Report Number 69-8526.16w-03

MEASUREMENTS REPORT: THERMAL PROPERTY MEASUREMENTS OF MANNED SPACECRAFT CENTER SPACESUIT MATERIALS

Contract Number NAS 9-3670

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I. INTRODUCTION

The thermophysical properties of polysulfane (with an LEV-32 coating on the rear surface) have been measured by TRW Thermophysics Section laboratory personnel. The properties of interest were: (a) solar reflectance; (b) solar transmittance; and (c) normal emittance. Measurements of the subject properties were taken both on the coated (LEV-32) and uncoated (polysulfane) surfaces. These measurements were taken in response to a verbal request by J. Poradek of the Manned Spacecraft Center. Results of the solar reflectance and transmittance measurements on the polysulfane (uncoated) side of the sample were previously reported (1). They are included herewith as an aide to data evaluation.

II. MEASUREMENT METHODS

A. Test Plan

Because of test sample transparency, reflectance was measured indirectly as described below. First, reflectance and transmittance were measured simultaneously and then integrated over the Johnson solar energy spectrum (2). Transmittance was next measured, integrated over the Johnson solar energy spectrum, and then subtracted from the combined reflectance/transmittance to yield solar reflectance.

B. Reflectance/Transmittance Measurement

The near-normal directional spectral reflectance properties of the specimen were measured over a spectral interval extending from 0.28 to 2.5 microns. These measurements were taken in an integrating sphere reflectometer similar to that described by Edwards, et al. (3) The reflectometer was operated in the absolute mode during these measurements, i.e., the measurements were not relative.

The combined reflectance/transmittance was integrated over the Johnson (2) solar energy spectrum. Solar absorptance was calculated by subtracting this integral from unity.

C. Solar Transmittance Measurement

Transmittance was measured by placing the test sample at the entrance port of an integrating sphere reflectometer of the Edwards (3) design. Incident energy transmitted by the specimen was detected either by a photomultiplier tube or a lead sulfide (choice determined by wavelength) mounted at the integrating sphere wall. Solar transmittance was calculated by integrating the transmittance data over the Johnson (2) solar energy spectrum.

D. Normal Emittance Measurement

The near normal emittance was determined from reflectance data measured with a Gier Dunkle Infrared Reflectometer (Model DB 100), This instrument is similar to that described by Nelson, et al. (4). Normal emittance was calculated from the expression

$$\varepsilon_Q = 1 - \rho$$

where ε_Q = normal emittance measured with the Quick Emittance Device

ρ = reflectance as read directly from the reflectometer scale.

It should be pointed out that these inspection measurements are of limited absolute accuracy (generally ±0.05), but good relative accuracy (generally, ±0.02). Therefore, these measurements when used in conjunction with accurate absolute methods (e.g., calorimetric methods) are extremely useful for scanning large quantities of similar materials. Care should be exercised when comparing different classes of materials based on the ε_Q measurement only, since the accuracy of the instrument is a strong function of material class; i.e., metals, opaque dielectrics, and semi-transparent materials are all subject to errors of differing magnitude. A complete discussion of the instrument is presented in Reference 4.

III. MEASUREMENT RESULTS

A. Calculated Measurement Results

MSC S/N	TRW S/N	SAMPLE SIDE	SOLAR ABSORPTANCE (α_s)	SOLAR REFLECTANCE (ρ_s)	SOLAR TRANSMITTANCE (τ_s)	NORMAL EMITTANCE (ε_N)	HEMISPHERICAL EMITTANCE (ε_H)[a]
P 000-1	925-68	Uncoated	0.45_4[b]	0.40_1[b]	0.14_5[b]	0.90_5[b]	0.86_0[b]
		Coated	0.50_5	0.33_9	0.15_6	0.04_4	0.05_6

(a) Calculated from normal emittance data using Figure 13-15 of Reference 5.

(b) Accuracy of the measurement (±0.02) does not justify a third significant figure. It is given here, depressed, merely to indicate data trends.

B. Spectral Data

Graphs of reflectance and transmittance versus wavelength are given in Figures 1 through 4.

IV. REFERENCES

1. Measurements Report: Thermal Property Measurements of Manned Spacecraft Center Spacesuit Materials, TRW Report Number 68-3346.11ja-102, dated 16 December 1968.

2. F. S. Johnson, "The Solar Constant", J. Meteorol, 11:431-439 (1954).

3. D. K. Edwards, et al., "Integrating Sphere for Imperfectly Diffuse Samples", J.O.S.A. 51:1279-88 (1961).

4. J. T. Bevans, E. E. Luedke, and K. E. Nelson, "A Device for the Rapid Measurement of Total Emittance", Journal of Spacecraft and Rockets, Vol. 3, pp. 758-760 (May 1966).

