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TARGET SIGNATURE ANALYSIS CENTER: DATA COMPILATION

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Institute of Science and Technology
The University of Michigan
Ann Arbor, Michigan

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AUG 12 1969
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Air Force Avionics Laboratory
Research and Technology Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

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NOTICES

Sponsorship. The work reported herein was conducted by the Willow Run Laboratories of the Institute of Science and Technology for the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio, under Contract F33615-67-C-1293 (continuation of Contracts AF 33(657)-10974 and AF 33(615)-3654). Contracts and grants to The University of Michigan for the support of sponsored research are administered through the Office of the Vice-President for Research.

January 1969

NOTE TO USERS

Target Signature Analysis Center: Data Compilation is a periodically updated publication of the optical and microwave target and background data stored on magnetic tape at the Target Signature Analysis Center established at The University of Michigan and sponsored by the Air Force Avionics Laboratory. Separate volumes are maintained for classified and unclassified data. The compilation is distributed in loose-leaf form so that supplemental publications can be readily integrated in accordance with the established indexing system. The complete publication history of the Target Signature Analysis Center: Data Compilation is summarized in the foreword to the enclosed document.

This present document is the fourth publication of unclassified data and the eighth publication in the overall compilation. It consists of optical data, revised explanatory text, and composite cross indexes, and is meant to be integrated with the previous unclassified publications. The following suggestions are made for revising the existing unclassified Data Compilation and adding the enclosed material.

(1) Remove and destroy previously published cover, Notices, and all front matter (dated August 1968). Insert corresponding new pages, supplied herewith.

(2) Remove and destroy all numbered text pages and Distribution List (dated August 1968 or earlier) from the previously integrated compilation (pp. 1 through 72).

(3) Insert new section 1 (Introduction, pp. 1-1 through 1-11).

(4) Insert new section 2 (Cumulative Subject Cross Index, pp. 2-1 through 2-9).

(5) Insert new text for section 3 (Optical Spectral Data, pp. 3-1 through 3-46). Following p. 3-46, insert optical data sheets and dividers AA through CJ from previous compilations.

(6) Following p. CJ-14, insert new text for section 4 (Optical Reflectance Distribution Function Data, pp. 4-1 through 4-17), followed by the enclosed reflectance distribution data sheets.

(7) Following p. (f)CJA 25, insert new text for section 5 (Radar (Active Microwave) Data, pp. 5-1 through 5-10). Following p. 5-10, insert radar data sheets and dividers from preious compilations.

(8) Insert new text for section 6 (Passive Microwave Data, pp. 6-1 through 6-3). Following p. 6-3, insert passive microwave data sheets from previous compilations.

(9) Insert new distribution list.

(10) Remove and destroy DD Form 1473, and replace it with the new page supplied herewith.

January 1969

TARGET SIGNATURE ANALYSIS CENTER: DATA COMPILATION

Seventh Supplement

Dwayne Carmer

January 1969

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FOREWORD

This is the eighth publication overall and the fourth unclassified publication of the Target Signature Analysis Center: Data Compilation (July 1966). It was prepared at the Willow Run Laboratories, a unit of The University of Michigan's Institute of Science and Technology. The preparation was begun under Air Force Contract AF 33(657)-10974 and continued under Contracts AF 33(615)-3654 and F33615-67-C-1293. The originator's report number is 8492-35-B. The work was administered under the direction of the Air Force Avionics Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, with Mr. Bruno K. Wernicke as the project engineer.

Dwayne Carmer is author of this supplement, under the direction of Howard Courtney, Principal Investigator. The author gratefully acknowledges the assistance of Glenn Curtis, who was responsible for processing the data included with the present in this revision. Contributors to previous supplements include Dianne Earing, Dr. I. W. Ginsberg, Elmer Haag, and Jerry Beard.

PUBLICATION HISTORY OF THE TARGET SIGNATURE ANALYSIS CENTER: DATA COMPILATION

Report	Author	Date	WRL Report No.	AD Number (DDC)
Unclassified Publications				
Original Compilation	Dianne Earing James A. Smith	July 1966	7850-2-B	AD 489 968
Second Supplement	Dianne Earing	July 1967	8492-5-B	AD 819 712
Fifth Supplement	Dianne Earing	August 1968	8492-15-B	AD 840 091
Seventh Supplement	Dwayne Carmer	January 1969	8492-35-B	-
Classified Publications				
First Supplenent	Dianne Earing	December 1966	7850-9-B	AD 379 650
Third Supplement	Dianne Earing	October 1967	8492-12-B	AD 384 874
Fourth Supplement	Dianne Earing Elmer Haag	December 1967	8492-14-B	AD 391 239
Sixth Supplement	Dianne Earing	November 1968	8492-25-B	AD 394 783
Eighth Supplement	Dwayne Carmer	January 1969	8492-43-B	-

ABSTRACT

This supplement to the Target Signature Analysis Center: Data Compilation augments an ordered, indexed compilation of reflectances, radar cross sections, and apparent temperatures of target and background materials. The Data Compilation includes spectral reflectances and transmittances in the optical region from 0.3 to 15 μ and normalized radar cross sections (active) and apparent temperatures (passive), plotted as functions of aspect or depression angle, at millimeter wavelengths. When available, the experimental parameters associated with each curve are listed to provide the user with a description of the important experimental conditions.

This supplement contains the initial addition of reflectance distribution function data to the unclassified compilation. The data are presented in tabular form as a function of reflection angle for fixed incidence angles and discrete wavelengths in the visible and near-infrared spectral regions. These data were obtained from the Laboratory Measurements Phase of the Target Signature Measurements Program conducted at The University of Michigan and sponsored by the Air Force Avionics Laboratory. The unclassified compilation, including these data, consists of about 4300 curves and 112 tables (in general, each table is the equivalent of four unique curves).

January 1969

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TABLES

TARGET SIGNATURE ANALYSIS CENTER: DATA COMPILATION

Seventh Supplement

1

INTRODUCTION

The Target Signature Analysis Center established at the Willow Run Laboratories of The University of Michigan's Institute of Science and Technology and sponsored by the Air Force Avionics Laboratory comprises a document collection, a data library, and a staff of analysts. It provides a centralized source of data and analysis techniques useful for improving remote sensors. The routine functions of the Center include collecting, evaluating, and categorizing data on the properties of various target and background objects. In the optical portion of the electromagnetic spectrum from 0.3 to 15 μ, the data are primarily on reflectance and transmittance; at microwave frequencies, they consist of normalized radar cross sections (active) and apparent temperatures (passive). The primary source of data is reports published by laboratories making such measurements. In some instances, unpublished data have also been acquired directly from an experimenter.

Each document received by the Analysis Center is examined for data to be added to the library. Selected data are then manually digitized using an established format. Coded descriptors are assigned to each curve for retrieval purposes, and the conditions of each experiment are recorded. Data points and the descriptive and parametric information are also stored on magnetic tape. Since the parameters required to define radar measurements differ in many respects from those required for optical measurements, separate formats were designed to handle the different types of information. However, a general format has recently been devised and will eventually be used for all data. This new format is discussed in section 6 and has been used for processing the passive microwave data.

Optical ($0.3 < \lambda < 1000\ \mu$) and microwave ($\lambda > 1000\ \mu$) instruments were used to obtain the data reported here; the experiments were conducted during the last three decades. Three types of measurements are represented:

(1) Laboratory measurements of materials such as leaves, soil, and paints

(2) Ground-based field measurements of objects such as plants, soil plots, and vehicles

(3) Airborne measurements of scenes

In the optical portion of the spectrum, laboratory measurement programs are far more abundant than either ground-based field measurements or airborne measurement programs. In the microwave region, field and airborne instrument measurements predominate. There is a much larger amount of data on background materials (e.g., leaves, crops, and soils) than on man-made materials. The reason is that most of the past measurements were performed by scientists in the fields of botany, agronomy, and natural science, and, therefore, the primary motivation for these measurements was an interest in natural objects.

This data compilation is the product of a survey of existing data on target and background materials and is intended to present the results of such a survey in a single source. The picture it presents of natural and man-made objects in the real world and their interaction with electromagnetic radiation is in no way complete. Although many data have been gathered on some materials and at a few wavelengths, data are completely lacking for other materials and other wavelengths. Moreover, even the existing data are not accompanied with all the parametric and support information required for their adequate interpretation. The extensive Target Signature Measurements Program currently sponsored by the Air Force Avionics Laboratory is planned to fill existing data gaps. This program provides for laboratory and field measurements of target and background materials and objects at both optical and microwave frequencies. In the optical region, bidirectional and directional reflectances are under investigation. In the microwave region, optical simulation studies are being conducted, and existing radiometric (passive) data are being collected. Some of the data from this program, specifically reflectance data in the 0.3- to 2.5-μ spectral interval and reflectance distribution data at laser wavelengths are included in this compilation.

Only unclassified data from the Target Signature Analysis Center's collection are included in this supplement. The classified data have been published separately and are referenced in the foreword to this publication. Each data curve or data table has been assigned alphabetic descriptor codes to describe the object measured, the instrumentation used, the optical property measured, and the spectral interval employed. An alphabetically arranged list of these codes is given in table 1-1. The data curves in this publication have been grouped according to the coded descriptor that best describes the object measured. This prime descriptor, a page number, and the common name(s) of the objects are arranged as a cross index in section 2, which will be revised as future supplements are published, thus making it cumulative.

Section 3 contains optical spectral data as well as (a) a theoretical treatment of reflectance, (b) a description of some of the instruments used to collect these data, and (c) a summary of experiments yielding optical spectral data. The data sources in the TSAC collection are listed with the experiments included in the summary; the additional references also noted there are listed in section 3.6, which cites the literature sources for all of section 3. Section 3 is thus self-contained, to facilitate future additions to the compilation.

Section 4 contains optical data of the bidirectional reflectance or reflectance distribution function type. Although covered conceptually in section 3, a definition of the reflectance distribution function is given in section 4 along with some equations for the application of such data and a description of the instruments used for data collection. Section 4.5 lists the literature sources for this material.

Section 5 contains active microwave data of two types: averaged normalized radar cross sections as a function of aspect angle, with frequency as a parameter, and cumulative probability distribution vs. radar cross section. The curves are grouped according to the type of object measured. Instrumentation and TSAC literature sources comprise section 5.3; again, section 5 is thus self-contained.

Section 6 contains passive microwave data and a generalized parameter list that is part of an expanded version developed from the parameter system used in sections 3 and 4. Later data compilations will make use of this generalized list.

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST

A	TARGETS
AA	Ground
AAA	Buildings
AAAA	Steel
AAAB	Brick, Stone, Concrete
AAAC	Wood Frame
AAAD	Stick Huts
AAAE	Mud Huts
AAB	Guns
AABA	Artillery
AABB	Rifles
AAC	Industrial Facilities
AACA	Power Stations
AACB	Shipyards
AAD	Military Facilities
AADA	Communication Centers
AADB	Fortifications
AADC	Launching Sites
AADCA	Antiaircraft
AADD	Marshalling Yards
AADE	Supply Depots
AAE	Airfields
AAF	Railroad
AAFA	Tracks
AAFB	Yards
AAG	Roads
AAH	Bridges
AAI	Dams
AAJ	Locks
AAK	Personnel
AAKA	Clothing
AAKAA	Cotton Fibers (Cellulose)
AAKAB	Synthetic Fibers
AAKAC	Wool Fibers
AAKAD	Noncloth Items
AAKB	Troop Concentrations
AAKC	Skin
AAKCA	Asiatic
AAKCB	Caucasian
AAKCC	Negro
AAL	Vehicles
AALA	Aircraft
AALB	Armored
AALC	Convoys
AALD	Earth-Moving
AALE	Tanks
AALF	Trucks
AB	Marine
ABA	Submarine
ABB	Surface Vessels
ABBA	Barges
ABBB	Landing Craft
AC	Camouflage
AD	Decoys
AE	Materials
AEA*	Aluminum
AEB	Asphalt
AEC	Brick
AED	Burlap
AEE	Canvas
AEF	Cinder
AEG	Concrete
AEH	Dirt
AEI*	Galvanized Steel
AEJ	Glass
AEK	Gravel
AEL	Metal
AELA	Aluminum
AELB	Brass
AELC	Bronze
AELD	Copper
AELE	Steel
AELEA	Galvanized
AELEB	Stainless
AEM	Paint
AEMA	White Pigments
AEMAA	Zinc Oxide (Zinc White)
AEMAB	Lead Basic Carbonate (White Lead)
AEMAC	Titanium Dioxide
AEMB	Green Pigments
AEMBA	Chromic Oxide (Chrome Green)
AEMC	Red Pigments
AEMCA	Ferric Oxide (Hematite)
AEMCB	Trilead Tetroxide (Red Lead)
AEMD	Metallic Pigments
AEMDA	Aluminum Powder
AEME	Other Pigments (Color Unknown)
AEMEA	Mica
AEMEB	Aluminum Silicate
AEMF	Mediums, Thinners, Driers
AEMFA	Resin
AEMFAA	Oleo
AEMFAB	Alkyd
AEMFB	Ester
AEMFC	Xylene
AEMG	Primer
AEN	Paper/Cardboard
AEO	Plastic
AEP	Rubber
AEQ	Tar
AER	Tile
AES	Varnish
AET	Wood
AF	Radiation Control
AFA	Antireflection Coating

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*Not being used in the present system.

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST (Continued)

AFB	Shielding
AFC	Temperature Control
AG	Signatures
AH	Geometric Shapes
AHA	Flat Plates
AHB	Dihedrals (Concave)
AHC	Trihedrals (Concave)
AHD	Spheres and Spheroids
AHE	Cylindrical Shapes
AHF	Conical Shapes
AHG	Wedges
AHH	Dipoles
AHI	Rayleigh Scatters
AHJ	Other
AI	Contaminants
AIA	Corrosion
AIB	Dew
AIC	Dirt
AID	Dust
AIE	Oxide
AIF	Rust
AIG	None Visible
B	BACKGROUNDS
BA	Atmosphere
BAA	Constituents
BAAA	Aerosols
BAAB	Dust
BAAC	Fog
BAAD	Gases
BAAE	Haze
BAAF	Rain
BAAG	Smog
BAAH	Smoke
BAAI	Snow
BAAJ	Spray
BAAK	Water Vapor
BAB	Sky
BB	Clouds
BBA	Cumulonimbus
BBB	Cirrus
BBC	Cirrocumulus
BBD	Cirrostratus
BBE	Altocumulus
BBF	Altostratus
BBG	Cumulus
BBH	Nimbostratus
BBI	Stratocumulus
BC	Light Conditions
BCA	Day
BCB	Sunrise or Sunset
BCC	Twilight
BCD	Night
BCE	Clear
BCF	Overcast
BD	Season
BDA	Summer
BDB	Fall
BDC	Winter
BDD	Spring
BE	Terrain Uniformity
BEA	Flat
BEB	Rolling
BEC	Hilly
BED	Mountainous
BEE*	Rural
BEF*	Urban
BF	Soil
BFA*	Cultivated
BFB*	Uncultivated
BFC	Coarse Textured
BFCA	Sand
BFCB	Loamy Sand
BFD	Moderately Coarse Textured
BFDA	Sandy Loam
BFDB	Fine Sandy Loam
BFE	Medium Textured
BFEA	Loam
BFEB	Silt Loam
BFEC	Silt
BFF	Moderately Fine Textured
BFFA	Clay Loam
BFFB	Sandy Clay Loam
BFFC	Silty Clay Loam
BFG	Fine Textured
BFGA	Sandy Clay
BFGB	Silty Clay
BFGC	Clay
BFH	Other Constituents
BFHA	Organic Material
BFHB	Gravel (Less Than 3-in. Diameter)
BFHC	Cobbles (3- to 10-in. Diameter)
BFHD	Stones (Greater Than 10-in. Diameter)
BFHE	Bedrock
BFHF	Salt
BFI	Series
BFIA	Aguan
BFIB	Aiken
BFIC	Akron
BFID	Alamance
BFIE	Albion
BFIF	Alonso
BFIG	Barnes
BFIH	Blakely
BFII	Clareville

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*Not being used in the present system.

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST (Continued)

BFIJ	Clarion
BFIK	Collington
BFIL	Colts Neck
BFIM	Decatur
BFIN	Dublin
BFIO	Gooch
BFIP	Grady
BFIQ	Greenville
BFIR	Guthrie
BFIS	Hainamanu
BFIT	Hall
BFIU	Hamakua
BFIV	Herradura
BFIW	Joplin
BFIX	Marias
BFIY	Marshall
BFIZ	Matanzas
BFJ	Series (Continued)
BFJA	Maury
BFJB	Moaula
BFJC	Naalehu
BFJD	Onomea
BFJE	Ookala
BFJF	Orangeburg
BFJG	Oriente
BFJH	Orman
BFJI	Pallman
BFJJ	Penn
BFJK	Pierre
BFJL	Putnam
BFJM	Quibdo
BFJN	Rubicon
BFJO	Ruston
BFJP	Santa Barbara
BFJQ	Texas Dune
BFJR	Tifton
BFJS	Tillman
BFJT	Tilsit
BFJU	Vernon
BFJV	Weld
BFJW	Windthorst
BFJX	Yolo
BFJY	Zanesville
BFK	Minerals
BFL	Chemicals
BFM	Moisture Content
BFMA	Dry
BFMB	Damp
BFMC	Saturated
BG	Vegetation
BGA	Herbaceous, Algae Fungi
BGAA	Cladoniaceae Family
BGAAA	Reindeer Moss
BGB	Moss-Liverwort
BGBA	Sphagnum Family
BGBAA	Sphagnum Moss
BGC	Vascular
BGCA	Banana Family
BGCAA	Banana
BGCB	Bromeliaceae Family
BGCBA	Bunch Grass
BGCC	Buckwheat Family
BGCCA	Buckwheat
BGCD	Composite Family (cf. Ligneous)
BGCDA	Daisy
BGCDB	Goldenrod
BGCDC	Ragweed
BGCDD	Sunflower
BGCE	Convolvulus Family
BGCEA	Sweet Potato
BGCF	Crowfoot Family
BGCFA	Crowfoot
BGCG	Duckweed Family
BGCGA	Duckweed
BGCH	Evening-Primrose Family
BGCHA	Willow Herb (cf. Willow Family)
BGCI	Fern Family
BGCIA	Bracken Fern
BGCJ	Flax Family
BGCJA	Flax
BGCK	Goosefoot Family
BGCKA	Pigweed
BGCKB	Sugar Beet
BGCL	Gourd Family
BGCLA	Squash
BGCM	Grass Family
BGCMA	Barley
BGCMB	Bermuda Grass
BGCMC	Corn
BGCMD	Creeping Grass
BGCME	Fescue
BGCMF	Foxtail
BGCMG	Ilyas
BGCMH	Millet
BGCMI	Oats
BGCMJ	Reeds
BGCMK	Rice
BGCML	Rye
BGCMM	Selin
BGCMN	Timothy
BGCMO	Vetch
BGCMP	Wheat
BGCN	Heath Family (see also Ligneous)
BGCNA	European Blueberry
BGCNB	Heather
BGCO	Mallow Family
BGCOA	Cotton

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST (Continued)

BGCP	Mustard Family
BGCPA	Cabbage
BGCPB	Mustard
BGCQ	Nightshade Family
BGCQA	Potatoes
BGCQB	Tomatoes
BGCR	Pea (or Pulse) Family (see also Ligneous)
BGCRA	Alfalfa
BGCRB	Clover
BGCRC	Coffee Plant
BGCRD	Lentil
BGCRE	Lima Bean
BGCRF	Pea
BGCRG	Peanut
BGCRH	Soybean
BGCRI	String Bean
BGCS	Plantain Family
BGCSA	Plantain
BGCT	Sedge Family
BGCTA	Cotton Grass
BGCTB	Sedge
BGD	Ligneous
BGDA	Arecaceae Family
BGDAA	Areca Palm
BGDB	Beech Family
BGDBA	Beech
BGDBB	Chestnut
BGDBC	Oak
BGDC	Bignonia Family
BGDCA	Catalpa
BGDD	Calycanthaceae Family
BGDDA	Meratia Praecox
BGDE	Carduacea Family
BGDEA	Rabbit Brush
BGDF	Cashew Family
BGDFA	Chinese Pistachio
BGDFB	Sumach
BGDG	Composite Family (cf. Herbaceous)
BGDGA	Sagebrush
BGDGB	Wormwood
BGDH	Dogwood Family
BGDHA	Dogwood
BGDI	Ebony Family
BGDIA	Ironwood (cf. Hazel Family)
BGDIB	Persimmon
BGDJ	Elm Family
BGDJA	Elm
BGDK	Figwort Family
BGDKA	Paulowina
BGDL	Hazel Family
BGDLA	Alder
BGDLB	Birch
BGDLC	Hazelnut
BGDLD	Hornbeam
BGDLE	Ironwood (cf. Ebony Family)
BGDM	Heath Family (cf. Herbaceous)
BGDMA	Mountain Laurel
BGDN	Holly Family
BGDNA	Holly
BGDO	Honeysuckle Family
BDGOA	Viburnum
BGDP	Laurel Family
BGDPA	Laurel
BGDPB	Sassafrass
BGDQ	Lily Family
BGDQA	Yucca
BGDR	Linden Family
BGDRA	Basswood
BGDRB	Linden
BGDS	Logania Family
BGDSA	Privet (Ligustrum)
BGDT	Magnolia Family
BGDTA	Magnolia
BGDTB	Tulip
BGDTC	Tulip Poplar
BGDU	Maple Family
BGDUA	Maple
BGDV	Mulberry Family
BGDVA	Rubber
BGDW	Olive Family
BGDWA	Ash
BGDX	Pine Family
BGDXA	Cedar
BGDXB	Fir
BGDXC	Juniper
BGDXD	Larch
BGDXE	Pine
BGDXF	Spruce
BGDY	Plane-Tree Family
BGDYA	Sycamore
BGDZ	Pea Family (cf. Herbaceous)
BGDZA	Locust
BGE	Ligneous (Continued)
BGEA	Rose Family
BGEAA	Blackberry
BGEAB	Cherry
BGEAC	Hawthorn
BGEAD	Juneberry
BGEAE	Peach
BGEAF	Pin Cherry
BGEAG	Plum
BGEB	Sour Gum Family
BGEBA	Gum
BGEC	Trumpet-Creeper Family
BGECA	Calabash

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST (Continued)

BGED	Vine Family
BGEDA	Virginia Creeper
BGEE	Walnut Family
BGEEA	Hickory
BGEF	Willow Family
BGEFA	Aspen
BGEFB	Poplar
BGEFC	Willow (cf. Evening Primrose Family)
BGEFCA	Dwarf
BGEFCB	Ground
BGEG	Witch Hazel Family
BGEGA	Sweet Gum
BGF	Leaf
BGFA	Narrow
BGFB	Broad
BGFBA	Coriaceous (Leathery)
BGFBB	Membranous
BGFBC	Lower Leaf Surface
BGFBD	Upper Leaf Surface
BGFC	Young (Spring)
BGFD	Mature (Summer)
BGFE	Old (Fall)
BGFF	Dry
BGG	Bark
BGH	Twig
BH	Water
BHA	Formations
BHAA	Lake
BHAB	Puddle
BHAC	River
BHAD	Sea
BHB	State
BHBA	Ice
BHBB	Ice and Liquid
BHBC	Liquid
BHBD	Snow
BI	Climate
BJ	Composite Backgrounds
BJA	Urban
BJAA	Villages
BJAB	Towns
BJAC	Cities
BJB	Rural-Uncultivated
BJBA	Jungle
BJBB	Forest
BJBC	Grassplains
BJBD	Marsh
BJBE	Tundra
BJBF	Desert
BJC	Rural-Cultivated
BJCA	Orchard
BJCB	Bushes and Shrubs
BJCC	Plowed Fields

BJCD	Pasture or Grain
BJCE	Rice Paddy
C	EQUIPMENT
CA	Radar
CAA	Coherent
CAB	Noncoherent
CAC	Pulse
CAD	CW
CAE	MTI
CAF	Resolution Limited by Antenna
CAG	Synthetic Aperture
CB	Radiometer
CBA	Optical (Wavelength Less Than 1000 μ)
CBB	Microwave (Wavelength Greater Than or Equal to 1000 μ)
CBBA	Unmodulated
CBBB	Post-Detection Modulated
CBBC	Signal Modulated
CBBD	Cross Correlated
CBBE	Two-Channel Subtraction
CC	Spectrograph
CCA	Eastman Kodak
CD	Spectrometer
CDA	Beckman
CDAA	Model DU
CDAB	Model DK-1
CDAC	Model DK-2
CDAD	Microspec
CDB	General Electric
CDC	Perkin-Elmer
CDCA	Model 12
CDCB	Model 21
CDD	Interference
CDE	Cary
CDEA	Model 14
CDEB	Model 90
CE	Platform
CEA	Aircraft
CEB	Balloon
CEC	Ground
CED	Laboratory
CEE	Shipborne
CF	Optical
CFA	Ultraviolet
CFB	Visible
CFC	Infrared
CFD	Active
CFE	Passive
CG	Detectors
CH	Filters
CI	Image Tubes
CJ	Materials

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST (Continued)

CJA	Reflectance Standards (Optical)
CJAA	Magnesium Oxide
CJAAA	Smoked
CJAAB	Pressed
CJAB	Magnesium Carbonate
CJAC	Sulphur
CJAD	Aluminum
CJADA	Mirror
CJADB	Sandblasted
CJAE	Sapphire Felt
CJAF	Other Specular Standards
CJAG	Other Diffuse Standards
CJB	Reflectance Standards (Microwave)
CJBA	Metallic Sphere
CJBB	Luneberg Reflector
CJBC	Corner Reflector
CK	Evaluation
CKA	Noise
CL	Reflectometer (Bidirectional)
CLA	EGR
CLB	PGR
CM	Polarimeter
D	RADIATION
DA	Pattern
DAA	Aspect Dependence
DAB	Optical Cross Section
DAC	Radar Cross Section (σ)
DACA	Normalized (σ_0)
DB	Attenuation
DBA	Absorption
DBB	Scatter
DBBA	Backscatter Coefficient (ρ)
DC	Modulation
DD	Polarization
DDA	Radar
DDAA	Circular
DDAAA	Right
DDAAB	Left
DDAB	Elliptic
DDABA	Right
DDABB	Left
DDAC	Linear
DDACA	Horizontal or Perpendicular
DDACB	Vertical or Parallel
DDACC	Oblique
DDACCA	Cross-Polarized
DDACCB	Parallel-Polarized
DDAD	Random
DDB	Optical
DDBA	Circular
DDBAA	Right
DDBAB	Left
DDBB	Elliptic
DDBBA	Right
DDBBB	Left
DDBC	Linear
DDBCA	Perpendicular
DDBCB	Parallel
DDBD	Random
DE	Refraction
DF	Reflectance
DFA	Directional
DFAA	Specular Included
DFAB	Specular Not Included
DFB	Specular
DFC	Standard
DFCA	Baryte
DFCB	Flowers of Sulfur
DFCC	Gypsum
DFCD	Magnesium Carbonate
DFCE	Magnesium Oxide
DFCF	Paper
DFCG	Rhodium Mirror
DFCH	Aluminum Mirror
DFD	Bidirectional
DFE	Total (Albedo)
DFF	Absolute
DG	Scintillation
DH	Solar Influence
DI	Transmittance
DIA	Directional
DIB	Bidirectional
DJ	Emission
DJA	Atmosphere
DJB	Emissivity
DJC	Emittance
DJD	Blackbody
DJE	Greybody
DJF	Fluorescence
DJG	Thermal
DK	Artificial Sources
DKA	Arc
DKB	Beacon
DKC	Flame
DKD	Flare
DKE	Gas
DKF	Gas Discharge
DKG	Globar
DKH	Incandescent Lamp
DKI	Maser, Laser, Iraser, Uvaser
DKJ	Mantle
DKK	Nernst Glower
DKL	Nuclear Explosion
DKM	Oscillator
DKN	Shock Tube
DKO	Spark
DKP	Vapor Lamp
DKQ	Monochromator

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST (Continued)

