appearance.

## SECTION III

## TEST PROGRAM

The solar cells were mounted on a copper test plate using RTV 560. The test plate was in turn mounted to a heat sink with provisions for both heating and cooling so that the cells could be maintained at the desired temperature, independent of the solar intensity. All testing was carried out in a vacuum at a pressure of less than $1 \times 10^{-6}$ torr.

The illumination source used was a Spectrolab Model X-25 Mark II Spectrosun filtered solar simulator. This simulator uses an optical integrator lens in the optical system which uniformly distributes a relatively collimated light beam at specific distances from a 2.50-kW short-arc zenon lamp. A system of filters modifies the spectral distribution so that it approximates that of space sunlight. The light beam provides a pattern having a uniformity of $\pm 1\%$ over an area of 225 $cm^2$ at the test plane. Ilumination intensity is varied by position of the simulator in combination with transmission filters. The solar simulator beam is introduced into the vacuum chamber through a window of 7940 fused silica. The solar intensity and spectral integrity of the solar simulator are constantly monitored and maintained, using space-calibrated standard cells obtained with the NASA/JPL solar cell balloon flight standardization program. Photographs of the solar cell, the assembled plate, and the experimental characterization test facility are shown in Figures A-1 through A-4 in the appendix.

The temperature range covered in these measurements was -160 to 140°C, while the solar intensity range covered was 5 to 250 $mW/cm^2$. The data were taken at each environment point in the matrix in the form of an I-V curve. The appropriate parameters were then read from the I-V curves and punched on cards for the computer analysis and curve plotting functions. The cell temperature was monitored by a thermocouple attached to the surface of a separate cell mounted with the cells under test. Prior, intermediate, and posttest ambient measurements were performed daily to ensure that the accuracy and stability of the test equipment and the test specimens themselves were maintained within $\pm 2\%$ during the course of the testing program.

After the initial solar cell measurements over the above temperature and intensity ranges, the test plate was mounted in the evacuated target chamber of the JPL Dynamitron and irradiated with $10^{14}$ $e/cm^2$ of 1-MeV electrons. During the irradiation the cells were maintained at 28°C. After the irradiation the cells were annealed at 60°C for 66 hours, then illuminated for 4 hours at 28°C with the AMO simulator. No significant changes in cell electrical output were observed as a result of either the annealing or the photon illumination. The cells were then characterized over the same intensity and temperature schedule and the data processed as before. Following this, the cells were remeasured at 135.3 $mW/cm^2$, 28°C, under the same conditions as the postirradiation anneal.

## SECTION IV

## DISCUSSION OF RESULTS

A computer program computes statistical averages and standard deviations with respect to the measured cells for each intensity-temperature measurement condition. It then produces summary tables, as shown in Tables 1 to 14, that display averages and standard deviations of the cell characteristics in a two-dimensional array format, one dimension representing cell temperature and the second dimension representing incoming light intensity (AMO spectrum). The program then produces plots of the various electrical parameters of interest, with either incident intensity or cell temperature as the independent variable, as shown in Figures 1 to 14 and 19 to 32. Least square fits to the data points are then made automatically to the measured data points using a second-degree polynominal for most parameters. The $V_{oc}$ and $V_{mp}$ data points are fit with a linear equation. The curve factors and AMO efficiencies are not fit but are interconnected from point to point. In addition, the program calculates the temperature coefficients of the pertinent cell electrical parameters of interest, using the aforementioned curve fits, and plots these as a function of temperature, with intensity as a parameter, as shown in Figures 15 through 18 and 33 to 36. Tables 1 to 7 and Figures 1 to 18 summarize the preirradiation data. Tables 8 to 14 and Figures 19 to 36 summarize the postirradiation data.

The figures are intended to be working artifacts; that is, they are formatted in such a way that they can supply information of a general nature or may be used to generate predictions, comparisons, computer input data, etc. To facilitate comparisons and inputting, all units are standardized as follows:

(1) All currents are in units of $mA/cm^2$.

(2) All voltages are in units of mV.

(3) All power outputs are in units of $mW/cm^2$.

(4) All curve factors are in dimensionless units.

(5) All efficiencies are in percentages and are based on total cell area.

(6) All temperatures are in $^{o}C$.

(7) All incoming intensities are in units of $mW/cm^2$ and are representative of an AMO spectrum.

(8) All geometric dimensions are in units of cm or $\mu m$ (whichever is most convenient conceptually).

The tables included in this report contain complete numerical information with respect to the average values of the following solar cell electrical parameters: $I_{sc}$, $V_{oc}$, $IP_{max}$, $VP_{max}$, $P_{max}$, CF, and efficiency at each intensity-temperature combination. For each such parameter at each such intensity-temperature combination the standard deviation is presented to provide estimates of statistical validity. All efficiency, current, and power output data is on the basis of unit area derived by dividing measured output by total cell area.

After the $10^{14}$ e/cm$^2$ irradiations and anneal, the cells were found to degrade 8.8% in $P_m$, 6.0% in $I_{sc}$, and 2.9% in $V_{oc}$ when measured at 135.3 mW/cm$^2$ incident intensity and 28°C. After the parametric measurements they had degraded an additional 5.7% in $P_m$, 4.5% in $I_{sc}$, and 1.3% in $V_{oc}$. It is not known precisely when the additional degradation occurred. Measurements of other 2 ohm-cm cells in this laboratory have shown a reverse annealing which occurs at or below 200°C, suggesting the possibility that the reverse anneal may have occurred during the time the cells were held at elevated temperature.

The low-temperature, low-intensity I-V curves of these cells varied greatly from cell to cell as can be inferred from the large standard deviations in the tabulated electrical parameters. This is due to the onset of three effects: (1) the increasing relative importance of shunting at low cell current output, (2) the appearance of a voltage drop across the Schottky barrier at the rear contact silicon-metal interface, and (3) the appearance of a broken knee effect characterized by a rather abrupt change in slope of the I-V curve at voltages below normal knee voltage.

Unirradiated cells exhibited Schottky barriers at temperatures below -100°C at all intensities examined. Irradiated cells had Schottky barriers appearing at temperatures as high as -60°C at the 135.3- and 250-mW/cm$^2$ intensity levels, but at lower intensities the barriers appeared only at temperatures below -80°C. Most cells had broken knees at low intensities. The lower the incident intensity, the higher the temperature of broken knee occurrence. At 5 mW/cm$^2$, broken knees occurred at all temperatures below 0°C, but at 100 mW/cm$^2$ broken knees occurred at all temperatures below -120°C. The onset of the broken knee effect appears to be independent of radiation. Cell shunting is independent of radiation and simply occurs in those cells which have low shunt resistance.

The effects reported here for the wraparound cells are not attributable to the wraparound configuration since cells of standard design behave in the same manner. At the higher temperature regions of normal spacecraft operation the cells do not exhibit the low temperature I-V anomalous behavior.

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Characterization of Solar Cells for Space Applications, JPL Publication 78-15

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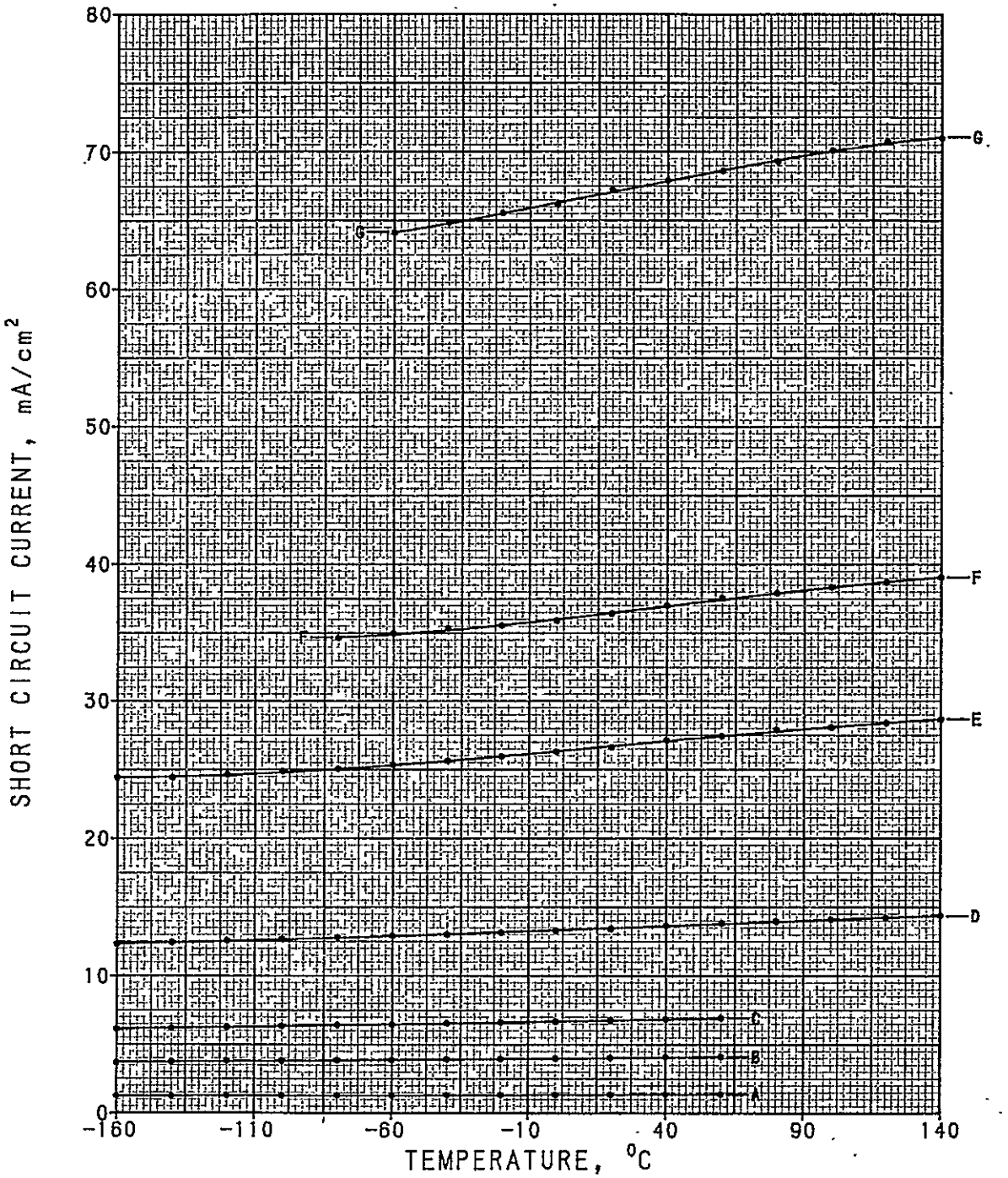
Volume III. Electrical Characteristics of OCLI Hybrid MLAR Solar Cells as a Function of Intensity and Temperature, September 1978.

Volume IV. Electrical Characteristics of Spectrolab BSF 200-Micron Helios Cells as a Function of Intensity and Temperature, November 1978.




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM .
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

Figure 1. Average $I_{SC}/cm^2$ as a Function of Temperature

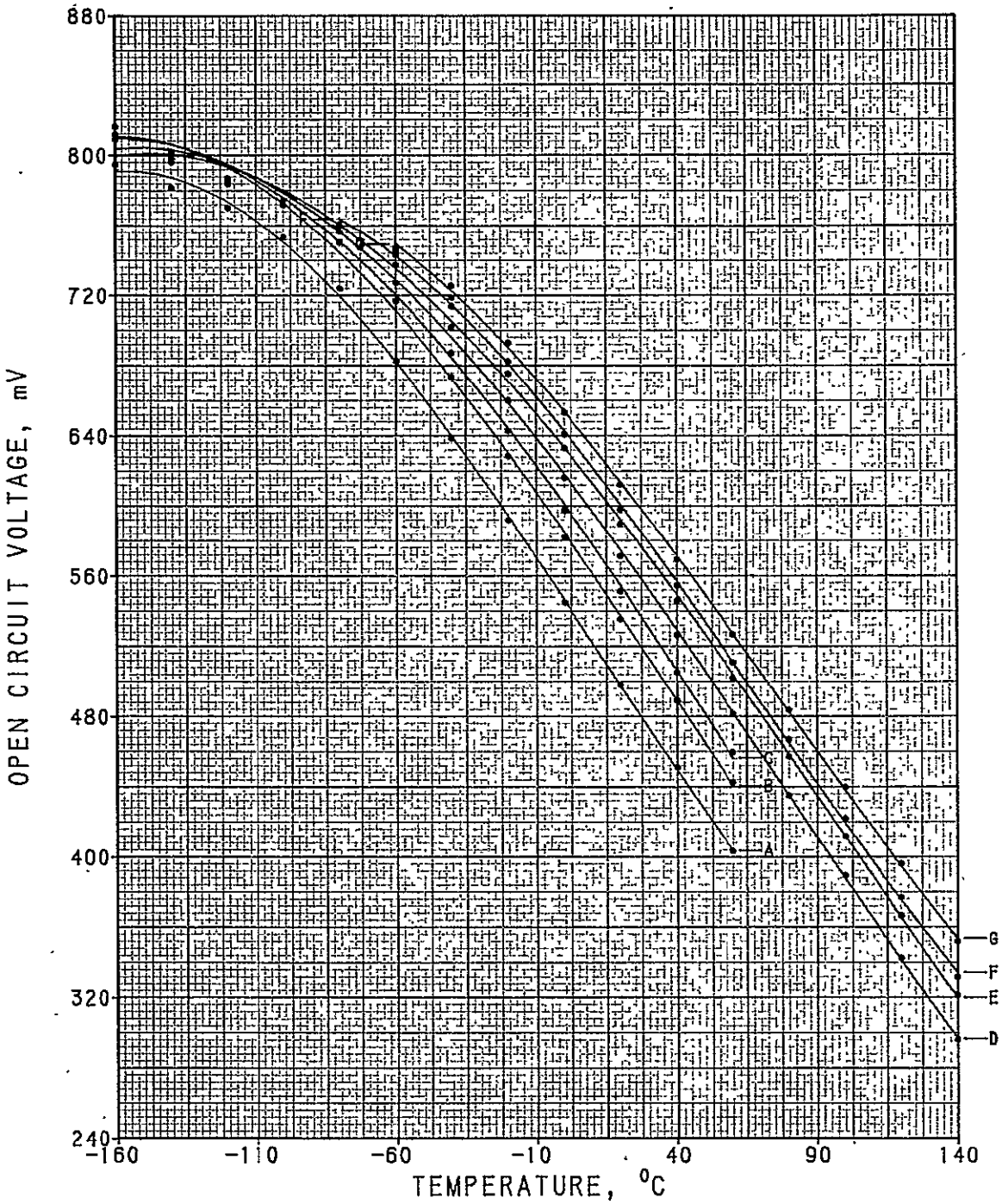



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Figure 2. Average $V_{OC}$ as a Function of Temperature

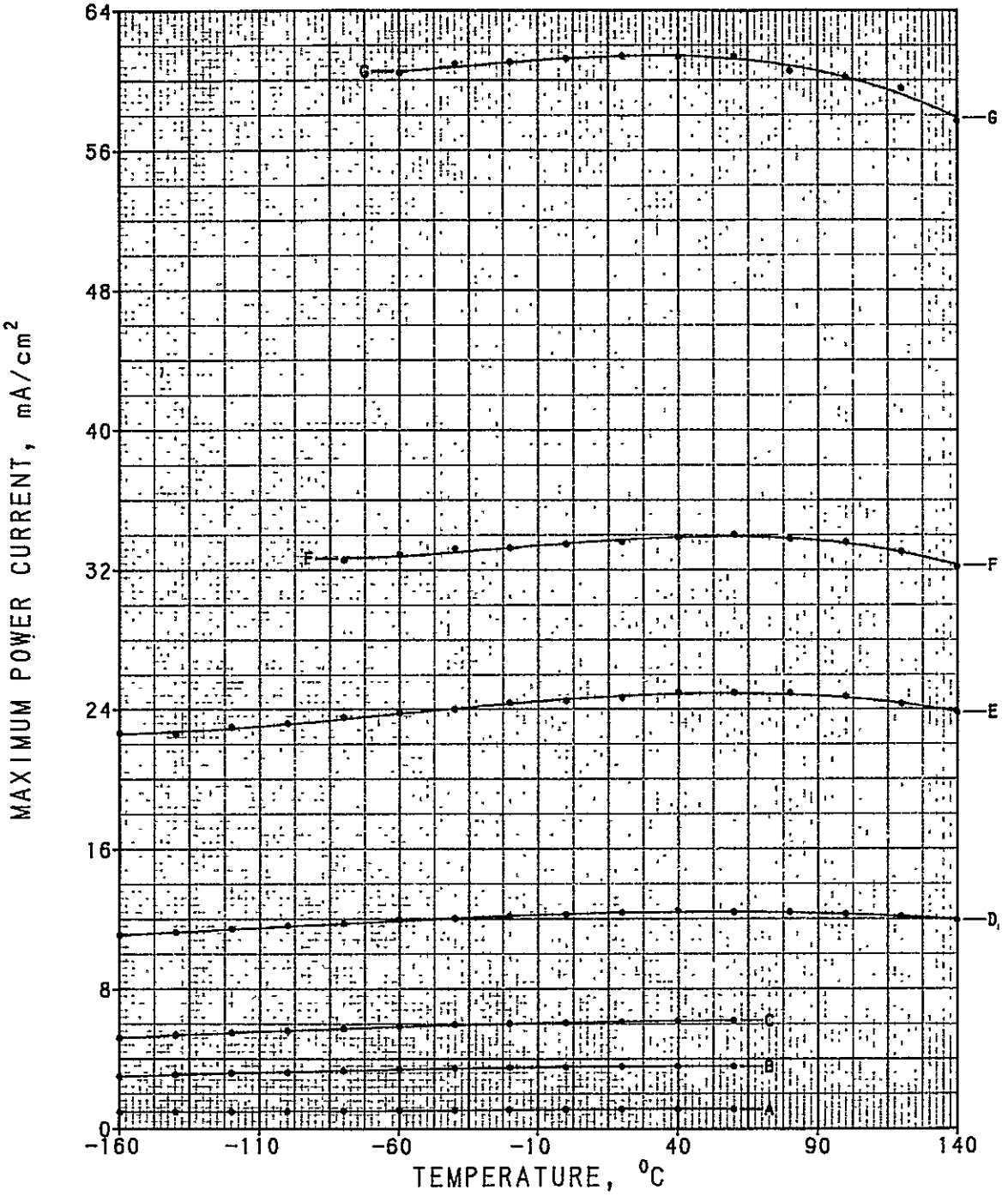



Figure 3. Average $I_{mp}/cm^2$ as a Function of Temperature

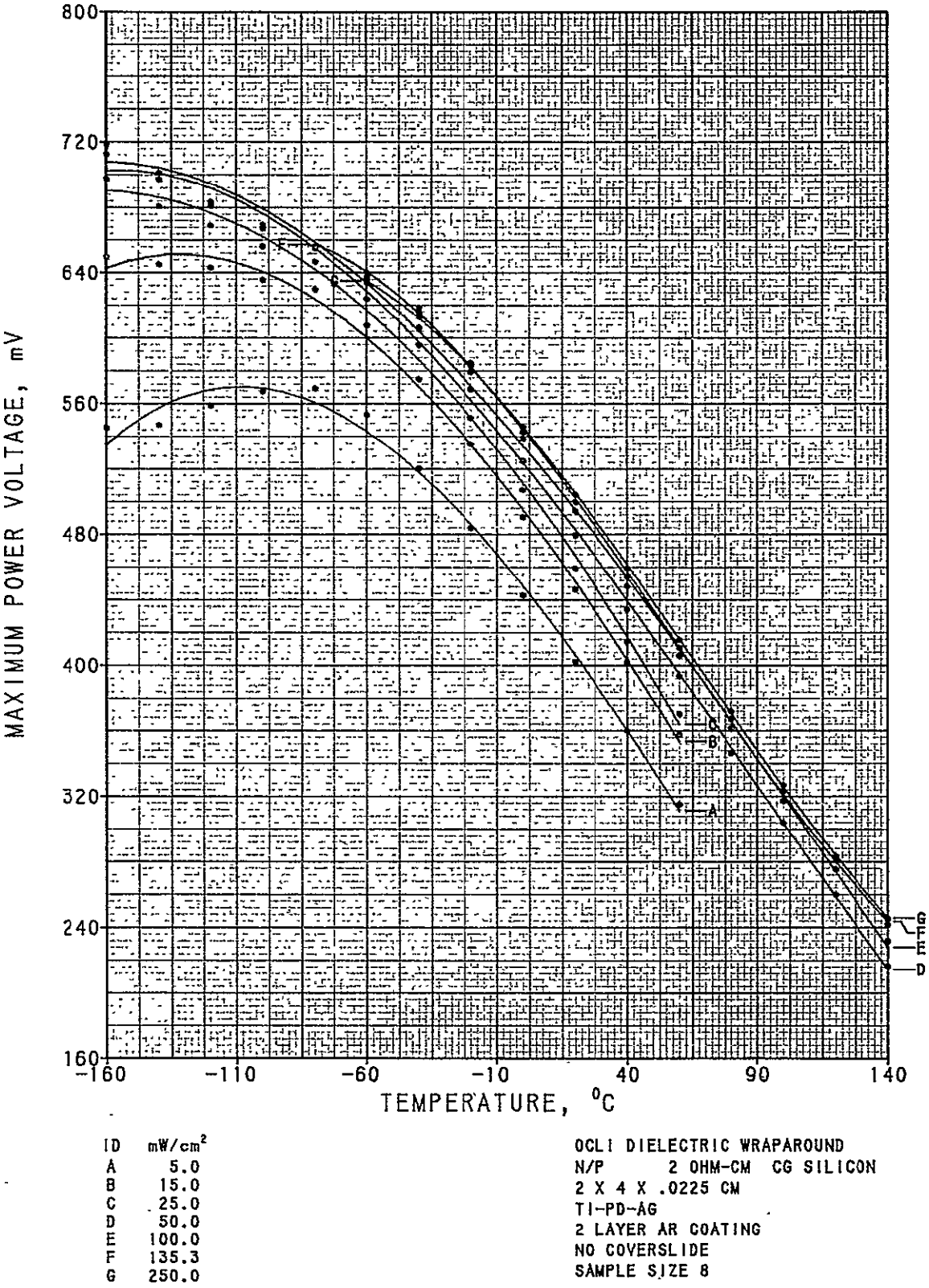
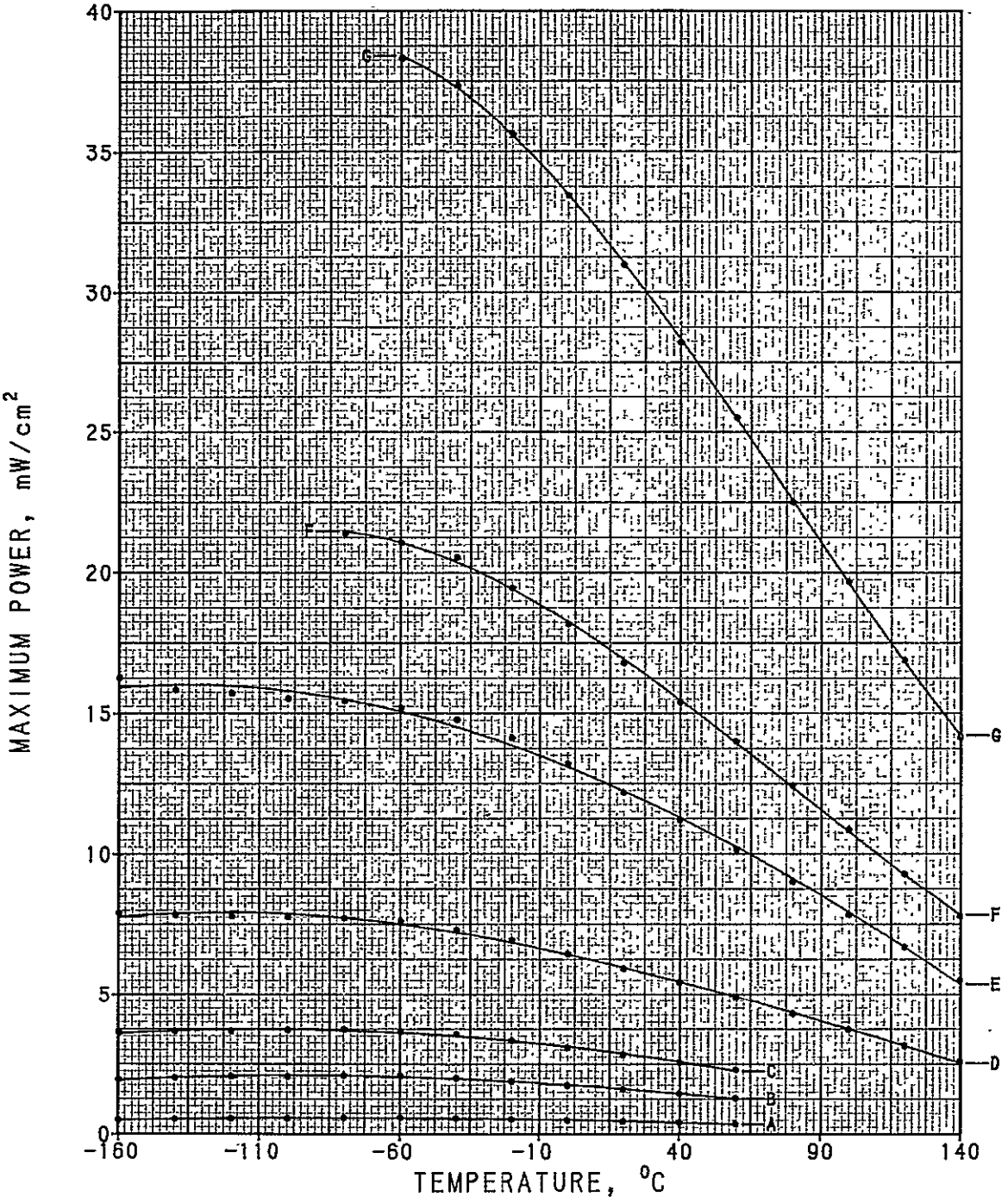