5. E. R. G. Eckert and R. M. Drake, Jr., "Heat and Mass Transfer," 2dn Edition, McGraw-Hill Book Co., Inc., New York (1959).

DIRECTIONAL SPECTRAL REFLECTANCE

CUSTOMER CODE NO.: 4085-002

TRW DESIGNATION: 925-68

MATERIAL: Polysulfane - Rear Surface Coated with LEV 32 - Energy Incident on the Uncoated Side

ANGLES

POLAR, $\theta =$ 15°

AZIMUTHAL, $\phi =$ 0°

MEASUREMENT Reflectance versus Wavelength

INSTRUMENTS Beckman Spectrophotometer with an Edwards Sphere

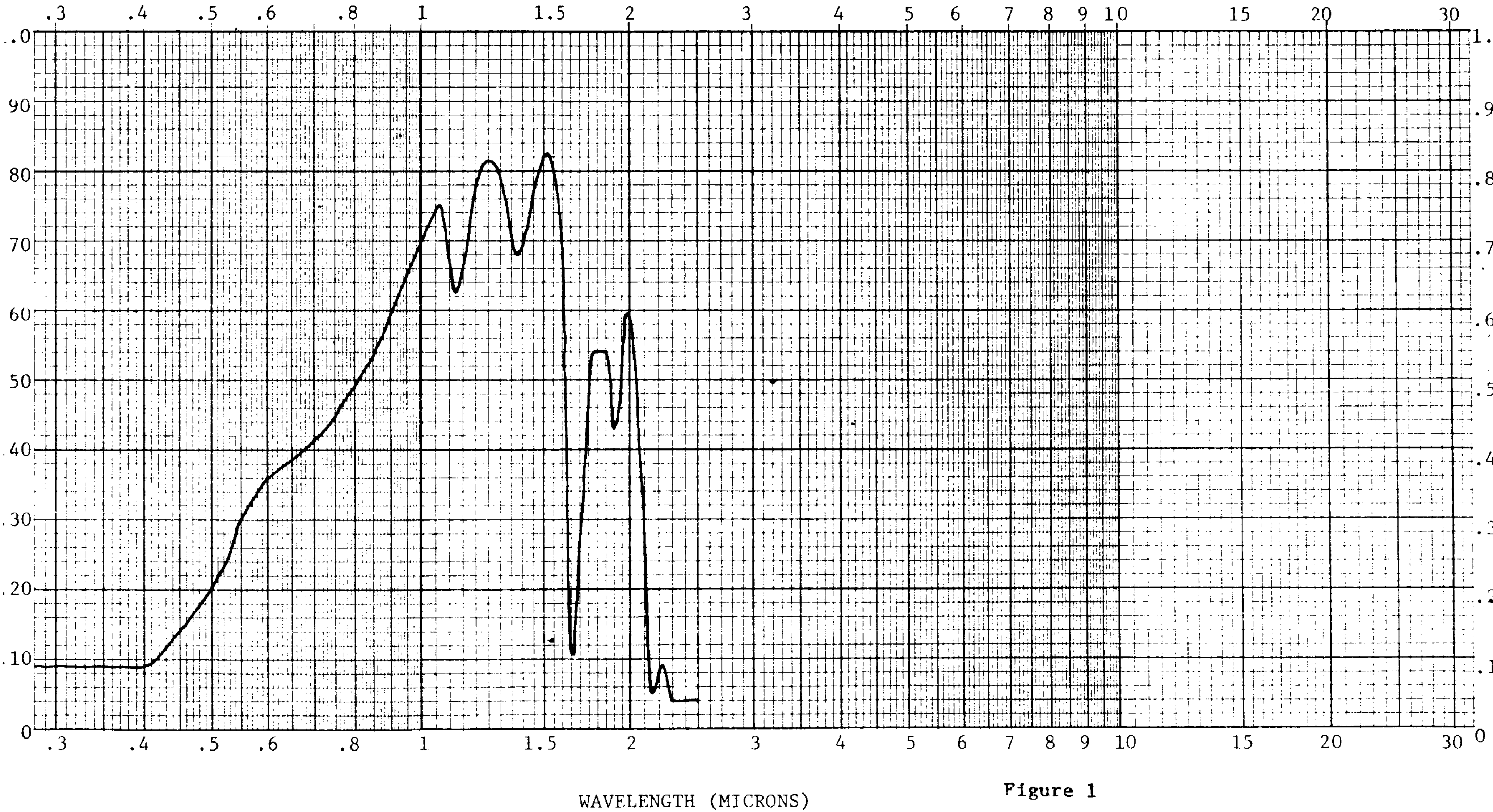


Figure 1

DIRECTIONAL SPECTRAL REFLECTANCE

CUSTOMER CODE NO.: 4085.002

TRW DESIGNATION: 925-68

MATERIAL: Polysulfane - Rear Surface Coated with LEV 32 Energy Incident on the Uncoated Side