DL	Natural Sources
DLA	Aurora
DLB	Airglow
DLC	Lightning
DLD	Lunar
DLE	Planetary
DLF	Solar
DLG	Stellar
DLH	Zodiacal Light
DLI	Sky
DM	Flux
DN	Radiance
DO	Coherence
DP	Diffraction
DQ	Apparent Temperature
DQA	Antenna
DQB	Target
DQC	Contrast
E	SPECTRA
EA	Gamma Rays
EB	X-Rays
EC	Optical
ECA	Ultraviolet
ECAA	Less than 0.1 μ
ECAB	0.1 to 0.2 μ
ECAC	0.2 to 0.3 μ
ECAD	0.3 to 0.4 μ
ECB	Visible (0.4 to 0.7 μ)
ECBA	Chromaticity
ECBB	Color
ECBBA	Blue
ECBBB	Green
ECBBC	Yellow
ECBBD	Orange
ECBBE	Red
ECBBF	Brown
ECBBG	Field Drab
ECBBH	Khaki
ECBBI	Olive Drab
ECBBJ	White
ECBBK	Grey
ECBBL	Black
ECC	Infrared
ECCA	0.7 to 1.5 μ
ECCB	1.5 to 3.0 μ
ECCC	3 to 5 μ
ECCD	5 to 8 μ
ECCE	8 to 15 μ
ECCF	15 to 50 μ
ECCG	50 to 100 μ
ECCH	100 to 1000 μ
ECCI	1.4-μ band
ECCJ	1.9-μ band
ECCK	2.2-μ band
ECCL	2.7-μ band
ECCM	4.3-μ band
ECCN	6.3-μ band
ECCO	9.6-μ band
ECCP	Other
ECD	Line
ED	Radio Frequency
EDA	EHF (30 to 300 GHz)
EDAN	V Band (46 to 56 GHz)
EDAQ	Q Band (36 to 46 GHz)
EDAT	Upper K_a Band (30 to 36 GHz)
EDB	SHF (3 to 30 GHz)
EDBF	Lower K_a Band (20.9 to 30 GHz)
EDBJ	K_u Band (10.9 to 20.9 GHz)
EDBM	X Band (5.2 to 10.9 GHz)
EDBP	Upper S Band (3.0 to 5.2 GHz)
EDC	UHF (0.3 to 3 GHz)
EDCE	Lower S Band (1.55 to 3.0 GHz)
EDCH	L Band (0.39 to 1.55 GHz)
EDCK	P Band (2.25 to 3.90 GHz)
EDD	VHF (30 to 300 MHz)
EDE	HF (3 to 30 MHz)
EDF	MF (0.3 to 3 MHz)
EDG	LF (30 to 300 kHz)
EDH	VLF (3 to 30 kHz)
F	OPERATIONS
FA	Detection
FB	Discrimination
FC	Reconnaissance
FD	Surveillance
FE	Imaging
FEA	Photography
FEB	Scanning
FEC	Contrast
FED	Resolution
FEE	Display
FF	Filtering
FFA	Spatial
FFB	Spectral
FG	Measurement
FGA	Temperature
FGB	Time
FGC	Position
FGD	Range
FGE	Angle
FGF	Velocity

TABLE 1-1. TARGET SIGNATURE SUBJECT-CODE LIST (Concluded)

FGG	Acceleration
FH	Calibration
FI	Homing
FJ	Pattern Recognition
G	ANALYSIS
GA	Mathematical
GAA	Model
GB	Statistical
GBA	Distribution
GBAA	Gaussian
GBB	Process
GBBA	Ergodic
GBBB	Stationary
GBBC	Nonstationary
GC	Information Processing
GCA	Digital
GD	Correlation
GDA	Auto-
GDB	Cross-
GE	One-Dimensional
GF	Two-Dimensional
GG	Linear
H	ACOUSTICS
HA	Attenuation
HAA	Absorption
HAB	Scatter
HABA	Backscatter Coefficient
HB	Modulation
HC	Refraction
HD	Reflectance
HE	Transmission
HF	Emission
HG	Artificial Sources
HH	Natural Sources
HI	Flux
HJ	Diffraction
HK	Frequency Spectrum
HL	Correlation

2

CUMULATIVE SUBJECT CROSS INDEX

Fir	BGD 123-125 3134: 6
Flax	BGC 3, 4
Foxtail	BGC 56, 57
Geranium	BGD 303, 304, 312, 313
Ginkgo Biloba	BGD 303
Goldenrod	BGD 34
Grass	BG 4 BGC 9, 12-31, 35, 55, 56, 58-60, 143, 146-148 3133: 1-11, 13-24, 29-34, 38-44, 46-49, 52, 53, 57-61, 63, 66, 77
Haloxylon	BG 8
Hawthorne	BGD 227
Hay	BG 9 (Also see Straw)
Hazelnut	BGD 51, 52
Heather	BGC 99
Hemlock	3134: 7
Hibiscus	BGC 158, 159
Hickory	BGD 232, 234
Holly	BGD 54
Hornbean	BGD 53
Ilyas	BGC 58, 59
Indian Mallow	BGC 158
Ironwood	BGD 44
Juneberry	BGD 228
Juniper	BGD 125, 126, 358, 359
Larch	BGD 126, 127
Lentil	BGC 113
Lichens	BG 9
Lilac	BGD 356, 357
Lima Beans	BGC 113, 114
Linden	BGD 69
Locust	BGD 223, 224
Madrone	BGD 342, 343
Magnolia	BGD 70, 345
Manzanita	BGC 156, 157
Maple	BGD 72-106, 345-353, 400, 402, 405
Marsh Grass	3136: 2, 3
Merion Blue Grass	(f)BGCM 1-6
Mesquite	BGD 223
Milkweed	BGC 144
Millet	BGC 61
Mint	BGC 144
Mockernut	BGD 233
Moss	BFHD 2 BG 2, 4 BGA 1 BGB 1-3
Mountain Laurel	BGD 53-55
Mulberry	BGD 353 (f)BGDV 1-6
Mullein	BGD 341
Mustard	BGC 104
Oak	AET 1 BGD 7-29, 320-336, 384-400, 402 3134: 4
Oats	BGC 62-65 3133: 56, 71, 75, 82
Pea	BGC 114
Peach	BGD 228, 229
Peanuts	BGC 114-116
Pear	BGD 226
Persimmon	BGD 44
Philodendron	BGD 316
Pigweed	BGC 5
Pine	BE 8 BGD 127-195, 359, 360, 403-406 3132: 1 3134: 4, 6, 7
Pinyon	BGD 121, 122
Plantain	BGC 142
Plum	BG 7 BGD 227, 230, 231, 374
Poplar	BGD 262-288, 382, 383
Potato	BGD 1, 104, 179, 180
Ragweed	BGC 1
Redbud	BGD 373
Reeds	BGC 65
Reindeer Moss	BGA 1
Rice	BGC 66
Rubber Leaf	BGD 106, 353-355
Rye	BGC 66, 67
Rye Grass	3133: 24, 25
Sagebrush	BGD 35
Sassafras	BGD 55, 344
Sedge	BGC 143 BH 2, 3
Selin	BGC 68
Sorghum	BGC 9-12
Soybeans	BGC 116-141 3133: 52, 54, 55, 59, 60, 77-79
Sphagnum Moss	BGB 1, 2
Spruce	BGD 195, 196, 361, 406, 407
Squash	BGC 8

3
OPTICAL SPECTRAL DATA

3.1. THEORY OF REFLECTANCE

The purpose of this discussion is to enable the user of this data compilation to consider the data in a proper perspective. The "reflectance" alone, for example, does not sufficiently describe the results of an experiment to allow the results to be used indiscriminately. One must have knowledge of the measuring instrument's characteristics, since they have measurable effect on interpretation of the output. Some important instrument parameters include spectral resolution, the solid angle of effective viewing, and characteristics of the radiation source.

Our present understanding of radiation theory does not permit an analytical description, in closed form, of the exact relationship between the radiation emitted by a source (whether natural or artificial) and the radiation received by a remote sensor after this radiation has been reflected by an object under surveillance. There are well known laws to describe the simple case of an electromagnetic wave incident upon a perfectly planar interface between two media. In this case, the reflected wave depends upon the radiation wavelength, the angle of incidence, and the physical properties (permittivity, permeability, and conductivity) of the two adjoining media. The laws governing such a case are sufficiently understood so that the refractive index and extinction coefficient of materials involved may be found by determining the reflection coefficients of the materials. For the more complicated case involving a surface with periodic or random surface irregularities, an analytic determination of the properties of the reflected electromagnetic field may only be approximated.

In the past ten years many papers have been published on scattering, or reflection from rough surfaces. Many theories have been developed, but none is both general and rigorous at the same time. To perform reasonably simple numerical calculations on the basis of these theories, certain simplifying assumptions are introduced, usually including one or more of the following:

(1) The dimensions of scattering elements of the rough surface are either much smaller or much greater than the wavelength of the incident radiation.
(2) The radii of curvature of the scattering elements are much greater than the wavelength of the incident radiation.
(3) Shadowing or obscuration effects occurring at the surface may be neglected.
(4) Only the far field is to be considered.
(5) Multiple reflections may be neglected.
(6) Consideration is restricted to a particular model of surface roughness (e.g., sawtooth, sinusoidal protrusions of definite shape and in random position, with random variations in height given by their statistical distribution and correlation function).

Electromagnetic scattering theory has been used in the past to compute radiation backscatter from targets in the microwave region of the spectrum, where the radiation wavelength is much greater than the minute irregularities of the target surface and where the conductivity of the target material is infinite. In the optical region, where materials have finite conductivity and the surface irregularities have a wide range in size relative to the radiation wavelength, present electromagnetic scattering theory is applicable to only a few special cases, so the only way to determine reflectance in this region for target and background objects is by experimentation.

One can arrive at the most general definition of reflectance ρ' (called bidirectional reflectance [3-1] by considering an infinitesimal element of surface, dA, upon which radiation of infinitesimal solid angle $d\omega_i$ and radiance L_i is incident. Taking a coordinate system fixed with respect to dA, with polar angle θ' measured from the normal and azimuth angle ϕ' measured from a fixed line (see fig. 3-1), the contribution to the reflected radiance, $dL_r(\theta'_r, \phi'_r)$, in the reflected pencil for the direction (θ'_r, ϕ'_r) is

$$dL_r(\theta'_r, \phi'_r) = \rho' L_i(\theta'_i, \phi'_i) \cos \theta'_i \, d\omega'_i \tag{3-1}$$

Generally, ρ' is a function of the incident and reflected directions (θ'_i, ϕ'_i and θ'_r, ϕ'_r respectively), the polarization (P), the wavelength (λ), and the optical parameters of the material on either side of the surface. Total radiance in a given reflected direction is obtained by integrating

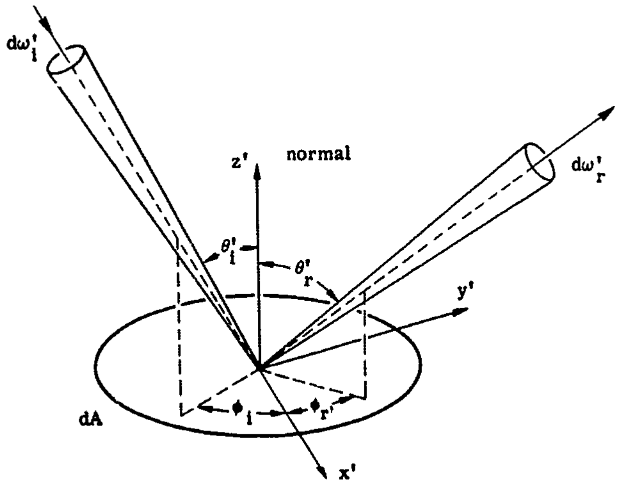

FIGURE 3-1. LOCAL COORDINATE SYSTEM FOR DETERMINING BIDIRECTIONAL REFLECTANCE

equation 1 over all incident directions, which yields

$$L_r(\theta'_r, \phi'_r) = \int \rho' L_i(\theta'_i, \phi'_i) \cos \theta'_i d\omega'_i \tag{3-2}$$

Also, by Helmholtz's reciprocity theorem, if the directions of the incident and reflected pencils are interchanged, the bidirectional reflectance is unchanged, i.e.,

$$\rho'(\theta'_1, \phi'_1; \theta'_2, \phi'_2; P; \lambda) = \rho'(\theta'_2, \phi'_2; \theta'_1, \phi'_1; P; \lambda) \tag{3-3}$$

Since the optical constants of materials may change from point to point, bidirectional reflectance becomes a function of the location of dA. If it is then assumed that the surface can be described by z' = f(x', y'), the correct functional dependence for reflectance is

$$\rho'(\theta'_i, \phi'_i; \theta'_r, \phi'_r; P; \lambda; x', y', z')_{z'=f(x',y')}$$

Generally, the direction of the normal to dA is also a function of the location of dA on the surface of the object. Hence, even if the incident and reflected radiation have a constant direction with respect to the (x', y', z') coordinates, the angles (θ'_i, ϕ'_i) and (θ'_r, ϕ'_r) (taken with respect to the local normal) would be a function of location of the surface element dA. For convenience, a second, absolute coordinate system is usually introduced, viz., (x, y, z). The x-y plane of this system is coincident with the average value of z' = f(x', y') along the surface A, and is, therefore, the "average" plane of the reflector. The normal to this average plane is parallel to the z axis. Instead of referring the incident and reflected radiation to the local coordinates, they are then referred to the absolute system, with θ as the polar angle and ϕ as the azimuthal angle. The bidirectional reflectance with respect to this system is

$$\rho'(\theta_i, \phi_i; \theta_r, \phi_r; P; \lambda; x, y)$$

Another type of reflectance commonly considered is the directional reflectance ρ_d which is a function of only one direction, either the incident or reflected direction. In the case where reflected power is integrated over a hemisphere and incident power is from a specific direction, directional reflectance is denoted by ρ_{di}. The incident power $d\Phi_i$ is

$$d\Phi_i = dL_i(\theta_i, \phi_i) \cos \theta_i d\omega_i dA \tag{3-4}$$

and using equation 3-2,

$$dL_r = \rho' \frac{d\Phi_i}{dA} \tag{3-5}$$

Since the reflected power $d\Phi_r$ is given by

$$d\Phi_r = dA\int_{2\pi} dL_r \cos\theta_r\, d\omega_r = d\Phi_i\int_{2\pi} \rho' \cos\theta_r\, d\omega_r \qquad (3\text{-}6)$$

therefore,

$$\rho_{di}(\theta_i, \phi_i; P; \lambda; x, y) = \int_{2\pi} \rho' \cos\theta_r\, d\omega_r \qquad (3\text{-}7)$$

When dA is uniformly illuminated from all directions (L_i = constant), the corresponding directional reflectance, ρ_{dr}, is defined as the ratio of the radiance reflected in a given direction to the incident radiance. To proceed as previously,

$$L_r = \int_{2\pi} \rho' L_i \cos\theta_i\, d\omega_i = L_i\int_{2\pi} \rho' \cos\theta_i\, d\omega_i$$

and, thus,

$$\rho_{dr}(\theta_r, \phi_r; P; \lambda; x, y) = \int_{2\pi} \rho' \cos\theta_i\, d\omega_i \qquad (3\text{-}8)$$

From comparison of equations 3-7 and 3-8,

$$\rho_{di}(\theta, \phi; P; \lambda; x, y) = \rho_{dr}(\theta, \phi; P; \lambda; x, y) = \rho_d \qquad (3\text{-}9)$$

ρ_d is called directional reflectance.

3.2. INSTRUMENTATION

This section describes several types of instruments used to generate the optical data included in this compilation. An expression is derived for the "reflected quantity" measured by each type.

3.2.1. GENERAL ELECTRIC SPECTROPHOTOMETER [3-2]. A schematic diagram of this measurement apparatus is presented in figure 3-2. Monochromatic radiation from the source passes through a Nicol prism (N_1) and then through a Wollaston prism (W_1) oriented to N_1 at an azimuth angle α. The prism W_1 converts the radiation into two linearly polarized beams, the polarization of one of which is perpendicular to that of the other. The beams then pass through a rapidly rotating Nicol prism (N_2) and into the integrating sphere where, with the same angle of incidence, one impinges on a reference and the other on the sample materials. A detector looks into the sphere in a direction perpendicular to the plane of the two incident beams. The integrating sphere is coated with a diffuse reflector (MgO), the reflectance of which is assumed independent of polarization.

If f is used to denote the frequency of rotation of N_2 and t the time, the subscripts 1 and 2 to distinguish the beams incident on reference and sample respectively, the symbols $\perp$ and $\parallel$

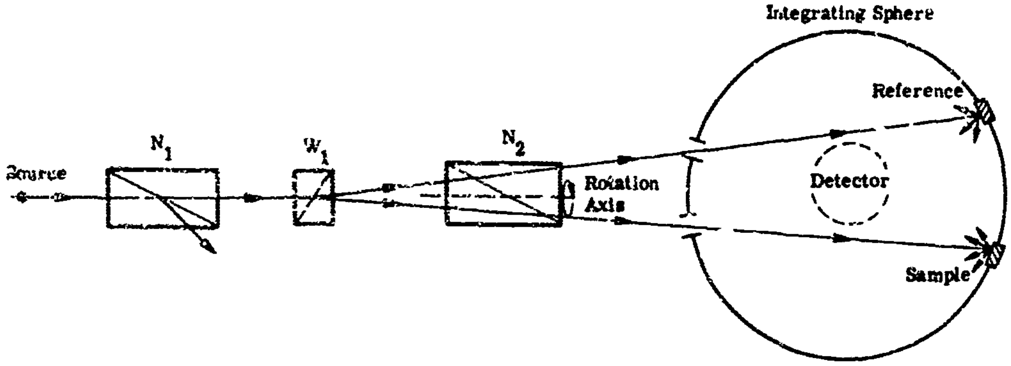

FIGURE 3-2. SCHEMATIC OF THE GENERAL ELECTRIC SPECTROFHOTOMETER

to represent the polarizations perpendicular to each other, and the superscripts i and r to represent incident and reflected radiation respectively, then the power at the detector (except for a factor dependent on the reflectance of the sphere) is

$$\Phi = \Phi_1^r + \Phi_2^r \tag{3-10}$$

The beams emerging from W_1 are linearly polarized and their powers given by

$$\begin{aligned} \Phi_1' &= \Phi_0 \sin^2 \alpha \\ \Phi_2' &= \Phi_0 \cos^2 \alpha \end{aligned} \tag{3-11}$$

where Φ_0 is the power from N_1. The prism N_2 passes that portion of the power polarized in a fixed direction, so that

$$\begin{aligned} \Phi_1^i &= \Phi_1' \sin^2 (2\pi ft) = \Phi_0 \sin^2 \alpha \sin^2 (2\pi ft) \\ \Phi_2^i &= \Phi_2' \cos^2 (2\pi ft) = \Phi_0 \cos^2 \alpha \cos^2 (2\pi ft) \end{aligned} \tag{3-12}$$

If it is assumed that the directional reflectance of the reference, $\rho_{d,1}(\lambda)$, is independent of polarization,

$$\Phi_1^r = \rho_{d,1}(\lambda)\Phi_1^i = \rho_{d,1}(\lambda)\Phi_0 \sin^2 \alpha \sin^2 (2\pi ft) \tag{3-13}$$

If the polarization symbols $||$ and $\perp$ are taken to refer to the polarization parallel to the directions in which beam 2 emerging from N_2 is maximum and minimum, respectively, then the power reflected from the sample is

$$\Phi_2^r = \Phi_0 \cos^2 \alpha \cos^2 (2\pi ft)\left[\rho_{d,2}(||, \lambda) \cos^2 (2\pi ft) + \rho_{d,2}(\perp, \lambda) \sin^2 (2\pi ft)\right] \tag{3-14}$$

The power at the detector is then*

$$\Phi = \Phi_0\left\{\rho_1 \sin^2 \alpha \sin^2 (2\pi ft) + \cos^2 \alpha \cos^2 (2\pi ft)\left[\rho_2(\|, \lambda) \cos^2 (2\pi ft) + \rho_2(\perp, \lambda) \sin^2 (2\pi ft)\right]\right\} \quad (3\text{-}15)$$

Rearranging terms gives

$$\begin{aligned}\Phi = {} & 1/2\left\{\rho_1(\lambda) \sin^2 \alpha + \cos^2 \alpha\left[\frac{3}{2}\rho^2(\|, \lambda) + \frac{1}{2}\rho_2(\perp, \lambda)\right]\right\} \\ & - 1/2\left[\rho_1(\lambda) \sin^2 \alpha - \rho_2(\|, \lambda) \cos^2 \alpha\right] \cos (4\pi ft) \\ & + 1/8\left[\rho_2(\|, \lambda) - \rho_2(\perp, \lambda)\right] \cos (3\pi ft) \cos^2 \alpha \end{aligned} \quad (3\text{-}16)$$

The a-c portion of the output from the detector, having a frequency of 2f, is fed to a motor which rotates N_1 so that it takes that position for which

$$\rho_1(\lambda) \sin^2 \alpha = \rho_2(\|, \lambda) \cos^2 \alpha \quad (3\text{-}17)$$

A simple measurement of α allows $\rho_2(\|, \lambda)$ to be computed from

$$\rho_2(\|, \lambda) = \rho_1 \tan^2 \alpha \quad (3\text{-}18)$$

when the reflectance of the reference, $\rho_1(\lambda)$, is known. The directional reflectance ρ_2 is, of course, a function of the direction of incidence, and, therefore, the calculated value is correct only for that particular direction.

Since the incident beam is not infinitesimally narrow, it illuminates a finite, albeit small, area of the sample. Therefore, the computed directional reflectance of the sample is really the true reflectance averaged over the illuminated area,

$$\bar{\rho}_2(\|, \lambda) = \frac{1}{A}\int_A \rho_2(\|; \lambda; x, y)\, dx\, dy \quad (3\text{-}19)$$

where A is the illuminated area of the sample, and similarly for ρ_1. Hence, in terms of the reference $\bar{\rho}_1$, the reflectance of the sample is

$$\frac{\bar{\rho}_2(\|, \lambda)}{\bar{\rho}_1(\lambda)} = \tan^2 \alpha$$

3.2.2. BECKMAN DK-2 SPECTROPHOTOMETER WITH REFLECTANCE ATTACHMENT. Figure 3-3 is an illustration of this measuring device. Monochromatic light is reflected from an oscillating plane mirror (M_1) alternately to one of two spherical mirrors (M_2 and M_3). M_1 is

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*The subscript d has been dropped.

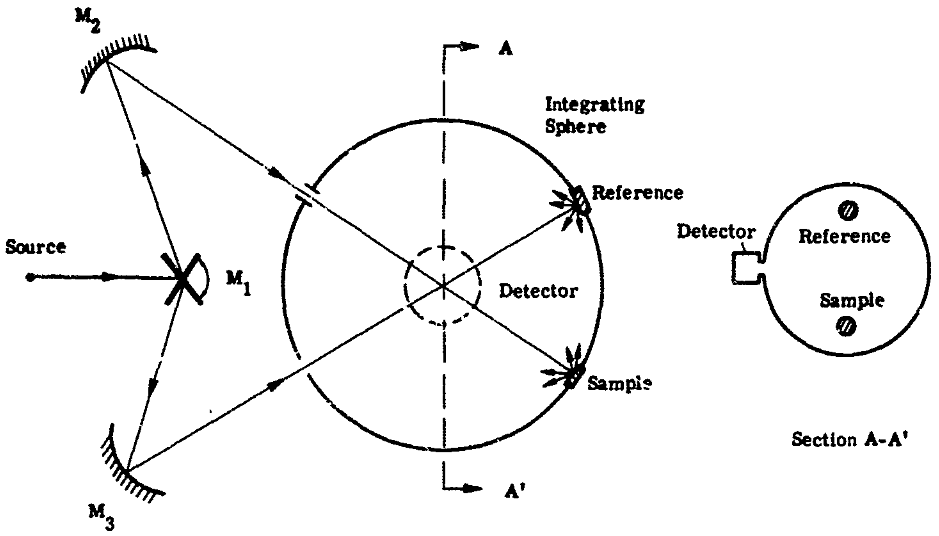


FIGURE 3-3. SCHEMATIC OF THE BECKMAN SPECTROPHOTOMETER WITH REFLECTANCE ATTACHMENT

positioned in the focal planes of M_2 and M_3. Thus, the radiation is reflected alternately, with little divergence, onto the reference and the sample at normal incidence. The detector compares the reflected power from the reference and sample and gives the ratio of the two.

Because the monochromator is a prism instrument, the radiation incident on M_1 is slightly polarized. More polarization results from reflection from the plane and spherical mirrors. Radiation entering the integrating sphere is probably elliptically polarized. If the subscripts 1 and 2 are used for quantities referring to the reference and sample respectively, and $\rho_d(P, \lambda, n)$ is taken to represent the directional reflectance at normal incidence, wavelength λ, and polarization P, the reflected powers are

$$\begin{aligned} \Phi_1^r &= \rho_{d,1}(\lambda, n)\Phi_0 \\ \Phi_2^r &= \rho_{d,2}(P, \lambda, n)\Phi_0 \end{aligned} \tag{3-20}$$

where Φ_0 is the incident power of wavelength λ and polarization P. It is assumed that the reflectance of the reference is not polarization dependent.

Because the radiation is incident normal to the reflectors, that portion of the power which is specularly reflected will exit through the entrance ports undetected. If $\rho_s(P, \lambda, n)$ is taken as the specular reflectance for normal incidence, wavelength λ, and polarization P, then the specularly reflected powers are $\rho_{s,1}(\lambda, n)\Phi_0$ and $\rho_{s,2}(P, \lambda, n)\Phi_0$ for the reference and sample respectively. If the incident radiation had no divergence and filled the whole entrance port, none of the specularly reflected radiation would be detected. However, because of the divergence of the incident beam and the configuration of the equipment, only a fraction k of this radiation would be undetected. Therefore, the detected powers are

$$\begin{aligned} \Phi_1^r &= [\rho_{d,1}(\lambda, n) - k\rho_{s,1}(\lambda, n)]\Phi_0 \\ \Phi_2^r &= [\rho_{d,2}(P, \lambda, n) - k\rho_{s,2}(P, \lambda, n)]\Phi_0 \end{aligned} \qquad (3\text{-}21)$$

The same value of k is used for both reference and sample because of symmetry. The value reported by the detector represents the ratio

$$\frac{\rho_{d,2}(P, \lambda, n) - k\rho_{s,2}(P, \lambda, n)}{\rho_{d,1}(\lambda, n) - k\rho_{s,1}(\lambda, n)} = \frac{\Phi_1^r}{\Phi_2^r}$$

Again, the indicated reflectances are averages over the illuminated areas.

3.2.3. COBLENTZ HEMISPHERE USED BY NEW YORK UNIVERSITY. This measurement apparatus uses a hemispherical specular reflector (see fig. 3-4) with the sample and detector located a small distance from and diametrically opposite to the center of the sphere. Through an entrance port, well collimated, monochromatic radiation becomes incident on the sample at a fixed angle. Because of imaging problems associated with the off-center location of the sample, the aperture of the detector should be larger than the sample to guarantee that most of the radiation reflected from the hemisphere is detected. With $L_i(\lambda; P_i; \theta_i, \phi_i)$ representing the radiance with wavelength λ and polarization P_i incident on the sample in the direction (θ_i, ϕ_i), the radiance reflected by the sample, L_r, is

$$L_r(\lambda; P_r; \theta_r, \phi_r) = \rho'(\lambda; P_i; \theta_r, \phi_r; \theta_i, \phi_i)L_i \cos\theta_i d\omega_r \qquad (3\text{-}22)$$

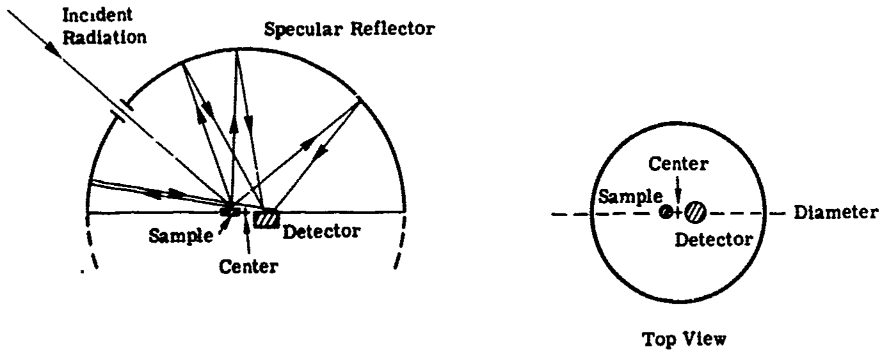


FIGURE 3-4. SCHEMATIC OF THE COBLENTZ HEMISPHERICAL REFLECTANCE ATTACHMENT USED BY NEW YORK UNIVERSITY

where the subscript r designates reflected radiation and ρ' is the bidirectional reflectance for incident polarization P_i. Given the directions of incidence and reflection, P_i, and λ, P_r may be determined.

If it can be assumed that the distance from the sample to the center of the sphere is very small compared to the radius of the sphere and that the area being illuminated is small, then the reflected radiance is approximately normally incident on the sphere. For normal incidence, the reflectance of the sphere, ρ_s, is independent of polarization of the incident radiation and depends only on its wavelength. The power Φ at the detector is, thus,

$$\Phi = \rho_s(\lambda)L_i \cos\theta_i \, d\omega_i A \int_{\omega_r=2\pi} \rho'(\lambda; P_i; \theta_r, \phi_r; \theta_i, \phi_i) \cos\theta_r \, d\omega_r \qquad (3\text{-}23)$$

where N_i is taken as uniform across the illuminated area A, ω_r as the solid angle for reflection from the sample, and ρ' as the bidirectional reflectance averaged over A. From the definition for ρ_d,

$$\Phi = L_i \cos\theta_i \, d\omega_i A \rho_s(\lambda)\rho_d(\lambda; P_i; \theta_i, \phi_i) \qquad (3\text{-}24)$$

By making two measurements, one with the sample and one with a reference having a directional reflectance $\rho_{d,1}$ which is known,

$$\frac{\rho_d(\lambda; P_i; \theta_i, \phi_i)}{\rho_{d,1}(\lambda; P_i; \theta_i, \phi_i)} = \frac{\Phi}{\Phi_1} \qquad (3\text{-}25)$$

is obtained, where the power reflected from the reference and the reflectances are averaged over the illuminated areas.