Figure 4. Average $V_{mp}$ as a Function of Temperature

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| E | 100.0 |
| F | 135.3 |
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Figure 5. Average $P_{max}/cm^2$ as a Function of Temperature

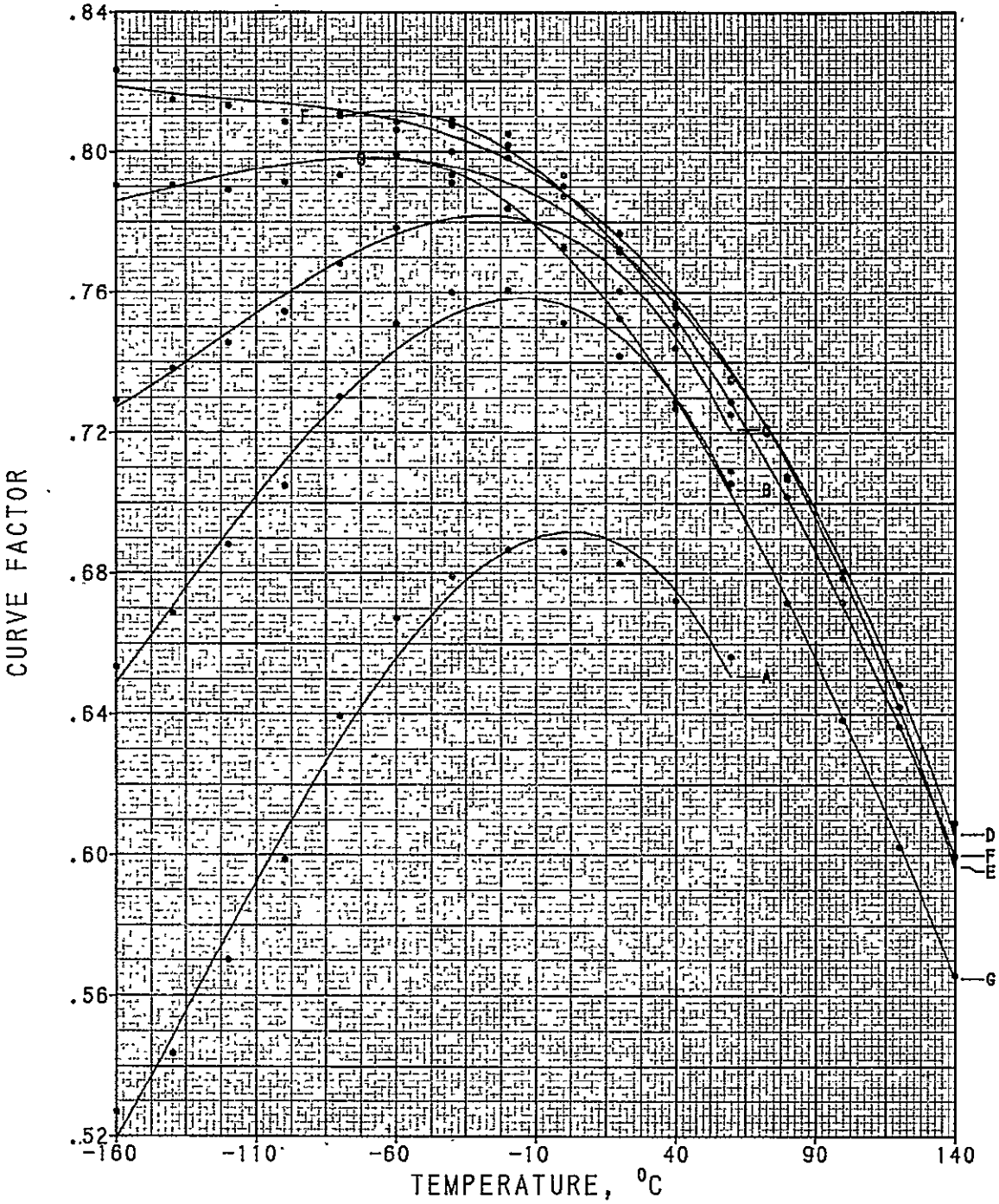


Figure 6. Average Curve Factor as a Function of Temperature

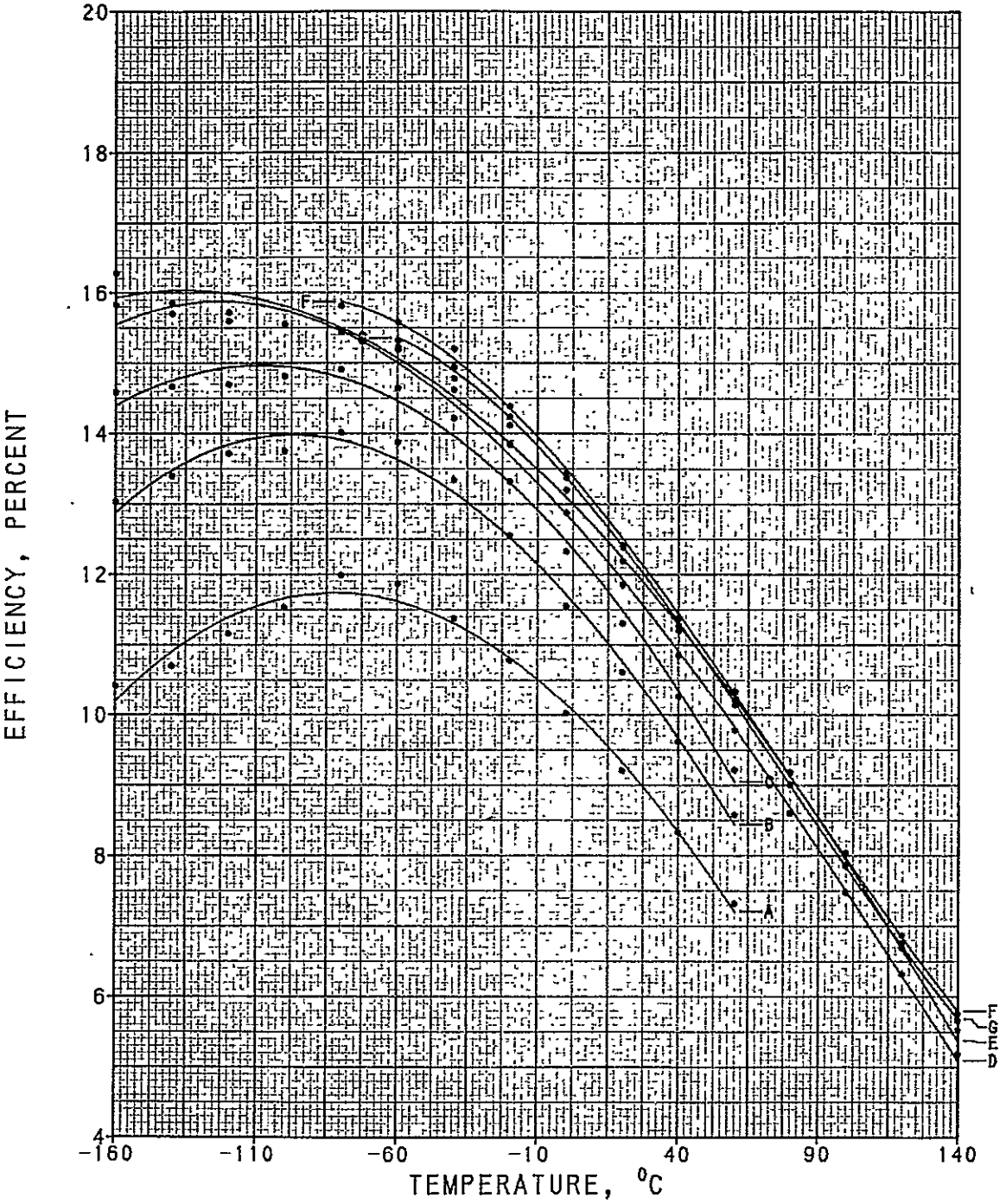


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Figure 7. Average AMO Efficiency as a Function of Temperature

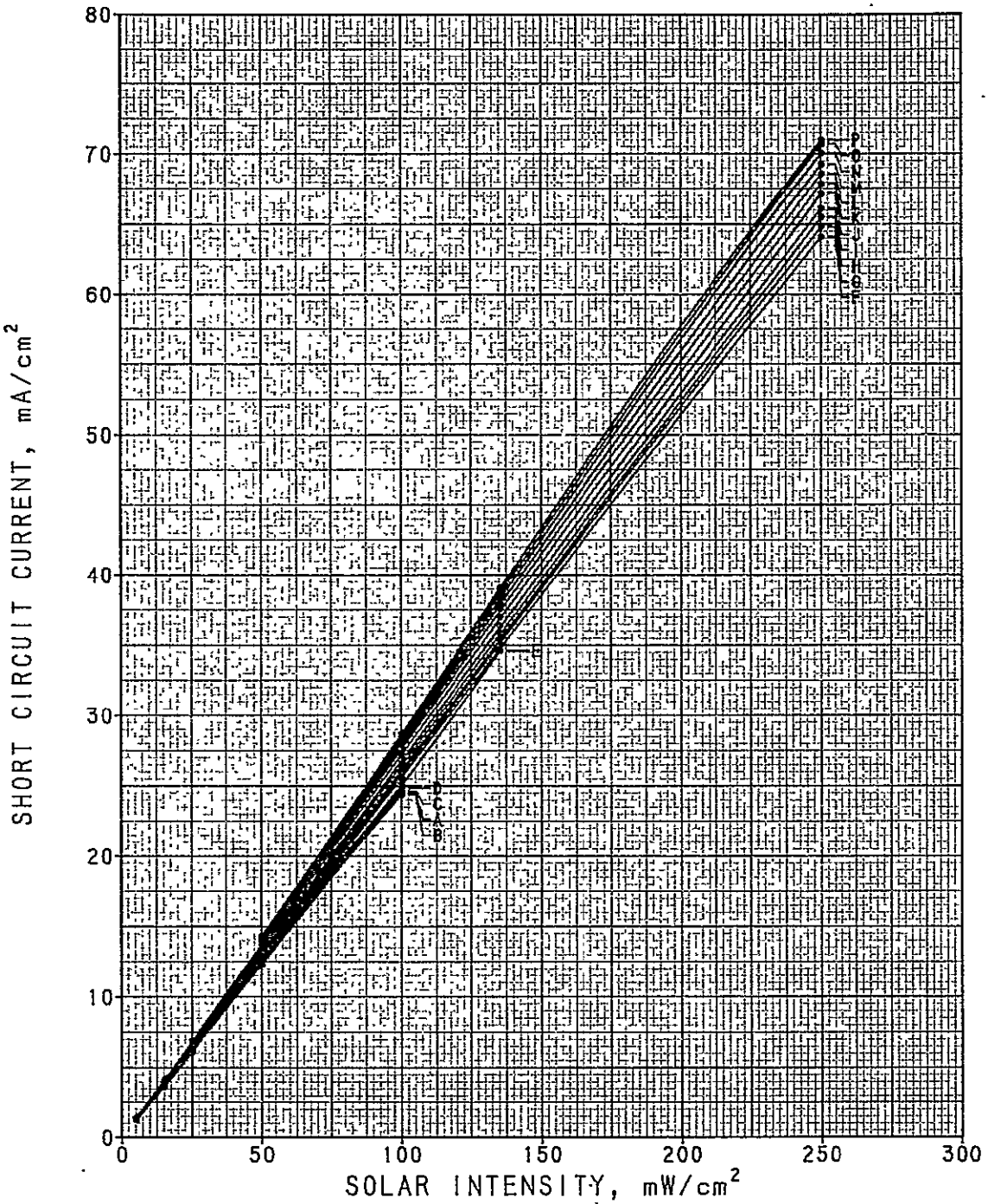
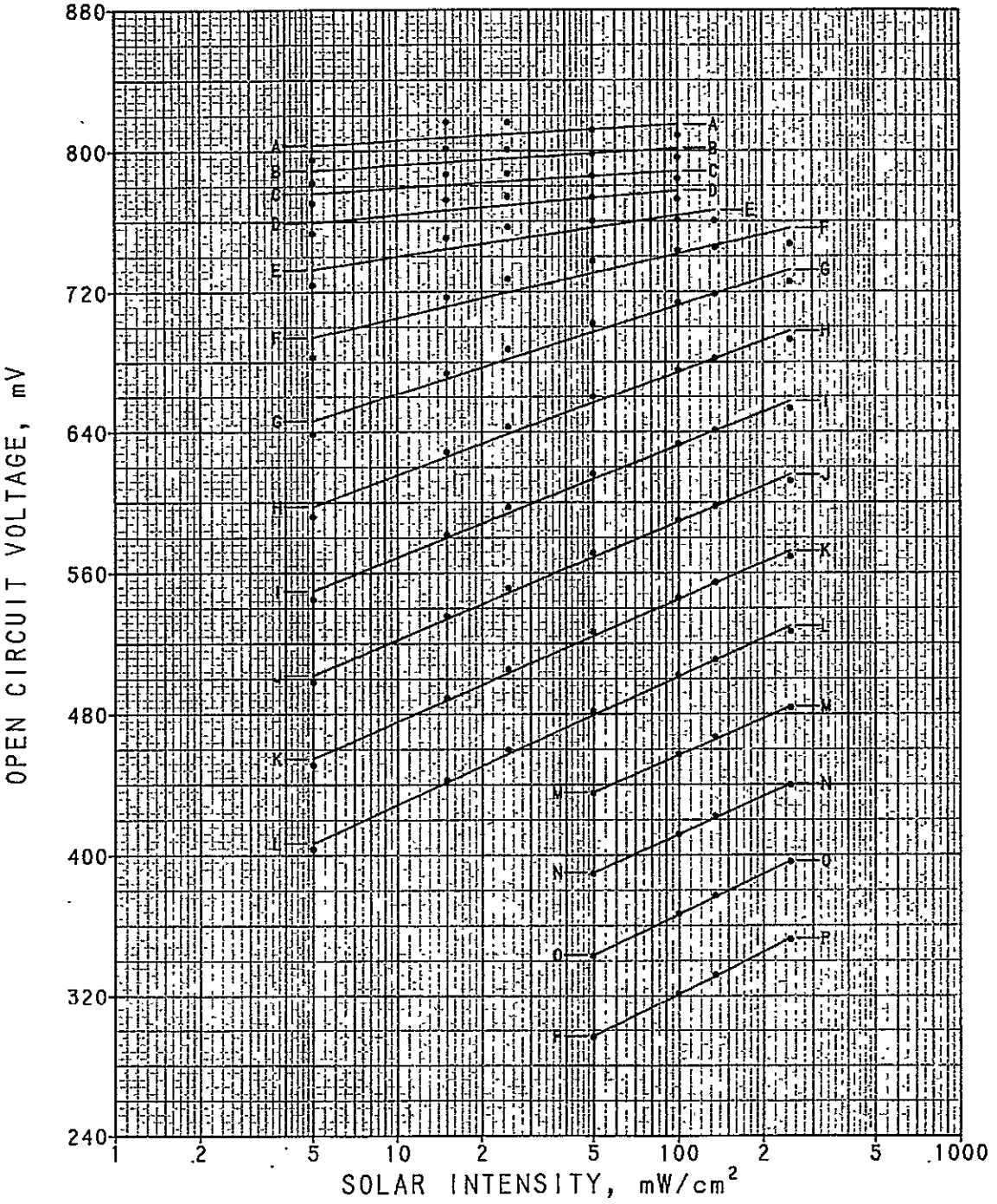



Figure 8. Average $I_{sc}/cm^2$ as a Function of Intensity

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|---|---|---|---|
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| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.( |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

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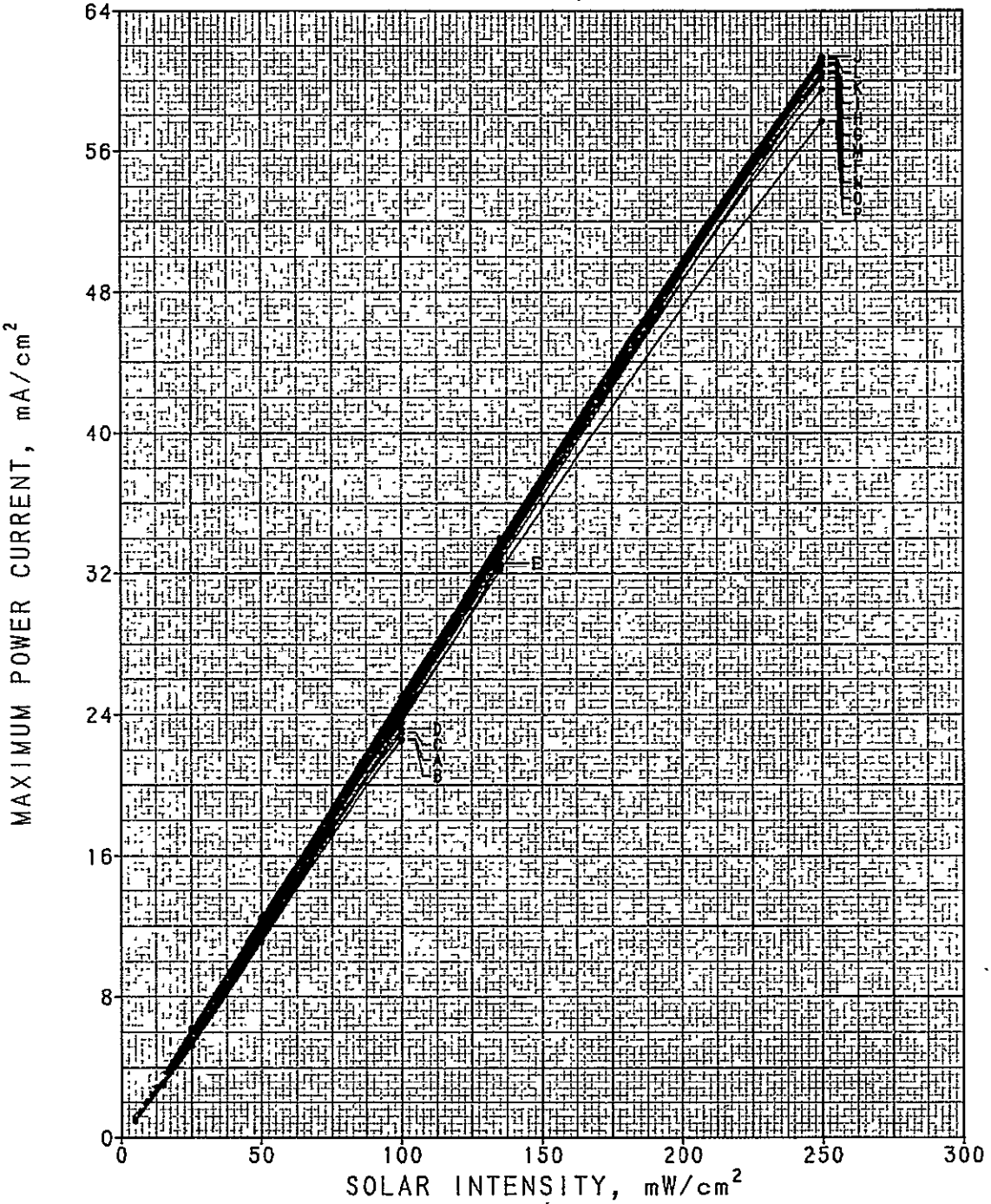
Figure 9. Average $V_{oc}$ as a Function of Intensity

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| F | -60.0 | N | 100.0 |
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Figure 10. Average $I_{mp}/cm^2$ as a Function of Intensity

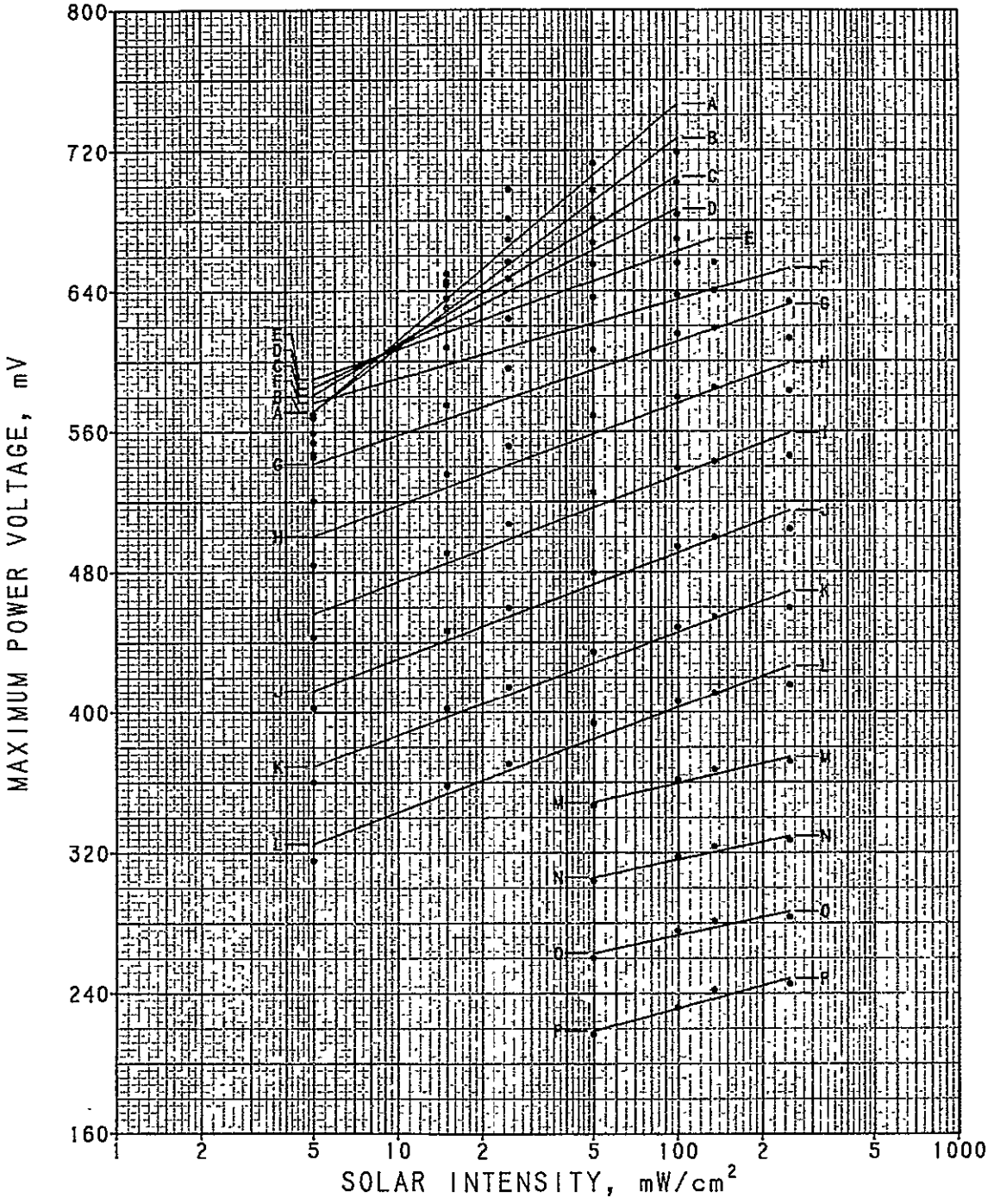


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Figure 11. Average $V_{mp}$ as a Function of Intensity