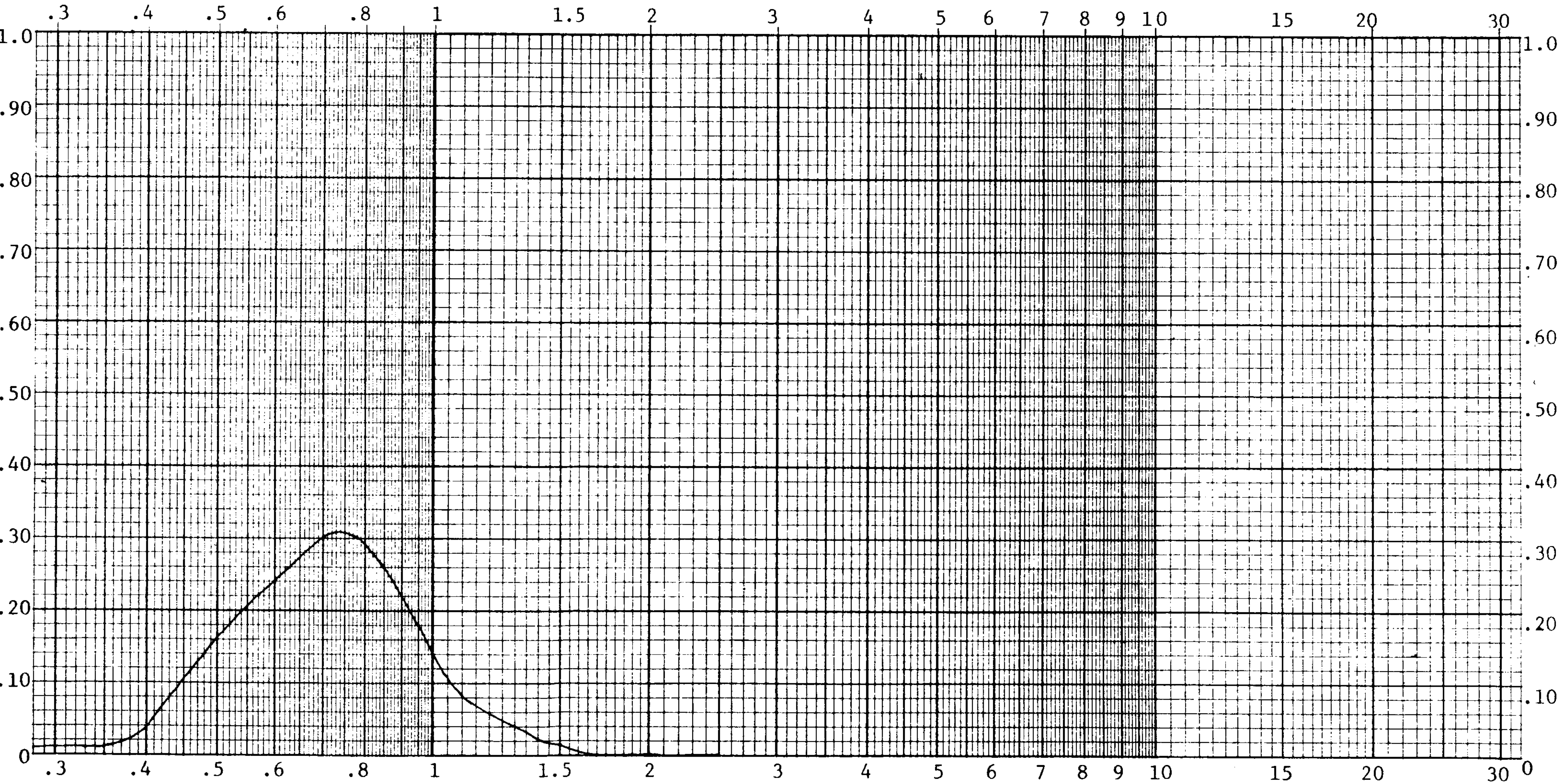
ANGLES

POLAR, θ= 15°

AZIMUTHAL, ϕ= 0°

MEASUREMENT Transmittance versus Wavelength

INSTRUMENTS Beckman Spectrophotometer with an Edwards Sphere



WAVELENGTH (MICRONS)