Equation 3-24 represents the power incident in the plane of the detector. In reality, however, the acceptance angle of the detector, ω_d, is less than 2π, so the power received by the detector, Φ_{rec}, is given by

$$\Phi_{rec} = (\omega_d/2\pi)\Phi$$

At angles of grazing incidence in the plane of the detector, radiation is reflected by the detector and is strongly polarized. This radiation is reflected off the hemisphere and onto the sample. Therefore, there will be some error caused by multiple reflections, and these reflections will be more strongly polarized than the initial radiation from the monochromator.

3.2.4. PORTABLE SPECTROPHOTOMETER USED BY USAERDL. This instrument is shown in figure 3-5. White, unpolarized radiation from the source is reflected from a plane mirror (M_1) onto the sample. Radiation reflected from the sample is focused onto the detector aperture by a spherical mirror (M_2). The detector is located in the focal plane of M_2 and thus

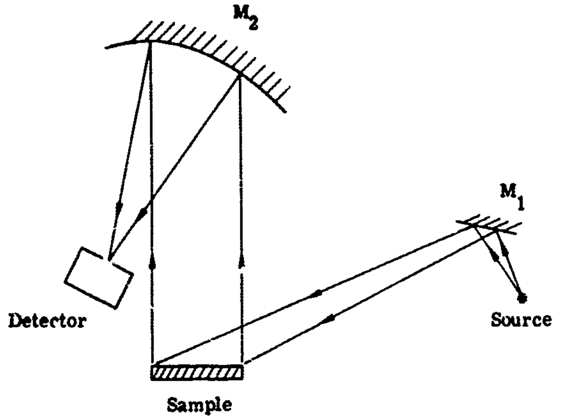


FIGURE 3-5. SCHEMATIC OF THE USAERDL PORTABLE SPECTROPHOTOMETER

receives only the radiation reflected normally from the sample. In practice, the detector is a monochromator, so only radiation at a particular wavelength λ is sensed. The source and M_1 can be moved about to give different angles of incidence on the sample. As a result of reflection from M_1 the radiance incident on the sample is probably partially polarized.

The spectral radiance incident on an area dA of the sample located at (x, y) is $L_i(\lambda; P; \theta_i, \phi_i; x, y)$, where P is the polarization for the incident direction (θ_i, ϕ_i). For this particular configuration, (θ_i, ϕ_i) is determined by (x, y). The spectral power reflected normally $(\theta_r = 0^\circ)$ by each dA is $d\Phi$:

$$d\Phi = dA L_i(\lambda, P)\left[\int_{\Delta\omega_i} \rho'(\lambda; P; \theta_i, \phi_i; n; x, y) \cos\theta_i \, d\omega_i\right] d\omega_r \qquad (3\text{-}26)$$

where ρ' is the spectral bidirectional reflectance for radiation of polarization P which is incident from (θ_i, ϕ_i) on the area at (x, y) and reflected normally (indicated by the symbol n); $\Delta\omega_i$ is the solid angle of the source as seen from the sample, and it is assumed that L_i is constant* in each $\Delta\omega_i$. The total power Φ reflected normally by the sample (of area A) is

$$\Phi = L_i(\lambda, P)\left[\int_A \int_{\Delta\omega_i} \rho'(\lambda; P; \theta_i, \phi_i; n; x, y) \cos\theta_i \, d\omega_i \, dA\right] d\omega_r \qquad (3\text{-}27)$$

---

*It has been assumed that $\Delta\omega_i$ is small enough so that a constant, meaningful polarization can be associated with the pencil of radiation.

For a reference with bidirectional reflectance ρ_r' that is independent of position and polarization, the detected power Φ is

$$\Phi' = L_i(\lambda, P)A\left[\int_{\Delta\omega_i} \rho_r'(\lambda;\ \theta_i,\ \phi_i;\ n)\ \cos\ \theta_i\, d\omega_i\right] d\omega_r \tag{3-28}$$

The ratio of the power detected from the sample to that from the reference is

$$\frac{\Phi}{\Phi'} = \frac{\int_{\Delta\omega_i} \bar{\rho}'(\lambda;\ P;\ \theta_i,\ \phi_i;\ n)\ \cos\ \theta_i\, d\omega_i}{\int_{\Delta\omega_i} \rho_r'(\lambda;\ \theta_i,\ \phi_i;\ n)\ \cos\ \theta_i\, d\omega_i} \tag{3-29}$$

where $\bar{\rho}$ is the average of ρ' over the area A, i.e.,

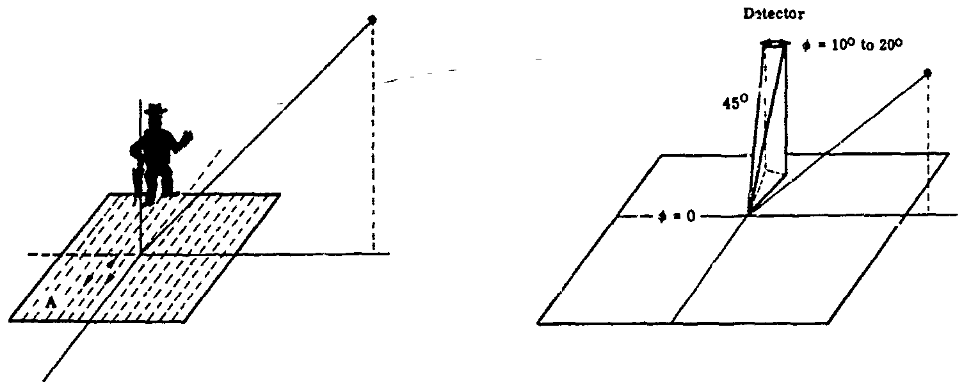
$$\bar{\rho}' = \frac{1}{A}\int_A \rho'\, dA \tag{3-30}$$

With $\Delta\omega_i$ so small that quantities may be considered constant throughout it, equation 3-29 becomes

$$\frac{\bar{\rho}'(\lambda;\ P;\ \theta_i,\ \phi_i;\ n)}{\rho_r'(\lambda;\ \theta_i,\ \phi_i;\ n)} = \frac{\Phi}{\Phi'} \tag{3-31}$$

In practice, the beam incident on the sample in this case is divergent. Since reflectance for most objects exhibits angular dependence, and since a divergent beam represents a range of incidence angles, it intuitively appears that the divergence angle will affect the final reflectance value.

3.2.5. KRINOV'S FIELD MEASUREMENTS [3-3]. The methods described in this section were used for field measurements with the sun and a clear sky as the radiation source. The measurement procedure varied depending upon whether the surface measured was horizontal or vertical. For horizontal surfaces, the detector was oriented in one of two positions: looking directly downward or looking downward at 45° to the vertical. To establish a reference system for further discussion, all azimuth values are relative to the sun which is defined to be at an azimuth of 180°; angles [illegible] considered positive when measured clockwise from the zero-azimuth line. When looking downward, the detector was either moved back and forth along the 90°-270° line over a large area (cf. fig. 3-6a) or rotated 5° to 10° about a vertical axis coincident with its viewing direction (cf. fig. 3-6b). In the first case, when the detector was moved back and forth over a large area of the ground being observed, the instrument was always oriented normal to the ground. In effect, the measurement was bidirectional if it can be assumed that all the incident radiation emanates from the sun. Under this assumption, $\rho'(\theta_i,\ \phi_i;\ \theta_r,\ \phi_r) = \rho'(\theta_{sun},\ 180;\ 0,\ 0)$. This measurement is integrated over the area of the ground observed. In the second case, the



(a) Horizontal surfaces: man walks over area A to be measured with the spectrograph; spectrograph is oriented normal to ground and looking downward for as much as 30 min.

(b) Horizontal surfaces: $\vartheta = 45^o$: $\phi = 270^o$; spectrograph rotated 10 to 20^o in azimuth.

FIGURE 3-6. SCHEMATIC OF MEASUREMENT CONFIGURATION USED BY KRINOV

spectrograph was mounted on a tripod and directed at the sample at an angle of 45^o from the normal and an azimuth of 270^o. The spectrograph was then rotated on the tripod through an azimuth of 10^o to 20^o. When measuring vertical surfaces, i.e., trees, cliffs, or walls, the spectrograph was directed horizontally or slightly upward at the surface and at azimuths of 45^o or 315^o, and the instrument was then also rotated through a small azimuth.

Because the incident radiation comes from the sun <u>and</u> clear sky, the incident spectral radiance is very dependent on angle and not quite unpolarized (particularly in the blue region of the spectrum): $L_i(\lambda; P_i; \theta_i, \phi_i)$, with (θ_i, ϕ_i) the direction of incidence and P_i the polarization. Also, the time of day, season, and atmospheric condition act as variables. $d\Phi_s$ is the spectral power reflected by a surface element dA and into the rather large solid angle ω_D which subtends the detector:

$$d\Phi_s(\lambda) = dA \int_{\omega_D} d\omega_D \int_{\omega_i=2\pi} \rho'(\lambda; P_i; \theta_i, \phi_i; \theta_r, \phi_r) L_i(\lambda; P_i; \theta_i, \phi_i) \cos\theta_i \, d\omega_i \tag{3-32}$$

where (θ_r, ϕ_r) is the direction of reflectance, ω_i the solid angle of incidence, and ρ' the bidirectional reflectance. The recorder for this system is photographic film, hence the system records energy. Assuming the detector views an area A at any time and scans at a constant rate over a time T, and that L_i is independent of time, then the spectral energy reflected by the sample, $Q_s(\lambda)$, is

$$Q_s(\lambda) = TA \int_{\omega_D} d\omega_D \int_{\omega_i=2\pi} \overline{\rho}'(\lambda; P_i; \theta_i, \phi_i; \theta_r, \phi_r) L_i(\lambda; P_i; \theta_i, \phi_i) \cos\theta_i \, d\omega_i \tag{3-33}$$

where $\bar{\rho}'$ is ρ' averaged over the scanned area A_s, i.e.,

$$\bar{\rho}' = \frac{1}{A_s}\int_{A_s} \rho' \, dA$$

The sample can be replaced by a reference the reflectance of which, ρ'_r does not vary with position, and the film exposed for a time T without scanning. The reflected spectral energy $Q_R(\lambda)$ is then

$$Q_R(\lambda) = TA\int_{\omega_D} d\omega_D \int_{\omega_i=2\pi} \rho'_r(\lambda;\, P_i;\, \theta_i,\, \phi_i;\, \theta_r,\, \phi_r) L_i \cos\theta_i \, d\omega_i \qquad (3\text{-}34)$$

A comparison of $Q_s(\lambda)$ and $Q_R(\lambda)$ may then be made.

For a second case referred to above, the results are the same if A_s is set equal to A, since it may be assumed that A is imaged onto a small area of the film and the average of $Q_s(\lambda)$ over this small area is taken. With the detector pointed downwards at 45° to the vertical and at an azimuth of 90° or 225° the results are obtained as shown with appropriate changes in θ_r and ϕ_r. Similar equations may be derived for vertical surfaces.

3.2.6. HOHLRAUM REFLECTANCE ATTACHMENT. This interesting apparatus for determining spectral reflectance is shown in figure 3-7. It consists of a blackbody cavity with a

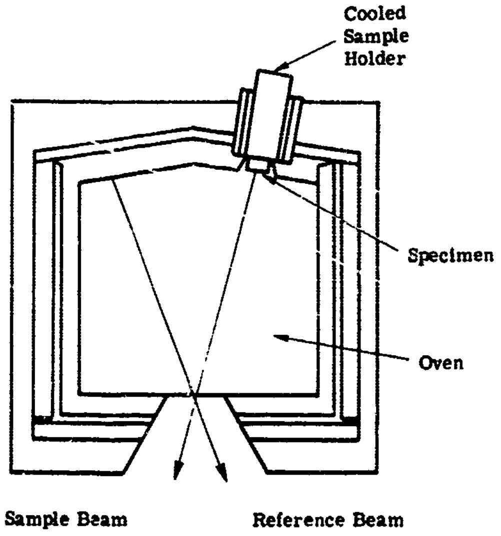


FIGURE 3-7. SCHEMATIC OF THE HOHLRAUM REFLECTANCE ATTACHMENT

viewing port. The viewing port is small enough so that the radiation in the cavity closely approximates the blackbody case, and the portions of the inner wall visible through the port occupy only a small solid angle. The sample is water cooled and is oriented with its normal at an angle of 13° to the viewing direction. If dA is again taken to represent the area of the sample viewed and ρ' to represent the bidirectional reflectance, the spectral power Φ_r reflected by the sample through the viewing port is

$$\Phi_r(\lambda) = dA L_r(\lambda) \cos (13^o) d\omega_r = d\Sigma d\omega_s L_r(\lambda) \tag{3-35}$$

where $L_r(\lambda)$ is the reflected spectral radiance, $d\omega_r$ the solid angle subtended by the viewing port at the sample, $d\Sigma$ the area of the detector (considered small), and $d\omega_s$ the solid angle subtended by the sample at the detector ($d\omega_s$ is considered normal to $d\Sigma$).

$$L_r(\lambda) = \int_{\omega_i} \rho'(\lambda; P_i; \theta_i, \phi_i; \theta_r, \phi_r) L_i(\lambda) \cos \theta_i d\omega_i \tag{3-36}$$

where $L_i(\lambda)$ is the incident spectral radiance, (θ_i, ϕ_i) the incident direction, ω_i the angle subtended at the sample by the entrance to the sample holder, and P_i the polarization of the incident radiation. The incident radiation is blackbody type and hence unpolarized; furthermore, the incident spectral radiance is a constant. Therefore,

$$\Phi_r(\lambda) = d\Sigma d\omega_s L_i(\lambda) \int_{\omega_i} \rho'(\lambda; P_i; \theta_i, \phi_i; 13^o, \phi_r) \cos \theta_i d\omega_i \tag{3-37}$$

Next, the detector is moved to view a flat area dA of the cavity wall far from the sample holder. The resulting spectral power, Φ_w, there is

$$\Phi_w(\lambda) = dA d\omega_w L_i(\lambda) \cos \theta_w = d\Sigma d\omega_s L_i(\lambda) \tag{3-38}$$

where θ_w is the angle between the viewing direction and the normal to the wall, and $d\omega_w$ is the solid angle subtended by the viewing port at the area dA on the wall. The ratio of the spectral powers detected is

$$\frac{\Phi_w(\lambda)}{\Phi_s(\lambda)} = \int_{\omega_i} \rho'(\lambda; P_i; \theta_i, \phi_i; 13^o, \phi_r) \cos \theta_i d\omega_i \tag{3-39}$$

Hence, the detector can be interpreted as giving the spectral bidirectional reflectance for unpolarized light, integrated over the projected solid angle of the source (as seen by the sample). Since it was assumed that the detector viewed only a very small area, dA, of the sample, the bidirectional reflectance appearing under the integral applies only to that area. In some instances, the sample has been placed at the wall of the Hohlraum cavity instead of further into the sample holder. The ratio of powers detected is then

$$\frac{\Phi_w(\lambda)}{\Phi_s(\lambda)} = \int_{\omega_i=2\pi} \rho'(\lambda; P_i; \theta_i, \phi_i; 13^o, \phi_r) \cos \theta_i \, d\omega_i = \rho_d(\lambda; P_i; 13^o, \phi_r)$$

Once again, the reflectance measured is an average over the illuminated area.

3.2.7. DETROIT ARSENAL REFLECTANCE MEASUREMENTS [3-4]

The measurements reported herein from the Detroit Arsenal were made with a Perkin-Elmer Recording Spectrometer and a Coblentz hemispherical reflectance attachment. Figure 3-8 is a schematic diagram of the measurement apparatus. Basically, the incident radiation, which is very nearly monochromatic, is focused on the sample through a small hole in the hemisphere. The sample is located at a small distance from the sphere's center. Energy reflected by the sample in any direction is re-reflected by the gold-coated hemisphere (a specular reflector)

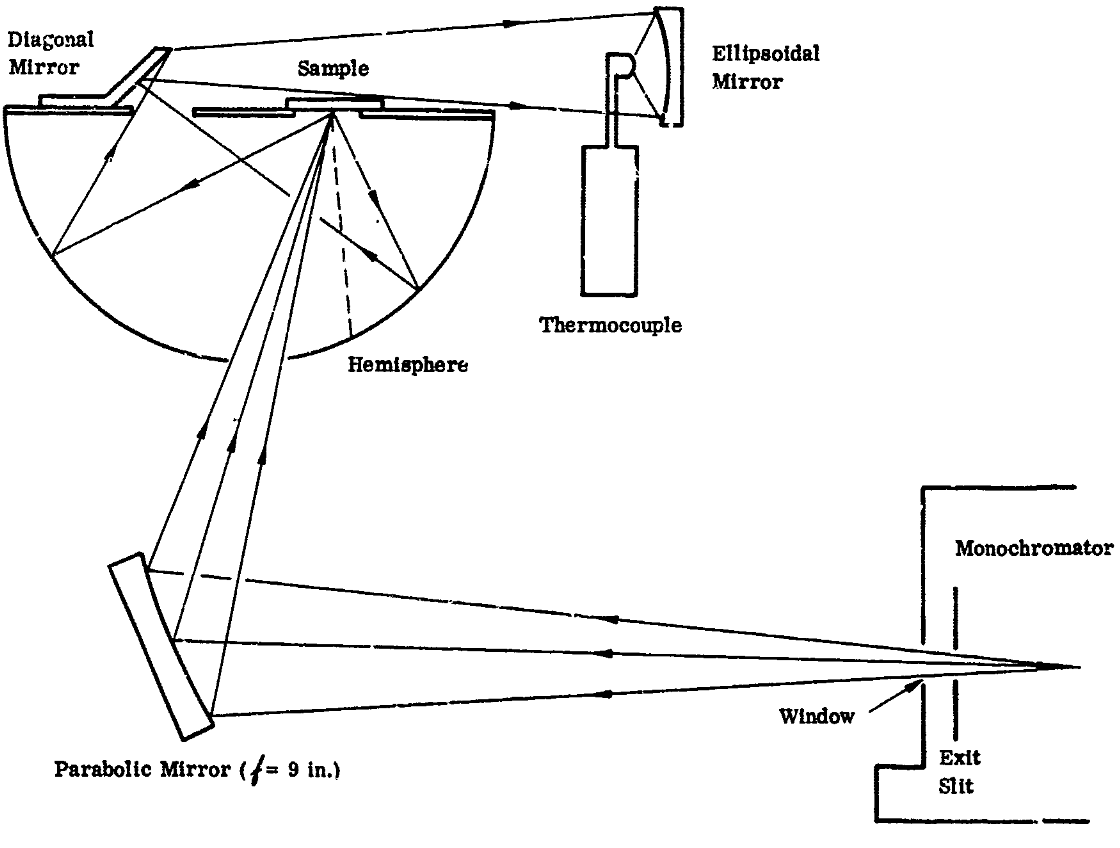


FIGURE 3-8. COBLENTZ HEMISPHERE USED BY DETROIT ARSENAL
Unclassified

and focused at a spot in the sample plane diametrically opposite the sample. By a system of mirrors the collected energy is focused on the detector.

The instrument was calibrated separately for specular reflectors and for diffuse reflectors. For specular reflectors, an evaporated aluminum standard of known reflectance was placed in the sample location, and the instrument slit widths were adjusted until the reading coincided with the predetermined value. The slit width was recorded for that wavelength and the procedure repeated at 1.0-μ intervals between 1 and 12 μ. The first wavelength read was 1 μ. The resulting set of slit widths was used for all samples considered specular, and the reading was recorded as reflectance. In the case of a diffuse reflector, the same procedure was followed using a smoked MgO standard.

3.2.8. NOTS POLARIZATION MEASUREMENTS [3-5]

The data obtained at the Naval Ordnance Test Station (NOTS), China Lake, Calif., consist of measurements of the degree of linear polarization of light reflected from target and background objects. The data result from a joint laboratory and field study and are reported in three forms:

(1) P_L vs. λ
(2) P_L vs. θ
(3) P_L vs. ϕ

where P_L = degree of linear polarization
λ = wavelength
θ = zenith angle of observation
ϕ = azimuth angle of observation

Field measurements were made using a specially designed polarimeter consisting of a Polaroid HN-22 high extinction linear polarization filter, an f/4 250-mm telephoto lens, an eyepiece to observe the field of view, and an RCA 200-4-25-2.0 silicon photodetector (fig. 3-9). The wavelength was monitored by inserting any one of a series of 20-mμ optical bandpass filters behind the polarization analyzer. The filters were centered at the following peak wavelengths: 486, 520, 546, 579, 589, 656, and 706 mμ. The detector field of view was 2°.

The polarimeter was mounted on a tripod for measuring terrain. The positions of the sun and polarimeter with respect to the observed ground were recorded using the notation shown in figure 3-3. The polarization analyzer was then rotated and currents corresponding to the maximum and minimum transmitted fluxes (I_1 and I_2) were recorded. The degree of linear polarization was calculated from the following equation:

$$P_L = \frac{I_1 - I_2}{I_1 + I_2}$$

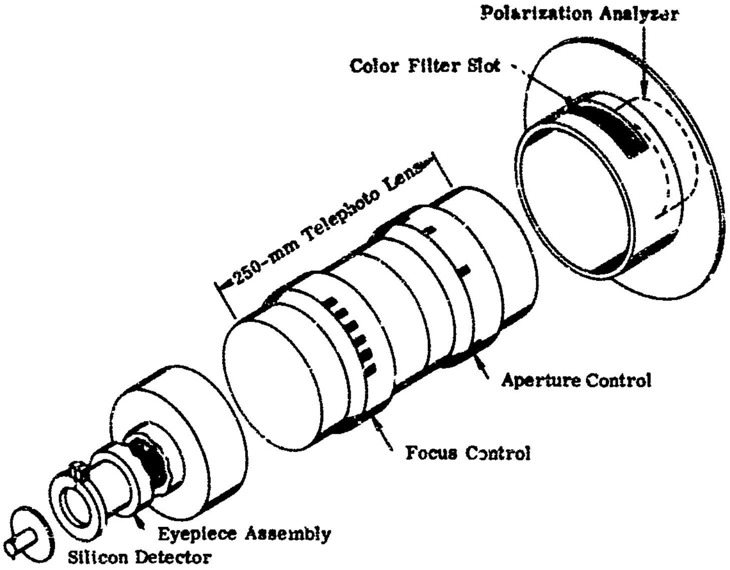


FIGURE 3-9. PHOTOELECTRIC FIELD POLARIMETER

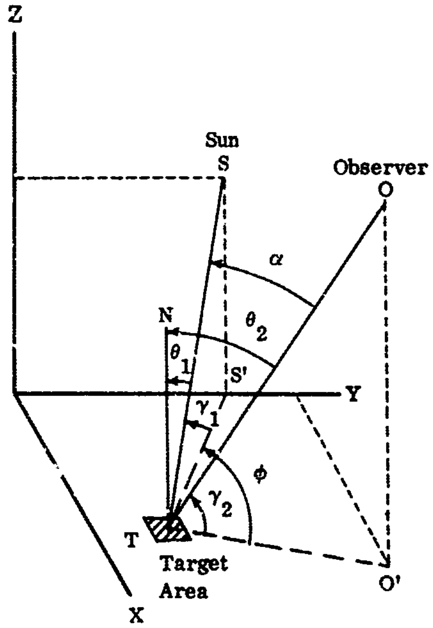


FIGURE 3-10. GEOMETRY OF FIELD MEASUREMENTS

Laboratory measurements were conducted in much the same way as the field studies. The instrument (fig. 3-11) differed basically from the field instrument in two respects: (1) an artificial source was used rather than the natural illumination, and (2) the source and the detector were coplanar; for the field measurements, the detector could be situated at any desired azimuth in relation to the sun. The source was fixed, while the sample could be tilted to allow various incidence angles. The detector could also be moved independent of the sample holder to permit several viewing angles.

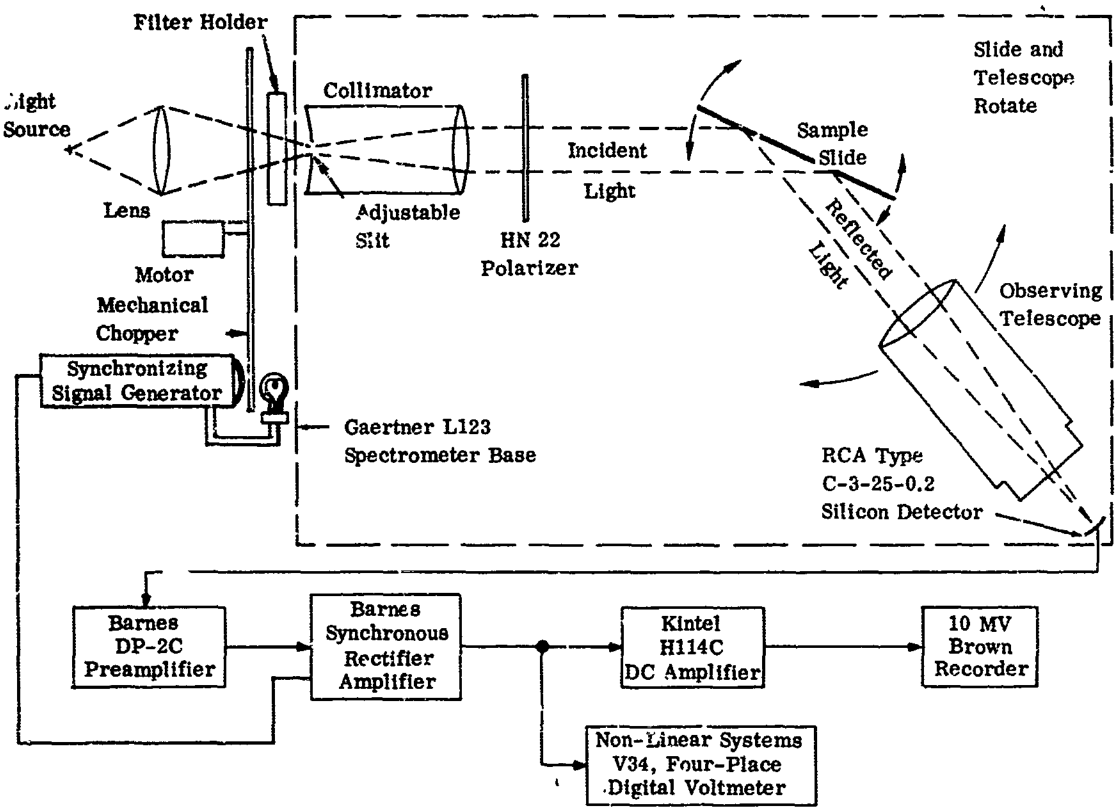


FIGURE 3-11. LABORATORY POLARIMETER AND INSTRUMENTATION

The illumination angles used in this study were 30°, 60°, and 80°, and the observation angle varied from 5° to 85°.

The polarizer was inserted in the incident beam in first the perpendicular and then the parallel orientation. Light reflected from the sample, $V_\perp$ and $V_\parallel$ respectively, was recorded.

Here the degree of linear polarization, P_L, is given by

$$P_L = \frac{V_\perp - CV_\parallel}{V_\perp + CV_\parallel}$$

where $V_{\perp_{i,r}}$ = voltage observed upon reflection in the direction θ_r of perpendicularly polarized light at an incidence angle θ_i

$V_{\parallel_{i,r}}$ = voltage observed upon reflection in the direction θ_r of parallel polarized light at an incidence angle θ_i

3.2.9. CARY 14R REFLECTOMETER. This instrument is shown schematically in figure 3-12. Sample illumination was achieved by placing a high intensity source at a small port in the bottom of the integrating sphere. The sample is thus illuminated by a broad spectral band, hemispherical source. A double prism grating monochromator then alternately looks at a $MgCO_3$ reference and the sample. This instrument may be operated over the 0.2- to 2.2-μ range.