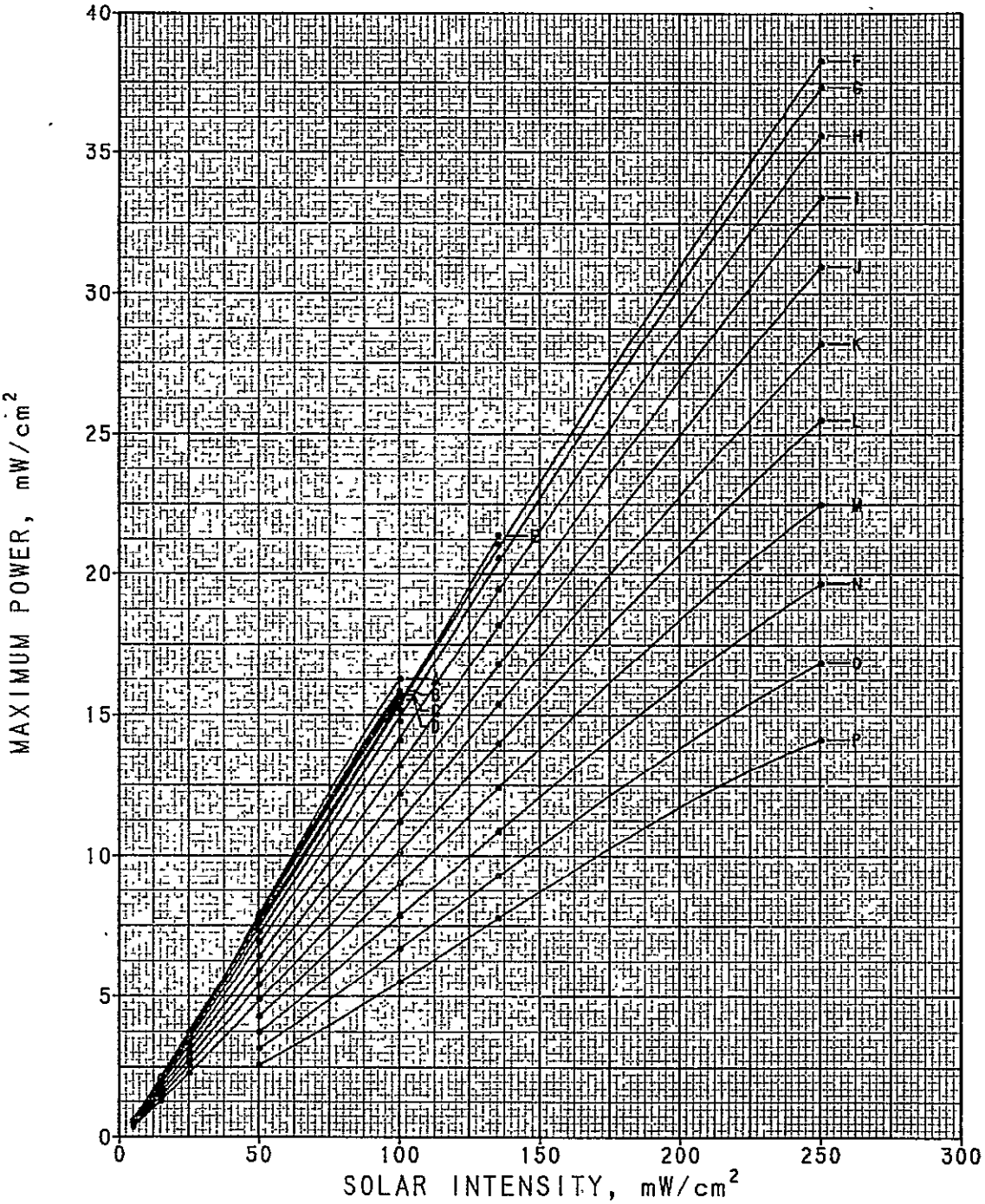


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Figure 12. Average $P_{max}/cm^2$ as a Function of Intensity

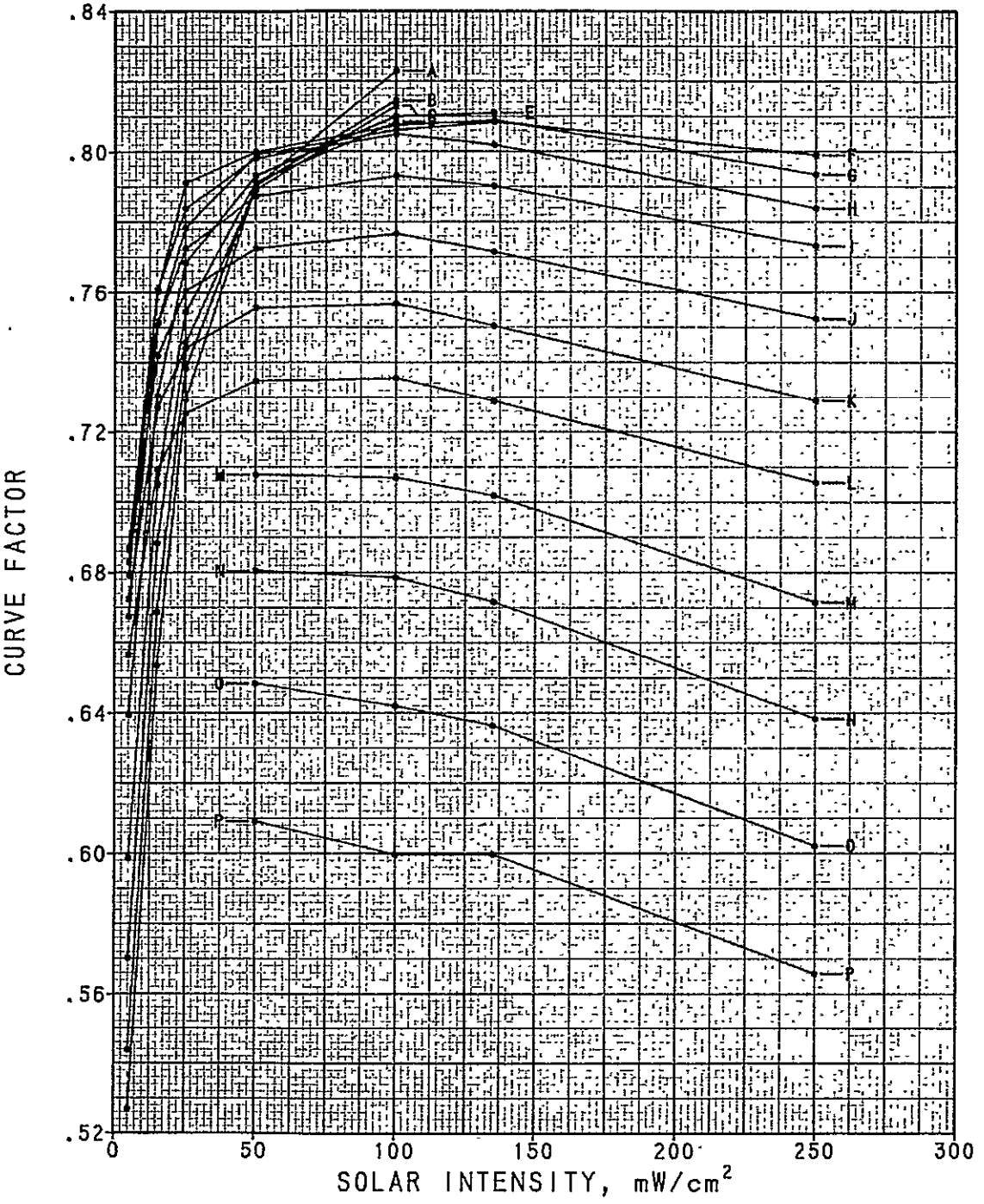


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Figure 13. Average Curve Factor as a Function of Intensity

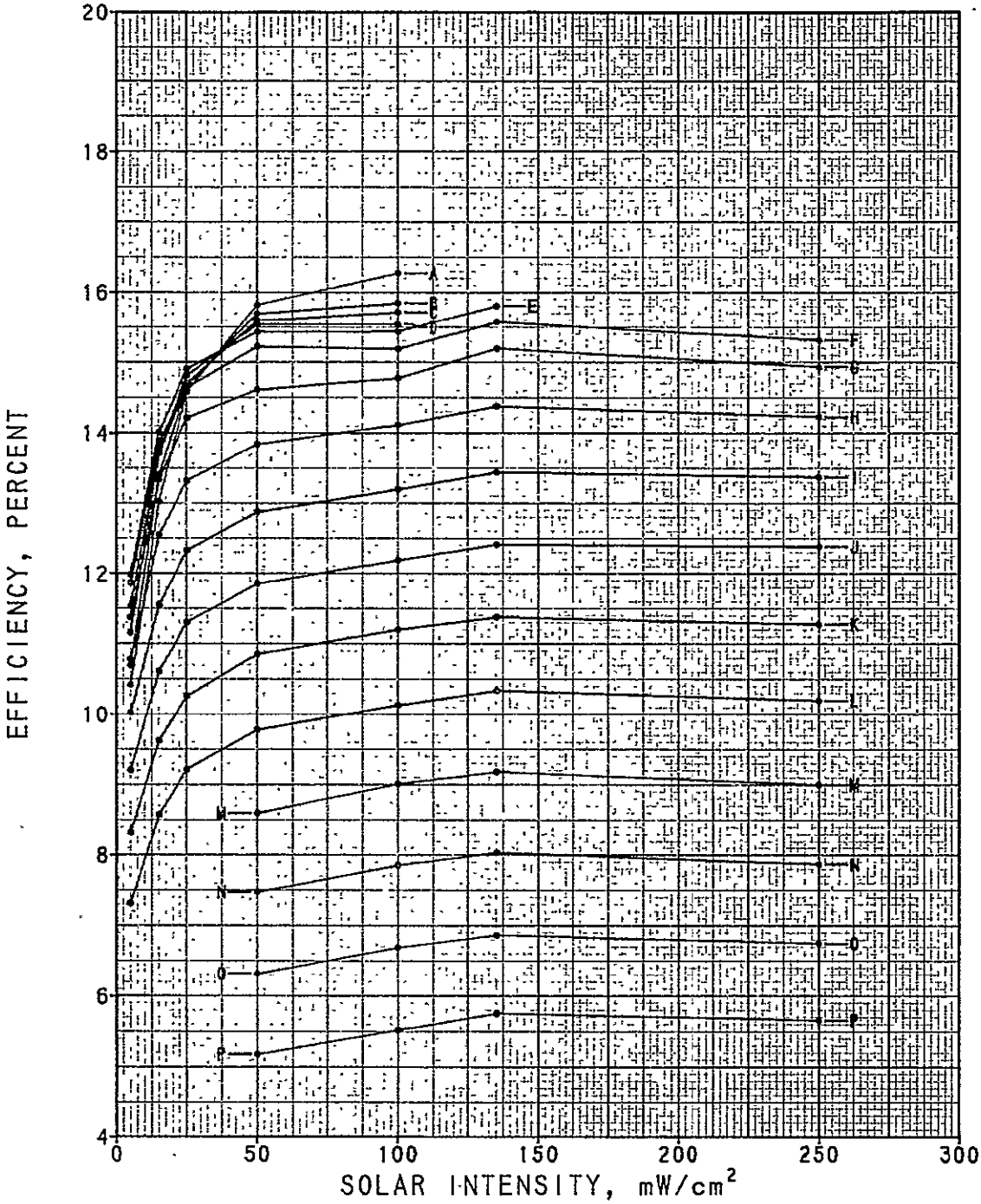


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Figure 14. Average AMO Efficiency as a Function of Intensity

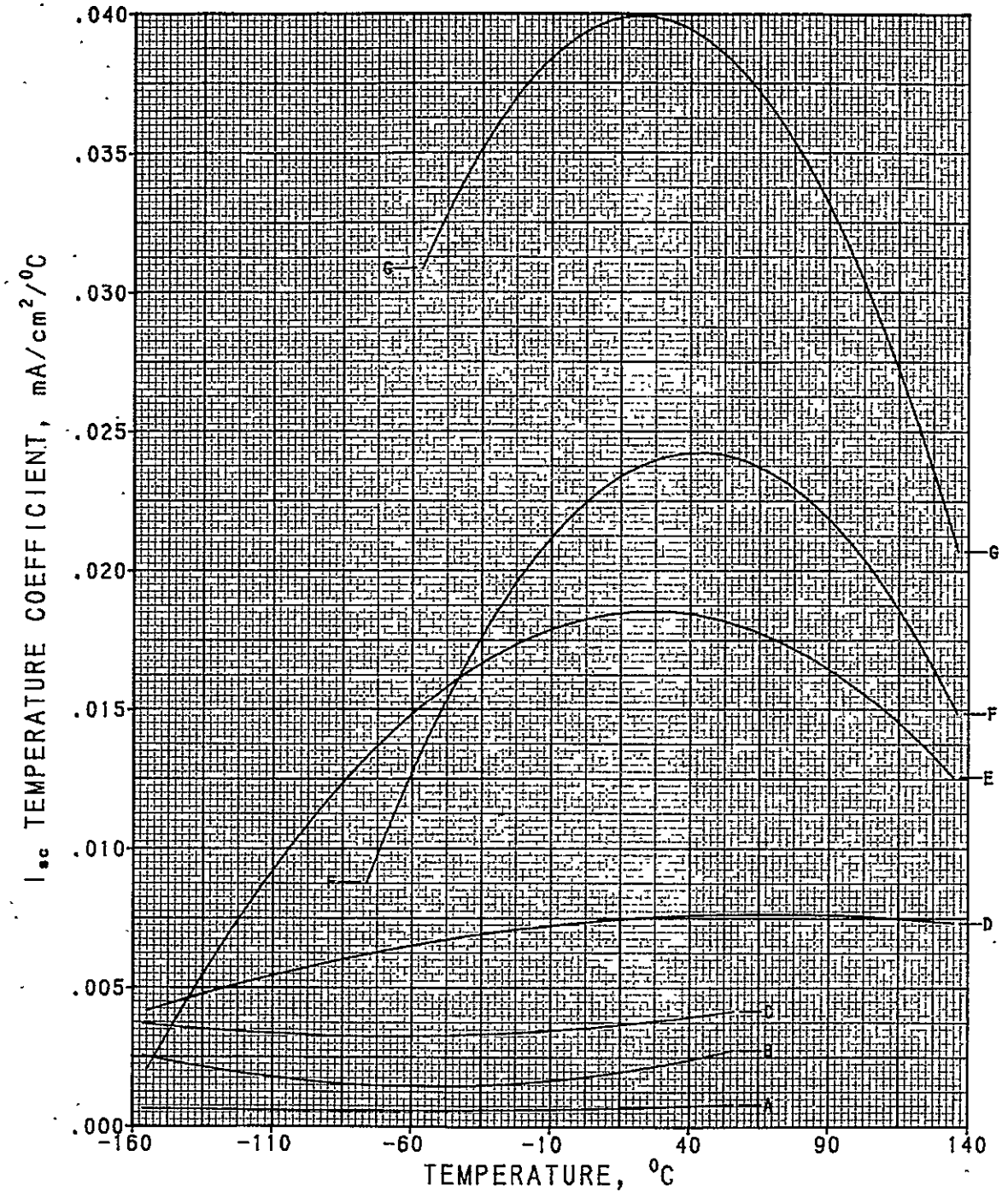
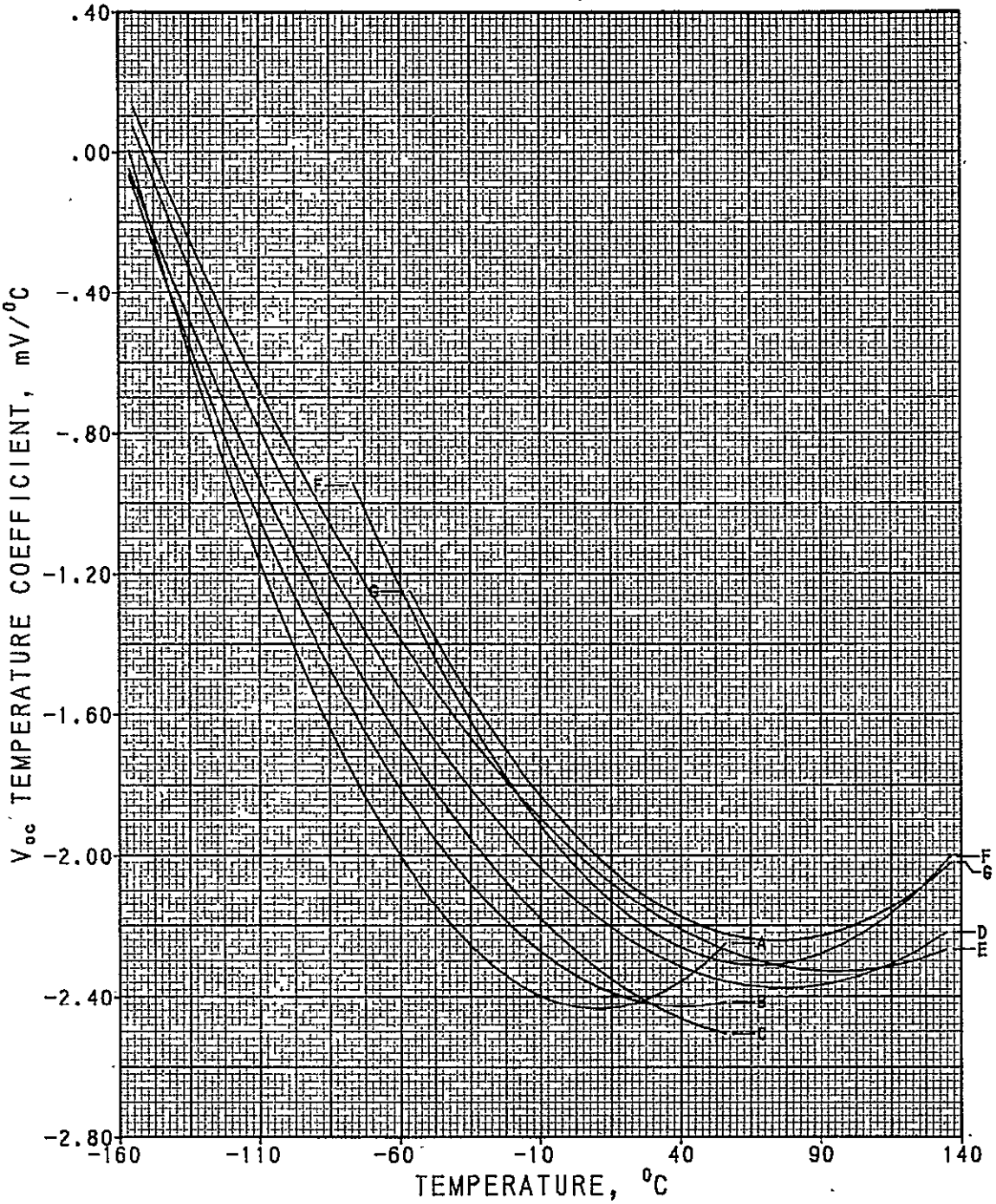


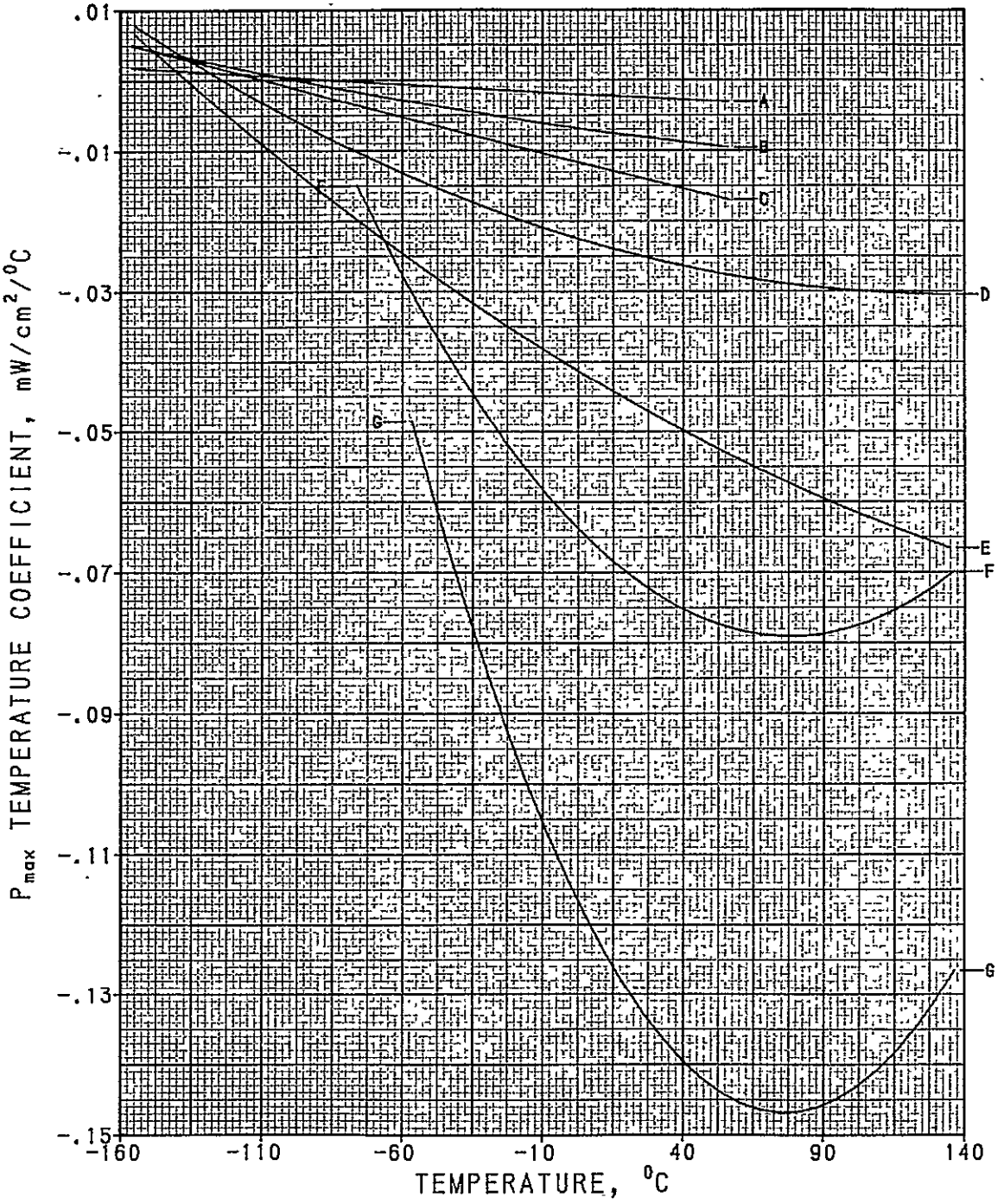

Figure 15. $I_{sc}$ Temperature Coefficient




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

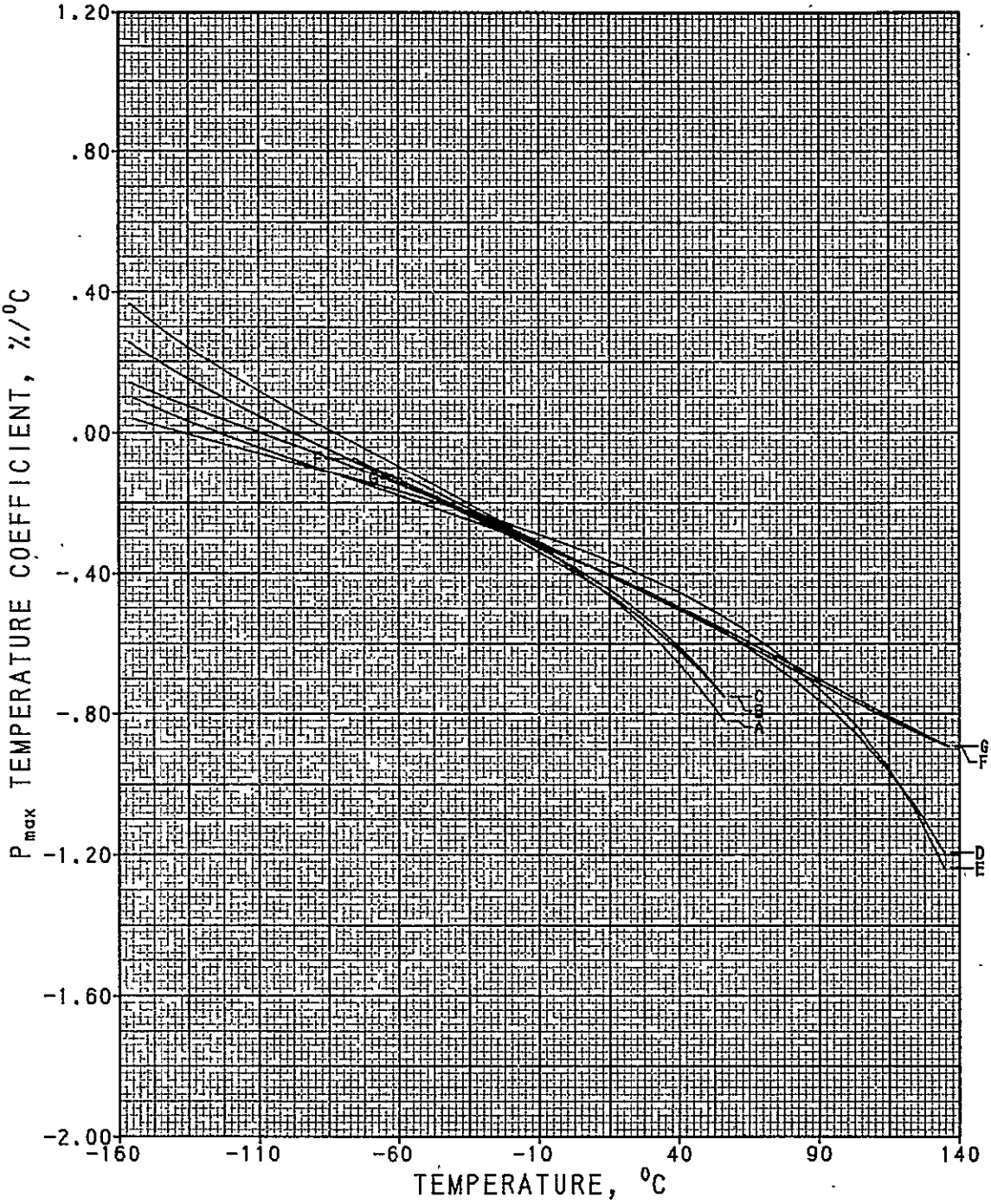
Figure 16. $V_{OC}$ Temperature Coefficient