Figure 2

DIRECTIONAL SPECTRAL REFLECTANCE

CUSTOMER CODE NO.: P 000-1

TRW DESIGNATION: 925-68

MATERIAL: Polysulfane with a LEV-32
Coating on the Rear Surface -
Energy Incident on the Coated Side

ANGLES

POLAR, $\theta = 15°$

AZIMUTHAL, $\phi = 0°$

MEASUREMENT Peflectance versus Wavelength

INSTRUMENTS Beckman Spectrophotometer

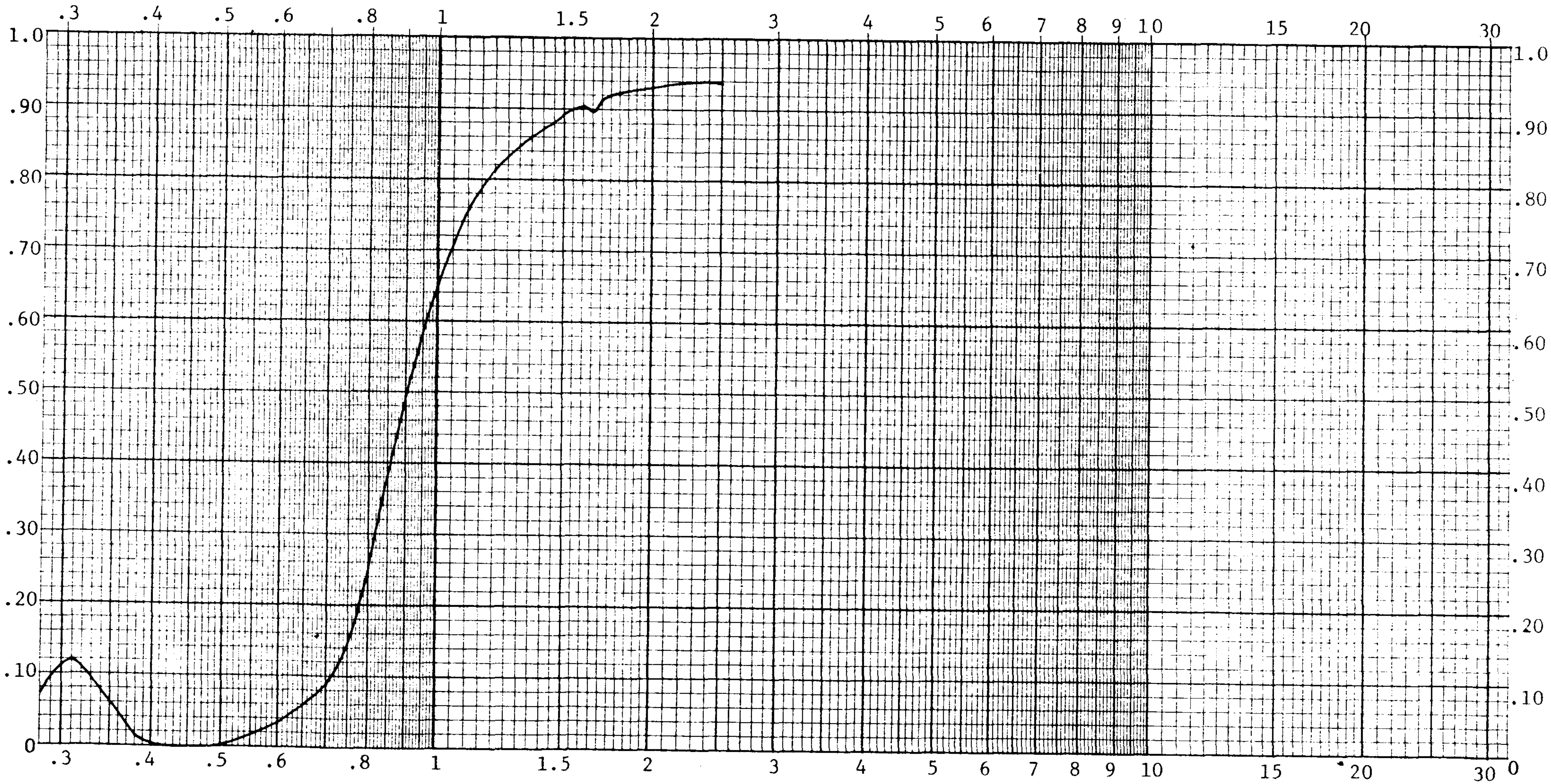


Figure 3

DIRECTIONAL SPECTRAL REFLECTANCE

CUSTOMER CODE NO.: P 000-1

TRW DESIGNATION: 925-68

MATERIAL: Polysulfane with a LEV-32 Coating on the Rear Surface - Energy Incident on the Coated Side