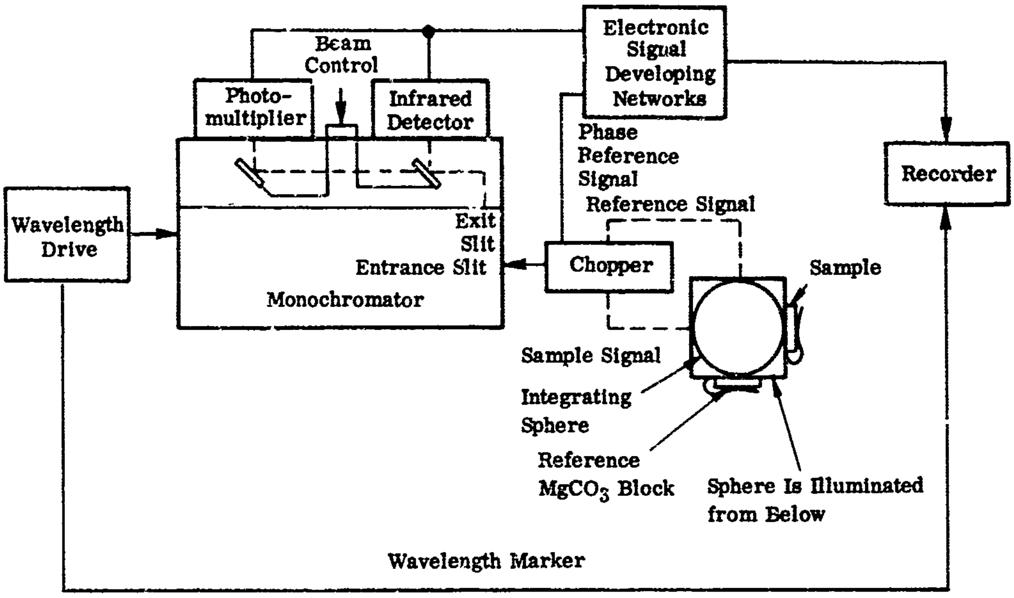


FIGURE 3-12. CARY 14R REFLECTOMETER [3-6]

3.2.10. PERKIN-ELMER NORMAL INCIDENCE REFLECTOMETER. This instrument is shown schematically in figure 3-13. In operation, broad spectral band light is collected and focused on the sample at the reflectance unit (fig. 3-14). Light reflected from the sample is collected and focused onto the entrance slit of a Perkin-Elmer Model 99 monochromator where it is analyzed spectrally from 0.2 to 0.4 μ. The measurements were made using a $MgCO_3$ reflectance standard.

3.3. ABSOLUTE REFLECTANCE

As is apparent from the earlier discussion, the measurement of reflectance is usually made relative to an arbitrary standard, and it is presented in that manner in many cases in this com-

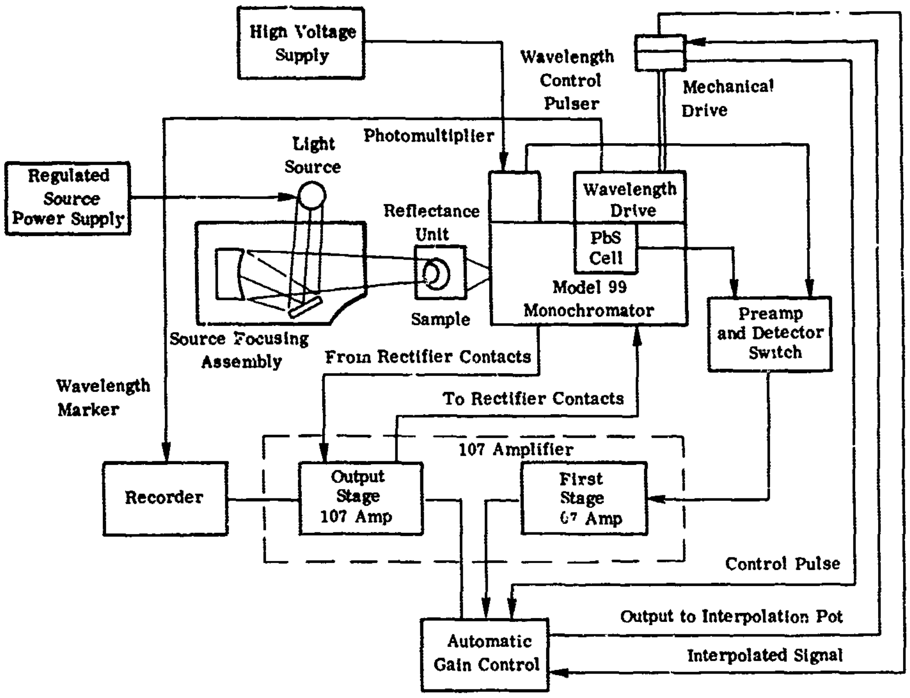


FIGURE 3-13. PERKIN-ELMER NORMAL INCIDENCE REFLECTOMETER [3-6]

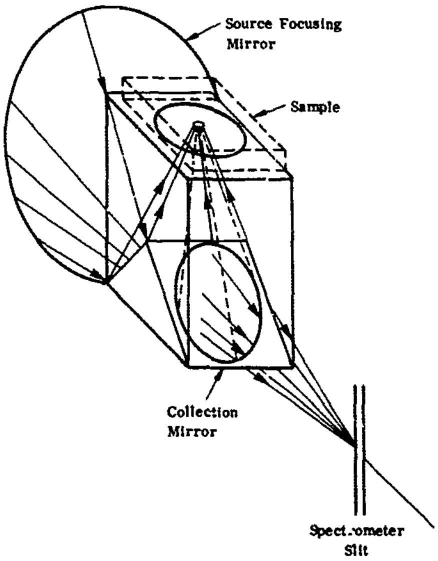


FIGURE 3-14. PERKIN-ELMER REFLECTANCE UNIT [3-6]

pilation. To convert such data to absolute values requires knowledge of the absolute reflectance of the standard used. An absolute measurement is of the following form:

$$\rho_d\left(\theta_i, \phi_i\right)_{abs} = \frac{p_{r,x}}{p_i} \tag{3-40}$$

where p_i is the power incident on the sample in the direction (θ_i, ϕ_i), and $p_{r,x}$ is the power reflected into a hemisphere by the sample. On the other hand, a relative measurement has the form

$$\rho_d\left(\theta_i, \phi_i\right)_{rel} = \frac{p_{r,x}}{p_{r,st}} \tag{3-41}$$

where, again, $p_{r,x}$ is the power reflected into a hemisphere by the sample, while $p_{r,st}$ is the power reflected into a hemisphere by some reflectance standard.

If the absolute directional reflectance of the standard, $\rho_{d,st}\left(\theta_i, \phi_i\right)_{abs}$ is known, the absolute reflectance of the sample can be calculated:

$$\rho_d\left(\theta_i, \phi_i\right)_{abs} = \frac{p_{r,st}}{p_i}$$

or

$$p_{r,st} = \rho_{d,st}\left(\theta_i, \phi_i\right)_{abs} p_i \tag{3-42}$$

Substituting equation 42 into equation 41 yields

$$\rho_d\left(\theta_i, \phi_i\right)_{rel} = \frac{p_{r,x}}{\rho_{d,st}\left(\theta_i, \phi_i\right)_{abs} p_i}$$

$$\rho_d\left(\theta_i, \phi_i\right)_{rel} = \frac{\rho_d\left(\theta_i, \phi_i\right)_{abs}}{\rho_{d,st}\left(\theta_i, \phi_i\right)_{abs}}$$

and, therefore,

$$\rho_d\left(\theta_i, \phi_i\right)_{abs} = \rho_d\left(\theta_i, \phi_i\right)_{rel} \rho_{d,st}\left(\theta_i, \phi_i\right)_{abs}$$

Thus, to obtain absolute values of the reflectance of a sample, it is necessary to multiply the relative reflectance of the sample by the absolute reflectance of the standard as measured at the same wavelength, incidence angle, etc.

To facilitate these computations, recommended values for the absolute reflectance of three commonly used reflectance standards, MgO, $BaSO_4$, and $MgCO_3$, are presented in figures 3-15 through 3-17. The reader is cautioned that although these curves are considered to represent the best data currently available, they are nevertheless subject to the errors inherent in the instrumentation used. If highly accurate results are necessary, the references cited should be consulted for a description of the measurement techniques and error analyses associated with the data. Section 3.4 indicates which of the optical data are reported as absolute and which as relative. For the relative data, the reflectance standard has also been designated.

It should also be noted that even after corrections for the standard are applied to data in this compilation, the curves may or may not more truly represent absolute reflectance. This is because the reflectance of such standards may vary within a few percent on the basis of preparation techniques, thickness and age of the samples, their exposure to ultraviolet radiation, etc. Since very few of the experiments considered have indicated in their reports the absolute reflectance of the standard used or completely described its preparation, it is impossible to say that the absolute reflectance shown in figures 3-15 through 3-17 is identical to that of the standard used in a given experiment.

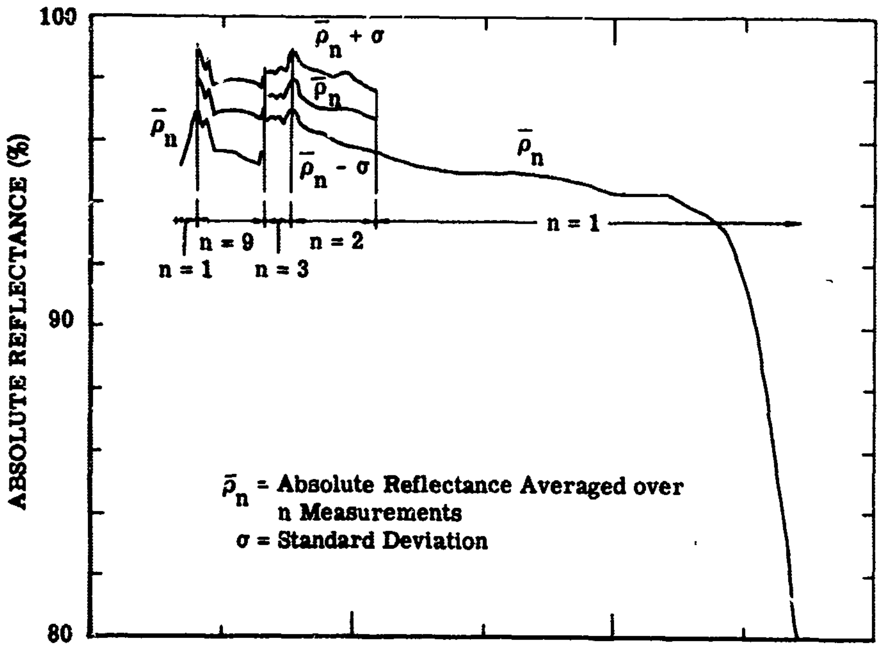


FIGURE 3-15. ABSOLUTE REFLECTANCE OF SMOKED MgO [3-7, 3-8, 3-9]

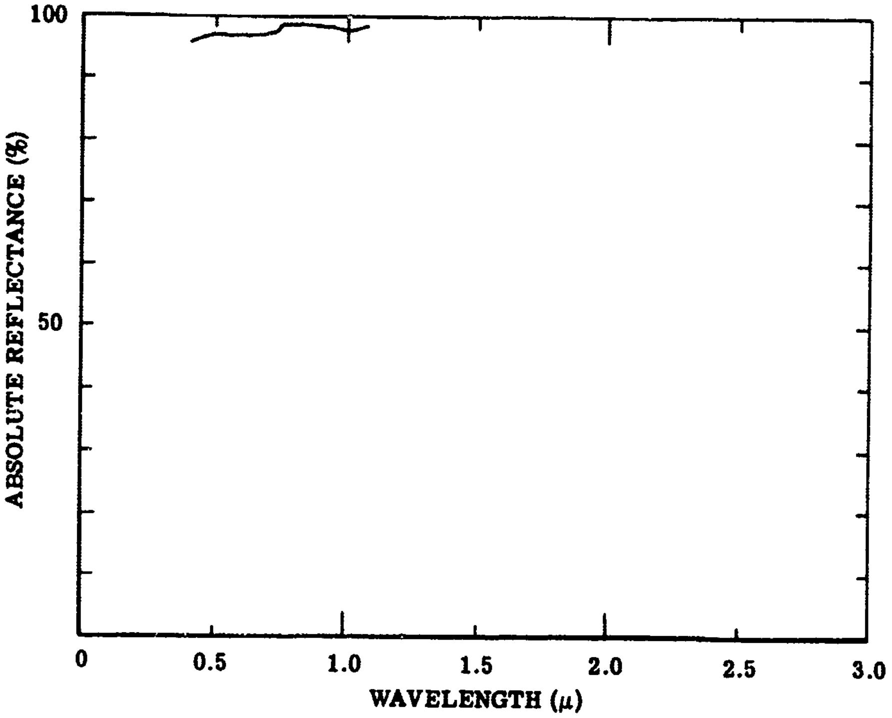


FIGURE 3-16. ABSOLUTE REFLEC NCE OF PRESSED $BaSO_4$ [3-8]

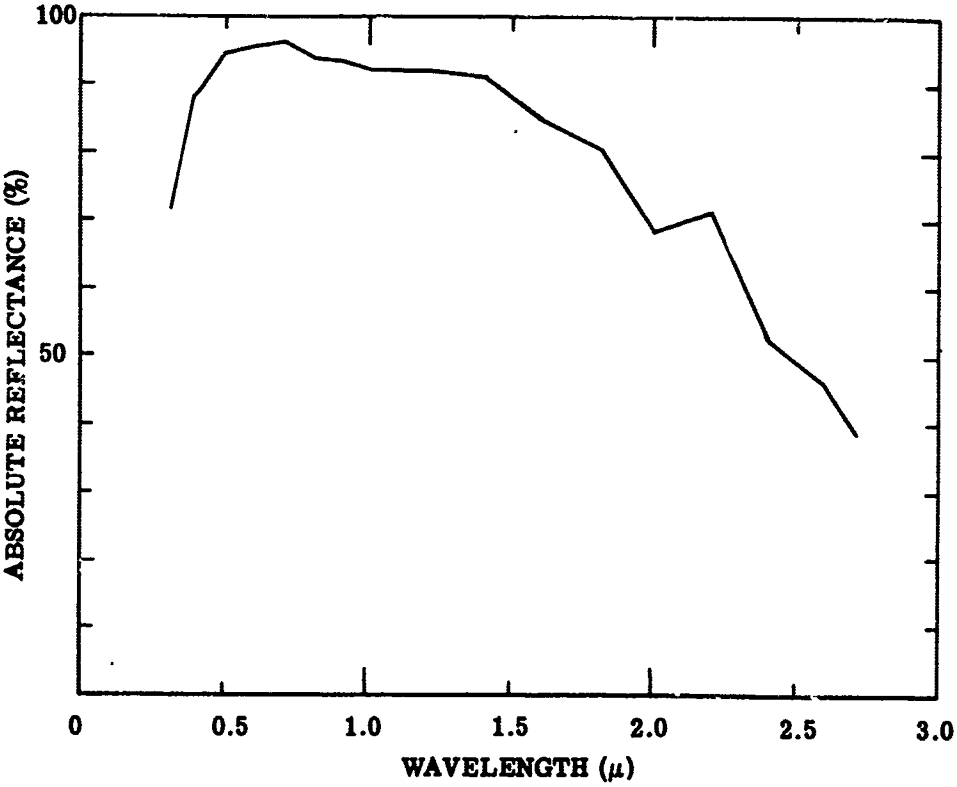


FIGURE 3-17. ABSOLUTE REFLECTANCE OF PRESSED $MgCO_3$ [3-7]

3.4. SUMMARY OF EXPERIMENTS YIELDING OPTICAL DATA

The documents from which the unclassified optical data have been extracted are briefly summarized on the following pages. These summaries are included to facilitate use of the data presented in section 3.7. Information on the experimental platform, instrumentation, reflectance standards (for relative data) and other related matters has been included, and additional references describing some of the instrumentation in greater detail are cited. As already indicated, the code consisting of the letter B and five digits at the beginning of each entry is the accessions number assigned to the document by the Target Signature Analysis Center. All curves extracted from the document carry this accessions number plus a number from 001 to 999, which is an arbitrary designation assigned to specific curves. The two numbers together constitute a curve's identification number. Bibliographical information on each of the documents is stated; the user is referred to the original source if more detailed information is required.

B-00829. Hopkins: Reflectance Curves of Various Leaves, unpub., USAERDL, Ft. Belvoir, Va., 1955 (est.).

Platform: laboratory

Instrument: USAERDL spectrophotometer (original design)
Quantity measured: ρ_d
Wavelength range: 0.9 to 2.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Comments: This instrument is no longer in operation. Basically, it consisted of a Gaertner monochromator coupled with an integrating sphere.

B-00830. Hopkins: Reflectance Curves of Various Soils, unpub., USAERDL, Ft. Belvoir, Va., 1955 (est.).

Platform: laboratory

Instrument 1: Beckman DU spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.2 μ
Reflectance attachment: ellipsoidal mirror that collects radiation diffusely reflected from the sample
Reflectance standard: MgO
Additional reference: 3-10

Instrument 2: USAERDL spectrophotometer (original design)
Quantity measured: ρ_d
Wavelength range: 0.9 to 2.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Comments: This instrument is no longer in operation. Basically, it consisted of a Gaertner monochromator coupled with an integrating sphere.

B-01035. Sigler: Airborne Rapid Scan Spectrometer and Earth Reflectance Measurements as a Function of Altitude (Final Report), Inst. Div., Radiation, Inc., Orlando, Fla., July 1957.

Platform: airborne

Instrument: Perkin-Elmer 108 rapid-scan spectrometer
Quantity measured: α (albedo)
Wavelength range: 0.4 to 3.0 μ
Reflectance standard: data are absolute
Comments: These data were obtained by rotating a periscope (installed through a hole in the side of the aircraft) 180° to alternately view the sky radiation and that reflected by the earth.

B-01049. Billings: Reflection of Visible and Infrared Radiation from Leaves of Different Ecological Groups, Am. J. Bot., Vol. 38, 1951.

Platform: laboratory

Instrument: Beckman DU spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.1 μ
Reflectance attachment: ellipsoidal mirror that collects radiation diffusely reflected from the sample
Reflectance standard: $MgCO_3$
Additional reference: 3-10

B-01175. Derksen, Monahan: A Reflectometer for Measuring Diffuse Reflectance in the Visible and Infrared Regions, J. Opt. Soc. Am., Vol. 42, No. 4, 1952.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.0 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references. 3-2, 3-11, 3-12
Comments: See section 3.2.1.

Instrument 2: Perkin-Elmer 12-B spectrometer
Quantity measured: ρ_d
Wavelength range: 1.0 to 2.7 μ
Reflectance attachment: Coblentz hemisphere
Reflectance standard: MgO
Additional references: 3-13, 3-14
Comments: See section 3.2.3.

B-01176. Wright: Spectral Reflectance Characteristics of Camouflage Greens Versus Camouflage Detection, IRMA III Report No. 1281, USAERDL, Ft. Belvoir, Va., March 1953.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-01337. Dvornik, Orr, Young: Reflectance Curves of Soil, Rocks, Vegetation, and Pavement, Report No. 1746R, USAERDL, Ft. Belvoir, Va., April 1963.

Platform: ground-based field

Instrument: USAERDL portable spectrophotometer
Quantity measured: ρ'
Wavelength range: 0.25 to 2.5 μ
Reflectance attachment: collecting mirror
Reflectance standard: measured relative to thermoglass and values converted to MgO
Additional reference: 3-15
Comments: See section 3.2.4.

B-01339. Haas et al.: Spectrophotometric and Colorimetric Study of Color Transparencies of Some Natural Objects, Report No. 4794, NBS, Washington, D. C., March 1957.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-01352. Haas, et al.: Spectrophotometric and Colorimetric Study of Diseased and Rust Resisting Cereal Crops, Report No. 4591, NBS, Washington, D. C., July 1956.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-01353. Hall, Keegan, Schleter: Spectrophotometric and Colorimetric Change in the Leaf of a White Oak Tree under Conditions of Natural Drying and Excessive Moisture, Report No. 4322, NBS, Washington, D. C., September 1955.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-01367. Haas et al.: Spectrophotometric and Colorimetric Study of Foliage Stored in Covered Metal Containers, Report No. 4370, NBS, Washington, D. C., November 1955.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-01368. Haas et al.: Spectrophotometric and Colorimetric Record of Some Leaves of Trees, Vegetation and Soils, Report No. 4528, NBS, Washington, D. C., April 1956.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-01370. Duntley: Reflectance of Natural Terrains, Report No. OSRD 6554, Louis Comfort Tiffany Foundation, Oyster Bay, N. Y., September 1945.

Platform: airborne

Instrument: Eastman Kodak spectrogeograph
Quantity measured: α (albedo)
Wavelength range: 0.43 to 0.73 μ
Reflectance standard: data are absolute
Comments: The data were obtained by rotating a periscope (installed through a hole in the side of the aircraft) 180° to alternately view the sky radiation and that reflected by the earth. The spectrophotometric curves obtained were derived from densitometer readings of spectrograms.

B-01643. Reflectance Data on Crops (unpub.), Mine Detection Branch, USAERDL, Ft. Belvoir, Va., 1962 (est.).

Platform: ground-based field

Instrument: USAERDL portable spectrophotometer
Quantity measured: ρ'
Wavelength range: 0.25 to 2.5 μ
Reflectance attachment: collecting mirror
Reflectance standard: measured relative to thermoglass and values converted to MgO
Additional reference: 3-15
Comments: See section 3.2.4.

B-01761. Shull: A Spectrophotometric Study of Reflection of Light from Leaf Surfaces, Botan. Gaz., Vol. 87, 1929.

Platform: laboratory

Instrument: spectrophotometer (original design)
Quantity measured: ρ_d
Wavelength range: 0.43 to 0.70 μ
Reflectance attachment: integrating sphere
Reflectance standard: $MgCO_3$

B-01813. Kronstein: Research, Studies, and Investigations on Spectral Reflectances and Absorption Characteristics of Camouflage Paint Materials and Natural Objects, Final Report, Contract DA-44-009 ENG-1447, New York Univ., New York, March 1955.

Platform: laboratory

Instrument 1: Beckman DK-2 spectrophotometer
  Quantity measured: ρ_d
  Wavelength range: 0.4 to 2.5 μ
  Reflectance attachment: integrating sphere
  Reflectance standard: data obtained relative to $MgCO_3$, but values converted to absolute
  Comments: See section 3.2.2.

Instrument 2: Perkin-Elmer Model 12 and Model 112 spectrophotometers
  Quantity measured: ρ_d
  Wavelength range: 2.5 to 15 μ
  Reflectance attachment: Coblentz hemisphere
  Reflectance standard: Specular samples were measured relative to a rhodium mirror and diffuse samples relative to flowers of sulphur. Data have been converted to absolute values.
  Comments: See section 3.2.3.

B-01948. Dinger: The Absorption of Radiant Energy in Plants, Ph.D thesis, Iowa State Univ., Iowa City, 1941.

Platform: laboratory

Instrument: photometric goniometer (original design)
Quantity measured: ρ', τ' (bidirectional transmittance)
Wavelength range: 0.35 to 0.75 μ
Reflectance standard: bond paper
Comments: Reflectance data were obtained by focusing monochromatic light on the sample at normal incidence, then examining the reflected component at 10° off normal. Bond paper, believed by the experimenter to have scattering properties similar to those of foliage, was measured in the same way, and the ratio of the two quantities is the reported reflectance. Transmittance measurements relative to bond paper were also made.

B-02250. Haas et al.: Spectrophotometric and Colorimetric Study of Color Transparencies of Some Man-Made Objects, Report No. 4953, NBS, Washington, D. C., November 1957.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: For transmittance measurements, the sample was placed at one of the entrance ports of the sphere, and MgO covered both the sample and reference ports. See section 3.2.1 also.

B-02418. Spectral Reflectance of Several Crops (unpub.), Purdue Univ., Lafayette, Ind., 1964.

Platform: laboratory

Instrument: Beckman DK-2 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.28 to 2.6 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Comments: See section 3.2.2.

B-03070. Gates et al.: Spectral Properties of Plants, Appl. Opt., Vol. 4, No. 1, 1965.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1. For transmittance measurements, the sample was placed at one of the entrance ports of the sphere, and MgO covered both the sample and reference ports.

Instrument 2: Cary 14 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.385 to 2.2 μ
Reflectance attachment: integrating sphere (Cary 1411)
Reflectance standard: MgO
Additional reference: 3-16
Comments: Operation is similar to that of the integrating sphere discussed in section 3.2.2. However, in this experiment the sample was illuminated with white light, and the radiation was spectrally dispersed after reflection. Also, the sample was viewed at 60° off normal.

B-03117. Turner: Reflectance Properties of Thin Films and Multilayers, Presented at Conf. on Radiative Transfer from Solid Materials, Boston, Mass., December 1960.

No descriptive information on these data was available.

B-03231. Dunkle, Gier: Spectral Reflectivity of Certain Minerals and Similar Inorganic Materials, Inst. Eng. Res., Univ. of Calif., Berkeley, January 1954, AD 26 394.

Platform: laboratory

Instrument: Perkin-Elmer spectrophotometer
Quantity measured: ρ_d
Wavelength range: 1.0 to 15.0 μ
Reflectance attachment: Hohlraum
Reflectance standard: data are absolute
Comments: See section 3.2.6.

B-03256. Clark, Hardy, Vinegar: Goniometric Spectrometer for the Measurement of Diffuse Reflectance and Transmittance of Skin in the Infrared Region, J. Opt. Soc. Am., Vol. 43, No. 11, 1953.

Platform: laboratory

Instrument: goniometer coupled with a Wadsworth-Littrow spectrometer
Quantity measured: ρ_d
Wavelength range: 0.55 to 2.5 μ
Reflectance attachment: see comments below
Reflectance standard: data are absolute
Comments: Measurement of diffuse reflectance was obtained by illuminating the sample with monochromatic light and automatically scanning the detector about the sample. The detector thus recorded the reflectance integrated over 180°. This process was repeated at several discrete wavelengths.

B-03258. Ashburn, Wilson: Spectral Diffuse Reflectance of Desert Surfaces, J. Opt. Soc. Am., Vol. 46, No. 8, 1956.

Platform: ground-based field and airborne

Instrument: albedometer (original design)
Quantity measured: α (albedo)
Wavelength range: 0.4 to 0.65 μ
Reflectance attachment: integrating sphere
Reflectance standard: unspecified, if any
Additional reference: 3-17
Comments: No information on whether the data are absolute or relative was available.

B-03303. Jacquez, Kuppenheim: Spectral Reflectance of Human Skin in the Region 235-1000 Millimicrons, J. Appl. Physiol., Vol. 7, March 1955.

Platform: laboratory

Instrument 1: Beckman DU spectrophotometer
  Quantity measured: ρ_d
  Wavelength range: 0.235 to 0.70 μ
  Reflectance attachment: ellipsoidal mirror that collects radiation diffusely reflected from the sample
  Reflectance standard: MgO
  Additional reference: 3-10

Instrument 2: General Electric spectrophotometer
  Quantity measured: ρ_d
  Wavelength range: 0.4 to 1.0 μ
  Reflectance attachment: integrating sphere
  Reflectance standard: MgO
  Additional references: 3-2, 3-11, 3-12
  Comments: See section 3.2.1.

B-03304. Dimmitroff et al.: Spectral Reflectance of Human Skin in the Region 0.7-2.6 Microns, J. Appl. Physiol., Vol. 8, November 1955.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
  Quantity measured: ρ_d
  Wavelength range: 0.4 to 0.7 μ
  Reflectance attachment: integrating sphere
  Reflectance standard: MgO
  Additional references: 3-2, 3-11, 3-12
  Comments: See section 3.2.1

Instrument 2: Perkin-Elmer infrared spectrometer
  Quantity measured: ρ_d
  Wavelength range: 0.7 to 2.6 μ
  Reflectance attachment: integrating sphere
  Reflectance standard: MgO
  Additional references: 3-13, 3-18
  Comments: This instrument is similar in operation to the Beckman DK-2 spectrophotometer discussed in section 3.2.2.

B-03305. Heer, Kuppenheim: Spectral Reflectance of White and Negro Skin between 440 and 1000 Millimicrons, J. Appl. Physiol., Vol. 4, April 1952.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.431 to 1.0 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-03333. Infrared Optical Measurements, Report No. 8626, NBS, Washington, D. C., December 1964.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

Instrument 2: Cary 14 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.26 to 2.2 μ
Reflectance attachment: integrating sphere (Cary 1411)
Reflectance standard: MgO
Additional reference: 3-16
Comments: Operation is similar to that of the integrating sphere discussed in section 3.2.2. However, in this experiment the sample was illuminated with white light, and the radiation was spectrally dispersed after reflection. Also, the sample was viewed at 60° off normal.

Instrument 3: Cary 90 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 2.5 to 15 μ
Reflectance attachment: white hemisphere
Reflectance standard: data are absolute
Additional reference: 3-19
Comments: The White attachment is basically a Coblentz-type hemisphere (see sec. 3.2.3). The sample was hemispherically illuminated with white light, and the reflected radiation was viewed slightly off normal.

B-03355. Miscellaneous data from several sources including N. Y. Univ., Syracuse Univ., and Detroit Arsenal, Warren, Mich. (unpub.), 1950 (est.).