| ID | mW/cm$^2$ |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

Figure 17. Absolute $P_{max}$ Temperature Coefficient




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

Figure 18. Percent $P_{max}$ Temperature Coefficient

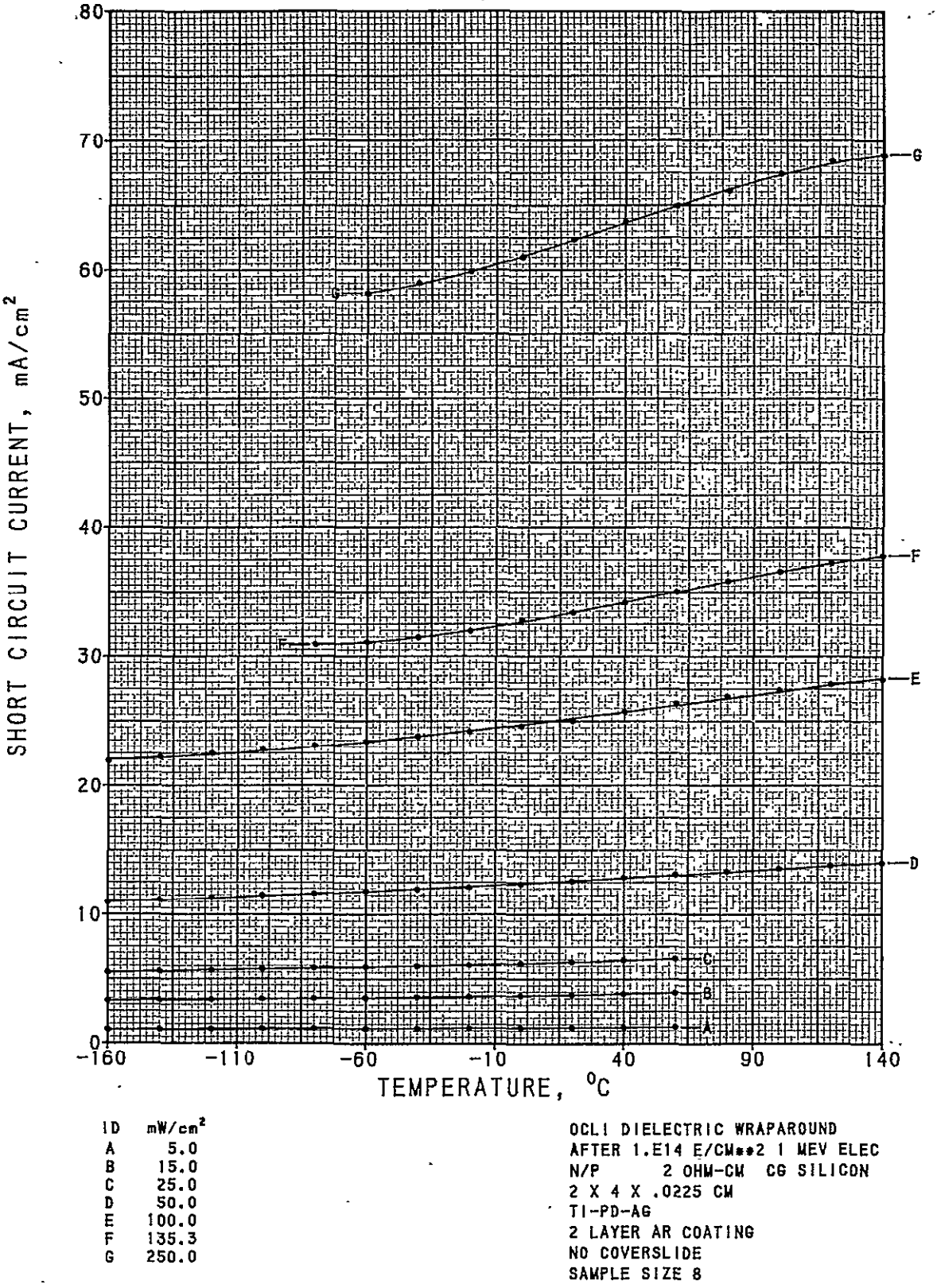
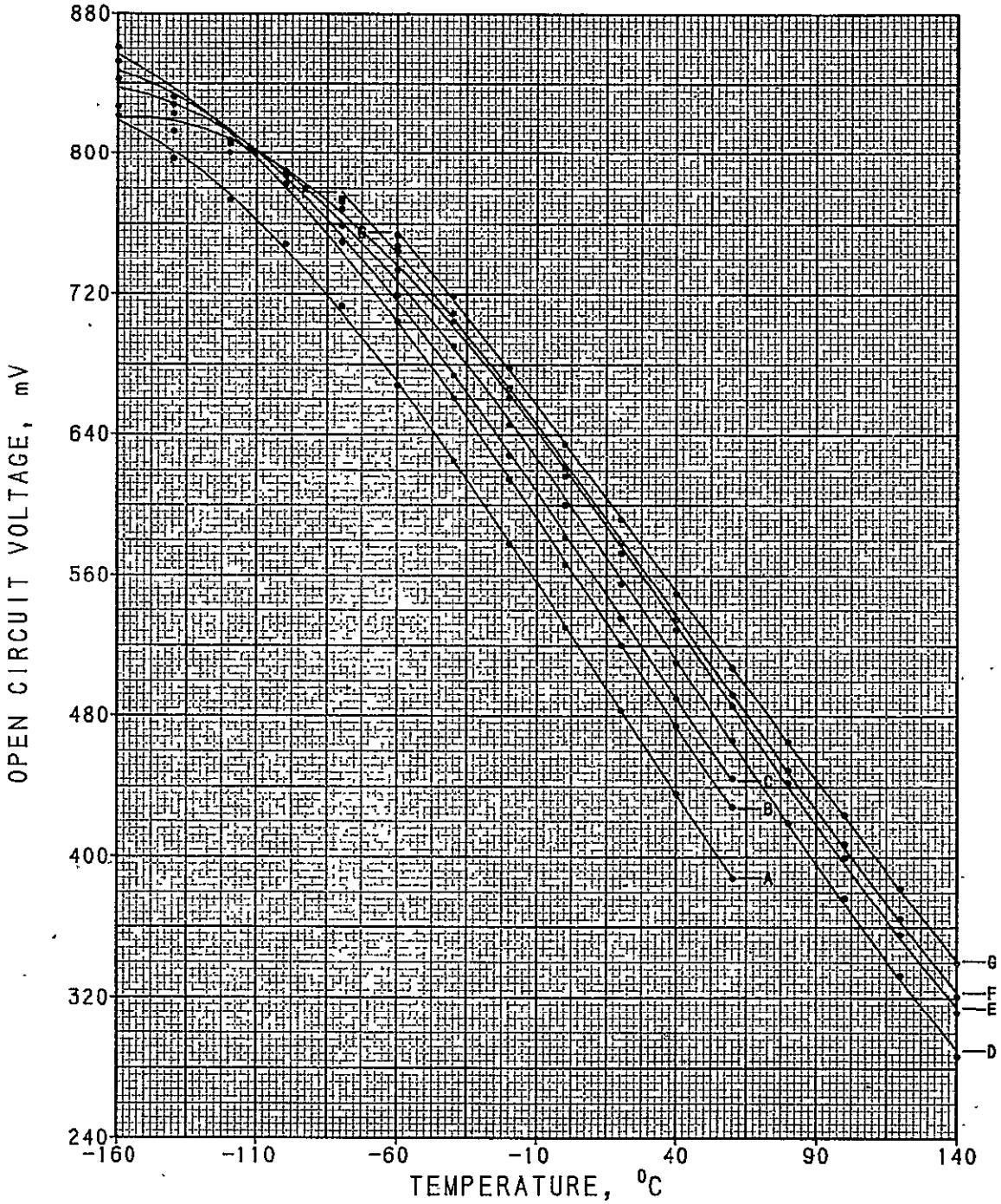


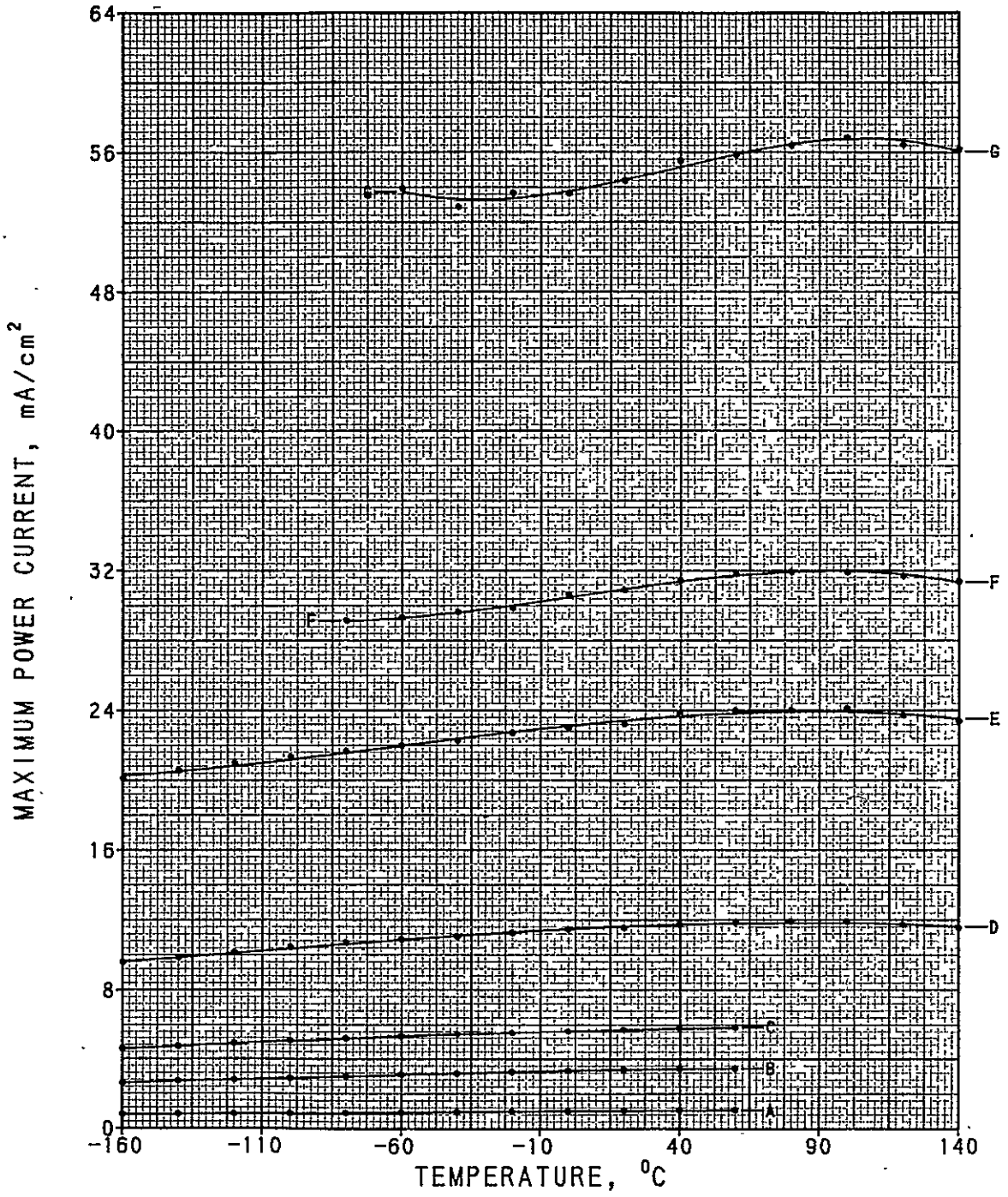

Figure 19. Average $I_{SC}/cm^2$ as a Function of Temperature After $10^{14}$ electrons/$cm^2$




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

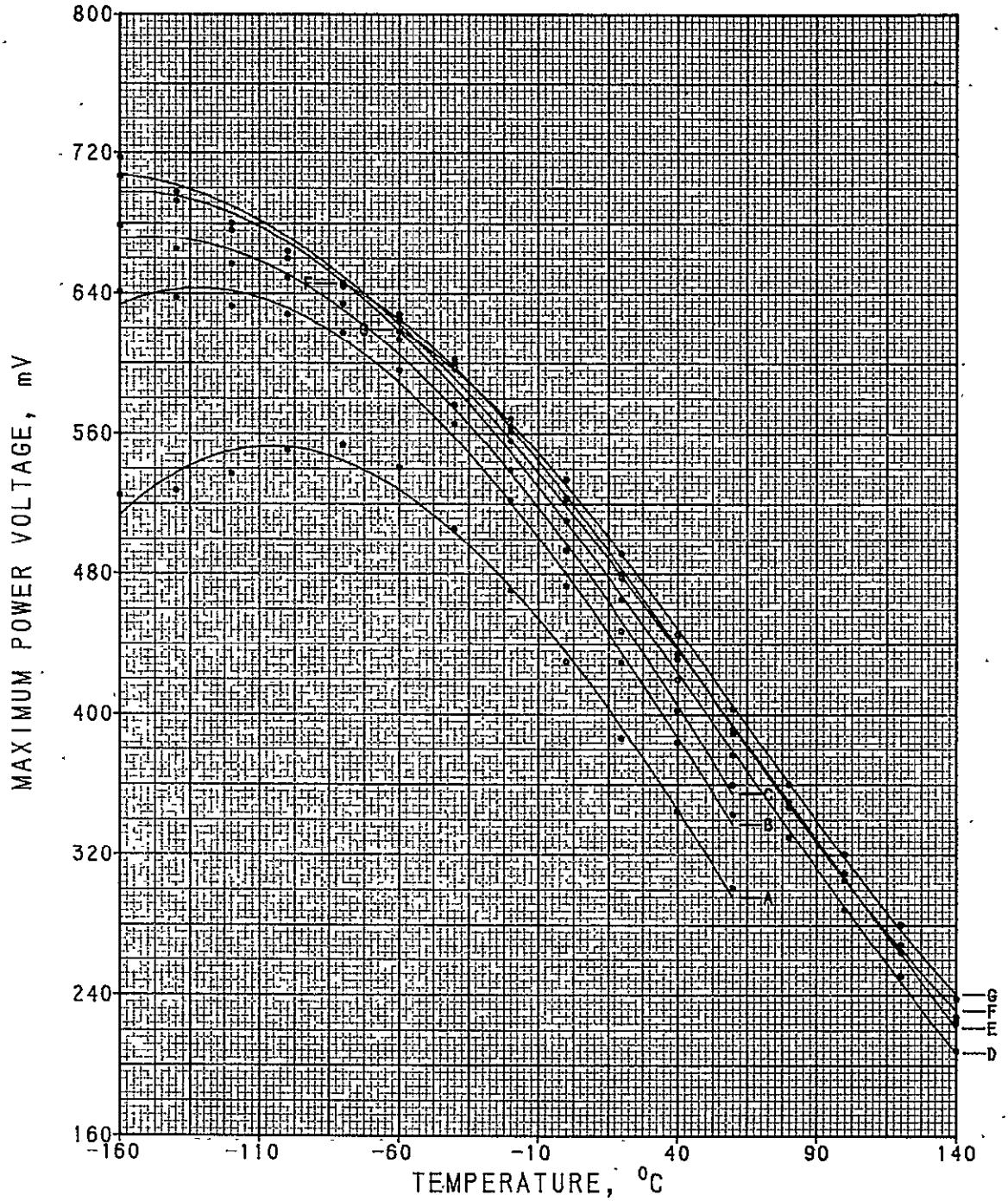
Figure 20. Average $V_{oc}$ as a Function of Temperature After $10^{14}$ electrons/cm$^2$




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

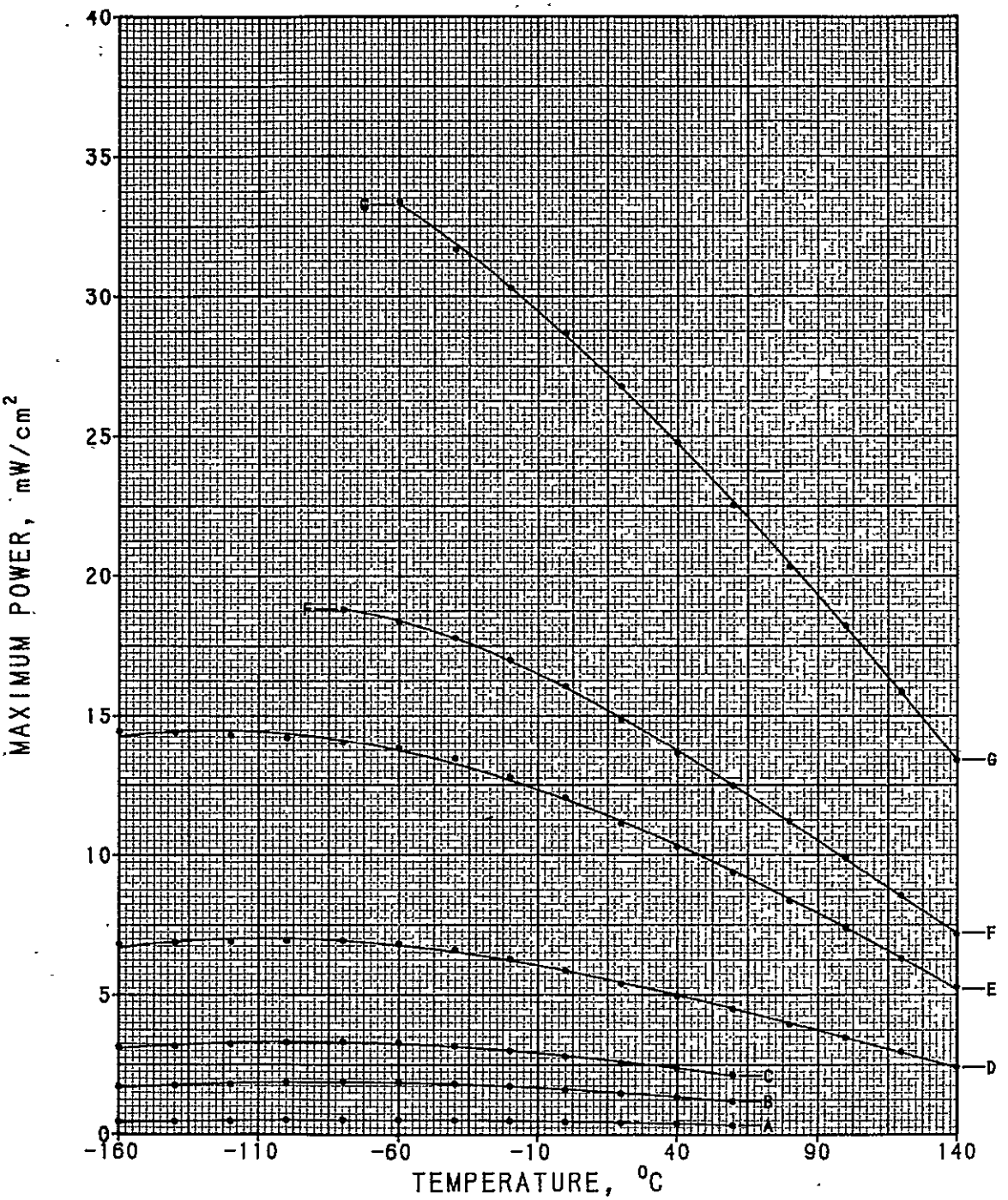
Figure 21. Average $I_{mp}/cm^2$ as a Function of Temperature After $10^{14}$ electrons/$cm^2$




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

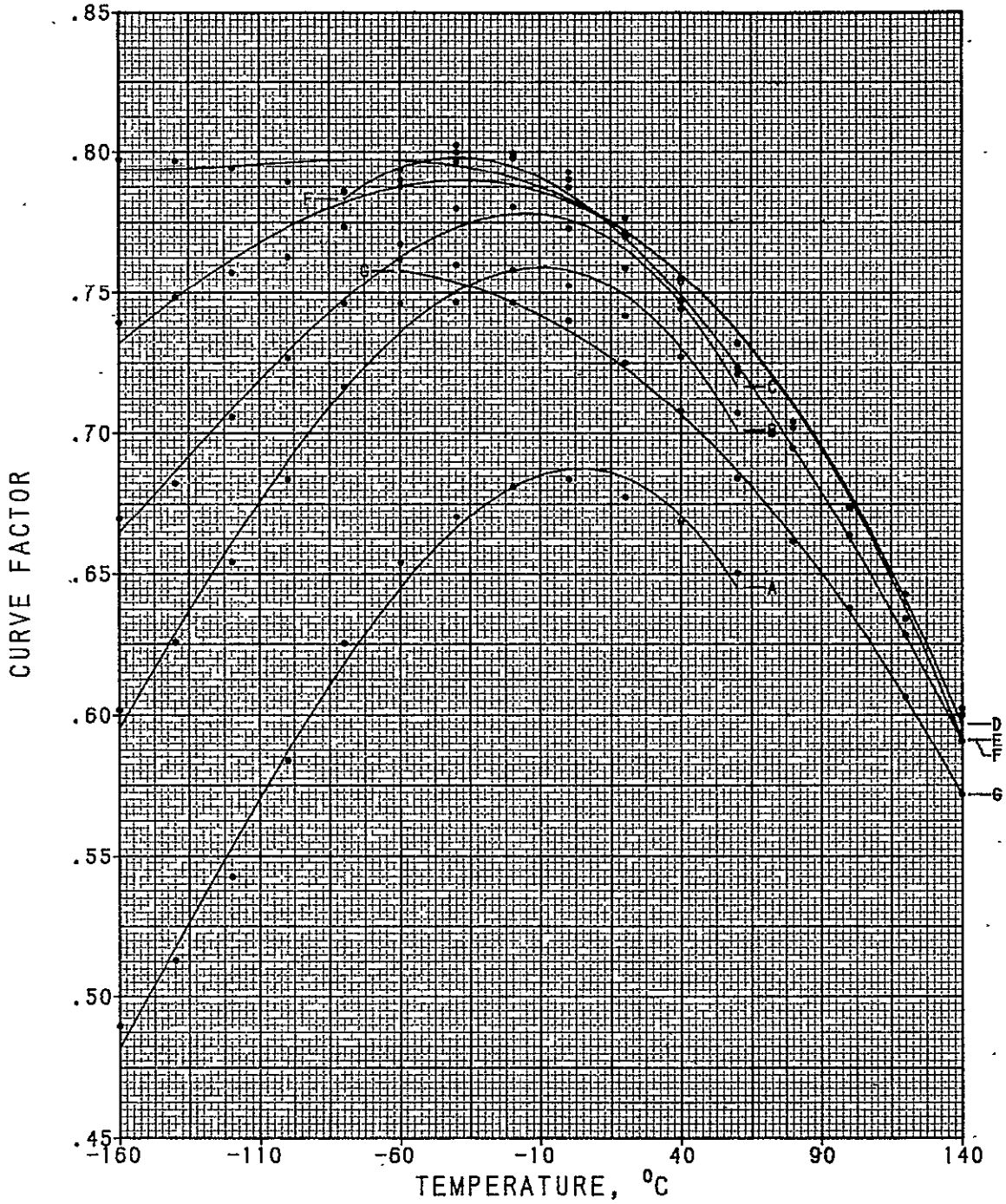
Figure 22. Average $V_{mp}$ as a Function of Temperature After $10^{14}$ electrons/cm$^2$




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

Figure 23. Average $P_{max}/cm^2$ as a Function of Temperature After $10^{14}$ electrons/$cm^2$




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

Figure 24. Average Curve Factor as a Function of Temperature After $10^{14}$ electrons/cm$^2$