ANGLES

POLAR, $\theta =$ 15°

AZIMUTHAL, $\phi =$

MEASUREMENT Transmittance versus Wavelengtl

INSTRUMENTS Beckman Spectrophotometer with an Edwards Sphere

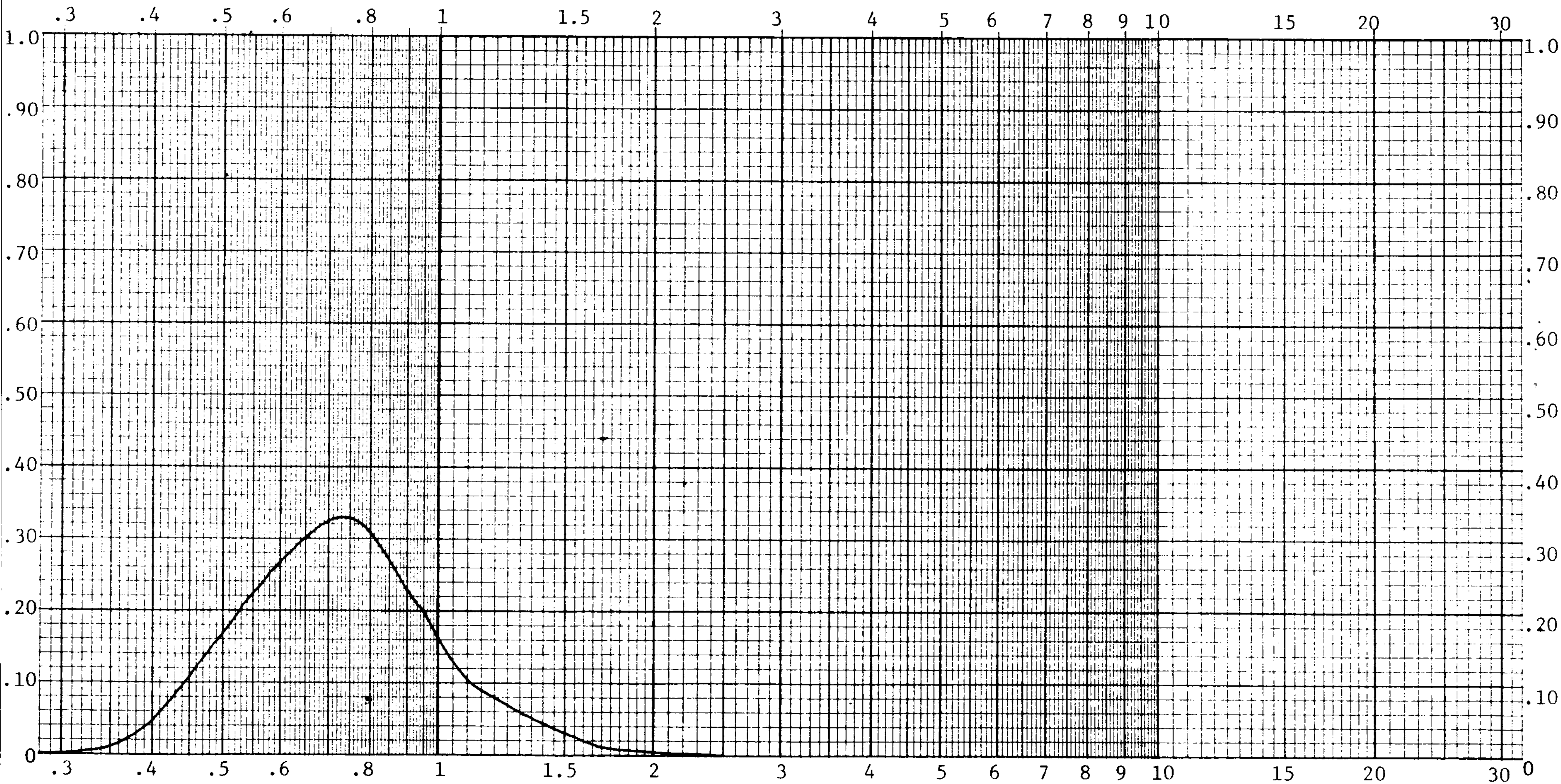


Figure 4