Platform: laboratory

Instrument: see comments below
Quantity measured: ρ_d, τ
Wavelength range: 0.4 to 15.0 μ
Reflectance attachment: see comments below
Reflectance standard: see comments below
Comments: Several unpublished, miscellaneous curves from various sources are collected here. Curves B-03355-001 through B-03355-006 are transmission data on optical materials, and no descriptive information on the instrumentation for them was available. Curves B-03355-007 through B-03355-009 are the reflectance of water from 1 to 15 μ, for angles of incidence of 0^o, 60^o, and 80^o. Again, no descriptive information on this experiment was available. Curves B-03355-010 through B-03355-037 are reflectance data on foliage species for the visible and near-infrared regions and appear to be standard spectrophotometric curves (ρ_d). Curves B-03355-039 through B-03355-046 are the reflectance (ρ_d) of paints in the 0.4 to 2.6-μ interval and are believed to have been obtained, relative to MgO, on the Beckman DK-2 spectrophotometer (see sec. 3.2.2). Curves B-03355-047 through B-03355-053 were obtained on the Bausch and Lomb spectrophotometer (see under B-04642).

B-03374. Olson et al.: An Analysis of Measurements of Light Reflectance from Tree Foliage Made during 1960 and 1961, Report on Contract NR-387-025, Agricultural Expt. Sta., University of Illinois, Urbana, June 1964, AD 608-114.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 0.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-03463. Specular Spectral Reflectance of Paints from 0.4 to 40.0 Microns, Report No. 31, U. S. Dept. of Commerce, Washington, D. C., April 1964.

Platform: laboratory

Instrument 1: Cary 14 spectrophotometer
  Quantity measured: ρ'
  Wavelength range: 0.4 to 2.5 μ
  Reflectance attachment: Cary Model 1413 specular-reflectance attachment
  Reflectance standard: aluminum mirror
  Comments: Angle of incidence was 8^o off normal.

Instrument 2: Beckman IR-7 spectrophotometer
  Quantity measured: ρ'
  Wavelength range: 2.5 to 15 μ
  Reflectance attachment: Cary Model 24425 specular-reflectance attachment
  Reflectance standard: aluminum mirror
  Comments: Angle of incidence was 30^o off normal.

B-03559. Barbrow: Calibration on the Spectral Directional Reflectance of Six Samples of Red Pine Needles (unpub.), NBS, Test No. G-35201-1, Agr. Res. Serv., Beltsville, Md., November 1964.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

Instrument 2: Cary 14 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.26 to 2.2 μ
Reflectance attachment: integrating sphere (Cary 1411)
Reflectance standard: MgO
Additional reference: 3-16
Comments: Operation is similar to that of the integrating sphere discussed in section 3.2.2. However, in this experiment, the sample was illuminated with white light, and the radiation was spectrally dispersed after reflection. Also, the sample was viewed at 60° off normal.

Instrument 3: Cary 90 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 2.5 to 15 μ
Reflectance attachment: White hemisphere
Reflectance standard: data are absolute
Additional reference: 3-19
Comments: The White attachment is basically a Coblentz-type hemisphere (see sec. 3.2.3). The sample was hemispherically illuminated with white light, and the reflected radiation was viewed slightly off normal.

B-03804. Morris, Olson: Determination of Emissivity and Reflectivity Data on Aircraft Structural Materials, Part II, Supplement I, Report No. 56-222, Armour Res. Foundation, Chicago, Ill., October 1958, AD 202 494.

Platform: laboratory

Instrument 1: original design using a Perkin-Elmer monochromator
Quantity measured: ρ_d
Wavelength range: 0.3 to 0.4 μ and 0.7 to 2.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: data obtained relative to $MgCO_3$, but values converted to absolute
Comments: The instrument is similar in operation to the Beckman DK-2 spectrophotometer discussed in section 3.2.2, except that it is operated in the single-beam mode. Ratio recording is achieved by the substitution method.

Instrument 2: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 0.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: data obtained relative to $MgCO_3$, but values converted to absolute
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-03858. Betz et al.: Techniques for Measurements of Total Normal Emissivity, Solar Absorptivity and Presentation of Results, Armour Res. Foundation, Chicago, Ill., October 1958.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 0.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: data obtained relative to $MgCO_3$, but values converted to absolute
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

Instrument 2: Original design using a Perkin-Elmer monochromator
Quantity measured: ρ_d
Wavelength range: 0.3 to 0.4 μ and 0.7 to 2.7 μ
Reflectance attachment. integrating sphere
Reflectance standard: data obtained relative to $MgCO_3$, but values converted to absolute
Comments: This instrument is similar to the integrating sphere device described in section 3.2.[illegible] The sample and reference are alternately illuminated with monochromatic energy at 9° off normal.

B-03959. Edwards, Hall: Far Infrared Reflectance of Spacecraft Coatings, presented at the AIAA Thermophysics Specialist Conference, Monterey, Calif., September 1965.

Platform: laboratory

Instrument 1: Perkin-Elmer 98 monochromator coupled with an integrating sphere (original design)
Quantity measured: ρ_d
Wavelength range: 0.33 to 2.5 μ
Reflectance attachment: integrating sphere
Reflectance standard: data are absolute
Additional reference: 3-20
Comments: This instrument operates in the single-beam mode.

Instrument 2: Perkin-Elmer 98 monochromator with Hohlraum attachment
Quantity measured: ρ_d
Wavelength range: 1.5 to 15 μ
Reflectance attachment: Hohlraum
Reflectance standard: data are absolute
Additional references: 3-21 through 3-25
Comments: See section 3.2.6.

B-03960. Albright et al.: Solar Absorptance and Thermal Emittance of Aluminum Coated with Surface Films of Evaporated Aluminum Oxide, presented at the AIAA Thermophysics Specialist Conference, Monterey, Calif., September 1965.

Platform: laboratory

Instrument: Perkin-Elmer Model 13 and Model 20 spectrophotometers
Quantity measured: ρ'
Wavelength range: 5 to 15 μ
Reflectance attachment: specular-reflectance attachment
Reflectance standard: not specified

B-03995. Krinov: Spectral Reflectance Properties of Natural Formations (trans. by Belkov), Technical Translation No. 439, Nat. Res. Council of Canada, Ottawa, 1953.

Platform: Ground-based field and airborne

Instrument: several spectrographs
Quantity measured: ρ'
Wavelength range: 0.4 to 0.9 μ
Reflectance attachment: none
Reflectance standard: barite paper, gypsum
Comments: See section 3.2.5.

B-04424. Hall: Measurement on the Optical Properties of Snow, unpub., Willow Run Laboratories of the Institute of Science and Technology, The University of Michigan, Ann Arbor, 1965 (est.).

Platform: laboratory

Instrument: interferometric device
Quantity measured: ρ'
Wavelength range: 0.95 to 2.7 μ
Reflectance standard: flowers of sulphur

B-04616. Myers, Thomas: Reflectance of Cotton Leaves Under Various Conditions of Drying (unpub. data), U. S. Dept. of Agr., Agr. Res. Serv., Weslaco, Texas, June 1966.

Platform: laboratory

Instrument: Beckman DK-2 spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.5 to 2.5 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO for ρ_d, but values of τ_d are absolute
Comments: For transmittance measurements, the sample was positioned at one of the entrance ports of the integrating sphere, and MgO was placed at both the sample and reference ports (cf. fig. 3-3). Thus, energy transmitted into a hemisphere was seen by the detector. (See section 3.2.2.)

B-04642. Wilburn: Spectra Notebook, Vol. I; Material, Target and Background Data, Tech. Report No. 8863, Components Research and Development Laboratories, U. S. Army Tank Automotive Center, Warren, Mich., May 1965.

Platform: laboratory

Instrument: Bausch and Lomb 808 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 0.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO

B-04802. Korbel: Thermal and Optical Characteristics of Eniwetok Sand (Final Report), Materials Lab., New York Naval Shipyard, Brooklyn, N. Y., November 1952.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.08 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-04803. Cooper, Derksen: Spectral Reflectance and Transmittance of Forest Fuel Materials (Final Report), Material Lab., New York Naval Shipyard, Brooklyn, N. Y., March 1952.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
  Quantity measured: ρ_d, τ_d
  Wavelength range: 0.4 to 1.0 μ
  Reflectance attachment: integrating sphere
  Reflectance standard: ρ_d data obtained relative to MgO, but values converted to absolute; values of τ_d are absolute
  Additional references: 3-2, 3-11, 3-12
  Comments: For transmittance measurements, the sample was placed at one of the entrance ports of the integrating sphere, and MgO covered both the sample and reference ports. See section 3.2.1 also.

Instrument 2: Perkin-Elmer infrared spectrometer
  Quantity measured: ρ_d, τ_d
  Wavelength range: 1.0 to 2.7 μ
  Reflectance attachment: Coblentz hemisphere
  Reflectance standard: ρ_d data obtained relative to MgO, but converted to absolute; values of τ_d are absolute
  Additional references: 3-13, 3-14
  Comments: See section 3.2.3.

B-04804. Hovis: Infrared Reflectivity of Some Common Minerals, Appl. Opt., Vol. 5, No. 2 (1966).

Platform: laboratory

Instrument 1: Beckman DK-2 spectrophotometer
  Quantity measured: ρ_d
  Wavelength range: 0.5 to 2.5 μ
  Reflectance attachment: integrating sphere
  Reflectance standard: unspecified
  Comments: See section 3.2.2.

Instrument 2: Cary 90 spectrophotometer
  Quantity measured: ρ_d
  Wavelength range: 2.5 to 6.0 μ
  Reflectance attachment: White hemisphere
  Reflectance standard: data are absolute
  Additional reference: 3-19
  Comments: The White attachment is basically a Coblentz type hemisphere (see sec. 3.2.3). The sample was hemispherically illuminated with white light, and the reflected radiation was viewed slightly off normal.

B-04805. Byrne, Mancinelli: Optical Transmittance, Reflectance, and Absorptance of Materials (Final Report), Materials Lab., New York Naval Shipyard, Brooklyn, N. Y., March 1954.

Platform: laboratory

Instrument 1: Beckman DU spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.22 to 0.4 μ
Reflectance attachment: ellipsoidal mirror that collects radiation diffusely reflected from the sample
Reflectance standard: ρ_d data obtained relative to MgO, but values converted to absolute; values of τ_d are absolute
Additional reference: 3-10

Instrument 2: General Electric spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.4 to 1.0 μ
Reflectance attachment: integrating sphere
Reflectance standard: ρ_d data obtained relative to MgO, but values converted to absolute; values of τ_d are absolute
Additional references: 3-2, 3-11, 3-12
Comments: For transmittance measurements, the sample was placed at one of the entrance ports of the integrating sphere, and MgO covered both the sample and reference ports. See section 3.2.1 also.

Instrument 3: Perkin-Elmer infrared spectrometer
Quantity measured: ρ_d, τ_d
Wavelength range: 1.0 to 2.7 μ
Reflectance attachment: Coblentz hemisphere
Reflectance standard: ρ_d data obtained relative to MgO, but converted to absolute; values of τ_d are absolute
Additional references: 3-13, 3-14
Comments: See section 3.2.3.

B-04806. Byrne, Schilling: Spectral Reflectance and Transmittance of Interior Fuel Materials (Final Report), Materials Lab., New York Naval Shipyard, Brooklyn, N. Y., November 1953.

Platform: laboratory

Instrument 1: Beckman DU spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.22 to 0.4 μ
Reflectance attachment: ellipsoidal mirror that collects radiation diffusely reflected from the sample
Reflectance standard: ρ_d data obtained relative to MgO, but values converted to absolute; values of τ_d are absolute
Additional reference: 3-10

Instrument 2: General Electric spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.4 to 1.0 μ
Reflectance attachment: integrating sphere
Reflectance standard: ρ_d data obtained relative to MgO, but values converted to absolute; values of τ_d are absolute
Additional references: 3-2, 3-11, 3-12
Comments: For transmittance measurements, the sample was placed at one of the entrance ports of the integrating sphere, and MgO covered both the sample and reference ports. See section 3.2.1 also.

Instrument 3: Perkin-Elmer infrared spectrometer
Quantity measured: ρ_d, τ_d
Wavelength range: 1.0 to 2.7 μ
Reflectance attachment: Coblentz hemisphere
Reflectance standard: ρ_d data obtained relative to MgO, but converted to absolute; values of τ_d are absolute
Additional references: 3-13, 3-14
Comments: See section 3.2.3.

B-04679. Edwards et al.: Basic Studies on the Use and Control of Solar Energy (Annual Report, Aug. 1959 to Aug. 1960), Univ. of California, Los Angeles, October 1960.

Platform: laboratory

Instrument 1: Beckman DK-2 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.25 to 2.5 μ
Reflectance attachment: integrating sphere
Reflectance standard: data obtained relative to MgO, but values converted to absolute
Comments: See section 3.2.2.

Instrument 2: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.0 μ
Reflectance attachment: integrating sphere
Reflectance standard: data obtained relative to $MgCO_3$, but values converted to absolute
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

Instrument 3: Perkin-Elmer spectrophotometer
Quantity measured: ρ_d
Wavelength range: 1.25 to 15 μ
Reflectance attachment: Hohlraum
Reflectance standard: data are absolute
Comments: See section 3.2.6.

B-05289. Ohlsen, Etemad: Spectral and Total Radiation Data of Various Aircraft Materials, North American Aviation, Inc., Los Angeles Div., Eng. Dept., Los Angeles, Calif., 23 July 1957.

Platform: laboratory

Instrument 1: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.4 to 1.0 μ
Reflectance attachment: integrating sphere
Reflectance standard: data obtained relative to $MgCO_3$, but values converted to absolute
Comments: See section 3.2.1.

Instrument 2: Original design using a Perkin-Elmer 83 monochromator
Quantity measured: ρ_d
Wavelength range: 1 to 25 μ
Reflectance attachment: Hohlraum
Reflectance standard: Data are absolute
Comments: A Hohlraum device is discussed in section 3.2.6.

B-05370. Betz et al.: Determination of Emissivity and Reflectivity Data on Aircraft Structural Materials, Part I: Techniques for Measurements of Total Normal Emissivity and Reflectivity with Some Data on Copper and Nickel, Document Service Center, Knott Bldg., Dayton, Ohio, October 1956.

Platform: laboratory

Instrument: General Electric spectrophotometer
Quantity measured: ρ_d
Wavelength range: 0.38 to 0.7 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO
Additional references: 3-2, 3-11, 3-12
Comments: See section 3.2.1.

B-013522. Funai, Starr, Streed: Principles of Infrared Camouflage for Low Temperature Targets, Naval Civil Engineering Lab., Port Hueneme, Calif., July 1953, AD 139 720.

Platform: laboratory

Instrument: Beckman IR-3 spectrophotometer
Quantity measured: ρ_d
Wavelength range: 1.8 to 13 μ
Reflectance attachment: Hohlraum
Reflectance standard: data are absolute
Comments: See section 3.2.6.

B-19999, B-20000, B-20001, B-20002. Reflectance of Target and Background Materials, unpublished data from the Air Force Target Signature Measurement Program, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, Ann Arbor, 1967.

Platform: laboratory

Instrument: Beckman DK-2 spectrophotometer
Quantity measured: ρ_d, τ_d
Wavelength range: 0.28 to 2.6 μ
Reflectance attachment: integrating sphere
Reflectance standard: MgO for ρ_d, but values of τ_d are absolute
Comments: For transmittance measurements, the sample was positioned at one of the entrance ports of the integrating sphere, and MgO was placed at both the sample and reference ports (cf. fig. 3-3). Thus, energy transmitted into a hemisphere was seen by the detector. See section 3.2.2 also.

3.5. DATA FORMAT

In order to transfer a data curve from a source document to the Target Signature Library, the curve is first semi-automatically digitized and keypunched on IBM cards. Great care is exercised to preserve all significant details of the original curve except those attributable to instrument noise. Data points are taken in such a way that the new curve formed by connecting the data points with straight lines will duplicate the original curve. In essence, this amounts to taking data points at all significant inflection points on the original curve, so that relatively few data points are required to describe a smooth curve, although many points may be required to describe a highly erratic curve. The keypunched cards are the mechanism for transferring the data to magnetic tape in the Target Signature Library and for printing out data curves in a standard format on a plotting machine.

The header information above each of the data curves includes the curve's identification number, the curve's title, subject codes, and parameter information. The identification number consists of the internal control letter B and eight digits. The first five digits identify the document from which the data were taken. (Section 3.4 lists the documents by control letter and these five digits.) The last three digits of the identification number have been arbitrarily assigned by the Target Signature Analysis Center for retrieval and to identify a particular curve within a given source document. The subject code is a group of letters assigned to each curve to permit retrieval by subject. Each letter represents a specific descriptor, and each curve is assigned as many letters and as many codes as are required to describe it adequately. The Target Signature Subject-Code List (table 1-1) explains these codes. As an example, a curve may be described as follows:

Object measured: loam (BFEA)
Instrumentation: General Electric spectrophotometer (CDB)
Experimental platform: Laboratory (CED)
Quantity measured: Directional reflectance with the specular component included in the measurement (DFAA)
Reflectance standard: MgO (DFCE)
Spectral interval: 0.4 to 0.7 μ (ECB) and 0.7 to 1.5 μ (ECCA)

The conditions of the experiment, called parameter information, are also listed on the printed header in abbreviated form. This information is derived from the original source when possible. For many of the data, very few parameter entries appear either because the source did not document all of the experimental parameters or because some parameters are not applicable to all measurements, e.g., altitude and range are not parameters for laboratory measurements. Table 3-1 is the key for interpreting this parameter information. Figure 3-18 illustrates the angle parameters pertinent to some measurements.

The optical data in this section are arranged according to the subject code most descriptive of the object or sample measured. Since the Target Signature Subject-Code List contains a large number of specific types of target and background categories, it was necessary in some cases to group the data into somewhat broader categories. These are cross-indexed by subject in section 2.

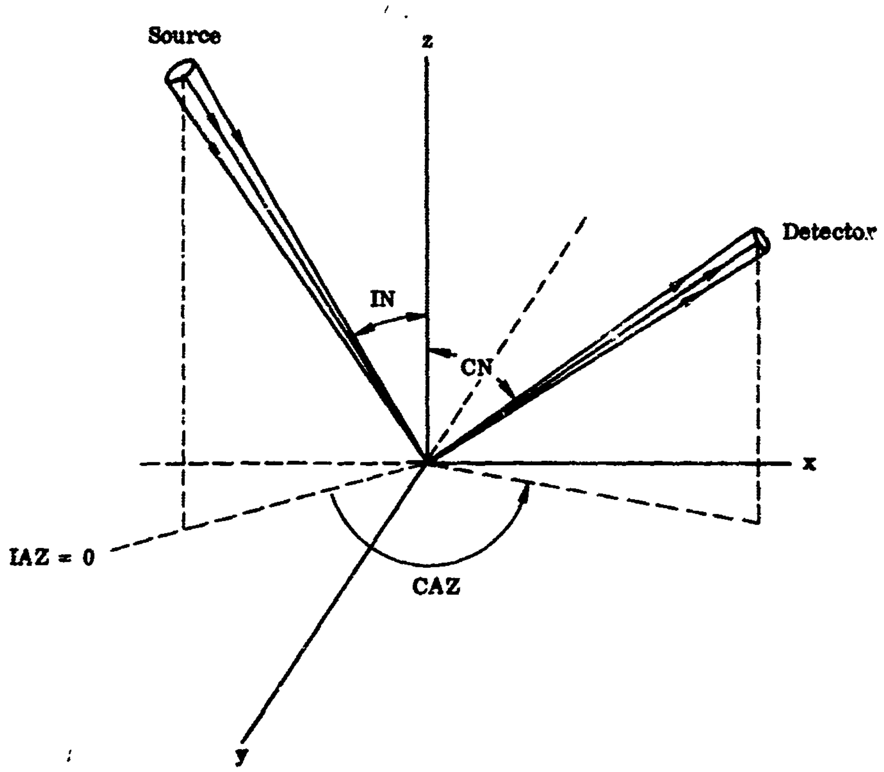


FIGURE 3-18. GEOMETRY FOR SOME SPECIFIED OPTICAL DATA PARAMETERS

TABLE 3-1. OPTICAL DATA PARAMETERS

DATE	Date of measurement (day, month, and year)
TIME	Time of measurement (24-hour clock)
LAT	Latitude of measurement (field measurement) or of location at which specimen was collected (laboratory measurement)
LONG	Longitude of measurement or of location at which specimen was collected, as with LAT
ALT	Altitude of experimental platform (thousands of feet)
RANGE	Slant range (thousands of feet)
DAYS RE	Number of days sample had been removed from its natural environment
IN*	Incidence angle (degrees from normal)
IAZ*	Azimuth of incident radiation (degrees)
CN**	Collection angle (degrees from normal)
CAZ**	Azimuth of collection angle (degrees)
IRR	Type of target irradiation coded as follows: A Sun B Moon C Skylight (extended source) D Laser E Other artificial point sources
OBST	Obstructions in the air that prevent a clear view of the target, coded as follows: A Smoke B Haze C Dust D Sand E Fog F Drizzle G Rain H Snow I Hail
TTEMP	Temperature of target or measured object (°K)
WIND SP	Average wind speed (mph)
WIND DI	Wind direction
CLD	Total cloud cover coded as follows: A 0 to 0.1 B 0.2 to 0.5 C 0.6 to 0.8 D 0.9 to 1.0
VIS	Visibility (miles)
TEMP	Temperature of environment (°F)
DEW PT	Dew point temperature (°F)
N AVE	Number of curves or measurements averaged to make up this curve

---

*These angles are defined only if the major portion of radiation incident on the target comes from a point source, e.g., the sun (see fig. 3-18).

**These angles are defined when the target is observed from one direction (see fig. 3-18).

3.6. REFERENCES FOR SECTION 3

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Insert Optical Spectral Data Sheets Here

4

OPTICAL REFLECTANCE DISTRIBUTION FUNCTION DATA

The data treated in this section were obtained through a reflectance measurement of a different type than that used for the data of section 3. As pointed out in section 3.1, the term "reflectance" by itself is vague and should not be used unless the exact type of reflectance is indicated. The common concept for reflectance employs a dimensionless quantity, perhaps as a function of wavelength and always between the values 0 and 1 (or 0% and 100%). Further, it is assumed that the total power reflected by a surface is collected and the ratio of this to the total incident power is the reflectance of that surface; however, situations where total powers are involved seldom occur naturally. Laboratory instruments have been built to approximate or simulate the conditions for such a total reflectance measurement, but each type of instrument (sec. 3.2) really measures only its particular type of reflectance.

Section 3.1 contains a derivation of a "general reflectance" ρ', called bidirectional reflectance, which is based on a directional source and a point receiver; thus the problems of collecting all reflected power or illuminating the surface from all directions are avoided. However, ρ' is not really a reflectance. Since the initial publication of that derivation, the symbol ρ' has been changed to f_r and the name from "bidirectional reflectance" to "quadravariate reflectance distribution function" (4RDF) [4-1] (this notation is used in this section). This was necessary because f_r is not simply a ratio of reflected to incident powers but is a measure of power per unit projected solid angle reflected in a given direction to power incident from a given source direction. Thus, f_r with units of reciprocal steradians (sr^{-1}), is not bounded by 0 and 1, and can vary with the source and receiver angles. This is the type of reflectance that occurs naturally and is of most value to the analysis of remote sensory systems.

A formal definition of the reflectance distribution function and some mathematical manipulations of 4RDF are given in section 4.1; section 4.2 contains equations illustrating how the 4RDF data can be applied to sensor systems. A description of the instrument used for collection of 4RDF data is given in section 4.3. The format used for presenting the data in this compilation is explained in section 4.4.

4.1. DEFINITION OF THE REFLECTANCE DISTRIBUTION FUNCTION 4RDF

The definition given here is based on the treatment of reflectance and emissivity in the Handbook of Military Infrared Technology [4-1]. However, the symbols and terminology are those used in reference 4-2.

Consider radiant power incident on an element of surface area δA from direction θ_i, ϕ_i and contained within the a beam of solid angle $d\omega_i$, where θ_i is the polar and ϕ_i the azimuth angle relative to a coordinate system fixed to area δA, as shown in figure 4-1. If the radiant power source has a radiance of $L_i(\theta_i, \phi_i)$ in direction θ_i, ϕ_i, then the power incident on the surface from this source is

$$\delta P_i = L_i(\theta_i, \phi_i) \cos \theta_i \, \delta A \, d\omega_i \qquad (4\text{-}1)$$

$$= \delta E(\theta_i, \phi_i) \delta A$$

where

$$d\omega_i = \sin \theta_i \, d\theta_i \, d\phi_i$$

and

$$\delta E = L_i \, d\omega_i \cos \theta_i$$

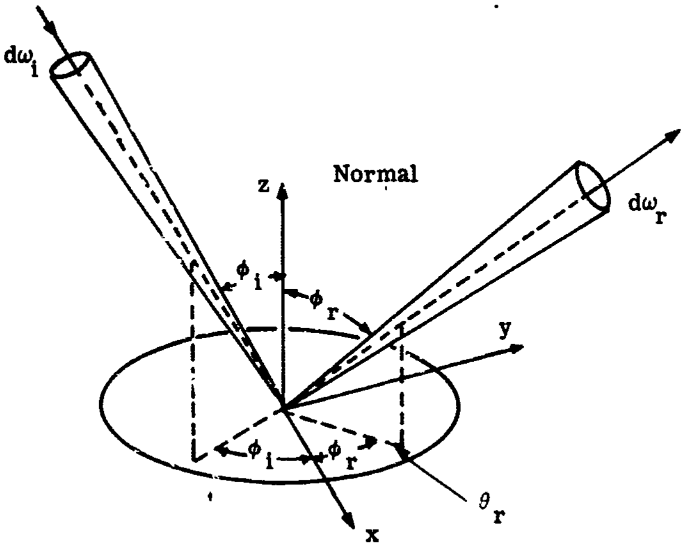

FIGURE 4-1. LOCAL COORDINATE SYSTEM FOR DETERMINING BIDIRECTIONAL REFLECTANCE

Now considering only the incident power δP_i from direction θ_i, ϕ_i, the radiant intensity $\delta I_r(\theta_r, \phi_r)$ of the area δA in direction θ_r, ϕ_r due to reflection or scattering is

$$\delta I_r(\theta_r, \phi_r) = \delta P_i(\theta_i, \phi_i) \, f_r(\theta_i, \phi_i; \theta_r, \phi_r) \cos \theta_r \qquad (4\text{-}2)$$

and since

$$\frac{\delta I_r}{\cos \theta_r \, \delta A} = \delta L_r$$

and

$$\frac{\delta P_i}{\delta A} = \delta E$$

we have the reflected radiance relation

$$\delta L_r(\theta_r, \phi_r) = \delta E(\theta_i, \phi_i) f_r(\theta_i, \phi_i; \theta_r, \phi_r) \qquad (4\text{-}3)$$

In equations 4-2 and 4-3, f_r is defined as the operator that acts on incident power or irradiance to give the reflected radiant intensity or reflected radiance, respectively, of an element δA that is a reflector or scatterer. Explicitly,

$$f_r(\theta_i, \phi_i; \theta_r, \phi_r) = \frac{\delta L_r(\theta_r, \phi_r)}{\delta E(\theta_i, \phi_i)} = \frac{\delta L_r(\theta_r, \phi_r)}{L_i(\theta_i, \phi_i) \cos \theta_i d\omega_i} \tag{4-4}$$

(The geometrical factor $\cos \theta_i$ in equation 4-2 does not appear in equation 4-3 because radiance is defined as watts per square centimeter per projected unit solid angle in the direction of propagation.) The reflectance distribution function, f_r, is thus the ratio of reflected radiance to irradiance, each quantity having a direction associated with it. If certain conditions are met, one may apply a theorem of reciprocity [4-3], generally attributed to Helmholtz, which states that the respective directions may be interchanged; i.e.,

$$f_r(\theta_1, \phi_1; \theta_2, \phi_2) = f_r(\theta_2, \phi_2; \theta_1, \phi_1)$$

From equation 4-4:

$$\delta L_r(\theta_r, \phi_r) = f_r \, \delta E(\theta_i, \phi_i) = f_r \frac{\delta P_i(\theta_i, \phi_i)}{\delta A}$$

But, the total power reflected by δA due to δE is

$$P_r = \delta A \int_h \delta L_r(\theta_r, \phi_r) \cos \theta_r d\omega_r$$

$$= \delta A \int_h f_r \frac{\delta P_i(\theta_i, \phi_i)}{\delta A} \cos \theta_r d\omega_r$$

where the integral is over the hemisphere above δA.