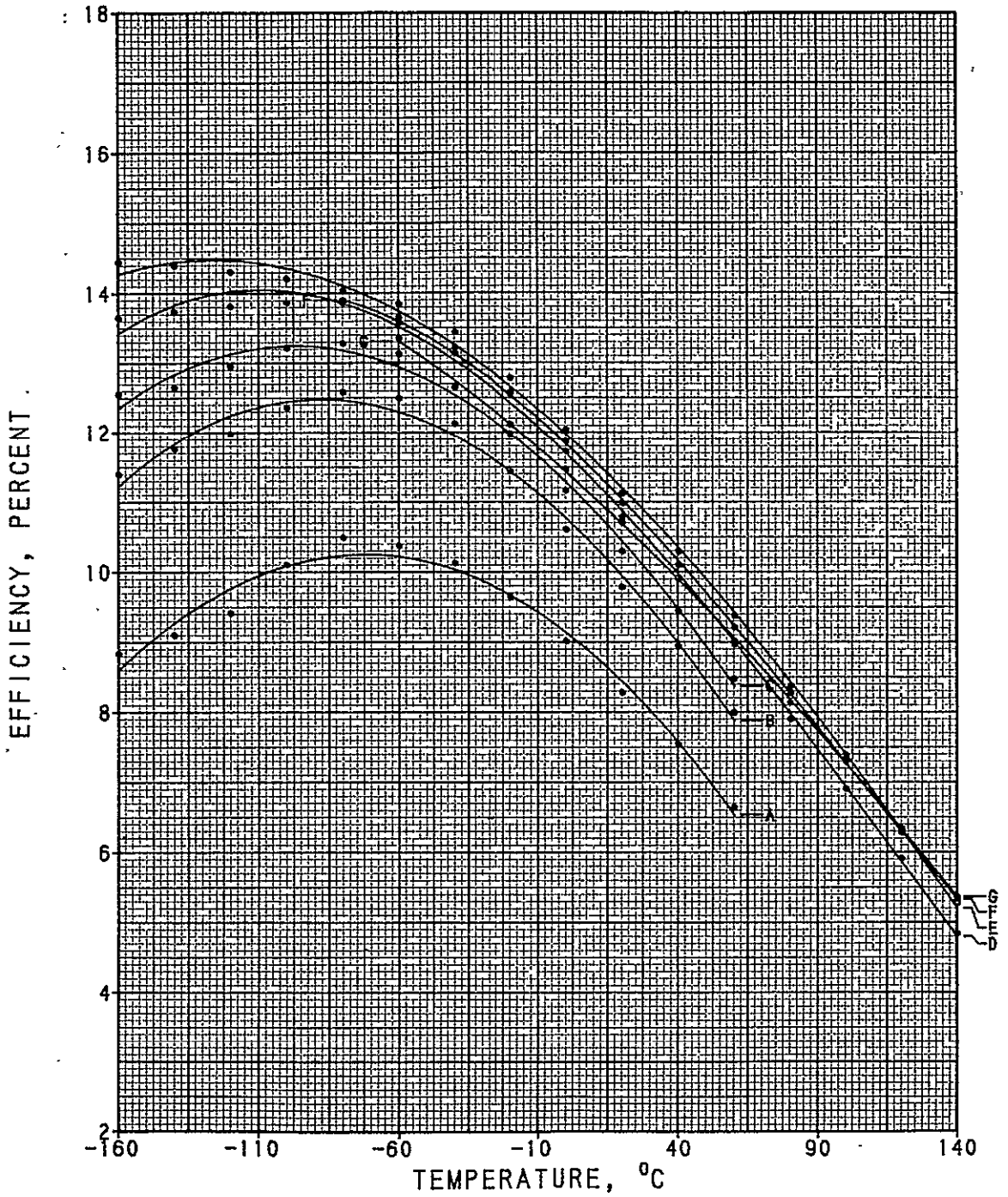
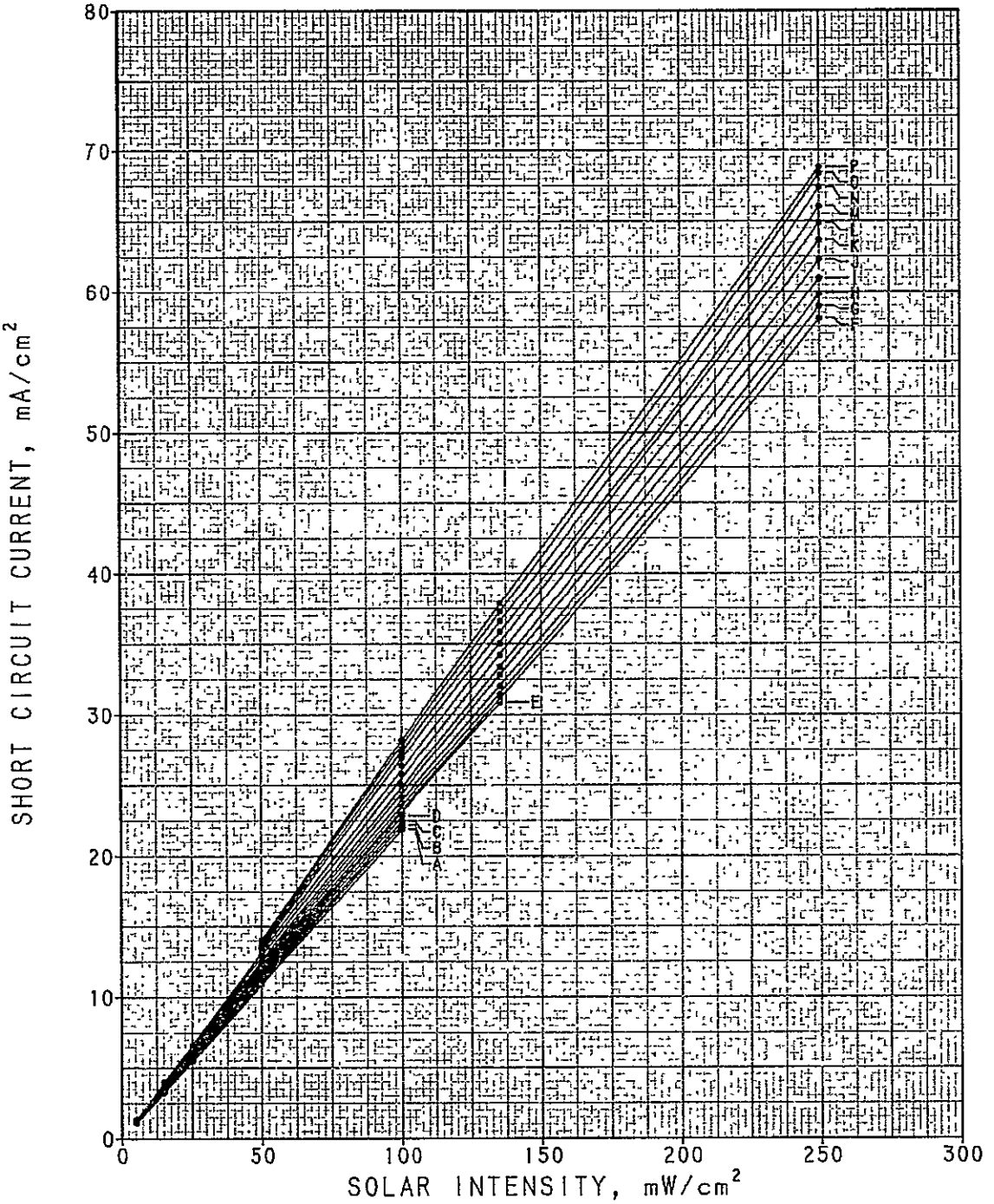


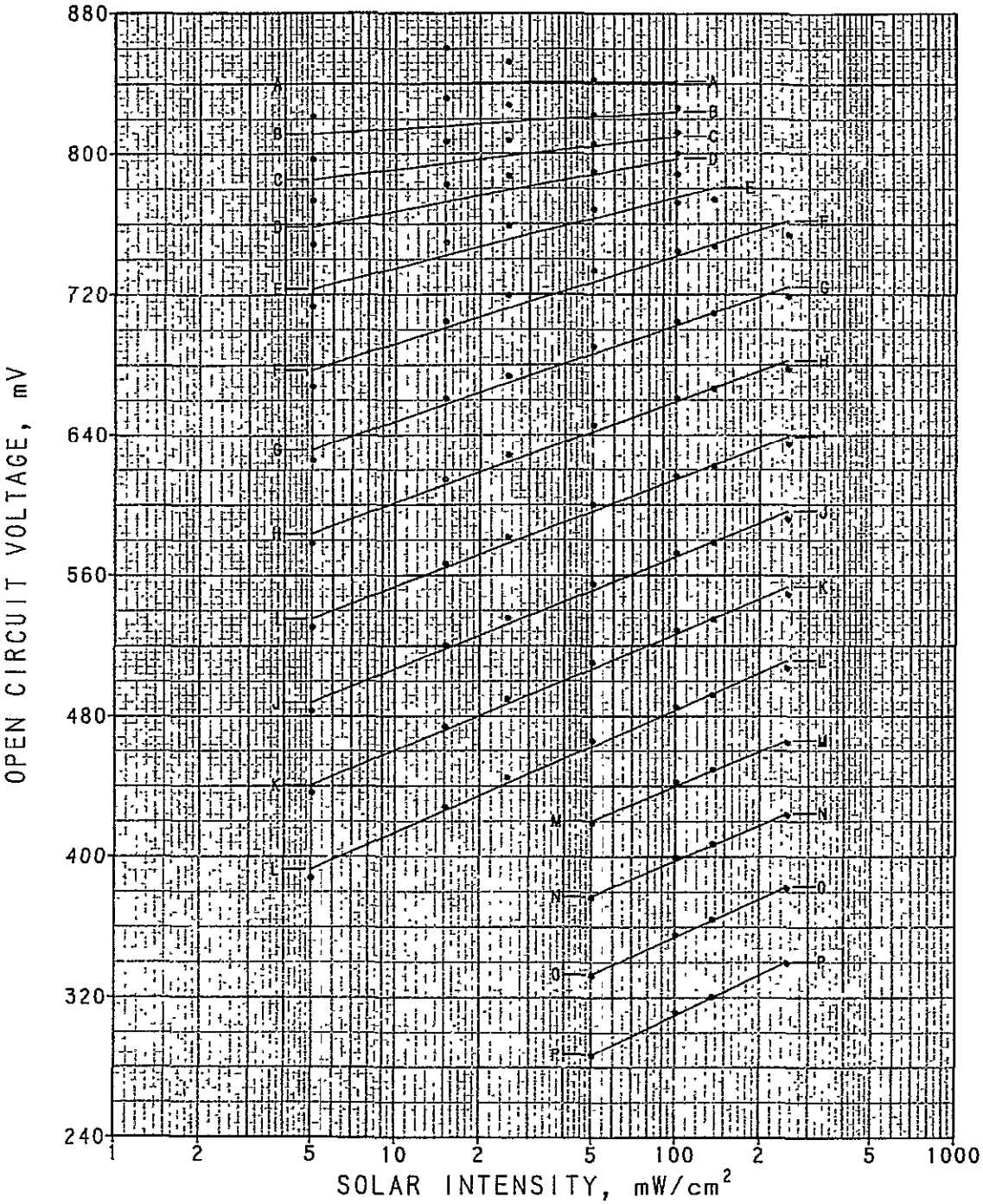

Figure 25. Average AMO Efficiency as a Function of Temperature After $10^{14}$ electrons/cm$^2$




| ID | °C | ID | °C |
|---|---|---|---|
| A | -160.0 | I | .0 |
| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.0 |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

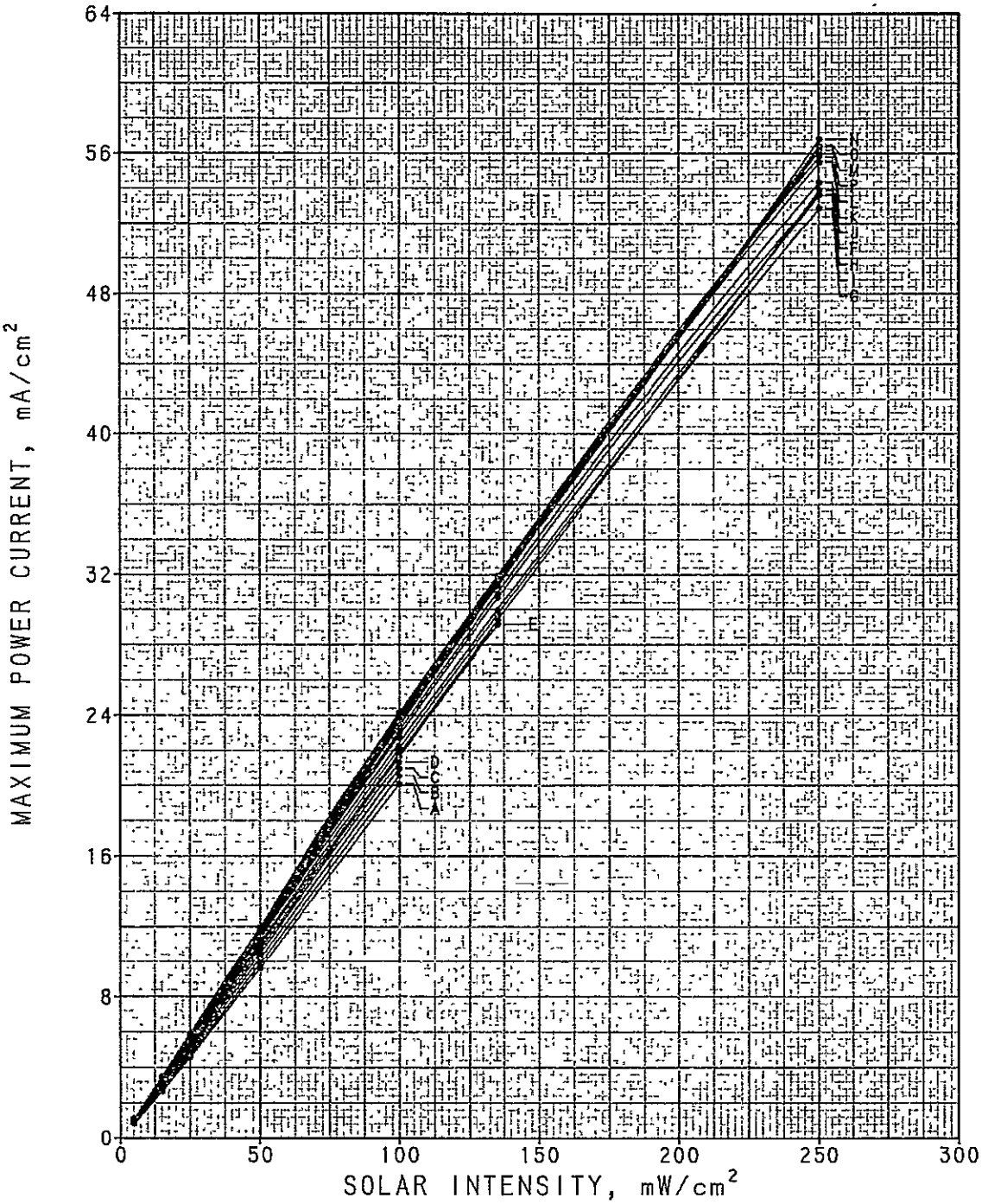
Figure 26. Average $I_{sc}/cm^2$ as a Function of Intensity After $10^{14}$ electrons/$cm^2$




| ID | °C | ID | °C |
|---|---|---|---|
| A | -160.0 | I | .0 |
| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.0 |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

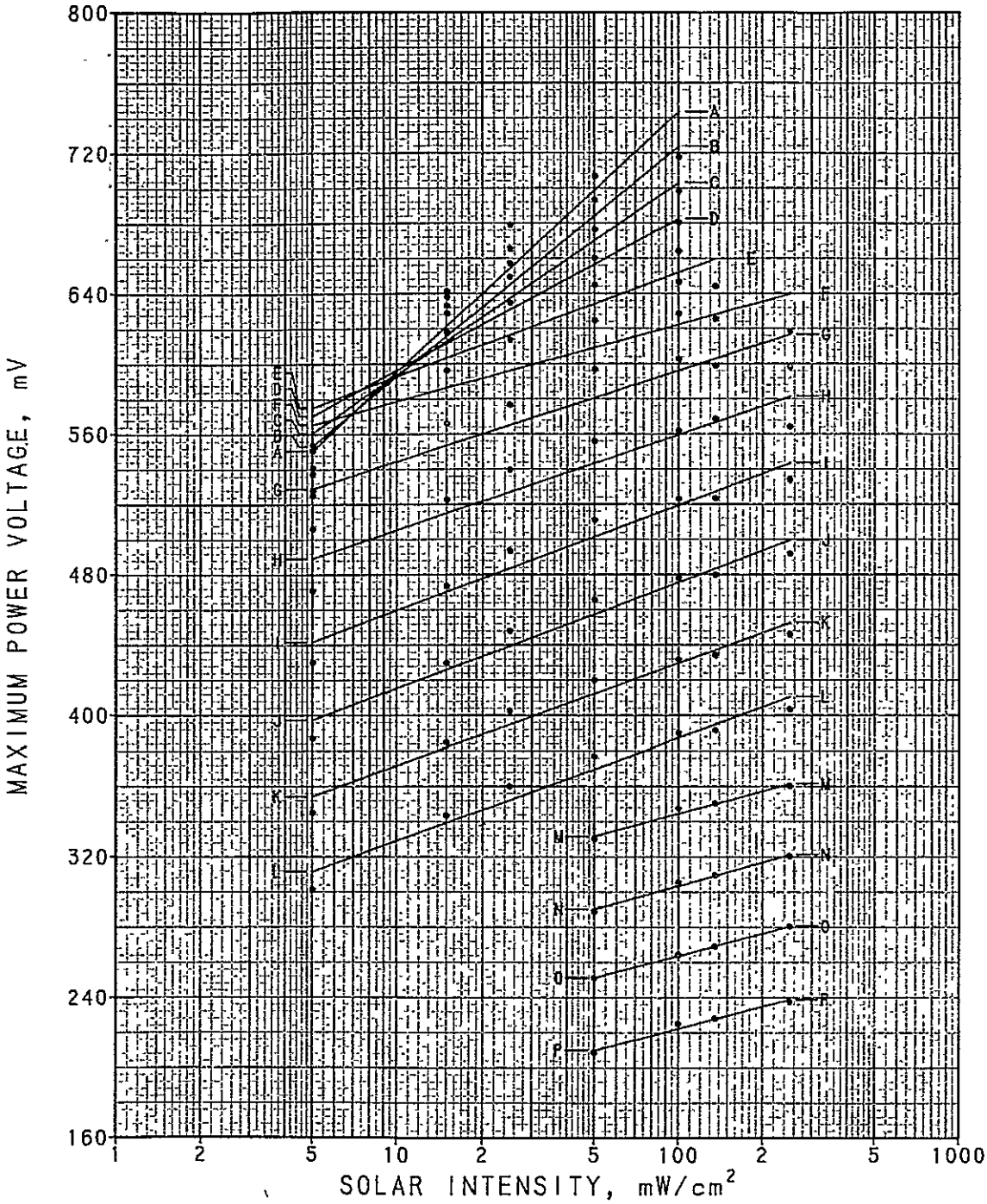
Figure 27. Average $V_{oc}$ as a Function of Intensity After $10^{14}$ electrons/cm$^2$




| ID | °C | ID | °C |
|---|---|---|---|
| A | -160.0 | I | .0 |
| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.0 |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

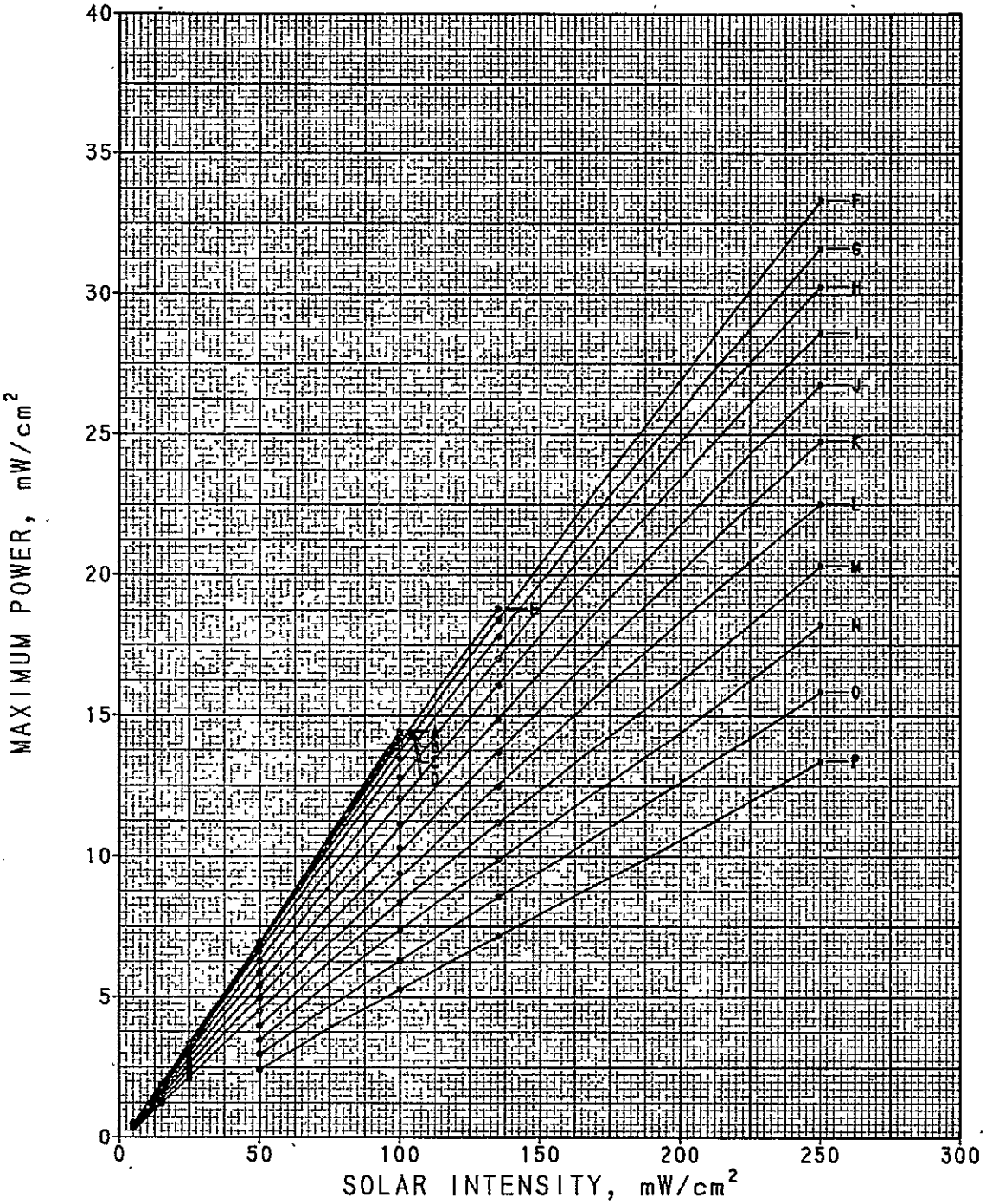
Figure 28. Average $I_{mp}/cm^2$ as a Function of Intensity After $10^{14}$ electrons/$cm^2$




| ID | °C | ID | °C |
|---|---|---|---|
| A | -160.0 | I | .0 |
| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.0 |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

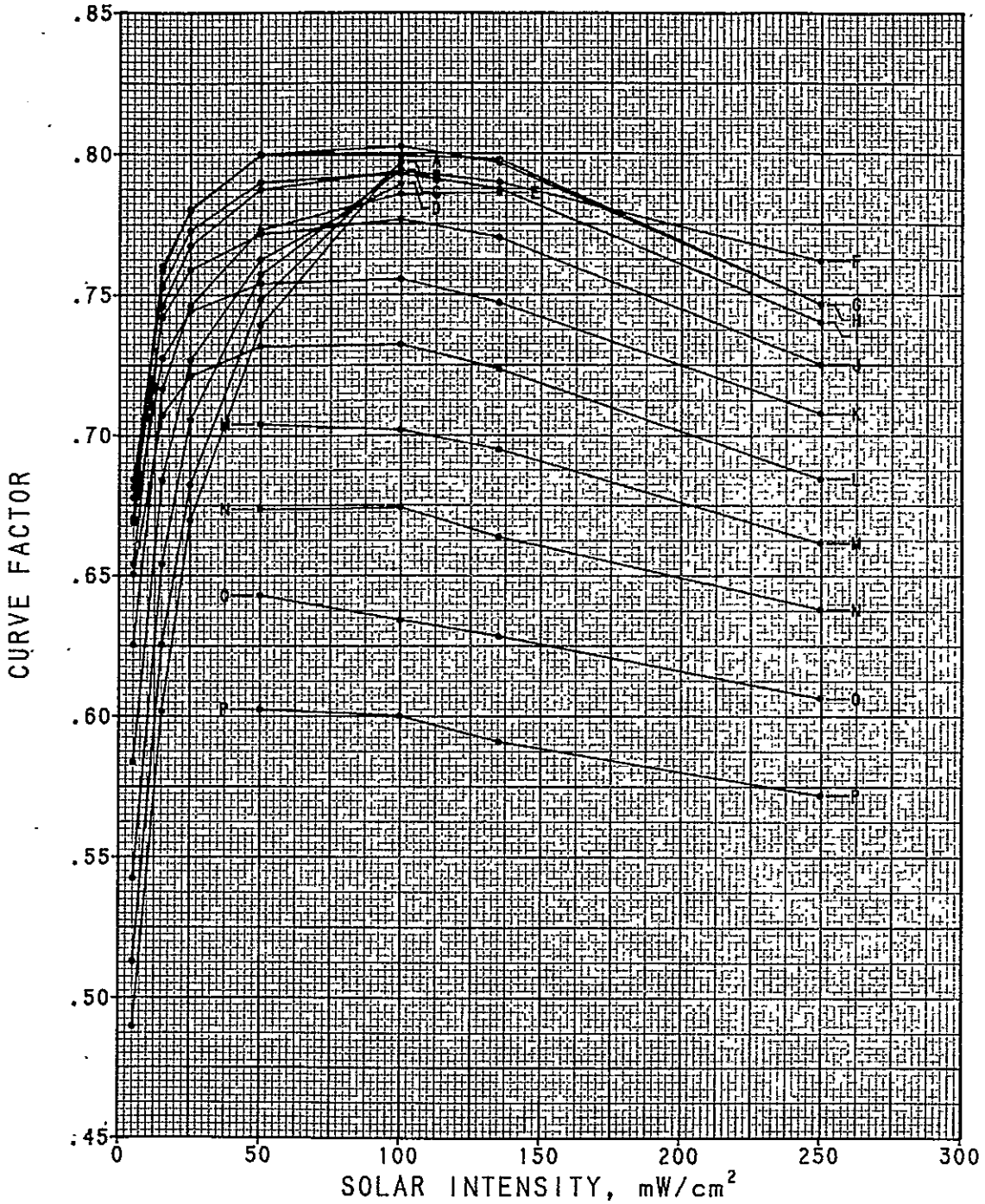
Figure 29. Average $V_{mp}$ as a Function of Intensity After $10^{14}$ electrons/cm$^2$




| ID | °C | ID | °C |
|---|---|---|---|
| A | -160.0 | I | .0 |
| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.0 |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

* OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

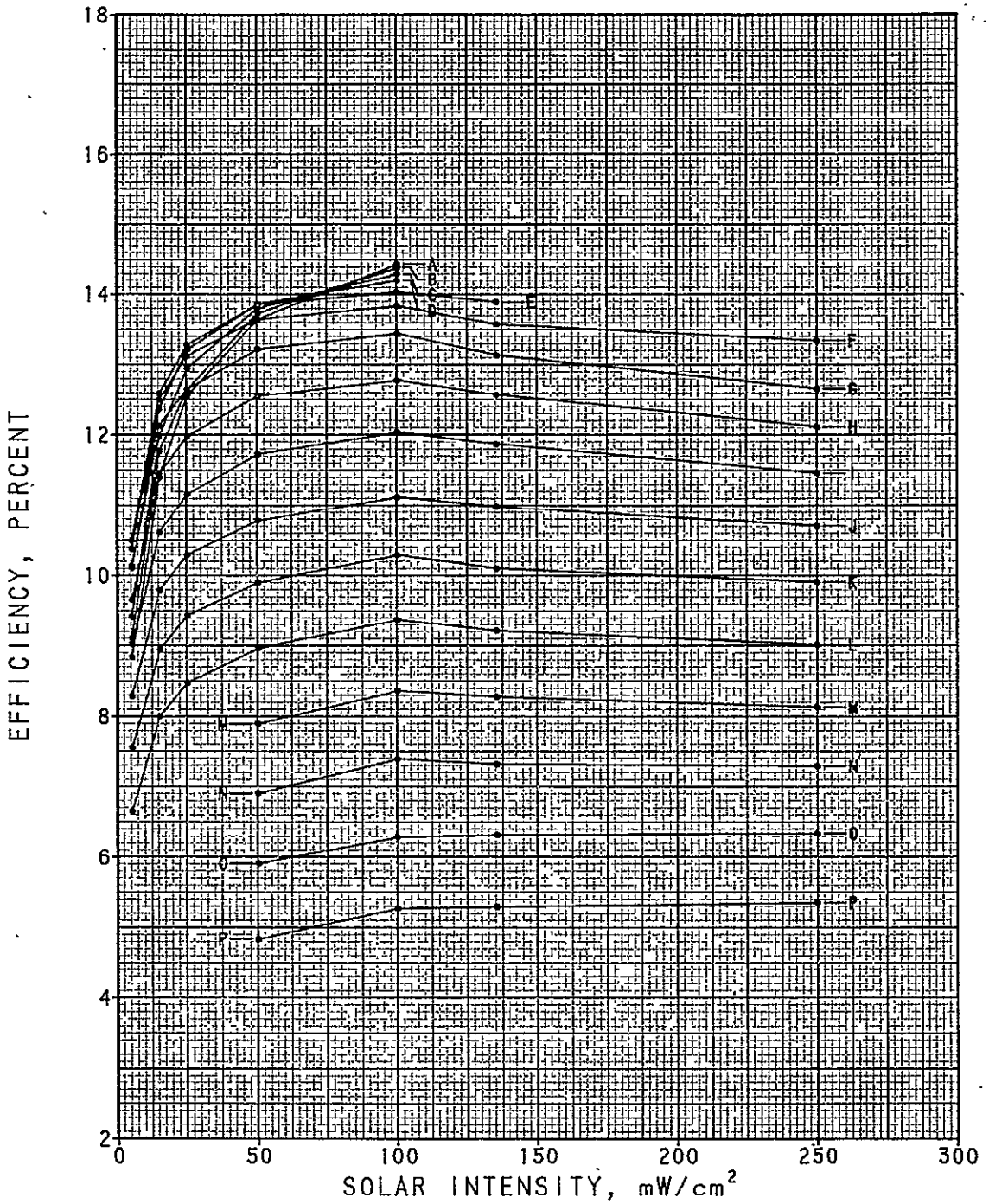
Figure 30. Average $P_{max}/cm^2$ as a Function of Intensity After $10^{14}$ electrons/$cm^2$




| ID | °C | ID | °C |
|---|---|---|---|
| A | -160.0 | I | .0 |
| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.0 |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

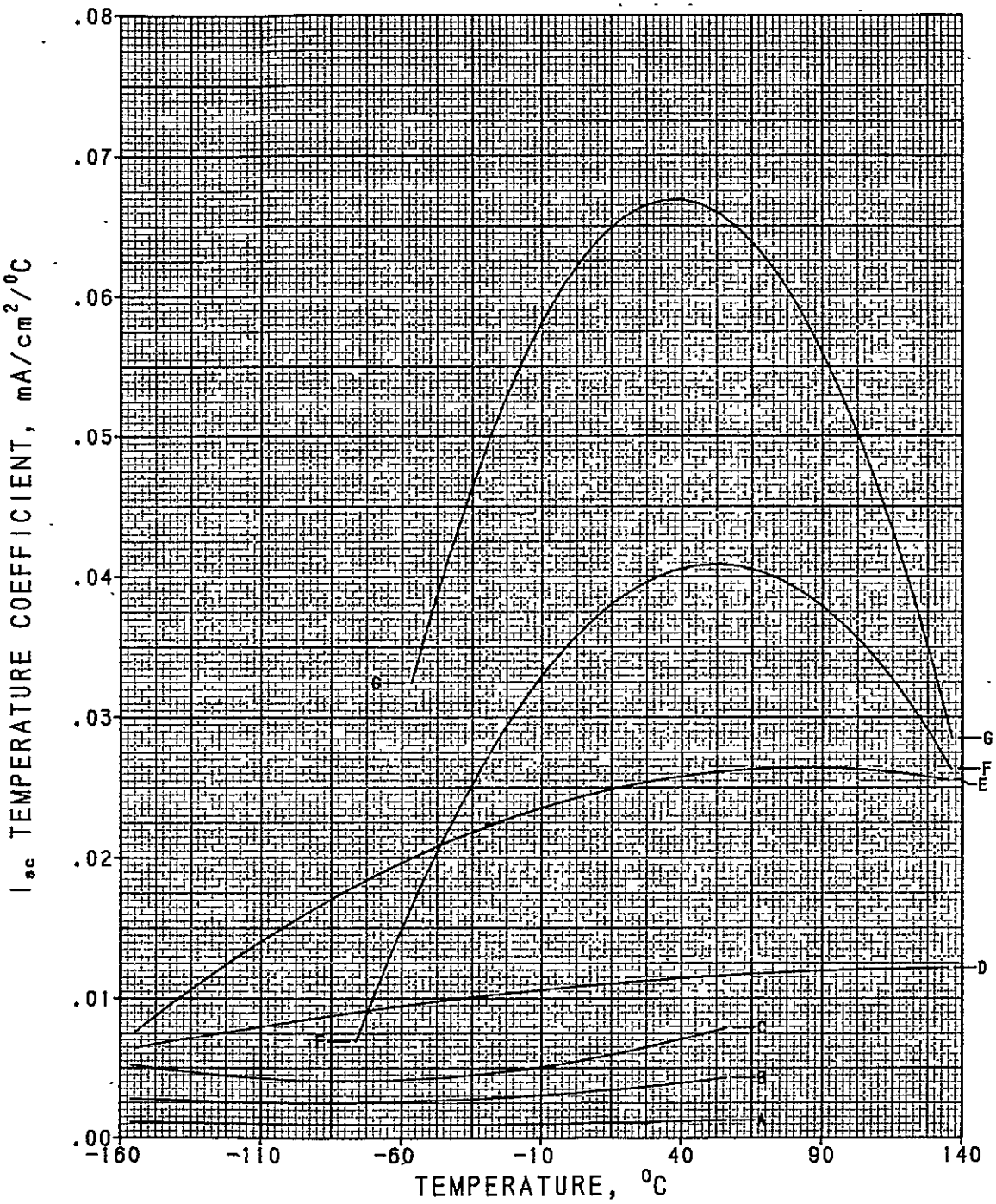
Figure 31. Average Curve Factor as a Function of Intensity After $10^{14}$ electrons/cm$^2$




| ID | °C | ID | °C |
|---|---|---|---|
| A | -160.0 | I | .0 |
| B | -140.0 | J | 20.0 |
| C | -120.0 | K | 40.0 |
| D | -100.0 | L | 60.0 |
| E | -80.0 | M | 80.0 |
| F | -60.0 | N | 100.0 |
| G | -40.0 | O | 120.0 |
| H | -20.0 | P | 140.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

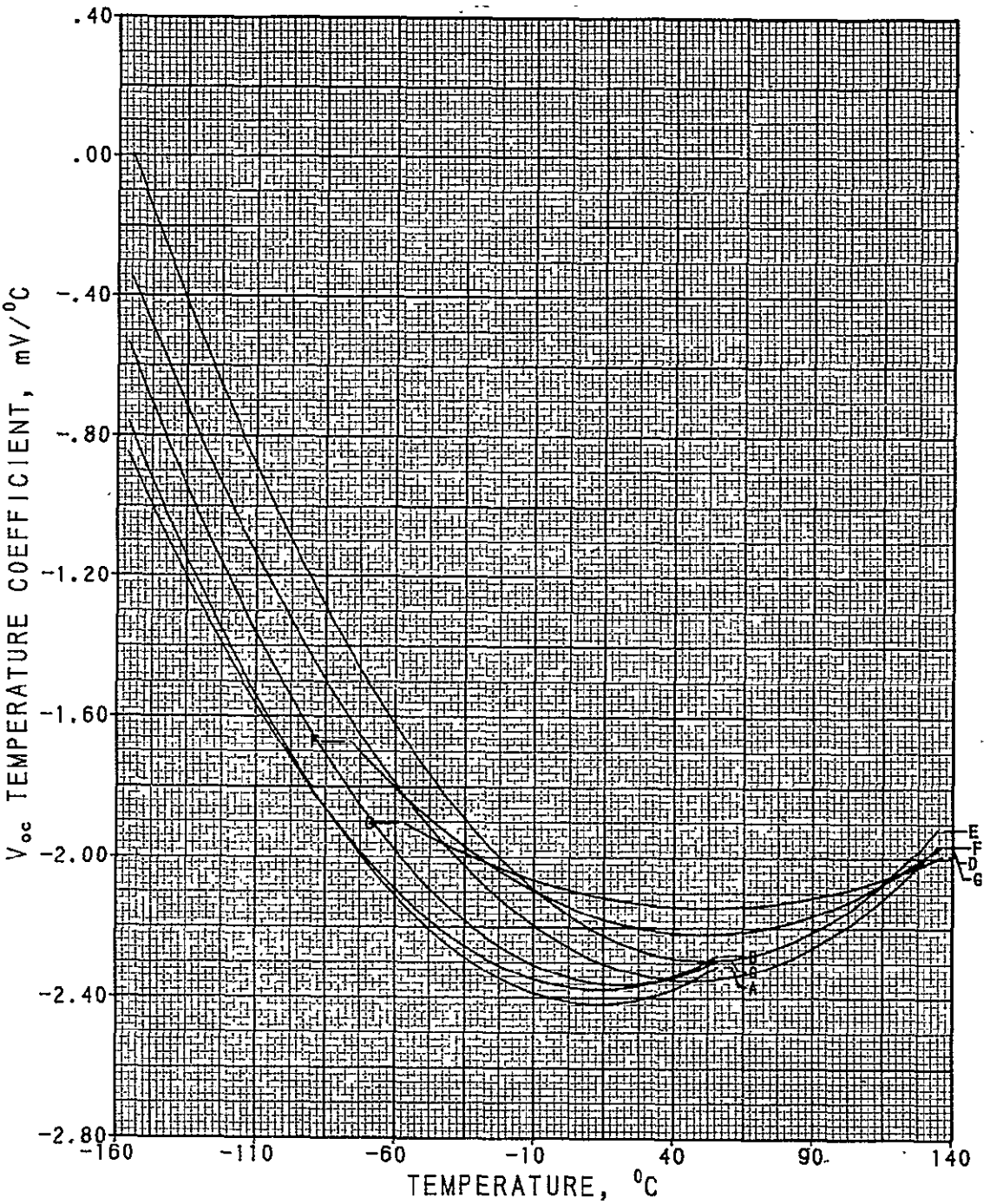
Figure 32. Average AMO Efficiency as a Function of Intensity After $10^{14}$ electrons/cm$^2$




| ID | mW/cm$^2$ |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

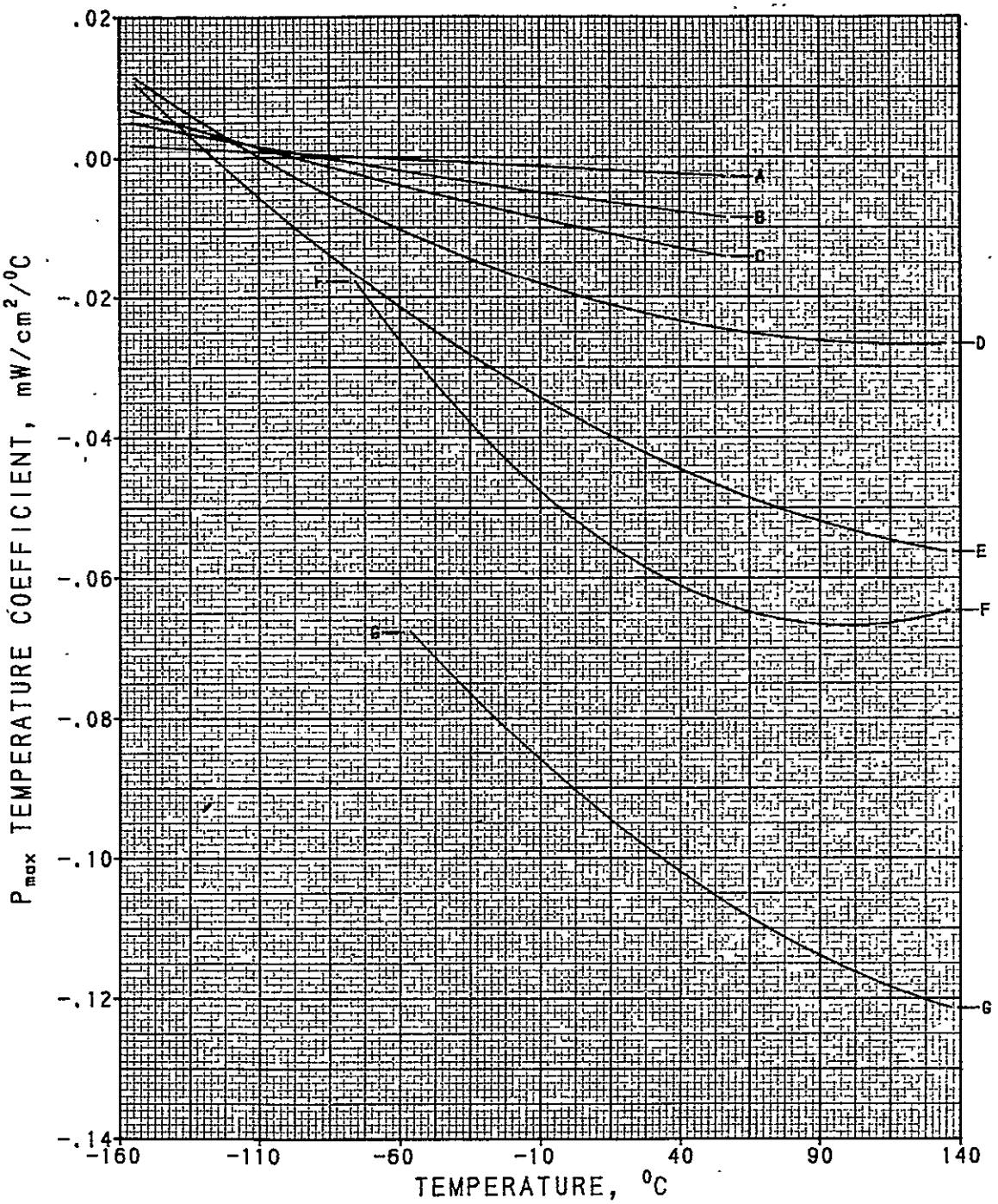
Figure 33. $I_{sc}$ Temperature Coefficient After $10^{14}$ electrons/cm$^2$




| ID | mW/cm² |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

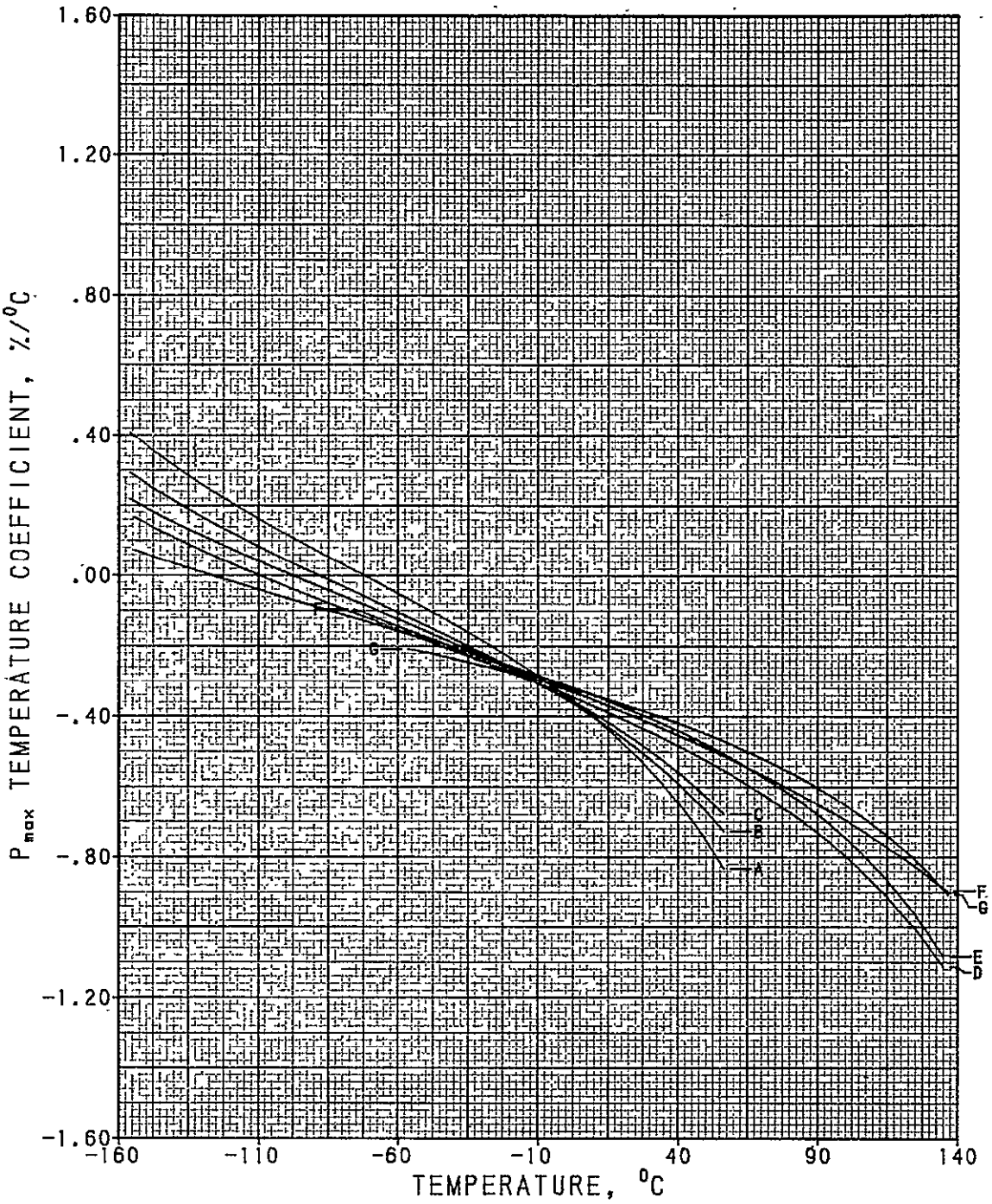
Figure 34. $V_{oc}$ Temperature Coefficient After $10^{14}$ electrons/cm$^2$




| ID | mW/cm$^2$ |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

Figure 35. Absolute $P_{max}$ Temperature Coefficient After $10^{14}$ electrons/cm$^2$




| ID | mW/cm$^2$ |
|---|---|
| A | 5.0 |
| B | 15.0 |
| C | 25.0 |
| D | 50.0 |
| E | 100.0 |
| F | 135.3 |
| G | 250.0 |

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

Figure 36. Percent $P_{max}$ Temperature Coefficient After $10^{14}$ electrons/cm$^2$

Table 1. Average Short-Circuit Current

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 1.24 | 3.67 | 6.13 | 12.33 | 24.45 | - | - |
| | (.02) | (.04) | (.08) | (.13) | (.29) | | |
| -140.00 | 1.25 | 3.75 | 6.20 | 12.44 | 24.44 | - | - |
| | (.02) | (.04) | (.07) | (.14) | (.29) | | |
| -120.00 | 1.27 | 3.80 | 6.26 | 12.57 | 24.66 | - | - |
| | (.02) | (.04) | (.08) | (.14) | (.36) | | |
| -100.00 | 1.27 | 3.79 | 6.35 | 12.70 | 24.89 | - | - |
| | (.02) | (.04) | (.09) | (.15) | (.34) | | |
| -80.00 | 1.29 | 3.83 | 6.41 | 12.80 | 25.06 | 34.67 | - |
| | (.02) | (.04) | (.09) | (.15) | (.29) | (.40) | |
| -60.00 | 1.30 | 3.87 | 6.47 | 12.91 | 25.34 | 34.99 | 64.15 |
| | (.02) | (.05) | (.09) | (.16) | (.40) | (.43) | (.85) |
| -40.00 | 1.31 | 3.91 | 6.54 | 13.01 | 25.63 | 35.37 | 64.85 |
| | (.02) | (.04) | (.09) | (.16) | (.36) | (.46) | (.83) |
| -20.00 | 1.32 | 3.94 | 6.61 | 13.14 | 25.97 | 35.57 | 65.55 |
| | (.02) | (.05) | (.09) | (.15) | (.35) | (.46) | (.94) |
| .00 | 1.34 | 3.96 | 6.68 | 13.28 | 26.29 | 35.91 | 66.17 |
| | (.02) | (.05) | (.10) | (.16) | (.38) | (.50) | (.88) |
| 20.00 | 1.35 | 4.01 | 6.74 | 13.43 | 26.62 | 36.41 | 67.22 |
| | (.02) | (.04) | (.09) | (.15) | (.35) | (.45) | (.93) |
| 40.00 | 1.37 | 4.06 | 6.82 | 13.65 | 27.13 | 37.00 | 67.93 |
| | (.02) | (.05) | (.10) | (.15) | (.36) | (.47) | (.95) |
| 60.00 | 1.38 | 4.10 | 6.91 | 13.81 | 27.45 | 37.57 | 68.61 |
| | (.02) | (.05) | (.09) | (.18) | (.38) | (.51) | (.97) |
| 80.00 | - | - | - | 13.97 | 27.91 | 37.92 | 69.29 |
| | | | | (.17) | (.40) | (.51) | (1.00) |
| 100.00 | - | - | - | 14.10 | 28.11 | 38.34 | 70.08 |
| | | | | (.18) | (.39) | (.51) | (.97) |
| 120.00 | - | - | - | 14.22 | 28.42 | 38.73 | 70.76 |
| | | | | (.17) | (.35) | (.53) | (.88) |
| 140.00 | - | - | - | 14.36 | 28.67 | 39.08 | 71.02 |
| | | | | (.18) | (.39) | (.50) | (.98) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 2. Average Open-Circuit Voltage