Now, if $\delta P_i(\theta_i, \phi_i)$ is the only source power considered and all its rays are contained within a small solid angle $d\omega_i$, then

$$P_r = P_i(\theta_i, \phi_i) \int_h f_r(\theta_i, \phi_i; \theta_r, \phi_r) \cos \theta_r d\omega_r$$

$$\frac{P_r}{P_i(\theta_i, \phi_i)} = \int_h f_r(\theta_i, \phi_i; \theta_r, \phi_r) \cos \theta_r d\omega_r$$

Now, it is recognized that

$$\frac{P_r}{P_i(\theta_i, \phi_i)} = \rho_{di}$$

where ρ_{di} is the quantity obtained when a detector is at one port of an integrating sphere and a sample at another port of the sphere is illuminated by a small beam of light from direction θ_i, ϕ_i. Thus,

$$\int_h f_r(\theta_i, \phi_i; \theta_r, \phi_r) \cos \theta_r \, d\omega_r = \rho_{di} \tag{4-5}$$

But,

$$\int_h \cos \theta_r \, d\omega_r = \pi$$

therefore,

$$\frac{\int_h f_r(\theta_i, \phi_i; \theta_r, \phi_r) \cos \theta_r \, d\omega_r}{\int_h \cos \theta_r \, d\omega_r} = \frac{\rho_{di}}{\pi}$$

Now, the notation $\bar{f}_r$ is defined as

$$\bar{f}_r(\theta_i, \phi_i) = \frac{\int_h f_r(\theta_i, \phi_i; \theta_r, \phi_r) \cos \theta_r \, d\omega_r}{\int_h \cos \theta_r \, d\omega_r} \tag{4-6}$$

where $\bar{f}_r$ is a weighted average of f_r over the hemisphere. Because of the reciprocity theorem,

$$\bar{f}_r(\theta_i, \phi_i) = \bar{f}_r(\theta_r, \phi_r) = \bar{f}_r(\theta, \phi)$$

or, in the former notation

$$\rho_{di} = \rho_{dr} = \rho_d$$

Note, however that

$$\rho_d \neq \bar{f}_r(\theta, \phi)$$

but rather,

$$\rho_d = \pi \bar{f}_r(\theta, \phi)$$

The terms $f_r(\theta_i, \phi_i; \theta_r, \phi_r)$ and $\bar{f}_r(\theta, \phi)$ also have the names "quadravariant reflectance distribution function" and "bivariant reflectance distribution function," which are shortened to the acronyms 4RDF and 2RDF, respectively. For a further discussion of f_r and different types of $\bar{f}_r$ derived from it, i.e., f_r averaged over other angles, see reference 4-2, where f_r is termed f_4.

4.2. SOME EQUATIONS FOR THE APPLICATION OF 4RDF DATA

Reflection characteristics of targets and backgrounds are generally used with appropriate equations to predict the operational capabilities of active or semi-active detection or mapping systems. In the past, most of the reflectance data has necessarily been of the ρ_d type, i.e., reflectance, without consideration of how the reflected power is distributed throughout the hemisphere. It should be obvious that generally much better predictions could be made for the operation of such systems if reflectance distribution function data were used. Er[illegible]d by assuming a target to be a diffuse reflector, i.e., taking ρ_d and dividing by π, when in reality it is a forward scatter or a backscatter, would be completely eliminated.

The price one pays to obtain these better predictions, in addition to the data acquisition costs, is the necessity of working with large amounts of data since $f_r(\theta_i, \phi_i; \theta_r, \phi_r)$ or 4RDF varies with both source and receiver directions.* The manner in which 4RDF varies depends on the particular surface considered and the polarization states of the source and receiver, as shown by the data in section 4.5. Much of the variation in 4RDF as a function of receiver angle (θ_r) is unimportant when application is made to active detection or mapping systems where the source and receiver are typically colinear or separated by only a small bistatic angle. For such a system, only those data points where the receiver angle is close, or equal, to the incidence angle would be needed. On the other hand, all the 4RDF data is necessary when application is made to semi-active systems where a flare or the sun is the source and the receiver can be almost anywhere.

The determination of relative contrast in a proposed strip map or other scene could be made very accurately by ranking the $f_r(\theta_r, \phi_r; \theta_i, \phi_i)$ values for all targets and backgrounds that are to be included. An important assumption here is that 4RDF data are available for the targets and backgrounds considered or that mathematical models for these have been formulated from data collected for the basic materials. A similar ranking of ρ_d (or $\bar{f}_r$ or 2RDF in the new notation) values for the same targets and backgrounds could not be depended upon to predict relative contrast unless the angular reflection properties of everything in the scene were the same. This is certainly possible but not very probable.

An important advantage to using 4RDF data lies in the polarization parameters that can be exploited to enhance contrast. Since all four polarization components** usually have different values, there are many combinations—sums, differences, and ratios—that could be used with appropriate instrumentation to change the contrast between specified targets or target classes and their backgrounds. A simple illustration of this is the blinking effect one observes when a polaroid filter is rotated between one's eye and a sun-lighted automobile. Extensive analysis is needed to determine the optimum source polarization plane or planes, receiver analyzer orientations, and/or signal processing; but the effort would pay off, especially when new detection or mapping systems are designed.

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*The reflectance distribution function also varies with wavelength just as ρ_d does; in fact, it may be possible (for certain targets and certain angles) to determine the λ-dependence of f_r data through ρ_d versus λ measurements. Such a procedure would certainly not apply for incidence angles near grazing, for targets with surface textures whose dimensions are comparable to the wavelengths employed, or in spectral regions where absorption bands occur.

**See discussion of polarization at the beginning of section 4.4.

For a given system design, the received power for calculation of signal-to-noise ratios can be computed with 4RDF data in the following manner. By definition from equation 4-4,

$$f_r(\theta_i, \phi_i; \theta_r, \phi_r) = \frac{\delta L_r(\theta_r, \phi_r)}{L_i(\theta_i, \phi_i)\, d\Omega_i} \qquad (4\text{-}4a)$$

or

$$\delta L_r(\theta_r, \phi_r) = f_r(\theta_i, \phi_i; \theta_r, \phi_r) L_i(\theta_i, \phi_i)\, d\Omega_i$$

where subscripts r and i refer to reflected and incident, respectively

$d\Omega_i = d\omega_i \cos \theta_i$ is the projected solid angle through which the source illuminates the target surface

L is radiance

A specified λ and $\Delta\lambda$ are assumed. The radiant power P passing through a remote aperture and coming from a surface with a radiance L is

$$P = LA\Omega$$

where A is the area of the radiating (or reflecting) surface

Ω is the projected solid angle subtended by the receiving aperture

$\Omega = \omega \cos \theta$, where θ is the angle between the surface normal and the receiving aperture normal and ω is the total solid angle. It is assumed here that ω is small and that the receiver is pointed directly toward the area A. Thus, in general, these equations give

$$P(\theta_r, \phi_r) = \left[\int_{\omega_i} f_r(\theta_i, \phi_i; \theta_r, \phi_r) L_i(\theta_i, \phi_i)\, d\Omega_i \right] A\Omega_r$$

where the integral is over the input solid angle. The term in brackets is the target radiance L_r due to reflection of a source that subtends a solid angle ω_i and has a radiance L_i. A is the area within the field of view subject to L_i, and Ω_r is the projected solid angle of the receiver.

This general equation can be simplified when certain conditions exist: if f_r does not vary over the range of incidence angles considered, it can be moved outside the integral; the remaining integral is the irradiance on the target E. Thus, under these conditions,

$$P(\theta_r, \phi_r) = f_r(\theta_i, \phi_i; \theta_r, \phi_r) E(\theta_i, \phi_i) A\Omega_r$$

At least five different equations can be derived for received power depending on the illumination source and/or the receiver field of view.

Case I. Solar or other source for which irradiance is known

In a selected wavelength band and assuming the field of view to be always fully illuminated,

$$P = f_r(\theta_i, \phi_i; \theta_r, \phi_r) E_s \cos \theta_i\, A_r \frac{\pi}{4} \alpha^2 S_a \qquad (4\text{-}7)$$

where $f_r(\theta_i, \phi_i; \theta_r, \phi_r)$ is the reflectance distribution function of the surface and is a function of source and receiver directions relative to the surface under study

E_s is the irradiance on a surface normal to the source

θ_i is the incident polar angle ($E_s \cos\theta_i$ is thus the target irradiance E)

A_r is the receiver aperture area

α is the total angle field of view

S_a is the loss term to account for atmospheric scattering or absorption

Note that equation 4-7 is independent of range since, when range is decreased, the target area decreases and the receiver solid angle increases.

Case II. Laser or other source with small beam properties arranged coaxially with a receiver

In a selected wavelength band and assuming the illuminated area to be larger than field of view,

$$P = f_r(\theta_i, \phi_i; \theta_r, \phi_r) P_t \frac{\alpha^2}{\gamma^2} \frac{A_r}{R^2} \cos\theta \, S_a^2 \tag{4-8}$$

where P_t is the total transmitted power

R is the range to the target

θ is the polar angle of incidence and reflection

γ is the half-power beam divergence angle of the transmitter and other terms are as in equation 4-7

The loss term is now squared since there is two-way propagation. When the receiver field of view α is smaller than the transmitter beam divergence γ, their ratio correctly weights the P_t term to account for power transmitted but not useful. When α is larger than γ, the ratio term drops out; i.e., for a field of view larger than the beam divergence

$$P = f_r(\theta_i, \phi_i; \theta_r, \phi_r) P_t \frac{A_r}{R^2} \cos\theta \, S_a^2 \tag{4-9}$$

Case III. Laser or other source with small beam properties not arranged coaxially with a receiver

In a selected wavelength band and assuming the illuminated area to be larger than the field of view,

$$P = f_r(\theta_i, \phi_i; \theta_r, \phi_r) P_t \frac{\alpha^2}{\gamma^2} A_r \cos\theta_i \frac{1}{R_t^2} S_{a_t} S_{a_r}$$

where θ_i is the polar angle of incidence

R_t is the range of the target from the transmitter

S_{a_t} and S_{a_r} are loss terms for the paths to the target from the transmitter and to the receiver from the target, respectively

Just as in equation 4-9 when α is larger than γ, their ratio drops out; i.e.,

$$P = f_r(\theta_i, \phi_i; \theta_r, \phi_r)P_t A_r \cos \theta_i \frac{1}{R_t^2} S_{a_t} S_{a_r} \tag{4-10}$$

In all of these equations one must be careful that the $f_r(\theta_i, \phi_i; \theta_r, \phi_r)$ used applies to the entire target area. If this is not possible, an averaged value should be used based on the relative areas of the several materials or objects comprising the target or filling the field of view.

4.3. DESCRIPTION OF INSTRUMENTATION

The instrument used in the Target Signature Measurements Program (laboratory phase) at The University of Michigan to collect the data presented in this section is called the breadboard gonioreflectometer or "BGR" [4-2]. It is a table-top instrument comprising two radiation sources, a receiver, a sample mount, signal-processing electronics, and chart recorder. One source is a plane-polarized He-Ne laser (Spectra-Physics Model 130B) operating at a wavelength of 0.6328 μm. The other source is a tungsten-quartz iodine lamp with a 250-mm grating monochromator (Bausch and Lomb with slits set for Δλ = ±50 Å bandwidth) for operation from 0.3 to 1.4 μ. However, the spectral interval is restricted by the detector in the receiver and the power available from the lamp. The receiver uses an S-1 response photomultiplier (RCA-7102) and has a two-element optical system and field stop that defines a field of view of 7.5 cm at a range of 53 cm and focuses the entrance aperture onto the photocathode. An adjustable iris at the entrance sets the aperture to about 3-cm diameter so that a solid angle of 0.0025 sr is defined for collection of reflected radiation.

Samples are mounted vertically on a hand-operated rotary table set in the path of the source beam to achieve the desired incidence angle. The receiver is mounted on a stand so that the source beam, the sample normal, and the receiver viewing direction all lie in a common plane parallel to the table top. The coordinate system used for a typical measurement is shown in figure 4-2. The choice of the $\phi = 0$ reference line on the sample is arbitrary.

The laser beam is diverged with a negative lens to yield an illuminated spot on the sample, about 2.5-cm diameter at normal incidence; the beam divergence angle (total) is less than 32 mrad. At the exit slits of the monochromator, a two-element optical system and an iris are used to focus a round spot on the sample. The maximum convergence of these rays forming the illuminated spot is less than 40 mrad total angle. The iris is used to reduce the spot size when necessary so that the illuminated area (an ellipse for large incidence angles) is not larger than the field of view of the receiver.

Polaroid filters, HN22 for the visible and HR for the near-IR spectral region, are used to polarize the beam from the monochromator, rotate the polarized beam from the laser, and serve as analyzers in front of the receiver entrance aperture. Inherent sensitivity of the receiver to the polarization of the input beam was checked by rotating the photomultiplier and then the optics about the longitudinal axis of the beam and was found to be negligible in both cases.

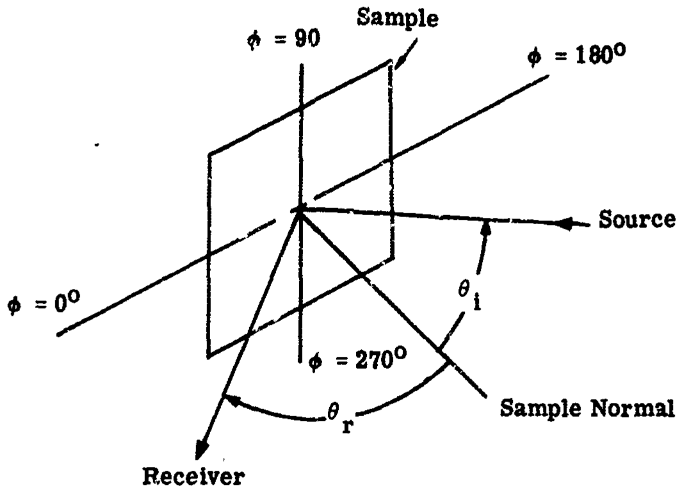


FIGURE 4-2. SAMPLE COORDINATE SYSTEM. Typical for measurements in the $\phi = 0^\circ$ and $\phi = 180^\circ$ planes.

The beams from the sources are chopped mechanically at a 90-Hz rate to allow use of narrowband filtering and a homodyne detector system. Precision electrical attenuators are used in the signal line between the receiver and the filter-homodyne detector so that only a small dynamic range is required for these systems. The attenuators are used over a range of 3 decades, and a test of system linearity over this range with calibrated neutral-density filters gave results of ±3%, which is comparable to the linearity of the photomultiplier alone. The dc output signal from the homodyne detector is recorded on a strip chart, signal vs. time, and the noise can be averaged out for seconds or minutes when necessary.

Calibration of the entire instrument is accomplished in the following manner. A calibrated neutral-density filter of sufficient density is placed between the source and receiver, and a signal proportional to the incident power is obtained. Such calibrations are repeated at half-hour intervals or before and after each run to insure good calibration values. Since the source power is usually constant, as shown by a monitor detector, calibration values are also constant.

The measured values of $f_r(\theta_i, \phi_i; \theta_r, \phi_r)$ are obtained for a given set of polarization conditions by use of the equation

$$f_r(\theta_i, \phi_i; \theta_r, \phi_r) = \frac{V_r(\theta_r, \phi_r)K_r}{V_c K_c K_{NDF} \omega_r \cos \theta_r}$$

where V_r is the voltage from the receiver due to reflected power

K_r is precision attenuator setting for voltage V_r

V_c is the calibration voltage (as measured or a linear interpolation if successive values differ)

K_c is the precision attenuator setting for voltage V_c

K_{NDF} is the attenuation of the calibrated neutral density filter used during the calibration measurement

$\omega_r \cos\theta_r$ is the projected solid angle of the receiver as seen from the sample surface

An error analysis considering all factors of the measurement to have normally distributed errors within measured or factory-specified limits resulted in a 50% probable error of ±5% on a stated value of f_r. Most of this error is due to uncertainties in the calibration of the neutral-density filter.

Since spatial coherence of the incident radiation beam may be a significant parameter of the reflection process, a Young's double-slit interference experiment was performed with the laser beam to determine its partial coherence factor. According to coherence theory [4-4] the real part of the complex partial coherence factor $|\gamma_{12}|$ can be obtained under certain conditions by measuring the visibility of fringes produced by a pair of illuminated slits. Visibility is defined here as

$$V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} ,$$

where I_{max} is the light intensity at a bright part of the interference pattern and I_{min} is the light intensity at the darker part. The required conditions for such a measurement are (a) that the slit widths be small relative to the distance from slit plane to the fringe observation plane, and (b) that monochromatic radiation be used.

In the experiment, slits of about 0.25-mm width separated by about 0.25 mm were illuminated by the laser beam after passing through the negative diverging lens. The visibility of the fringe pattern was measured at a distance of about 0.75 m with a photomultiplier having a small (0.2 mm) aperture. In moving the slit pair across the width of the laser beam, visibilities or $|\gamma_{12}|$ values between 0.83 to 0.98 were obtained. It was observed that dust particles on the lens caused the lower values of $|\gamma_{12}|$.

4.4. DATA FORMAT

The data are presented in a tabular format with certain parameters listed in a header. The f_r values in the table are those measured as well as one computed value. During the measurement, the source may be linearily polarized or unpolarized and the receiver may or may not employ a linear polarization analyzer. These possible conditions on the source and receiver result in nine different values of f_r if the planes of linear polarization take on orthogonal values relative to a reference plane. The reference plane is usually that formed by the normal to the sample surface (or average surface if it has some contour) and the illuminating beam direction. The nine values of f_r are identified by the letters $\ell\ell$, ℓp, pℓ, pp, ℓt, pt, oℓ, op, and ot, where ℓ = parallel, p = perpendicular, t = no analyzer on the receiver (total signal received). and o = source not polarized (or strictly speaking, randomly polarized). The first letter of each pair refers to the source polarization and the second to that of the receiver. The first four values of f_r, namely, $f_r(\ell\ell)$, $f_r(\ell p)$, $f_r(p\ell)$, and $f_r(pp)$[*] are the basic ones, and the others can be derived from them. The computed value given in the tables is $f_r(ot)$, obtained by the equation:

$$f_r(ot) = \frac{f_r(\ell\ell) + f_r(\ell p)}{2} + \frac{f_r(pp) + f_r(p\ell)}{2}$$

The other values can be computed by the following equations:

$$f_r(\ell t) = f_r(\ell\ell) + f_r(\ell p)$$

$$f_r(pt) = f_r(pp) + f_r(p\ell)$$

$$f_r(o\ell) = \frac{f_r(\ell\ell) + f_r(p\ell)}{2}$$

$$f_r(op) = \frac{f_r(pp) + f_r(\ell p)}{2}$$

Each of the four basic components has an ideal value of $1/2\pi = 0.159\ sr^{-1}$, which would apply for a perfectly diffuse reflector with 100% efficiency (no absorption or transmission). This value would also be independent of angle, that is, constant, for such an ideal diffuse reflector.

Because subscripts and lower case letters are not available in the computer printouts used for the data in this section, the notation RDF(LL), RDF(LP), RDF(PL), RDF(PP), and RDF(OT) are used instead of $f_r(\ell\ell)$, etc. The notation 1/SR used in the printout with RDF(LL), etc., refers to the units of RDF, in reciprocal steradians.

The data are arranged according to the prime subject code for each sample derived from the Target Signature Subject-Code List (table 1-1). These codes are prefixed with the letter f, and the filing divider sheets are labeled (f)AEM, etc., to distinguish between these data and those of section 3. The various parts of a typical page of tabular data and header information are shown and identified in table 4-1. Several pages are required to present all the data for a given sample.

Each page of data contains:

(a) Sample number and area/condition number
(b) Title and short description
(c) Subject codes
(d) Data set numbers included on that page
(e) Parameter information: the type of source, the coherence factor, if it applies, and the instrumentation used, the accuracy of the data, the number of data sets averaged, the angles θ_i, ϕ_i, θ_r, ϕ_r, $\beta = |\theta_i - \theta_r|$ if β is fixed, and the wavelength of the source (a fixed quantity)

---

[*] The complete notation for the reflectance distribution function with all angles and polarization parameters included is $f_r(\theta_i, \phi_i, \ell; \theta_r, \phi_r, \ell)$, $f_r(\theta_i, \phi_i, \ell; \theta_r, \phi_r, p)$, etc., where items to the left of the semicolon within the parentheses refer to the source and those to the right to the receiver.

(f) Data set numbers for each measured quantity

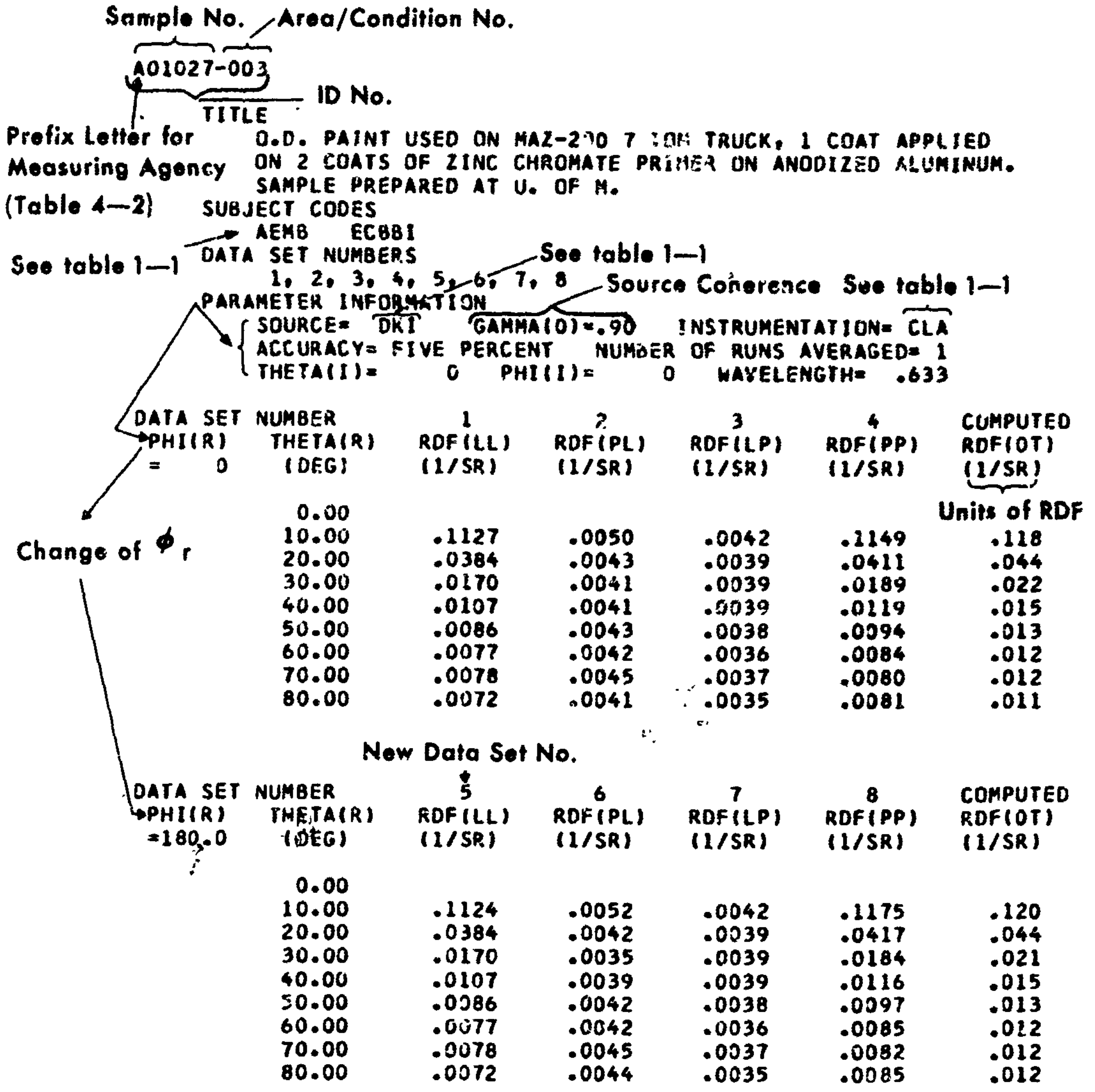
(g) A table of measured RDF values, one computed RDF value, and the variable angle

(h) Repeat of (f) and (g) when one of fixed angles changes value

Identification is provided by a letter (see table 4-2) to designate the agency that supplied the measurement data, followed by a 5-digit number that is assigned by the TSAC library to each sample, material, or object that has been measured. These six characters are followed by a dash and 3 digits designating a particular numbered area on the sample or designating (by an arbitrary number) a changed condition of the sample; that is, a new area/condition number would be assigned if the sample had been clean and was allowed to become dirty. The letter, the sample number, and the area/condition number comprise the ID number for that sample. Note the parts of this number identified in table 4-1. Data set numbers are assigned to a group of data points that has in common one variable, all other parameters including polarization being fixed. For example, one data set might contain RDF(LL) data where θ_i, ϕ_i, ϕ_r and the polarization parameters are fixed and θ_r is variable; when ϕ_r is changed to some other value a new data set number is assigned, etc. If the angle parameters are the same but the wavelength or the source type is changed, a new data set number is again assigned. Note the assignment of data set numbers in table 4-1. A similar rule is followed in assigning data set numbers for data when the bistatic angle $\beta = |\theta_i - \theta_r|$ is fixed during the measurement, although is this case two angles are varying at once.

Since the f_r data (see sec. 2 for a cross index) are given in a tabular format, several graphs of f_r versus θ_r are included here to help the reader visualize the spatial variation of f_r for various incidence angles. Four different types of materials were chosen, and for reasons of clarity the function plotted is f_r(ot) rather than the four basic components; i.e., for these data the source is unpolarized and no analyzer is used on the receiver. A polar coordinate system was chosen as the graphic format because the resulting figure is symbolic of the reflection or scattering process. Figures 4-3a and b show the somewhat diffuse reflection distribution function of 3M white velvet paint, and figure 4-4 shows data for an orange-colored nylon cloth which exhibits both forward scatter and backscatter. Logarithmic scales are used in figures 4-5 and 4-3a and b to accommodate the large dynamic range of the forward-scatter values of an olive drab paint and a mulberry leaf, respectively.

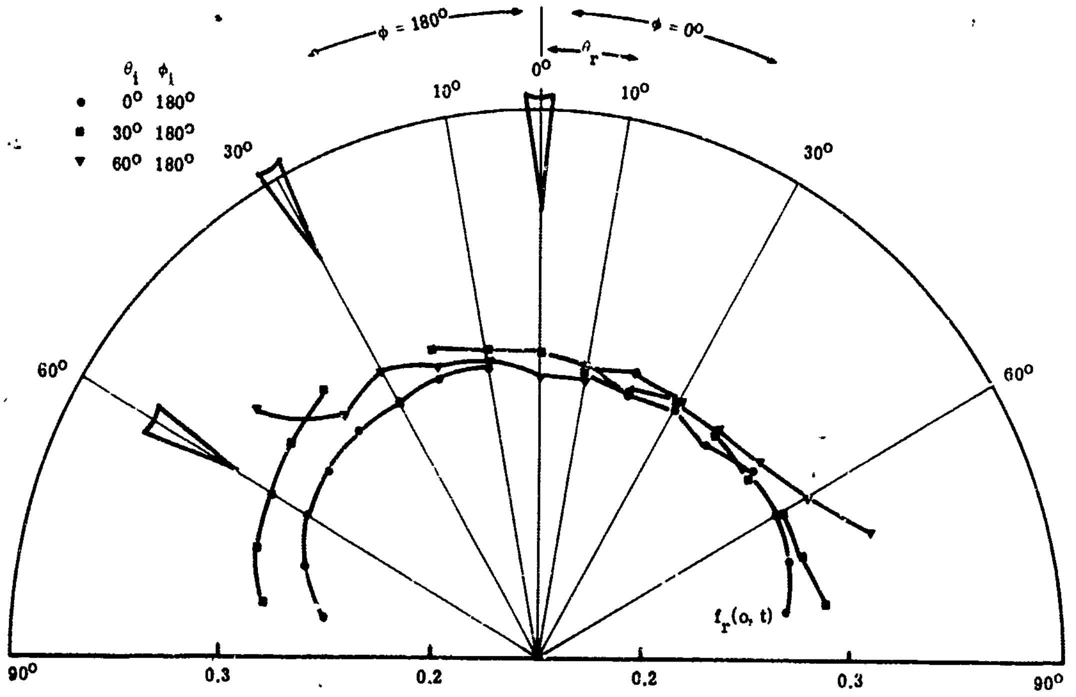
TABLE 4-1. IDENTIFICATION OF ITEMS ON TYPICAL DATA PAGE



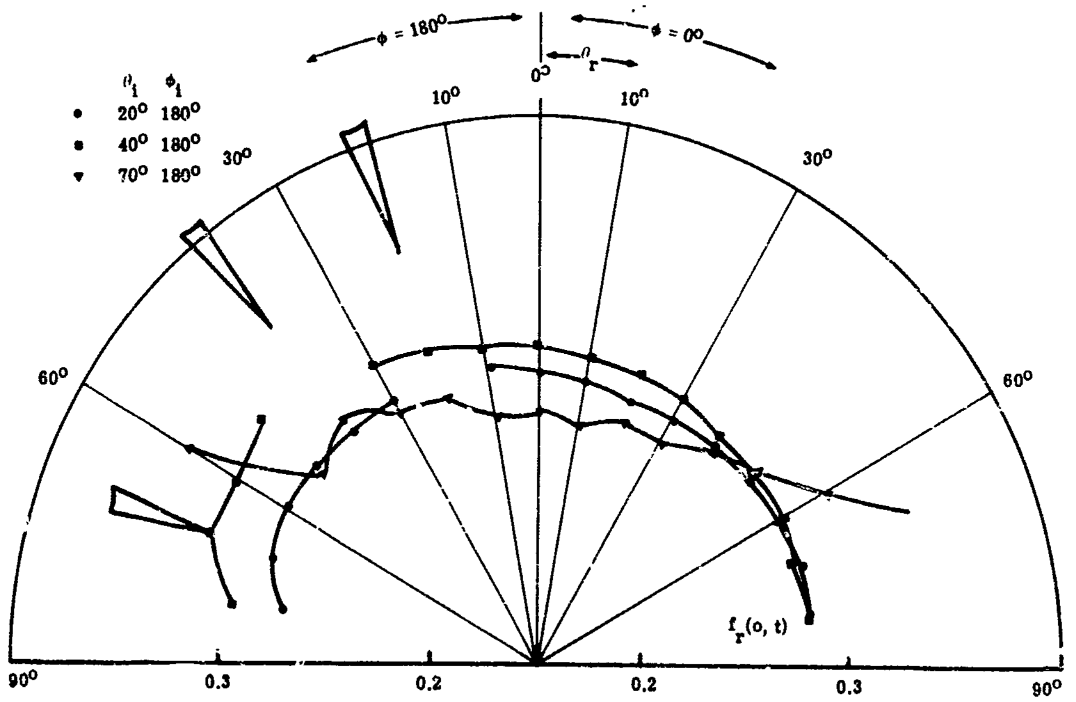
```
A01027-003
TITLE
O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 1 COAT APPLIED
ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
SAMPLE PREPARED AT U. OF M.
SUBJECT CODES
  AEMB   ECBBI
DATA SET NUMBERS
    1, 2, 3, 4, 5, 6, 7, 8
PARAMETER INFORMATION
  SOURCE= DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
  ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
  THETA(I)=     0   PHI(I)=     0   WAVELENGTH=  .633

DATA SET NUMBER       1         2         3         4       COMPUTED
PHI(R)  THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
=    0   (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

          0.00
         10.00      .1127     .0050     .0042     .1149      .118
         20.00      .0384     .0043     .0039     .0411      .044
         30.00      .0170     .0041     .0039     .0189      .022
         40.00      .0107     .0041     .0039     .0119      .015
         50.00      .0086     .0043     .0038     .0094      .013
         60.00      .0077     .0042     .0036     .0084      .012
         70.00      .0078     .0045     .0037     .0080      .012
         80.00      .0072     .0041     .0035     .0081      .011

DATA SET NUMBER       5         6         7         8       COMPUTED
PHI(R)  THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
=180.0   (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

          0.00
         10.00      .1124     .0052     .0042     .1175      .120
         20.00      .0384     .0042     .0039     .0417      .044
         30.00      .0170     .0035     .0039     .0184      .021
         40.00      .0107     .0039     .0039     .0116      .015
         50.00      .0086     .0042     .0038     .0097      .013
         60.00      .0077     .0042     .0036     .0085      .012
         70.00      .0078     .0045     .0037     .0082      .012
         80.00      .0072     .0044     .0035     .0085      .012
```

TABLE 4-2. CODE LIST FOR MEASURING AGENCY

Prefix Letters	Organization
A	The University of Michigan Target Signature Measurements
B	The University of Michigan Target Signature Analysis Center Document Library Reports
C	The University of Michigan C. Olson
D	National Bureau of Standards
E	Texas Instruments Inc.



(a) Incidence angle = 0°, 30°, 60°.



(b) Incidence angle = 20°, 40°, 70°.

FIGURE 4-3. REFLECTANCE DISTRIBUTION FUNCTION f_r(o, t) VS. RECEIVER ANGLE θ FOR 3M WHITE VELVET PAINT. λ = 1.06 μm. Sample ID No. A01290-001. Arrowheads indicate value of θ_i, incidence angle of source.

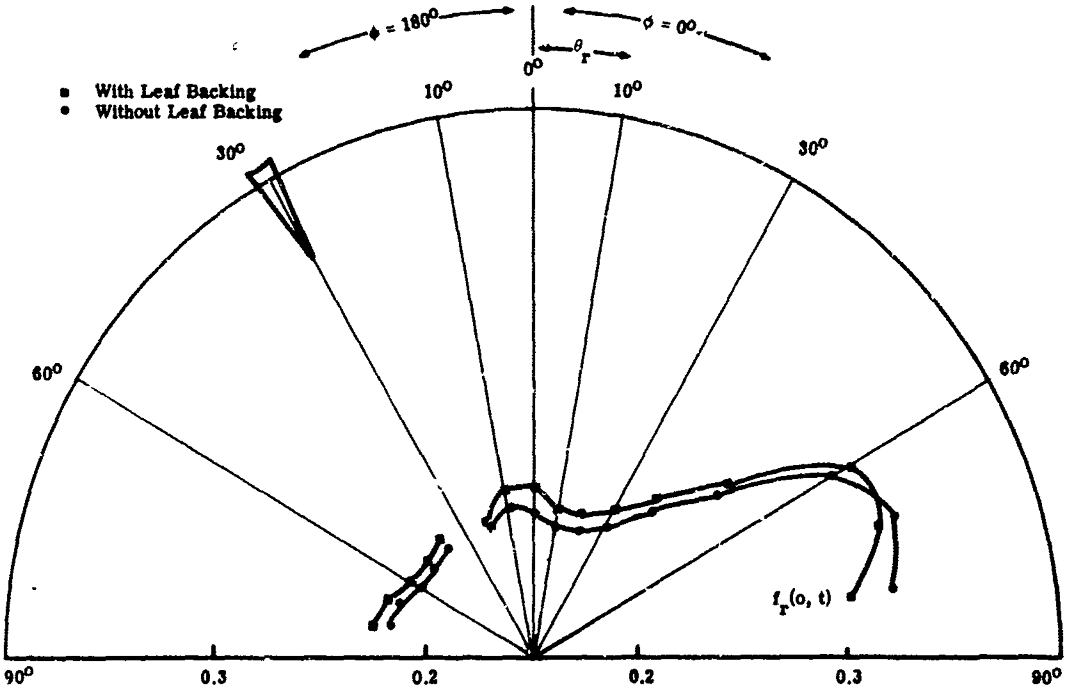


FIGURE 4-4. REFLECTANCE DISTRIBUTION FUNCTION $f_r(o, t)$ VS. RECEIVER ANGLE θ_r FOR ORANGE-COLORED NYLON CLOTH. λ = 0.6328 μm. Sample ID No. A01059-14 and -15. Arrowheads indicate value of θ_i, incidence angle of source.

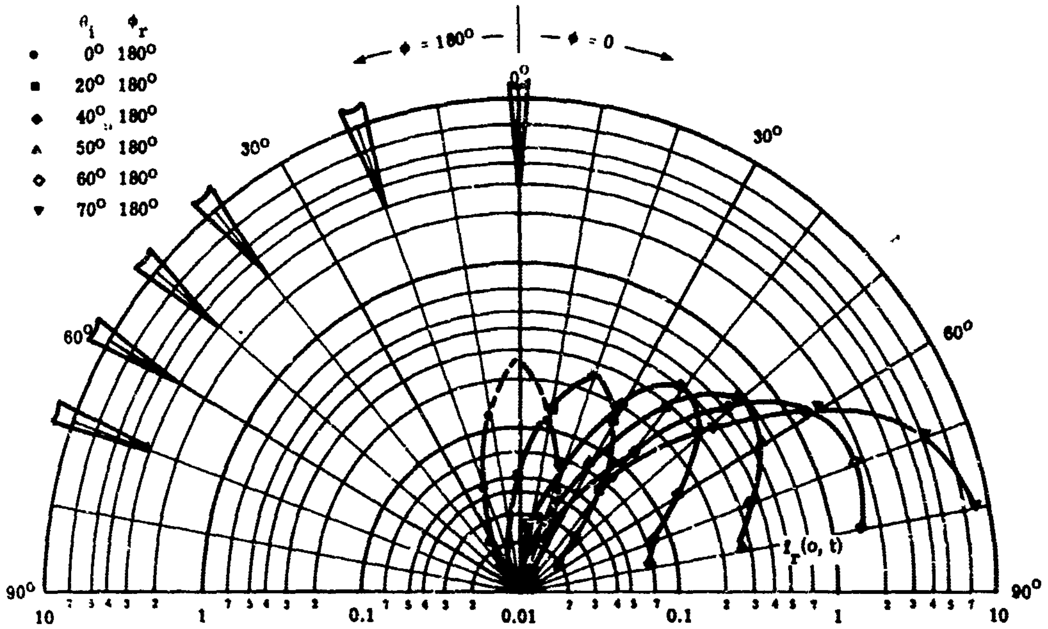
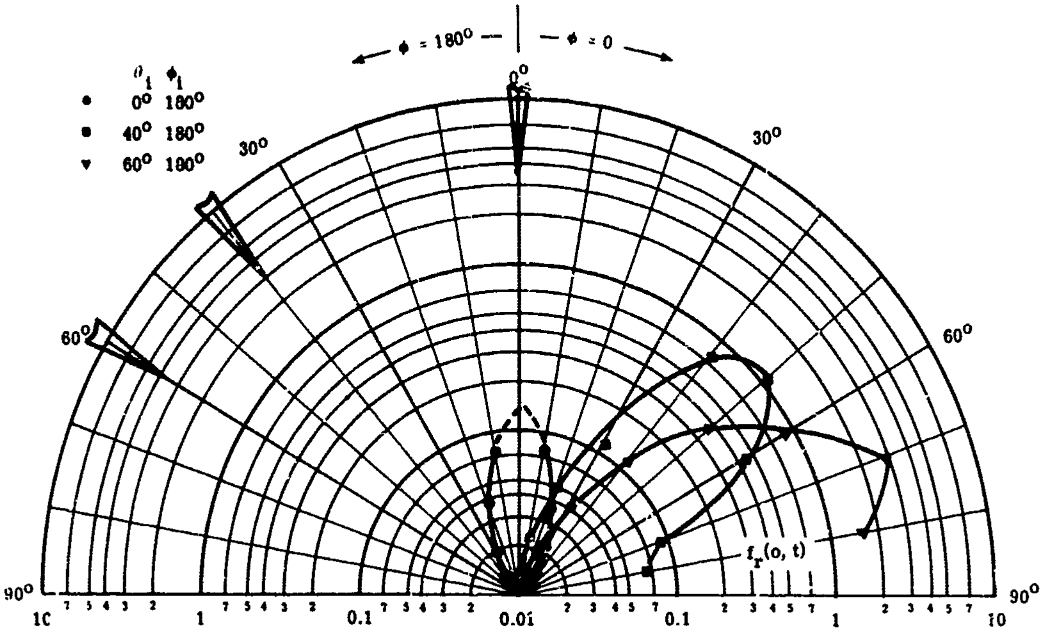
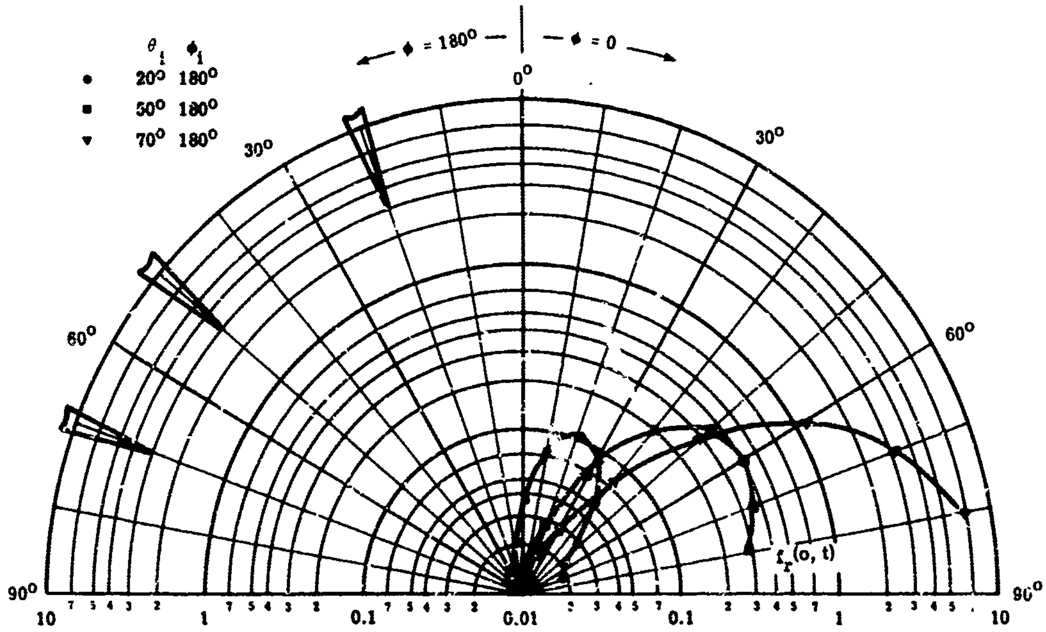


FIGURE 4-5. REFLECTANCE DISTRIBUTION FUNCTION $f_r(o, t)$ VS. RECEIVER ANGLE θ_r FOR AN OLIVE DRAB PAINT. λ = 0.6328 μm. Sample ID No. A01027-003. Arrowheads indicate value of θ_i, incidence angle of source.



(a) Incidence angle = 0°, 40°, 60°.



(b) Incidence angle = 20°, 50°, 70°.

FIGURE 4-6. REFLECTANCE DISTRIBUTION FUNCTION $f_r(o, t)$ VS. RECEIVER ANGLE θ_r FOR A MULBERRY LEAF. $\lambda = 0.6328$ µm. Sample ID No. A01324-001. Arrowheads indicate value of θ_i, incidence angle of source.

4.5. REFERENCES FOR SECTION 4

4-1. W. L. Wolfe (ed.), Handbook of Military Infrared Technology, Office of Naval Research, Washington, D. C., 1965, Chapter 2, p. 25.

4-2. Target Signature Measurements (U), Final Report, Rept. 8047-28-F, AFAL-TR-68-198, Willow Run Laboratories of the Institute of Science and Technology, The University of Michigan, Ann Arbor, September 1968 (CONFIDENTIAL). AD 932 735

4-3. A. T. DeHoop, A Reciprocity Theorem for the Electromagnetic Field Scattered by an Obstacle, Appl. Sci. Res., Sec. B, Vol. 8, p. 135, 1960.

4-4. M. Born and E. Wolf, Principles of Optics, Macmillan, 1964, Chapter 10.

```
AC1057-014

     TITLE
         NYLON CLOTH USED FOR PERSONNEL PARACHUTES, PLAIN WEAVE WITH
         RIB STOP PATTERN, 1.1 OZ MAX WT/SQ YD, SHRUNK,
         MIL-C-7020(ASG), TYPE I, UNDYED, (1 LAYER).
     SUBJECT CODES
         AAKAB  ECBBJ
     DATA SET NUMBERS
           1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 30.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4        COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

             0.00      .1053      .0141      .0139      .1308        .132
            10.00      .0913      .0142      .0145      .1156        .118
            20.00      .0942      .0168      .0172      .1182        .123
            30.00      .1055      .0228      .0220      .1326        .141
            40.00      .1210      .0302      .0285      .1539        .167
            50.00      .1528      .0433      .0386      .2046        .220
            60.00      .2035      .0656      .0571      .3020        .314
            70.00      .2634      .0928      .0826      .4390        .439
            80.00      .1969      .0785      .0635      .4049        .372


DATA SET NUMBER          5          6          7          8        COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

             0.00      .1053      .0141      .0139      .1308        .132
            10.00      .1382      .0143      .0144      .1657        .166
            20.00      .1125      .0145      .0144      .1474        .144
            30.00
            40.00      .1067      .0182      .0163      .1542        .148
            50.00      .0897      .0194      .0168      .1411        .133
            60.00      .0882      .0217      .0174      .1300        .129
            70.00      .1009      .0250      .0196      .1437        .145
            80.00      .0985      .0261      .0209      .1246        .135
```

```
AC1058-014

     TITLE
          NYLON CLOTH USED FOR PERSONNEL PARACHUTES, PLAIN WEAVE WITH
          RIB STOP PATTERN, 1.1 OZ MAX WT/SQ YD, SHRUNK,
          MIL-C-7020(ASG), TYPE I, OLIVE GREEN (ARMY 106), (1 LAYER).
     SUBJECT CODES
          AAKAB  ECBBI
     DATA SET NUMBERS
             1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
          SOURCE=  DKI     GAMMA(0)=.90    INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT    NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 30.00    PHI(I)=180.00    WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00        .0549      .0048       0050      .0624       .064
          10.00        .0467      .0053      .0053      .0597       .059
          20.00        .0468      .0059      .0058      .0656       .062
          30.00        .0483      .0075      .0071      .0753       .069
          40.00        .0496      .0089      .0089      .0866       .077
          50.00        .0535      .0116      .0110      .1065       .091
          60.00        .0626      .0178      .0164      .1570       .127
          70.00        .0613      .0208      .0168      .1915       .145
          80.00        .0516      .0166      .0133      .1933       .137


DATA SET NUMBER          5          6          7          8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00        .0549      .0048      .0050      .0624       .064
          10.00        .0502      .0046      .0048      .0532       .056
          20.00        .0423      .0046      .0045      .0424       .047
          30.00
          40.00        .0405      .0051      .0047      .0403       .045
          50.00        .0369      .0056      .0050      .0390       .043
          60.00        .0351      .0063      .0052      .0395       .043
          70.00        .0373      .0069      .0053      .0424       .046
          80.00        .0368      .0087      .0057      .0452       .048
```

```
AC1059-014

          TITLE
              NYLON CLOTH USED FOR PERSONNEL PARACHUTES, PLAIN WEAVE WITH
              RIB STOP PATTERN, 1.1 OZ MAX WT/SQ YD, SHRUNK,
              MIL-C-7020(ASG), TYPE I, ORANGE (FED 12197) (1 LAYER).
          SUBJECT CODES
              AAKAB  ECBBD
          DATA SET NUMBERS
               1,  2,  3,  4,  5,  6,  7,  8
          PARAMETER INFORMATION
              SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
              ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
              THETA(I)= 30.00   PHI(I)=180.00   WAVELENGTH=  .633

 DATA SET NUMBER          1          2          3          4       COMPUTED
  PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
  =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00       .1000      .0159      .0179      .1253       .130
            10.00       .0837      .0173      .0184      .1115       .115
            20.00       .0866      .0199      .0206      .1135       .120
            30.00       .0967      .0260      .0262      .1271       .138
            40.00       .1209      .0364      .0358      .1566       .175
            50.00       .1454      .0509      .0487      .2001       .223
            60.00       .1885      .0786      .0710      .3087       .323
            70.00       .2094      .0852      .0719      .3615       .364
            80.00       .1791      .0739      .0564      .3774       .343


 DATA SET NUMBER          5          6          7          8       COMPUTED
  PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
  =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00       .1000      .0159      .0179      .1253       .130
            10.00       .1040      .0149      .0174      .1339       .135
            20.00       .0909      .0148      .0161      .1198       .121
            30.00
            40.00       .0915      .0180      .0183      .1278       .128
            50.00       .0819      .0202      .0197      .1264       .124
            60.00       .0813      .0228      .0204      .1204       .122
            70.00       .0932      .0259      .0225      .1351       .138
            80.00       .0935      .0261      .0218      .1373       .139
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AC1059-015

     TITLE
         NYLON CLOTH USED FOR PERSONNEL PARACHUTES, PLAIN WEAVE WITH
         RIB STOP PATTERN, 1.1 OZ MAX WT/SQ YD, SHRUNK, MIL-C-7020
         (ASG),TYPE I,ORANGE(FED 1219) ON 4 LAYERS OF SYCAMORE LEAV.
     SUBJECT CODES
         AAKAB  ECBBD
     DATA SET NUMBERS
            1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 30.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          1         2         3         4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00       .1198     .0207     .0216     .1392      .151
           10.00       .0982     .0226     .0229     .1191      .131
           20.00       .0985     .0260     .0262     .1214      .136
           30.00       .1087     .0324     .0319     .1357      .154
           40.00       .1272     .0424     .0402     .1627      .186
           50.00       .1544     .0581     .0538     .2145      .240
           60.00       .2038     .0881     .0760     .3229      .345
           70.00       .2029     .0844     .0683     .3342      .345
           80.00       .1639     .0678     .0492     .3225      .302


DATA SET NUMBER          5         6         7         8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00       .1198     .0207     .0216     .1392      .151
           10.00       .1173     .0195     .0200     .1446      .151
           20.00       .1032     .0166     .0196     .1179      .129
           30.00
           40.00       .1045     .0214     .0216     .1271      .137
           50.00       .0946     .0235     .0228     .1280      .134
           60.00       .0937     .0259     .0236     .1200      .132
           70.00       .1058     .0281     .0245     .1340      .146
           80.00       .1114     .0291     .0233     .1464      .155
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AC1060-014

          TITLE
               NYLON CLOTH USED FOR PERSONNEL PARACHUTES, PLAIN WEAVE WITH
               RIB STOP PATTERN, 1.1 OZ MAX WT/SQ YD, SHRUNK,
               MIL-C-7020(ASG), SAND (AF 1005) (1 LAYER).
          SUBJECT CODES
               AAKAB  ECBBF
          DATA SET NUMBERS
                1,  2,  3,  4,  5,  6,  7,  8
          PARAMETER INFORMATION
               SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
               ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
               THETA(I)= 30.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

             0.00      .0836      .0073      .0074      .0946        .096
            10.00      .0605      .0072      .0075      .0698        .072
            20.00      .0604      .0087      .0090      .0692        .074
            30.00      .0666      .0124      .0123      .0816        .086
            40.00      .0713      .0171      .0158      .0987        .101
            50.00      .0884      .0263      .0236      .1352        .137
            60.00      .1272      .0493      .0429      .2252        .222
            70.00      .1392      .0528      .0449      .2759        .256
            80.00      .1098      .0341      .0251      .2390        .204


DATA SET NUMBER          5          6          7          8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

             0.00      .0836      .0073      .0074      .0946        .096
            10.00      .0844      .0070      .0070      .1044        .101
            20.00      .0687      .0068      .0068      .0818        .082
            30.00
            40.00      .0644      .0077      .0078      .0812        .081
            50.00      .0528      .0074      .0073      .0741        .071
            60.00      .0511      .0081      .0074      .0625        .065
            70.00      .0599      .0091      .0075      .0706        .074
            80.00      .0612      .0095      .0064      .0734        .075
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AC1061-014

     TITLE
          NYLON CLOTH USED FOR CARGO PARACHUTES, DOBBY WEAVE,
          2.25 OZ MAX WT/SQ YD, UNSHRUNK, MIL-C-7350(ASG), TYPE I,
          OLIVE GREEN (ARMY 106) (1 LAYER).
     SUBJECT CODES
          AAKAB  ECBBI
     DATA SET NUMBERS
             1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
          SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 30.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00      .0395      .0057      .0059      .0423        .047
           10.00      .0401      .0070      .0072      .0455        .050
           20.00      .0448      .0094      .0097      .0541        .059
           30.00      .0507      .0138      .0139      .0696        .074
           40.00      .0424      .0150      .0143      .0662        .069
           50.00      .0388      .0165      .0154      .0704        .071
           60.00      .0396      .0185      .0168      .0809        .078
           70.00      .0405      .0191      .0169      .0933        .085
           80.00      .0479      .0174      .0145      .1040        .092


DATA SET NUMBER          5          6          7          8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
=180.0     (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00      .0395      .0057      .0059      .0423        .047
           10.00      .0409      .0051      .0054      .0461        .049
           20.00      .0428      .0049      .0048      .0452        .049
           30.00
           40.00      .0314      .0045      .0043      .0317        .036
           50.00      .0240      .0043      .0039      .0253        .029
           60.00      .0215      .0044      .0038      .0203        .025
           70.00      .0223      .0046      .0037      .0210        .026
           80.00      .0261      .0049      .0037      .0244        .030
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AC1510-001

TITLE
O.D. CANVAS TARPAULIN, 24 IN. X 20-1/2 IN., TAKEN FROM A
U.S. 18 TON M4A HIGH SPEED TRACTOR.
SUBJECT CODES
AEE ECBBI
DATA SET NUMBERS
1, 2, 3, 4, 5, 6, 7, 8
PARAMETER INFORMATION
SOURCE= DKH GAMMA(O)= INSTRUMENTATION= CLA
ACCURACY= FIVE PERCENT NUMBER OF RUNS AVERAGED= 1
THETA(I)= 0 PHI(I)= 0 WAVELENGTH= .633

DATA SET NUMBER		1	2	3	4	COMPUTED
PHI(R) = 0	THETA(R) (DEG)	RDF(LL) (1/SR)	RDF(PL) (1/SR)	RDF(LP) (1/SR)	RDF(PP) (1/SR)	RDF(OT) (1/SR)
	0.00					
	10.00	.016	.007	.006	.016	.023
	20.00	.014	.006	.006	.015	.021
	30.00	.013	.006	.006	.014	.019
	40.00	.012	.006	.006	.014	.019
	50.00	.012	.006	.006	.015	.020
	60.00	.011	.007	.006	.016	.020
	70.00	.011	.007	.007	.018	.022
	80.00	.011	.007	.007	.019	.022

DATA SET NUMBER		5	6	7	8	COMPUTED
PHI(R) =180.0	THETA(R) (DEG)	RDF(LL) (1/SR)	RDF(PL) (1/SR)	RDF(LP) (1/SR)	RDF(PP) (1/SR)	RDF(OT) (1/SR)
	0.00					
	10.00	.017	.007	.007	.016	.024
	20.00	.015	.006	.006	.015	.021
	30.00	.014	.006	.006	.015	.021
	40.00	.013	.006	.006	.015	.020
	50.00	.012	.007	.007	.016	.021
	60.00	.012	.007	.007	.017	.022
	70.00	.012	.008	.007	.019	.023
	80.00	.013	.008	.008	.023	.026

(f) AEE 2

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AC1510-001

     TITLE
         O.D. CANVAS TARPAULIN, 24 IN. X 20-1/2 IN., TAKEN FROM A
         U.S. 18 TON M4A HIGH SPEED TRACTOR.
     SUBJECT CODES
         AEE    ECBBI
     DATA SET NUMBERS
          9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(O)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 45.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          9         10         11         12      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            5.00        .011       .006       .006       .014       .018
           15.00        .010       .006       .006       .015       .019
           25.00        .010       .006       .006       .016       .019
           35.00        .010       .006       .006       .018       .020
           45.00        .010       .007       .006       .021       .022
           55.00        .011       .007       .007       .025       .025
           65.00        .012       .008       .007       .030       .028
           75.00        .016       .009       .008       .037       .035
           85.00        .023       .011       .010       .053       .049


DATA SET NUMBER         13         14         15         16      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            5.00        .012       .006       .006       .013       .018
           15.00        .013       .006       .006       .014       .019
           25.00        .015       .007       .007       .015       .022
           35.00        .018       .007       .007       .017       .024
           45.00
           55.00        .021       .009       .009       .020       .029
           65.00        .019       .009       .009       .019       .028
           75.00        .019       .009       .009       .020       .028
           85.00        .019       .010       .009       .022       .030
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(f)AEG 1

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AC1329-001

     TITLE
          OLD CONCRETE (20 YEARS) FROM WILLOW RUN AIRPORT APRON.
     SUBJECT CODES
          AEG
     DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
          SOURCE=  DMI     GAMMA(0)=.90    INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT    NUMBER OF RUNS AVERAGED= 1
          THETA(I)=      0    PHI(I)=      0    WAVELENGTH=  .633

DATA SET NUMBER           1          2          3          4       COMPUTED
 PHI(R)    THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0     (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00
            10.00       .0654      .0491      .0439      .0704       .114
            20.00       .0603      .0479      .0425      .0658       .108
            30.00       .0582      .0450      .0438      .0605       .104
            40.00       .0551      .0442      .0424      .0602       .101
            50.00       .0497      .0435      .0399      .0601       .097
            60.00       .0502      .0424      .0412      .0590       .096
            70.00       .0469      .0418      .0399      .0600       .094
            80.00       .0458      .0412      .0399      .0608       .094


DATA SET NUMBER           5          6          7          8       COMPUTED
 PHI(R)    THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00
            10.00       .0640      .0449      .0430      .0626       .107
            20.00       .0609      .0446      .0427      .0612       .105
            30.00       .0552      .0408      .0400      .0556       .096
            40.00       .0530      .0419      .0400      .0562       .096
            50.00       .0509      .0413      .0394      .0564       .094
            60.00       .0482      .0422      .0390      .0593       .094
            70.00       .0442      .0396      .0370      .0567       .089
            80.00       .0391      .0372      .0330      .0558       .083
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(f)AEG 2

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AC1329-001

     TITLE
        OLD CONCRETE (20 YEARS) FROM WILLOW RUN AIRPORT APRON.
     SUBJECT CODES
        AEG
     DATA SET NUMBERS
          9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(C)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 20.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER         9          10          11          12       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)     RDF(PL)     RDF(LP)     RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)      (1/SR)      (1/SR)      (1/SR)     (1/SR)

            0.00      .0612       .0481       .0433       .0648       .109
           10.00      .0583       .0443       .0434       .0605       .103
           20.00      .0544       .0432       .0420       .0594       .100
           30.00      .0493       .0430       .0393       .0605       .096
           40.00      .0499       .0418       .0415       .0600       .097
           50.00      .0473       .0418       .0393       .0602       .094
           60.00      .0460       .0403       .0406       .0626       .095
           70.00      .0488       .0417       .0405       .0694       .100
           80.00      .0461       .0399       .0384       .0703       .097


DATA SET NUMBER        13          14          15          16       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)     RDF(PL)     RDF(LP)     RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)      (1/SR)      (1/SR)      (1/SR)     (1/SR)

            0.00      .0612       .0481       .0433       .0648       .109
           10.00      .0671       .0497       .0447       .0703       .116
           20.00
           30.00      .0663       .0463       .0434       .0655       .111
           40.00      .0633       .0462       .0442       .0631       .108
           50.00      .0576       .0427       .0412       .0572       .099
           60.00      .0541       .0423       .0414       .0567       .097
           70.00      .0502       .0417       .0393       .0541       .093
           80.00      .0450       .0384       .0355       .0526       .086
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AC1329-001

          TITLE
             OLD CONCRETE (20 YEARS) FROM WILLOW RUN AIRPORT APRON.
          SUBJECT CODES
             AEG
          DATA SET NUMBERS
              17, 18, 19, 20, 21, 22, 23, 24
          PARAMETER INFORMATION
             SOURCE=  DKI     GAMMA(O)=.90   INSTRUMENTATION= CLA
             ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
             THETA(I)= 40.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          17        18        19        20     COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)   RDF(OT)
 =    0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

            0.00        .0556     .0440     .0427     .0600      .101
           10.00        .0498     .0440     .0400     .0611      .097
           20.00        .0507     .0419     .0416     .0603      .097
           30.00        .0479     .0423     .0408     .0631      .097
           40.00        .0481     .0410     .0410     .0655      .098
           50.00        .0492     .0434     .0398     .0726      .102
           60.00        .0478     .0411     .0396     .0742      .101
           70.00        .0452     .0387     .0355     .0774      .098
           80.00        .0471     .0357     .0347     .0837      .101


DATA SET NUMBER          21        22        23        24     COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)   RDF(OT)
 =180.0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

            0.00        .0556     .0440     .0427     .0600      .101
           10.00        .0594     .0462     .0441     .0618      .106
           20.00        .0646     .0495     .0455     .0698      .115
           30.00        .0726     .0503     .0479     .0748      .123
           40.00
           50.00        .0741     .0506     .0486     .0711      .122
           60.00        .0717     .0502     .0489     .0703      .121
           70.00        .0635     .0468     .0445     .0599      .107
           80.00        .0553     .0411     .0408     .0543      .096
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AC1329-001

     TITLE
         OLD CONCRETE (20 YEARS) FROM WILLOW RUN AIRPORT APRON.
     SUBJECT CODES
         AEG
     DATA SET NUMBERS
          25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 50.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          25        26        27        28      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00        .0505     .0442     .0403     .0610       .098
           10.00        .0508     .0427     .0426     .0600       .098
           20.00        .0480     .0419     .0405     .0625       .096
           30.00        .0466     .0409     .0409     .0649       .097
           40.00        .0493     .0427     .0416     .0705       .102
           50.00        .0492     .0411     .0392     .0782       .104
           60.00        .0459     .0391     .0356     .0836       .102
           70.00        .0484     .0374     .0349     .0914       .106
           80.00        .0513     .0350     .0329     .0997       .109


DATA SET NUMBER          29        30        31        32      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00        .0505     .0442     .0403     .0610       .098
           10.00        .0566     .0455     .0435     .0621       .104
           20.00        .0620     .0472     .0458     .0647       .110
           30.00        .0678     .0527     .0473     .0741       .121
           40.00        .0776     .0573     .0513     .0814       .134
           50.00
           60.00        .0832     .0547     .0538     .0818       .137
           70.00        .0790     .0560     .0535     .0757       .132
           80.00        .0668     .0495     .0473     .0633       .113
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(f)AEG 5

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AC1329-001

     TITLE
        OLD CONCRETE (20 YEARS) FROM WILLOW RUN AIRPORT APRON.
     SUBJECT CODES
        AEG
     DATA SET NUMBERS
         33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          33        34        35        36      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00        .0477     .0418     .0393     .0599      .094
           10.00        .0443     .0399     .0372     .0614      .091
           20.00        .0444     .0401     .0372     .0618      .092
           30.00        .0467     .0432     .0408     .0715      .101
           40.00        .0467     .0413     .0382     .0759      .101
           50.00        .0449     .0386     .0352     .0835      .101
           60.00        .0504     .0376     .0356     .0941      .109
           70.00        .0547     .0328     .0330     .1065      .113
           80.00        .0609     .0310     .0301     .1234      .123


DATA SET NUMBER          37        38        39        40      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00        .0477     .0418     .0393     .0599      .094
           10.00        .0498     .0440     .0399     .0621      .098
           20.00        .0576     .0454     .0438     .0598      .103
           30.00        .0641     .0490     .0467     .0667      .113
           40.00        .0723     .0568     .0506     .0778      .129
           50.00        .0872     .0625     .0561     .0886      .147
           60.00
           70.00        .0969     .0648     .0622     .0937      .159
           80.00        .0833     .0618     .0571     .0842      .143
```

```
AC1329-001

     TITLE
         OLD CONCRETE (20 YEARS) FROM WILLOW RUN AIRPORT APRON.
     SUBJECT CODES
         AEG
     DATA SET NUMBERS
          41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
         SOURCE=  DKI     GAMMA(C)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 70.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER        41         42         43         44       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00      .0458      .0401      .0385      .0589        .092
           10.00      .0460      .0378      .0396      .0593        .091
           20.00      .0471      .0400      .0402      .0671        .097
           30.00      .0459      .0385      .0381      .0721        .097
           40.00      .0458      .0248      .0365      .0779        .093
           50.00      .0492      .0353      .0348      .0903        .105
           60.00      .0528      .0340      .0320      .1060        .112
           70.00      .0667      .0313      .0316      .1348        .132
           80.00      .0997      .0306      .0308      .1889        .175


DATA SET NUMBER        45         46         47         48       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00      .0458      .0401      .0385      .0589        .092
           10.00      .0504      .0414      .0417      .0572        .095
           20.00      .0510      .0442      .0404      .0609        .098
           30.00      .0593      .0468      .0456      .0625        .107
           40.00      .0675      .0498      .0496      .0693        .118
           50.00      .0802      .0623      .0556      .0847        .141
           60.00      .1019      .0716      .0648      .1025        .170
           70.00
           80.00      .1203      .0793      .0761      .1134        .195
```

```
AC1194-001

     TITLE
        CHROME-PLATED GLASS BEADS, 3 MM DIA. BEADS IN REGULAR ARRAY,
        ON 4 IN. SQ. ALUMINUM SUBSTRATE.
     SUBJECT CODES
        AEL    CJAG
     DATA SET NUMBERS
          1,  2,  3,  4
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(O)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=     0   PHI(I)=     0   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .0962      .0039      .0035      .0984      .101
           20.00       .0482      .0036      .0033      .0464      .051
           30.00       .0321      .0035      .0036      .0339      .037
           40.00       .0322      .0036      .0037      .0365      .038
           50.00       .0326      .0038      .0041      .0439      .042
           60.00       .0344      .0039      .0044      .0517      .047
           70.00       .0415      .0032      .0046      .0698      .060
           80.00       .0335      .0013      .0023      .0644      .051
```