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 794.99 (53.75) | 816.26 (33.29) | 816.14 (18.98) | 811.90 (11.90) | 809.15 (11.70) | - | - |
| -140.00 | 782.15 (42.97) | 801.31 (24.85) | 800.71 (15.26) | 798.26 (12.88) | 796.32 (12.80) | - | - |
| -120.00 | 770.61 (32.66) | 786.75 (18.28) | 787.09 (14.44) | 786.00 (13.47) | 784.29 (13.39) | - | - |
| -100.00 | 753.70 (24.53) | 772.10 (14.87) | 774.15 (13.34) | 773.84 (13.07) | 772.75 (13.12) | - | - |
| -80.00 | 724.12 (18.36) | 750.71 (10.57) | 756.95 (10.21) | 760.40 (11.10) | 760.94 (11.69) | 760.85 (11.89) | - |
| -60.00 | 682.99 (15.54) | 716.86 (7.07) | 727.64 (5.74) | 737.82 (6.58) | 743.54 (8.03) | 745.40 (8.89) | 747.31 (9.67) |
| -40.00 | 638.79 (14.04) | 673.95 (5.84) | 687.54 (3.87) | 702.22 (3.16) | 714.24 (3.73) | 718.89 (4.46) | 725.95 (5.64) |
| -20.00 | 592.21 (12.73) | 628.71 (5.20) | 642.96 (3.23) | 660.35 (2.06) | 675.74 (1.85) | 682.61 (1.99) | 693.12 (2.52) |
| .00 | 545.39 (10.79) | 582.01 (4.96) | 597.77 (2.60) | 616.30 (1.89) | 633.34 (1.48) | 641.17 (1.53) | 653.72 (1.94) |
| 20.00 | 498.41 (9.73) | 535.70 (4.28) | 551.54 (2.74) | 571.67 (1.86) | 589.92 (1.52) | 598.35 (1.50) | 612.59 (1.95) |
| 40.00 | 451.45 (8.81) | 489.61 (4.06) | 505.59 (2.57) | 526.67 (1.77) | 546.10 (1.58) | 554.82 (1.70) | 569.76 (1.80) |
| 60.00 | 403.46 (7.83) | 442.82 (3.98) | 459.95 (2.34) | 481.97 (1.90) | 502.07 (1.77) | 511.24 (1.81) | 527.12 (2.13) |
| 80.00 | - | - | - | 435.41 (2.23) | 457.26 (1.87) | 467.07 (1.96) | 483.90 (2.26) |
| 100.00 | - | - | - | 389.82 (2.17) | 412.21 (2.11) | 422.34 (2.10) | 440.12 (2.41) |
| 120.00 | - | - | - | 342.92 (2.39) | 367.01 (2.41) | 377.25 (2.27) | 396.34 (2.44) |
| 140.00 | - | - | - | 296.36 (2.37) | 321.47 (2.56) | 332.44 (2.66) | 352.30 (2.80) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 3. Average Maximum Power Current

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | .95 | 3.00 | 5.22 | 11.10 | 22.66 | - | - |
| | (.07) | (.23) | (.32) | (.46) | (.60) | | |
| -140.00 | .97 | 3.10 | 5.38 | 11.25 | 22.59 | - | - |
| | (.07) | (.22) | (.29) | (.43) | (.52) | | |
| -120.00 | .99 | 3.19 | 5.49 | 11.45 | 23.00 | - | - |
| | (.08) | (.20) | (.25) | (.36) | (.46) | | |
| -100.00 | 1.01 | 3.24 | 5.64 | 11.65 | 23.22 | - | - |
| | (.08) | (.18) | (.21) | (.34) | (.36) | | |
| -80.00 | 1.05 | 3.33 | 5.76 | 11.78 | 23.56 | 32.61 | - |
| | (.08) | (.16) | (.17) | (.26) | (.33) | (.44) | |
| -60.00 | 1.07 | 3.42 | 5.87 | 11.97 | 23.83 | 32.94 | 60.44 |
| | (.08) | (.14) | (.14) | (.21) | (.35) | (.47) | (.76) |
| -40.00 | 1.09 | 3.48 | 5.97 | 12.06 | 24.02 | 33.25 | 60.94 |
| | (.07) | (.11) | (.11) | (.19) | (.28) | (.38) | (.80) |
| -20.00 | 1.11 | 3.52 | 6.04 | 12.17 | 24.37 | 33.30 | 61.06 |
| | (.06) | (.11) | (.08) | (.18) | (.30) | (.51) | (.69) |
| .00 | 1.13 | 3.53 | 6.08 | 12.26 | 24.50 | 33.52 | 61.25 |
| | (.06) | (.09) | (.10) | (.17) | (.28) | (.50) | (.66) |
| 20.00 | 1.14 | 3.57 | 6.15 | 12.37 | 24.67 | 33.62 | 61.42 |
| | (.05) | (.08) | (.07) | (.16) | (.32) | (.45) | (.83) |
| 40.00 | 1.16 | 3.59 | 6.19 | 12.50 | 25.00 | 33.91 | 61.37 |
| | (.05) | (.06) | (.06) | (.12) | (.30) | (.46) | (.81) |
| 60.00 | 1.16 | 3.59 | 6.22 | 12.42 | 24.97 | 34.06 | 61.39 |
| | (.04) | (.06) | (.05) | (.14) | (.26) | (.38) | (.62) |
| 80.00 | - | - | - | 12.42 | 24.95 | 33.84 | 60.55 |
| | | | | (.14) | (.38) | (.44) | (.76) |
| 100.00 | - | - | - | 12.30 | 24.77 | 33.64 | 60.20 |
| | | | | (.14) | (.29) | (.50) | (.89) |
| 120.00 | - | - | - | 12.16 | 24.31 | 33.08 | 59.56 |
| | | | | (.16) | (.33) | (.50) | (.75) |
| 140.00 | - | - | - | 11.98 | 23.83 | 32.23 | 57.69 |
| | | | | (.15) | (.44) | (.46) | (.91) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 4. Average Maximum Power Voltage

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 545.50 (101.22) | 649.75 (45.84) | 697.75 (26.01) | 712.50 (23.56) | 718.50 (20.05) | - | - |
| -140.00 | 547.25 (91.08) | 645.37 (42.43) | 681.00 (27.26) | 697.62 (21.51) | 701.62 (20.93) | - | - |
| -120.00 | 558.87 (80.99) | 643.12 (37.55) | 669.25 (24.86) | 681.25 (20.79) | 683.62 (18.72) | - | - |
| -100.00 | 567.75 (64.82) | 635.62 (33.52) | 656.37 (26.16) | 667.37 (20.90) | 669.62 (18.62) | - | - |
| -80.00 | 569.50 (52.38) | 630.00 (26.97) | 646.87 (21.28) | 655.12 (17.39) | 655.75 (17.42) | 656.12 (15.39) | - |
| -60.00 | 553.62 (39.03) | 607.75 (22.09) | 624.12 (18.43) | 636.25 (15.60) | 637.62 (12.93) | 640.25 (12.27) | 633.87 (13.75) |
| -40.00 | 520.62 (34.42) | 575.00 (17.57) | 595.87 (14.98) | 606.25 (11.15) | 615.62 (8.60) | 618.75 (9.60) | 613.12 (8.79) |
| -20.00 | 483.87 (28.07) | 535.50 (13.26) | 551.50 (11.19) | 569.12 (7.88) | 579.62 (7.82) | 584.87 (7.43) | 583.37 (5.29) |
| .00 | 442.87 (22.44) | 490.75 (14.37) | 507.25 (7.65) | 525.37 (5.60) | 539.12 (3.94) | 543.00 (4.60) | 546.12 (3.44) |
| 20.00 | 402.25 (20.06) | 446.62 (9.90) | 459.62 (7.87) | 479.62 (5.07) | 494.50 (3.78) | 500.00 (3.34) | 504.50 (4.17) |
| 40.00 | 360.12 (15.50) | 401.87 (9.64) | 414.50 (6.59) | 434.62 (4.14) | 448.50 (4.17) | 454.37 (3.66) | 459.75 (4.46) |
| 60.00 | 315.37 (13.18) | 358.00 (8.42) | 370.37 (4.60) | 393.75 (3.45) | 406.12 (3.56) | 411.12 (2.85) | 415.75 (3.37) |
| 80.00 | - | - | - | 346.50 (3.55) | 361.62 (3.16) | 367.37 (2.62) | 372.00 (3.34) |
| 100.00 | - | - | - | 304.12 (4.16) | 317.50 (3.25) | 323.37 (3.93) | 327.12 (3.76) |
| 120.00 | - | - | - | 260.12 (2.23) | 275.50 (4.04) | 281.12 (1.73) | 283.62 (5.13) |
| 140.00 | - | - | - | 216.50 (2.07) | 232.00 (2.51) | 241.75 (2.76) | 245.50 (4.17) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 5. Average Maximum Power

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | .52 | 1.96 | 3.65 | 7.91 | 16.29 | - | - |
| | (.12) | (.27) | (.34) | (.54) | (.79) | | |
| -140.00 | .54 | 2.01 | 3.67 | 7.85 | 15.86 | - | - |
| | (.12) | (.26) | (.33) | (.50) | (.74) | | |
| -120.00 | .56 | 2.06 | 3.68 | 7.80 | 15.73 | - | - |
| | (.11) | (.23) | (.28) | (.45) | (.68) | | |
| -100.00 | .58 | 2.06 | 3.71 | 7.78 | 15.55 | - | - |
| | (.10) | (.20) | (.25) | (.41) | (.59) | | |
| -80.00 | .60 | 2.10 | 3.73 | 7.72 | 15.45 | 21.40 | - |
| | (.09) | (.17) | (.21) | (.34) | (.50) | (.68) | |
| -60.00 | .59 | 2.08 | 3.66 | 7.62 | 15.20 | 21.09 | 38.31 |
| | (.08) | (.14) | (.17) | (.28) | (.45) | (.56) | (1.02) |
| -40.00 | .57 | 2.00 | 3.56 | 7.31 | 14.78 | 20.57 | 37.36 |
| | (.07) | (.12) | (.14) | (.21) | (.29) | (.40) | (.68) |
| -20.00 | .54 | 1.88 | 3.33 | 6.93 | 14.13 | 19.47 | 35.62 |
| | (.06) | (.10) | (.10) | (.16) | (.25) | (.33) | (.42) |
| .00 | .50 | 1.73 | 3.08 | 6.44 | 13.21 | 18.20 | 33.45 |
| | (.05) | (.09) | (.08) | (.14) | (.19) | (.27) | (.40) |
| 20.00 | .46 | 1.59 | 2.83 | 5.93 | 12.20 | 16.81 | 30.99 |
| | (.04) | (.06) | (.07) | (.11) | (.18) | (.23) | (.36) |
| 40.00 | .42 | 1.44 | 2.57 | 5.43 | 11.21 | 15.41 | 28.22 |
| | (.03) | (.05) | (.05) | (.08) | (.14) | (.21) | (.35) |
| 60.00 | .37 | 1.29 | 2.31 | 4.89 | 10.14 | 14.00 | 25.52 |
| | (.02) | (.05) | (.04) | (.07) | (.16) | (.18) | (.27) |
| 80.00 | - | - | - | 4.30 | 9.02 | 12.43 | 22.52 |
| | | | | (.07) | (.16) | (.18) | (.29) |
| 100.00 | - | - | - | 3.74 | 7.86 | 10.88 | 19.69 |
| | | | | (.07) | (.13) | (.16) | (.35) |
| 120.00 | - | - | - | 3.16 | 6.70 | 9.30 | 16.89 |
| | | | | (.05) | (.15) | (.15) | (.35) |
| 140.00 | - | - | - | 2.59 | 5.53 | 7.79 | 14.16 |
| | | | | (.05) | (.09) | (.17) | (.26) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 6. Average Curve Factor

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | .5270 | .6536 | .7295 | .7905 | .8232 | - | - |
| | (.1091) | (.0921) | (.0721) | (.0514) | (.0378) | | |
| -140.00 | .5439 | .6688 | .7384 | .7906 | .8148 | - | - |
| | (.1072) | (.0844) | (.0667) | (.0464) | (.0318) | | |
| -120.00 | .5703 | .6884 | .7456 | .7894 | .8132 | - | - |
| | (.1026) | (.0737) | (.0566) | (.0414) | (.0308) | | |
| -100.00 | .5988 | .7051 | .7545 | .7915 | .8087 | - | - |
| | (.0943) | (.0651) | (.0518) | (.0368) | (.0256) | | |
| -80.00 | .6396 | .7305 | .7685 | .7935 | .8103 | .8112 | - |
| | (.0899) | (.0566) | (.0435) | (.0297) | (.0200) | (.0176) | |
| -60.00 | .6675 | .7511 | .7787 | .7993 | .8064 | .8087 | .7992 |
| | (.0809) | (.0500) | (.0398) | (.0271) | (.0209) | (.0148) | (.0125) |
| -40.00 | .6791 | .7602 | .7913 | .8002 | .8077 | .8091 | .7936 |
| | (.0734) | (.0424) | (.0357) | (.0242) | (.0176) | (.0143) | (.0114) |
| -20.00 | .6870 | .7608 | .7840 | .7984 | .8053 | .8022 | .7841 |
| | (.0657) | (.0373) | (.0281) | (.0203) | (.0155) | (.0138) | (.0094) |
| .00 | .6864 | .7514 | .7726 | .7875 | .7934 | .7904 | .7733 |
| | (.0557) | (.0342) | (.0253) | (.0185) | (.0116) | (.0110) | (.0092) |
| 20.00 | .6830 | .7420 | .7606 | .7726 | .7770 | .7717 | .7526 |
| | (.0494) | (.0294) | (.0233) | (.0152) | (.0121) | (.0099) | (.0080) |
| 40.00 | .6725 | .7271 | .7442 | .7557 | .7569 | .7506 | .7291 |
| | (.0445) | (.0261) | (.0197) | (.0136) | (.0082) | (.0110) | (.0086) |
| 60.00 | .6567 | .7093 | .7255 | .7349 | .7357 | .7291 | .7057 |
| | (.0378) | (.0241) | (.0185) | (.0124) | (.0115) | (.0088) | (.0083) |
| 80.00 | - | - | - | .7079 | .7071 | .7021 | .6718 |
| | | | | (.0120) | (.0090) | (.0083) | (.0079) |
| 100.00 | - | - | - | .6806 | .6787 | .6718 | .6385 |
| | | | | (.0121) | (.0080) | (.0081) | (.0090) |
| 120.00 | - | - | - | .6487 | .6422 | .6365 | .6024 |
| | | | | (.0093) | (.0105) | (.0072) | (.0093) |
| 140.00 | - | - | - | .6093 | .5997 | .5999 | .5660 |
| | | | | (.0106) | (.0070) | (.0090) | (.0092) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 7. Average AMO Efficiency

OCLI DIELECTRIC WRAPAROUND
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 10.43 | 13.04 | 14.59 | 15.83 | 16.29 | - | - |
| | (2.49) | (1.82) | (1.35) | (1.07) | (.79) | | |
| -140.00 | 10.71 | 13.40 | 14.67 | 15.71 | 15.86 | - | - |
| | (2.38) | (1.71) | (1.30) | (.99) | (.74) | | |
| -120.00 | 11.17 | 13.72 | 14.70 | 15.60 | 15.73 | - | - |
| | (2.27) | (1.53) | (1.11) | (.89) | (.68) | | |
| -100.00 | 11.54 | 13.76 | 14.82 | 15.55 | 15.55 | - | - |
| | (2.05) | (1.35) | (1.02) | (.82) | (.59) | | |
| -80.00 | 11.99 | 14.02 | 14.92 | 15.44 | 15.45 | 15.82 | - |
| | (1.89) | (1.15) | (.83) | (.67) | (.50) | (.50) | |
| -60.00 | 11.87 | 13.88 | 14.65 | 15.23 | 15.20 | 15.59 | 15.32 |
| | (1.61) | (.95) | (.70) | (.55) | (.45) | (.41) | (.41) |
| -40.00 | 11.38 | 13.35 | 14.23 | 14.62 | 14.78 | 15.21 | 14.94 |
| | (1.39) | (.77) | (.56) | (.42) | (.29) | (.30) | (.27) |
| -20.00 | 10.79 | 12.56 | 13.32 | 13.85 | 14.13 | 14.39 | 14.25 |
| | (1.16) | (.63) | (.40) | (.33) | (.25) | (.24) | (.17) |
| .00 | 10.03 | 11.56 | 12.34 | 12.89 | 13.21 | 13.45 | 13.38 |
| | (.92) | (.57) | (.32) | (.27) | (.19) | (.20) | (.16) |
| 20.00 | 9.21 | 10.62 | 11.31 | 11.86 | 12.20 | 12.43 | 12.39 |
| | (.75) | (.43) | (.28) | (.22) | (.18) | (.17) | (.14) |
| 40.00 | 8.34 | 9.63 | 10.27 | 10.87 | 11.21 | 11.39 | 11.29 |
| | (.63) | (.36) | (.20) | (.17) | (.14) | (.15) | (.14) |
| 60.00 | 7.32 | 8.58 | 9.22 | 9.78 | 10.14 | 10.35 | 10.21 |
| | (.48) | (.31) | (.17) | (.15) | (.16) | (.13) | (.11) |
| 80.00 | - | - | - | 8.61 | 9.02 | 9.19 | 9.01 |
| | | | | (.13) | (.16) | (.13) | (.12) |
| 100.00 | - | - | - | 7.48 | 7.86 | 8.04 | 7.88 |
| | | | | (.15) | (.13) | (.12) | (.14) |
| 120.00 | - | - | - | 6.33 | 6.70 | 6.87 | 6.76 |
| | | | | (.10) | (.15) | (.11) | (.14) |
| 140.00 | - | - | - | 5.19 | 5.53 | 5.76 | 5.66 |
| | | | | (.10) | (.09) | (.13) | (.11) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 8. Average Short-Circuit Current After $10^{14}$ electrons/$cm^2$

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 1.09 | 3.30 | 5.50 | 10.96 | 21.92 | - | - |
| | (.01) | (.02) | (.05) | (.08) | (.27) | | |
| -140.00 | 1.10 | 3.39 | 5.60 | 11.16 | 22.23 | - | - |
| | (.02) | (.04) | (.05) | (.07) | (.28) | | |
| -120.00 | 1.11 | 3.40 | 5.68 | 11.32 | 22.51 | - | - |
| | (.01) | (.03) | (.06) | (.09) | (.28) | | |
| -100.00 | 1.15 | 3.46 | 5.77 | 11.51 | 22.84 | - | - |
| | (.01) | (.04) | (.06) | (.08) | (.32) | | |
| -80.00 | 1.17 | 3.51 | 5.86 | 11.66 | 23.13 | 30.90 | - |
| | (.01) | (.04) | (.06) | (.09) | (.26) | (.33) | |
| -60.00 | 1.19 | 3.57 | 5.95 | 11.82 | 23.42 | 31.12 | 58.11 |
| | (.01) | (.04) | (.07) | (.10) | (.32) | (.34) | (.79) |
| -40.00 | 1.21 | 3.62 | 6.02 | 11.97 | 23.77 | 31.48 | 58.99 |
| | (.01) | (.04) | (.06) | (.10) | (.33) | (.28) | (.82) |
| -20.00 | 1.22 | 3.68 | 6.11 | 12.16 | 24.20 | 31.98 | 59.88 |
| | (.01) | (.04) | (.06) | (.11) | (.38) | (.33) | (.77) |
| .00 | 1.24 | 3.73 | 6.21 | 12.37 | 24.64 | 32.81 | 60.99 |
| | (.01) | (.04) | (.06) | (.11) | (.28) | (.34) | (.76) |
| 20.00 | 1.26 | 3.80 | 6.33 | 12.60 | 25.03 | 33.37 | 62.33 |
| | (.01) | (.04) | (.07) | (.11) | (.32) | (.35) | (.82) |
| 40.00 | 1.29 | 3.89 | 6.47 | 12.87 | 25.77 | 34.21 | 63.72 |
| | (.01) | (.04) | (.07) | (.11) | (.31) | (.38) | (.75) |
| 60.00 | 1.32 | 3.96 | 6.61 | 13.14 | 26.37 | 35.03 | 64.93 |
| | (.01) | (.04) | (.07) | (.10) | (.35) | (.36) | (.80) |
| 80.00 | - | - | - | 13.39 | 26.95 | 35.87 | 66.07 |
| | | | | (.12) | (.34) | (.37) | (.78) |
| 100.00 | - | - | - | 13.61 | 27.43 | 36.61 | 67.42 |
| | | | | (.12) | (.33) | (.37) | (1.07) |
| 120.00 | - | - | - | 13.83 | 27.88 | 37.30 | 68.40 |
| | | | | (.12) | (.33) | (.41) | (.78) |
| 140.00 | - | - | - | 14.01 | 28.22 | 37.84 | 68.85 |
| | | | | (.12) | (.37) | (.35) | (.72) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 9. Average Open-Circuit Voltage After $10^{14}$ electrons/$cm^2$

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 821.44 | 860.55 | 852.52 | 842.31 | 826.64 | - | - |
| | (62.71) | (34.03) | (31.03) | (27.27) | (14.87) | | |
| -140.00 | 796.72 | 832.04 | 827.81 | 822.54 | 812.45 | - | - |
| | (52.34) | (25.71) | (23.47) | (20.13) | (13.78) | | |
| -120.00 | 773.19 | 806.80 | 807.20 | 805.36 | 800.12 | - | - |
| | (40.43) | (18.63) | (17.32) | (15.05) | (13.80) | | |
| -100.00 | 748.51 | 782.26 | 787.12 | 789.49 | 788.31 | - | - |
| | (28.19) | (13.63) | (12.65) | (12.55) | (13.08) | | |
| -80.00 | 713.35 | 749.49 | 758.77 | 768.22 | 772.12 | 773.90 | - |
| | (20.47) | (8.54) | (8.41) | (8.50) | (9.92) | (10.23) | |
| -60.00 | 667.59 | 704.55 | 719.24 | 733.52 | 744.51 | 747.30 | 753.57 |
| | (18.36) | (8.73) | (4.36) | (3.75) | (4.48) | (4.63) | (5.82) |
| -40.00 | 625.40 | 660.61 | 673.55 | 690.19 | 704.55 | 709.07 | 718.62 |
| | (13.63) | (4.81) | (7.14) | (2.30) | (1.90) | (1.78) | (2.12) |
| -20.00 | 578.01 | 614.34 | 628.31 | 645.51 | 660.94 | 666.27 | 677.62 |
| | (11.58) | (4.65) | (3.24) | (2.07) | (1.47) | (1.53) | (1.72) |
| .00 | 530.51 | 566.17 | 581.51 | 599.82 | 616.31 | 621.59 | 634.74 |
| | (10.16) | (5.10) | (3.05) | (2.07) | (1.64) | (1.46) | (1.68) |
| 20.00 | 482.97 | 520.25 | 535.47 | 554.82 | 572.44 | 578.21 | 591.92 |
| | (8.68) | (3.99) | (2.92) | (1.84) | (1.52) | (1.62) | (1.91) |
| 40.00 | 436.16 | 474.10 | 489.64 | 510.35 | 528.76 | 534.77 | 549.31 |
| | (7.70) | (3.72) | (2.65) | (1.80) | (1.97) | (1.71) | (1.99) |
| 60.00 | 388.15 | 428.11 | 444.60 | 466.11 | 485.40 | 492.12 | 507.37 |
| | (6.64) | (3.56) | (2.57) | (1.40) | (1.86) | (1.69) | (1.79) |
| 80.00 | - | - | - | 419.02 | 442.26 | 449.54 | 465.19 |
| | | | | (8.01) | (1.59) | (1.43) | (2.01) |
| 100.00 | - | - | - | 376.65 | 399.42 | 407.30 | 423.59 |
| | | | | (1.66) | (1.38) | (1.52) | (2.17) |
| 120.00 | - | - | - | 332.44 | 355.70 | 364.75 | 382.24 |
| | | | | (1.65) | (1.23) | (1.43) | (1.88) |
| 140.00 | - | - | - | 286.64 | 311.39 | 320.61 | 339.89 |
| | | | | (1.64) | (1.40) | (1.27) | (1.98) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 10. Average Maximum Power Current After $10^{14}$ electrons/$cm^2$

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | .84 | 2.65 | 4.61 | 9.65 | 20.12 | - | - |
| | (.06) | (.20) | (.29) | (.44) | (.58) | | |
| -140.00 | .86 | 2.76 | 4.74 | 9.90 | 20.61 | - | - |
| | (.06) | (.20) | (.28) | (.38) | (.60) | | |
| -120.00 | .87 | 2.83 | 4.92 | 10.20 | 21.02 | - | - |
| | (.07) | (.19) | (.26) | (.33) | (.54) | | |
| -100.00 | .91 | 2.94 | 5.08 | 10.50 | 21.39 | - | - |
| | (.07) | (.17) | (.24) | (.28) | (.43) | | |
| -80.00 | .94 | 3.05 | 5.23 | 10.74 | 21.70 | 29.19 | - |
| | (.07) | (.15) | (.19) | (.25) | (.38) | (.44) | |
| -60.00 | .96 | 3.14 | 5.35 | 10.93 | 22.02 | 29.36 | 53.94 |
| | (.07) | (.14) | (.17) | (.19) | (.34) | (.29) | (1.23) |
| -40.00 | 1.00 | 3.21 | 5.48 | 11.07 | 22.31 | 29.69 | 52.91 |
| | (.07) | (.12) | (.15) | (.18) | (.31) | (.30) | (.61) |
| -20.00 | 1.02 | 3.28 | 5.55 | 11.29 | 22.75 | 29.91 | 53.69 |
| | (.06) | (.10) | (.12) | (.17) | (.33) | (.33) | (.89) |
| .00 | 1.05 | 3.36 | 5.65 | 11.48 | 23.02 | 30.67 | 53.66 |
| | (.05) | (.09) | (.12) | (.13) | (.30) | (.27) | (.63) |
| 20.00 | 1.07 | 3.42 | 5.75 | 11.58 | 23.28 | 30.95 | 54.39 |
| | (.05) | (.08) | (.09) | (.09) | (.30) | (.24) | (.69) |
| 40.00 | 1.09 | 3.48 | 5.86 | 11.79 | 23.84 | 31.47 | 55.55 |
| | (.05) | (.06) | (.08) | (.12) | (.46) | (.20) | (.75) |
| 60.00 | 1.10 | 3.49 | 5.88 | 11.89 | 24.05 | 31.86 | 55.86 |
| | (.04) | (.04) | (.08) | (.07) | (.42) | (.23) | (.65) |
| 80.00 | - | - | - | 11.96 | 24.06 | 31.97 | 56.41 |
| | | | | (.07) | (.29) | (.20) | (.48) |
| 100.00 | - | - | - | 11.94 | 24.16 | 31.95 | 56.87 |
| | | | | (.11) | (.46) | (.27) | (.97) |
| 120.00 | - | - | - | 11.77 | 23.78 | 31.75 | 56.48 |
| | | | | (.11) | (.31) | (.35) | (.51) |
| 140.00 | - | - | - | 11.59 | 23.44 | 31.42 | 56.22 |
| | | | | (.10) | (.36) | (.32) | (.42) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 11. Average Maximum Power Voltage After $10^{14}$ electrons/$cm^2$

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 525.12 | 641.00 | 678.87 | 706.75 | 717.37 | - | - |
| | (95.47) | (51.74) | (34.65) | (23.86) | (20.07) | | |
| -140.00 | 527.87 | 637.87 | 665.37 | 693.00 | 698.12 | - | - |
| | (91.39) | (42.80) | (35.14) | (25.54) | (19.33) | | |
| -120.00 | 537.50 | 632.87 | 657.00 | 676.50 | 680.37 | - | - |
| | (80.41) | (39.14) | (28.22) | (24.63) | (18.37) | | |
| -100.00 | 550.50 | 628.37 | 649.25 | 660.00 | 664.12 | - | - |
| | (67.08) | (33.55) | (24.24) | (20.95) | (15.98) | | |
| -80.00 | 553.62 | 617.87 | 634.37 | 644.75 | 646.50 | 644.00 | - |
| | (55.82) | (27.97) | (23.69) | (18.58) | (16.35) | (15.27) | |
| -60.00 | 540.87 | 596.00 | 613.75 | 624.50 | 628.50 | 625.50 | 618.50 |
| | (41.40) | (21.85) | (16.81) | (15.22) | (15.28) | (12.82) | (13.37) |
| -40.00 | 506.12 | 565.75 | 576.50 | 596.87 | 602.37 | 598.87 | 598.12 |
| | (31.93) | (13.34) | (16.08) | (9.51) | (8.90) | (8.79) | (8.71) |
| -20.00 | 470.87 | 522.37 | 539.37 | 555.87 | 561.75 | 568.50 | 564.12 |
| | (27.47) | (12.96) | (9.13) | (5.03) | (4.80) | (5.32) | (7.04) |
| .00 | 430.00 | 473.37 | 493.50 | 510.87 | 523.00 | 523.50 | 534.00 |
| | (22.32) | (10.34) | (8.11) | (6.51) | (3.70) | (4.69) | (5.13) |
| 20.00 | 386.75 | 429.62 | 447.87 | 465.62 | 477.87 | 480.12 | 491.87 |
| | (17.40) | (9.01) | (6.51) | (5.45) | (4.19) | (3.56) | (4.36) |
| 40.00 | 345.12 | 384.62 | 402.50 | 420.00 | 431.62 | 434.25 | 446.00 |
| | (13.12) | (9.09) | (5.55) | (3.16) | (3.70) | (3.33) | (6.37) |
| 60.00 | 301.37 | 343.50 | 360.12 | 377.12 | 389.75 | 391.37 | 403.50 |
| | (12.00) | (8.33) | (5.22) | (4.12) | (2.60) | (3.25) | (4.24) |
| 80.00 | - | - | - | 330.25 | 347.62 | 350.37 | 360.50 |
| | | | | (8.41) | (2.39) | (2.20) | (3.82) |
| 100.00 | - | - | - | 289.12 | 305.75 | 309.75 | 320.37 |
| | | | | (2.85) | (3.54) | (3.33) | (3.78) |
| 120.00 | - | - | - | 251.12 | 264.50 | 269.25 | 280.62 |
| | | | | (2.64) | (2.88) | (2.38) | (3.85) |
| 140.00 | - | - | - | 208.75 | 225.00 | 228.12 | 238.00 |
| | | | | (2.87) | (2.27) | (2.47) | (3.07) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 12. Average Maximum Power After $10^{14}$ electrons/$cm^2$

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM C6 SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | .44 | 1.71 | 3.14 | 6.82 | 14.44 | - | - |
| | (.10) | (.26) | (.34) | (.49) | (.74) | | |
| -140.00 | .46 | 1.76 | 3.16 | 6.87 | 14.39 | - | - |
| | (.10) | (.23) | (.34) | (.47) | (.70) | | |
| -120.00 | .47 | 1.80 | 3.24 | 6.91 | 14.30 | - | - |
| | (.10) | (.22) | (.29) | (.43) | (.66) | | |
| -100.00 | .51 | 1.85 | 3.30 | 6.93 | 14.21 | - | - |
| | (.09) | (.19) | (.26) | (.36) | (.57) | | |
| -80.00 | .52 | 1.89 | 3.32 | 6.93 | 14.03 | 18.80 | - |
| | (.09) | (.17) | (.22) | (.33) | (.51) | (.60) | |
| -60.00 | .52 | 1.87 | 3.28 | 6.83 | 13.84 | 18.36 | 33.36 |
| | (.07) | (.14) | (.18) | (.25) | (.43) | (.43) | (1.14) |
| -40.00 | .51 | 1.82 | 3.16 | 6.61 | 13.44 | 17.78 | 31.64 |
| | (.06) | (.11) | (.16) | (.19) | (.32) | (.35) | (.59) |
| -20.00 | .48 | 1.72 | 3.00 | 6.28 | 12.78 | 17.00 | 30.29 |
| | (.05) | (.09) | (.11) | (.14) | (.25) | (.29) | (.58) |
| .00 | .45 | 1.59 | 2.79 | 5.86 | 12.04 | 16.06 | 28.65 |
| | (.04) | (.07) | (.09) | (.13) | (.20) | (.20) | (.50) |
| 20.00 | .41 | 1.47 | 2.57 | 5.39 | 11.13 | 14.86 | 26.75 |
| | (.04) | (.06) | (.07) | (.08) | (.18) | (.18) | (.45) |
| 40.00 | .38 | 1.34 | 2.36 | 4.95 | 10.29 | 13.67 | 24.77 |
| | (.03) | (.05) | (.06) | (.07) | (.26) | (.16) | (.36) |
| 60.00 | .33 | 1.20 | 2.12 | 4.48 | 9.37 | 12.47 | 22.54 |
| | (.02) | (.04) | (.05) | (.07) | (.19) | (.18) | (.40) |
| 80.00 | - | - | - | 3.95 | 8.36 | 11.20 | 20.33 |
| | | | | (.11) | (.13) | (.09) | (.32) |
| 100.00 | - | - | - | 3.45 | 7.39 | 9.90 | 18.22 |
| | | | | (.04) | (.19) | (.13) | (.42) |
| 120.00 | - | - | - | 2.95 | 6.29 | 8.55 | 15.85 |
| | | | | (.04) | (.12) | (.11) | (.28) |
| 140.00 | - | - | - | 2.42 | 5.27 | 7.17 | 13.38 |
| | | | | (.04) | (.09) | (.10) | (.25) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 13. Average Curve Factor After $10^{14}$ electrons/$cm^2$

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 E/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | .4898 | .6017 | .6696 | .7393 | .7972 | - | - |
| | (.0827) | (.0798) | (.0681) | (.0529) | (.0373) | | |
| -140.00 | .5130 | .6256 | .6822 | .7482 | .7969 | - | - |
| | (.0880) | (.0771) | (.0700) | (.0493) | (.0330) | | |
| -120.00 | .5424 | .6541 | .7056 | .7573 | .7941 | - | - |
| | (.0902) | (.0744) | (.0579) | (.0431) | (.0285) | | |
| -100.00 | .5837 | .6837 | .7267 | .7628 | .7892 | - | - |
| | (.0941) | (.0654) | (.0513) | (.0352) | (.0255) | | |
| -80.00 | .6254 | .7165 | .7463 | .7733 | .7856 | .7860 | - |
| | (.0885) | (.0604) | (.0456) | (.0339) | (.0228) | (.0196) | |
| -60.00 | .6540 | .7460 | .7675 | .7875 | .7937 | .7898 | .7618 |
| | (.0816) | (.0506) | (.0419) | (.0297) | (.0212) | (.0179) | (.0215) |
| -40.00 | .6705 | .7601 | .7800 | .8000 | .8025 | .7966 | .7466 |
| | (.0740) | (.0436) | (.0348) | (.0244) | (.0182) | (.0152) | (.0113) |
| -20.00 | .6813 | .7584 | .7805 | .7996 | .7991 | .7979 | .7464 |
| | (.0660) | (.0374) | (.0279) | (.0197) | (.0120) | (.0136) | (.0108) |
| .00 | .6840 | .7527 | .7730 | .7901 | .7927 | .7874 | .7401 |
| | (.0600) | (.0315) | (.0240) | (.0200) | (.0117) | (.0098) | (.0088) |
| 20.00 | .6776 | .7419 | .7590 | .7716 | .7766 | .7701 | .7251 |
| | (.0500) | (.0286) | (.0200) | (.0143) | (.0113) | (.0076) | (.0076) |
| 40.00 | .6688 | .7273 | .7442 | .7541 | .7553 | .7470 | .7077 |
| | (.0420) | (.0256) | (.0183) | (.0128) | (.0148) | (.0081) | (.0077) |
| 60.00 | .6505 | .7072 | .7212 | .7319 | .7322 | .7234 | .6842 |
| | (.0387) | (.0219) | (.0168) | (.0129) | (.0097) | (.0088) | (.0077) |
| 80.00 | - | - | - | .7041 | .7018 | .6948 | .6616 |
| | | | | (.0116) | (.0086) | (.0075) | (.0067) |
| 100.00 | - | - | - | .6736 | .6741 | .6638 | .6380 |
| | | | | (.0084) | (.0123) | (.0094) | (.0082) |
| 120.00 | - | - | - | .6429 | .6343 | .6284 | .6063 |
| | | | | (.0082) | (.0078) | (.0080) | (.0087) |
| 140.00 | - | - | - | .6023 | .6001 | .5909 | .5718 |
| | | | | (.0088) | (.0076) | (.0087) | (.0082) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

Table 14. Average AMO Efficiency After $10^{14}$ electrons/$cm^2$

OCLI DIELECTRIC WRAPAROUND
AFTER 1.E14 F/CM**2 1 MEV ELEC
N/P 2 OHM-CM CG SILICON
2 X 4 X .0225 CM
TI-PD-AG
2 LAYER AR COATING
NO COVERSLIDE
SAMPLE SIZE 8

| CELL TEMP. (DEG. C) | SOLAR INTENSITY (MW/CM**2) 5.00 | 15.00 | 25.00 | 50.00 | 100.00 | 135.30 | 250.00 |
|---|---|---|---|---|---|---|---|
| -160.00 | 8.84 | 11.40 | 12.56 | 13.65 | 14.44 | - | - |
| | (2.04) | (1.70) | (1.36) | (.98) | (.74) | | |
| -140.00 | 9.10 | 11.76 | 12.64 | 13.74 | 14.39 | - | - |
| | (2.08) | (1.56) | (1.35) | (.94) | (.70) | | |
| -120.00 | 9.41 | 11.98 | 12.95 | 13.61 | 14.30 | - | - |
| | (1.97) | (1.47) | (1.14) | (.85) | (.66) | | |
| -100.00 | 10.11 | 12.36 | 13.21 | 13.86 | 14.21 | - | - |
| | (1.88) | (1.28) | (1.03) | (.73) | (.57) | | |
| -80.00 | 10.49 | 12.58 | 13.28 | 13.86 | 14.03 | 13.89 | - |
| | (1.71) | (1.11) | (.88) | (.66) | (.51) | (.44) | |
| -60.00 | 10.38 | 12.50 | 13.13 | 13.65 | 13.84 | 13.57 | 13.35 |
| | (1.44) | (.94) | (.73) | (.50) | (.43) | (.32) | (.46) |
| -40.00 | 10.13 | 12.13 | 12.65 | 13.22 | 13.44 | 13.14 | 12.66 |
| | (1.27) | (.71) | (.63) | (.38) | (.32) | (.26) | (.24) |
| -20.00 | 9.65 | 11.44 | 11.98 | 12.55 | 12.78 | 12.57 | 12.11 |
| | (1.06) | (.58) | (.45) | (.28) | (.25) | (.22) | (.23) |
| .00 | 9.02 | 10.61 | 11.16 | 11.73 | 12.04 | 11.87 | 11.46 |
| | (.88) | (.48) | (.37) | (.25) | (.20) | (.15) | (.20) |
| 20.00 | 8.28 | 9.79 | 10.30 | 10.79 | 11.13 | 10.98 | 10.70 |
| | (.71) | (.41) | (.29) | (.16) | (.18) | (.13) | (.18) |
| 40.00 | 7.55 | 8.94 | 9.44 | 9.91 | 10.29 | 10.10 | 9.91 |
| | (.56) | (.33) | (.23) | (.14) | (.26) | (.12) | (.15) |
| 60.00 | 6.65 | 8.00 | 8.48 | 8.97 | 9.37 | 9.22 | 9.02 |
| | (.43) | (.27) | (.21) | (.13) | (.19) | (.13) | (.16) |
| 80.00 | - | - | - | 7.90 | 8.36 | 8.28 | 8.13 |
| | | | | (.22) | (.13) | (.06) | (.13) |
| 100.00 | - | - | - | 6.91 | 7.39 | 7.32 | 7.29 |
| | | | | (.07) | (.19) | (.10) | (.17) |
| 120.00 | - | - | - | 5.91 | 6.29 | 6.32 | 6.34 |
| | | | | (.07) | (.12) | (.08) | (.11) |
| 140.00 | - | - | - | 4.84 | 5.27 | 5.30 | 5.35 |
| | | | | (.07) | (.09) | (.07) | (.10) |

NOTE: STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES.

# APPENDIX

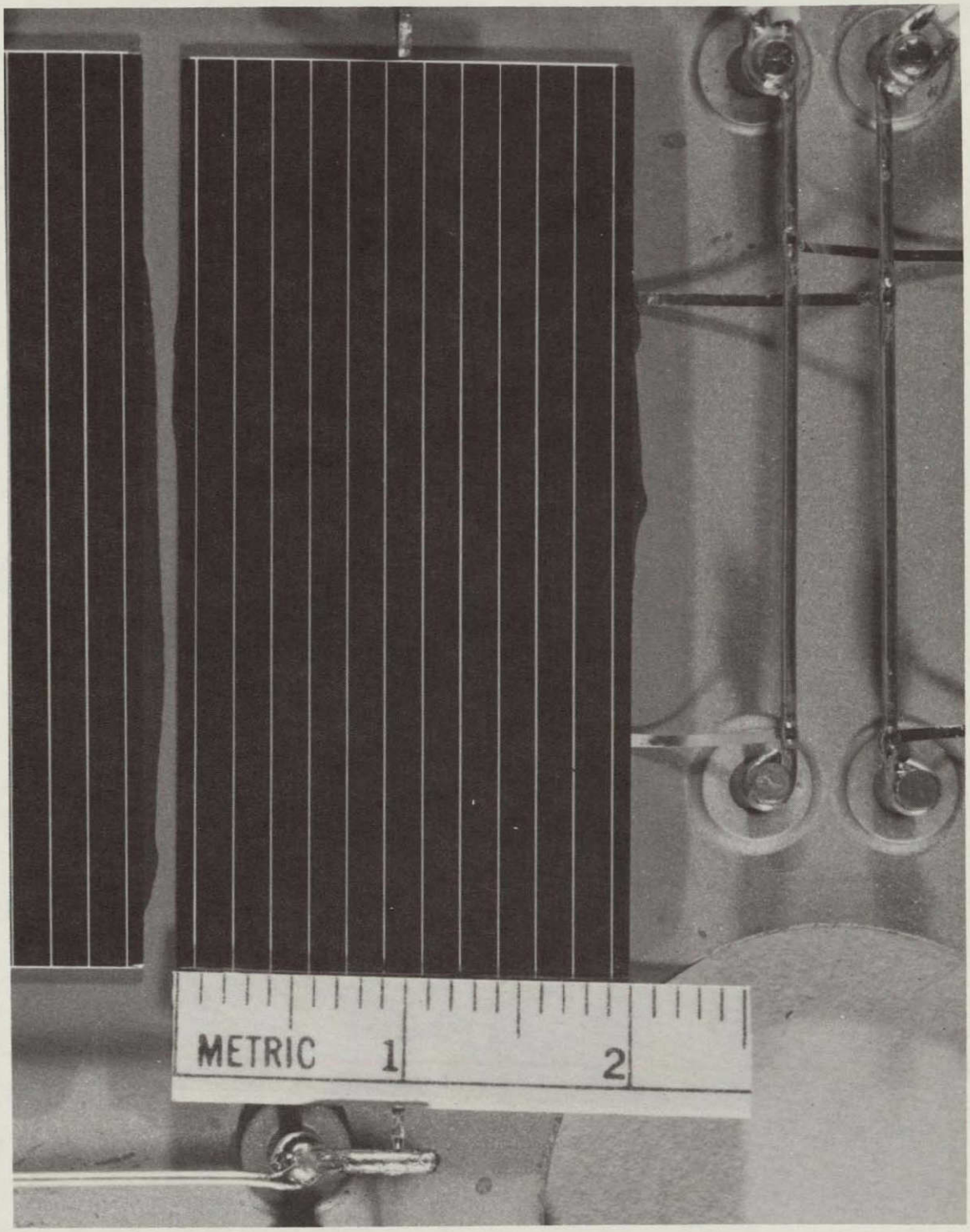



Figure A-1. Solar Cell

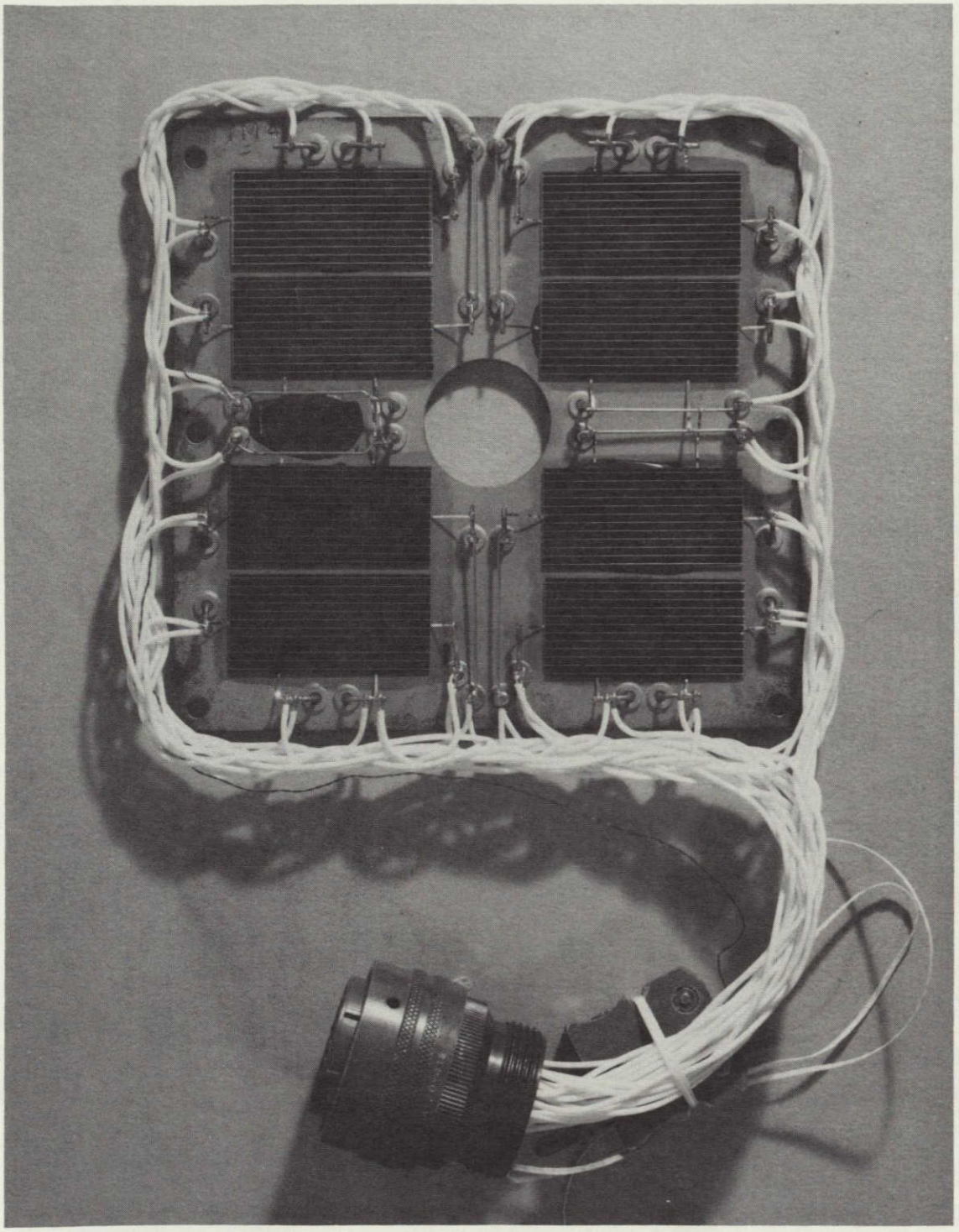


Figure A-2. Test Plate

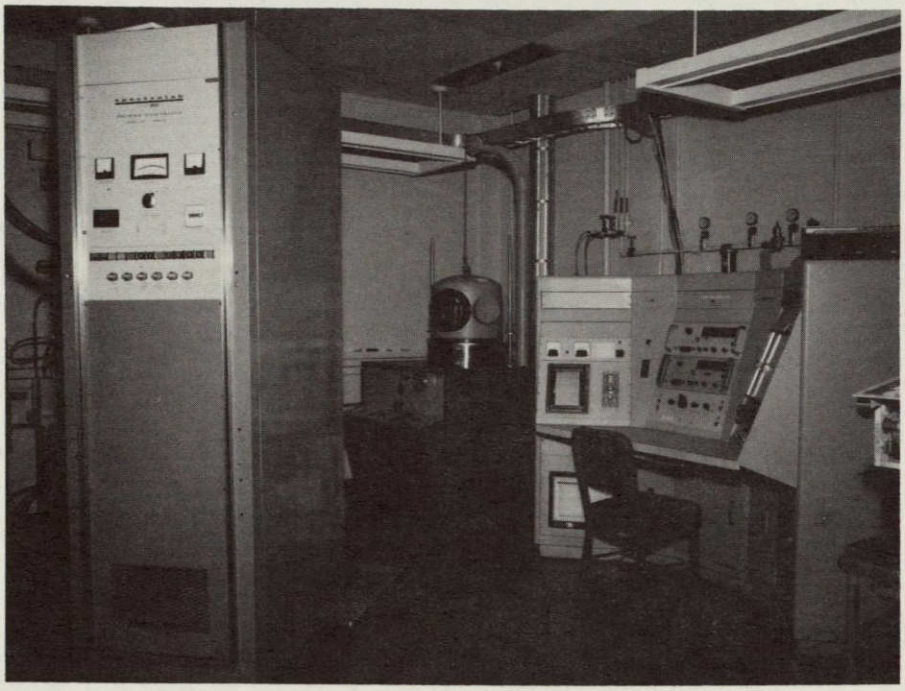


Figure A-3. Solar Cell Characterization Facility

Figure A-4. Solar Cell Environmental Test Chamber