(f)AEL 2

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AC1194-C01

     TITLE
        CHROME-PLATED GLASS BEADS, 3 MM DIA. BEADS IN REGULAR ARRAY,
        ON 4 IN. SQ. ALUMINUM SUBSTRATE.
     SUBJECT CODES
        AEL     CJAG
     DATA SET NUMBERS
          5,  6,  7,  8,  9, 10, 11, 12
     PARAMETER INFORMATION
        SOURCE=  DKH     GAMMA(0)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 40.00   PHI(I)= 180.0   WAVELENGTH=  .633

DATA SET NUMBER           5          6          7          8       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00        .0333      .0044      .0037      .0358        .039
           10.00        .0334      .0046      .0039      .0413        .042
           20.00        .0332      .0052      .0040      .0467        .045
           30.00        .0340      .0057      .0045      .0559        .050
           40.00        .0370      .0067      .0057      .0725        .061
           50.00        .0714      .0111      .0097      .1571        .125
           60.00        .0387      .0067      .0073      .1059        .079
           70.00        .0387      .0076      .0097      .1492        .103
           80.00        .0466      .0022      .0027      .2975        .175


DATA SET NUMBER           9         10         11         12       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00        .0333      .0044      .0037      .0358        .039
           10.00        .0320      .0044      .0036      .0356        .038
           20.00        .0360      .0046      .0038      .0353        .040
           30.00        .0461      .0050      .0055      .0383        .047
           40.00
           50.00        .0592      .0050      .0043      .0502        .059
           60.00        .0749      .0038      .0036      .0625        .072
           70.00        .0324      .0028      .0027      .0307        .034
           80.00        .0120      .0015      .0017      .0099        .013
```

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AC1272-C01

     TITLE
          CHROME-PLATED GLASS BEADS, 3 MM DIA. BEADS IN REGULAR ARRAY
          ON 9 IN. DIA. ALUMINUM SUBSTRATE USED AS FIELD STANDARD BY
          TEXAS INSTRUMENTS.
     SUBJECT CODES
          AEL     AHD     CJAG
     DATA SET NUMBERS
            1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
          SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)=      0   PHI(I)=      0   WAVELENGTH= 1.060

DATA SET NUMBER          1          2          3          4        COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00       .2014      .0021      .0023      .1969        .201
           20.00       .1656      .0019      .0021      .1615        .166
           30.00       .1319      .0020      .0021      .1290        .132
           40.00       .1428      .0019      .0019      .1462        .146
           50.00       .1772      .0019      .0021      .1948        .188
           60.00       .2257      .0024      .0023      .2625        .246
           70.00       .2128      .0025      .0025      .2748        .246
           80.00       .1961      .0027      .0025      .2836        .242


DATA SET NUMBER          5          6          7          8        COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00       .1800      .0022      .0020      .1755        .180
           20.00       .1520      .0017      .0018      .1504        .153
           30.00       .1310      .0018      .0018      .1361        .135
           40.00       .1354      .0021      .0022      .1476        .144
           50.00       .1689      .0018      .0020      .1919        .182
           60.00       .1833      .0019      .0020      .2246        .206
           70.00       .1572      .0019      .0019      .2107        .186
           80.00       .1274      .0018      .0017      .1912        .161
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AC1272-C01

     TITLE
        CHROME-PLATED GLASS BEADS, 3 MM DIA. BEADS IN REGULAR ARRAY
        ON 9 IN. DIA. ALUMINUM SUBSTRATE USED AS FIELD STANDARD BY
        TEXAS INSTRUMENTS.
     SUBJECT CODES
        AEL    AHD    CJAG
     DATA SET NUMBERS
         9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 30.00   PHI(I)= 180.0   WAVELENGTH= 1.060

DATA SET NUMBER          9         10         11         12       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .1305      .0017      .0020      .1307       .132
           10.00       .1576      .0049      .0056      .1707       .169
           20.00       .2139      .0143      .0153      .2579       .251
           30.00       .2370      .0252      .0270      .3391       .314
           40.00       .2663      .0267      .0291      .3782       .350
           50.00       .2600      .0252      .0282      .3781       .346
           60.00       .2211      .0256      .0286      .3580       .317
           70.00       .2760      .0167      .0189      .4859       .399
           80.00       .2868      .0076      .0082      .5693       .436


DATA SET NUMBER         13         14         15         16       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .1305      .0017      .0020      .1307       .132
           10.00       .1300      .0014      .0016      .1271       .130
           20.00       .1427      .0015      .0018      .1391       .143
           30.00
           40.00       .0915      .0016      .0016      .0911       .093
           50.00       .0578      .0012      .0013      .0560       .058
           60.00       .0078      .0011      .0010      .0080       .009
           70.00       .0039      .0011      .0010      .0039       .005
           80.00       .0037      .0013      .0011      .0032       .005
```

AC1272-001

TITLE

CHROME-PLATED GLASS BEADS, 3 MM DIA. BEADS IN REGULAR ARRAY ON 9 IN. DIA. ALUMINUM SUBSTRATE USED AS FIELD STANDARD BY TEXAS INSTRUMENTS.

SUBJECT CODES

AEL AHD CJAG

DATA SET NUMBERS

17, 18, 19, 20, 21, 22, 23, 24

PARAMETER INFORMATION

SOURCE= DKH GAMMA(0)= INSTRUMENTATION= CLA
ACCURACY= FIVE PERCENT NUMBER OF RUNS AVERAGED= 1
THETA(I)= 60.00 PHI(I)= 180.0 WAVELENGTH= 1.060

DATA SET NUMBER PHI(R) = 0	THETA(R) (DEG)	17 RDF(LL) (1/SR)	18 RDF(PL) (1/SR)	19 RDF(LP) (1/SR)	20 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00	.1723	.0021	.0025	.2092	.193
	10.00	.2000	.0056	.0057	.2682	.240
	20.00	.1837	.0088	.0091	.2731	.237
	30.00	.2052	.0222	.0253	.3389	.296
	40.00	.2670	.0372	.0422	.5231	.435
	50.00	.3580	.0491	.0561	.8129	.639
	60.00	.4040	.0571	.0667	1.081	.804
	70.00	.4245	.0479	.0579	1.418	.974
	80.00	.4144	.0319	.0440	2.073	1.282

DATA SET NUMBER PHI(R) =180.0	THETA(R) (DEG)	21 RDF(LL) (1/SR)	22 RDF(PL) (1/SR)	23 RDF(LP) (1/SR)	24 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00	.1723	.0021	.0025	.2092	.193
	10.00	.1148	.0015	.0018	.1360	.127
	20.00	.0759	.0012	.0015	.0838	.081
	30.00	.0126	.0010	.0012	.0128	.014
	40.00	.0053	.0011	.0013	.0047	.006
	50.00	.0039	.0012	.0013	.0031	.005
	60.00					
	70.00	.0035	.0015	.0014	.0028	.005
	80.00	.0033	.0014	.0013	.0028	.004

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AC1272-001

     TITLE
         CHROME-PLATED GLASS BEADS, 3 MM DIA. BEADS IN REGULAR ARRAY
         ON 9 IN. DIA. ALUMINUM SUBSTRATE USED AS FIELD STANDARD BY
         TEXAS INSTRUMENTS.
     SUBJECT CODES
         AEL     AHD     CJAG
     DATA SET NUMBERS
          25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
         SOURCE=  DKH     GAMMA(C)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 80.00   PHI(I)= 180.0   WAVELENGTH= 1.060

DATA SET NUMBER          25         26         27         28      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .1602      .0019      .0021      .2549       .210
           10.00       .1998      .0030      .0029      .3510       .278
           20.00       .1980      .0036      .0038      .3828       .294
           30.00       .1810      .0047      .0044      .4129       .302
           40.00       .1686      .0058      .0057      .4654       .323
           50.00       .2285      .0129      .0131      .8310       .543
           60.00       .3117      .0232      .0250      1.710      1.035
           70.00       .3338      .0269      .0269      2.275      1.331
           80.00       .5125      .0301      .0228      3.155      1.860


DATA SET NUMBER          29         30         31         32      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .1602      .0019      .0021      .2549       .210
           10.00       .0279      .0010      .0016      .0393       .035
           20.00       .0074      .0007      .0014      .0078       .009
           30.00       .0040      .0008      .0014      .0030       .005
           40.00       .0033      .0008      .0013      .0023       .004
           50.00       .0029      .0009      .0014      .0019       .004
           60.00       .0030      .0009      .0014      .0020       .004
           70.00       .0039      .0003      .0016      .0023       .004
           80.00
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AC1197-001

     TITLE
          SANDBLASTED ST ALUMINUM (FINE).
     SUBJECT CODES
          AELA   CJADB
     DATA SET NUMBERS
             1,  2,  3,  4
     PARAMETER INFORMATION
          SOURCE=  DKH     GAMMA(0)=        INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 10.00   PHI(I)= 180.0   WAVELENGTH=  .540

DATA SET NUMBER            1          2          COMPUTED
 PHI(R)    THETA(R)     RDF(LT)    RDF(PT)      RDF(OT)
 =    0     (DEG)       (1/SR)     (1/SR)       (1/SR)

             0.00        .3188      .3197        .319
            10.00        .3524      .3541        .353
            20.00        .3221      .3288        .325
            30.00        .2842      .2913        .288
            40.00        .2476      .2558        .252
            50.00        .2135      .2311        .222
            60.00        .1937      .2118        .203
            70.00        .1770      .1941        .186
            80.00        .1394      .1729        .156


DATA SET NUMBER            3          4          COMPUTED
 PHI(R)    THETA(R)     RDF(LT)    RDF(PT)      RDF(OT)
 =180.0     (DEG)       (1/SR)     (1/SR)       (1/SR)

             0.00        .3188      .3197        .319
            10.00
            20.00        .2336      .2382        .236
            30.00        .2004      .2044        .202
            40.00        .1686      .1815        .175
            50.00        .1569      .1682        .163
            60.00        .1453      .1574        .151
            70.00        .1298      .1386        .134
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AC1197-002

     TITLE
         SANDBLASTED ST ALUMINUM (FINE).
     SUBJECT CODES
         AELA   CJADB
     DATA SET NUMBERS
           1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(0)=        INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 10.00    PHI(I)= 180.0   WAVELENGTH= 1.080

DATA SET NUMBER            1          2          3          4       COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .3399      .0432      .0398      .3121        .368
           10.00        .3899      .0468      .0412      .3722        .425
           20.00        .3350      .0437      .0380      .3260        .371
           30.00        .2767      .0400      .0345      .2730        .312
           40.00        .2240      .0372      .0332      .2286        .261
           50.00        .1924      .0348      .0315      .2010        .230
           60.00        .1682      .0339      .0310      .1800        .207
           70.00        .1507      .0307      .0274      .1642        .186
           80.00        .1392      .0267      .0238      .1525        .171


DATA SET NUMBER            5          6          7          8       COMPUTED
 PHI(R)    THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0     (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00        .3399     .0432       .0398     .3121        .368
            10.00
            20.00        .2341     .0357       .0335     .2027        .253
            30.00        .1892     .0341       .0312     .1672        .211
            40.00        .1531     .0304       .0295     .1450        .179
            50.00        .1342     .0263       .0275     .1248        .156
            60.00        .1228     .0265       .0263     .1158        .146
            70.00        .1157     .0224       .0253     .1050        .134
            80.00        .1031     .0226       .0227     .0866        .118
```

(f)AEL 9

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AC1336-C01

     TITLE
         ALUMINUM ALCLAD PANEL USED AS LABORATORY STANDARD BY
         TEXAS INSTRUMENTS
     SUBJECT CODES
         AELA   CJAD
     DATA SET NUMBERS
           1,  2,  3,  4
     PARAMETER INFORMATION
         SOURCE=  DKH     GAMMA(C)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=      0   PHI(I)=      0   WAVELENGTH= 1.060

DATA SET NUMBER           1          2        COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)     RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00        .2288      .2248        .227
           20.00        .04[illegible]      .0434        .044
           30.00        .0184      .0178        .018
           40.00        .0111      .0101        .011
           50.00        .0086      .0067        .008
           60.00        .0077      .0049        .006
           70.00        .0075      .0038        .006
           80.00        .0079      .0031        .006


DATA SET NUMBER           3          4        COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)     RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00        .2263      .2217        .224
           20.00        .0434      .0427        .043
           30.00        .0186      .0181        .018
           40.00        .0116      .0109        .011
           50.00        .0088      .0070        .008
           60.00        .0080      .0050        .006
           70.00        .0080      .0036        .006
           80.00        .0085      .0029        .006
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AC1336-C01

     TITLE
         ALUMINUM ALCLAD PANEL USED AS LABORATORY STANDARD BY
         TEXAS INSTRUMENTS
     SUBJECT CODES
         AELA   CJAD
     DATA SET NUMBERS
           5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKH     GAMMA(0)=        INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00    PHI(I)=180.00    WAVELENGTH= 1.060

DATA SET NUMBER          5          6        COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)

            0.00       .0071      .0042       .006
           10.00       .0097      .0062       .008
           20.00       .0148      .0104       .013
           30.00       .0278      .0220       .025
           40.00       .0762      .0683       .072
           50.00       .4055      .4151       .410
           60.00      134.61     149.51    142.060
           70.00       .8373      .8487       .843
           80.00       .2393      .1624       .201


DATA SET NUMBER          7          8        COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)    RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)

            0.00       .0071      .0042       .006
           10.00       .0058      .0032       .004
           20.00       .0050      .0025       .004
           30.00       .0047      .0023       .003
           40.00       .0040      .0021       .003
           50.00       .0050      .0022       .004
           60.00
           70.00       .0074      .0029       .005
           80.00       .0145      .0062       .010
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AC1296-001

     TITLE
        COPPER PLATED, SANDBLASTED STAINLESS STEEL USED AS
        LABORATORY STANDARD BY TEXAS INSTRUMENTS, 4 INCHES SQUARE.
        (SAMPLE 1196 REPLATED)
     SUBJECT CODES
        AELC   AHA    CJAG
     DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(C)=      INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=      0   PHI(I)=      0   WAVELENGTH= 1.060

DATA SET NUMBER          1         2         3         4      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00
           10.00       .1919     .0669     .0648     .1978      .261
           20.00       .2026     .0645     .0649     .1968      .264
           30.00       .2144     .0638     .0649     .2050      .274
           40.00       .2203     .0597     .0623     .2065      .274
           50.00       .2347     .0567     .0603     .2212      .286
           60.00       .2450     .0523     .0556     .2327      .293
           70.00       .2570     .0457     .0492     .2402      .296
           80.00       .2685     .0357     .0384     .2532      .298


DATA SET NUMBER          5         6         7         8      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00
           10.00       .1914     .0641     .0643     .1894      .255
           20.00       .1925     .0635     .0625     .1915      .255
           30.00       .1945     .0610     .0600     .1959      .256
           40.00       .2069     .0580     .0589     .2037      .264
           50.00       .2172     .0556     .0557     .2139      .271
           60.00       .2263     .0512     .0511     .2258      .277
           70.00       .2355     .0453     .0457     .2382      .282
           80.00       .2543     .0375     .0366     .2596      .294
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AC1296-001

     TITLE
          COPPER PLATED, SANDBLASTED STAINLESS STEEL USED AS
          LABORATORY STANDARD BY TEXAS INSTRUMENTS, 4 INCHES SQUARE.
          (SAMPLE 1196 REPLATED)
     SUBJECT CODES
          AELC   AHA    CJAG
     DATA SET NUMBERS
            9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
          SOURCE=  DKH     GAMMA(C)=        INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT    NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 20.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER          9          10          11          12      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)     RDF(PL)     RDF(LP)     RDF(PP)    RDF(OT)
 =    0     (DEG)      (1/SR)      (1/SR)      (1/SR)      (1/SR)     (1/SR)

             0.00       .1971       .0402       .0639       .1187       .210
            10.00       .2021       .0402       .0672       .1208       .215
            20.00       .2012       .0390       .0648       .1219       .213
            30.00       .2140       .0398       .0643       .1315       .225
            40.00       .2285       .0382       .0623       .1399       .234
            50.00       .2526       .0367       .0604       .1544       .252
            60.00       .2773       .0325       .0580       .1683       .268
            70.00       .3220       .0297       .0518       .1977       .301
            80.00       .3755       .0257       .0451       .2365       .341


DATA SET NUMBER          13         14          15          16      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)     RDF(PL)     RDF(LP)     RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)      (1/SR)      (1/SR)      (1/SR)     (1/SR)

             0.00       .1971       .0402       .0639       .1187       .210
            10.00       .2007       .0402       .0648       .1231       .214
            20.00
            30.00       .2083       .0390       .0646       .1273       .220
            40.00       .2060       .0373       .0607       .1267       .215
            50.00       .2027       .0354       .0570       .1229       .209
            60.00       .2017       .0326       .0529       .1222       .205
            70.00       .2007       .0284       .0466       .1194       .198
            80.00       .1975       .0230       .0375       .1172       .188
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AC1296-C01

     TITLE
        COPPER PLATED, SANDBLASTED STAINLESS STEEL USED AS
        LABORATORY STANDARD BY TEXAS INSTRUMENTS, 4 INCHES SQUARE.
        (SAMPLE 1196 REPLATED)
     SUBJECT CODES
        AELD    AHA    CJAG
     DATA SET NUMBERS
         17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 30.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER          17        18        19        20      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
  =    0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00       .1969     .0662     .0610     .2054       .265
            10.00       .2014     .0629     .0621     .2010       .264
            20.00       .2076     .0623     .0634     .2094       .271
            30.00       .2151     .0632     .0631     .2173       .279
            40.00       .2332     .0621     .0621     .2370       .297
            50.00       .2553     .0589     .0583     .2602       .316
            60.00       .2934     .0561     .0564     .3030       .354
            70.00       .3423     .0508     .0512     .3641       .404
            80.00       .4384     .0460     .0476     .4710       .501


DATA SET NUMBER          21        22        23        24      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00       .196[illegible]     .0662     .0610     .2054       .265
            10.00       .2000     .0638     .0603     .2011       .263
            20.00       .20[illegible]     .0644     .0620     .2107       .270
            30.00
            40.00       .1975     .0628     .0599     .2059       .263
            50.00       .1912     .0572     .0545     .1949       .249
            60.00       .1828     .0526     .0498     .1855       .235
            70.00       .1736     .0457     .0434     .1771       .220
            80.00       .1709     .0377     .0335     .1709       .207
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AC1296-001

TITLE
COPPER PLATED, SANDBLASTED STAINLESS STEEL USED AS LABORATORY STANDARD BY TEXAS INSTRUMENTS, 4 INCHES SQUARE. (SAMPLE 1196 REPLATED)

SUBJECT CODES
AELC AHA CJAG

DATA SET NUMBERS
25, 26, 27, 28, 29, 30, 31, 32

PARAMETER INFORMATION
SOURCE= DKH GAMMA(C)= INSTRUMENTATION= CLA
ACCURACY= FIVE PERCENT NUMBER OF RUNS AVERAGED= 1
THETA(I)= 40.00 PHI(I)=180.00 WAVELENGTH= 1.060

DATA SET NUMBER		25	26	27	28	COMPUTED
PHI(R) = 0	THETA(R) (DEG)	RDF(LL) (1/SR)	RDF(PL) (1/SR)	RDF(LP) (1/SR)	RDF(PP) (1/SR)	RDF(OT) (1/SR)
	0.00	.2038	.0600	.0582	.2034	.263
	10.00	.2118	.0600	.0601	.2093	.271
	20.00	.2156	.0599	.0590	.2140	.274
	30.00	.2252	.0598	.0602	.2263	.286
	40.00	.2397	.0588	.0589	.2426	.300
	50.00	.2678	.0578	.0577	.2749	.329
	60.00	.3029	.0546	.0535	.3194	.365
	70.00	.3718	.0494	.0521	.3990	.436
	80.00	.4988	.0463	.0495	.5429	.569

DATA SET NUMBER		29	30	31	32	COMPUTED
PHI(R) =180.0	THETA(R) (DEG)	RDF(LL) (1/SR)	RDF(PL) (1/SR)	RDF(LP) (1/SR)	RDF(PP) (1/SR)	RDF(OT) (1/SR)
	0.00	.2038	.0600	.0582	.2034	.263
	10.00	.2047	.0603	.0597	.2037	.264
	20.00	.1995	.0595	.0578	.1982	.257
	30.00	.1984	.0594	.0599	.2012	.259
	40.00					
	50.00	.1968	.0578	.0550	.1912	.250
	60.00	.1855	.0521	.0523	.1762	.233
	70.00	.1747	.0452	.0447	.1630	.214
	80.00	.1644	.0365	.0357	.1527	.195

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AC1296-001

     TITLE
          COPPER PLATED, SANDBLASTED STAINLESS STEEL USED AS
          LABORATORY STANDARD BY TEXAS INSTRUMENTS, 4 INCHES SQUARE.
          (SAMPLE 1196 REPLATED)
     SUBJECT CODES
          AELD    AHA     CJAG
     DATA SET NUMBERS
            33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
          SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER          33         34         35         36       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .2332      .0520      .0526      .2248       .281
           10.00       .2410      .0531      .0521      .2441       .295
           20.00       .2557      .0549      .0517      .2663       .314
           30.00       .2791      .0543      .0535      .2904       .339
           40.00       .2991      .0537      .0528      .3156       .361
           50.00       .3231      .0539      .0534      .3527       .392
           60.00       .3712      .0536      .0505      .4168       .446
           70.00       .4540      .0496      .0503      .5326       .543
           80.00       .6281      .0512      .0537      .7913       .762


DATA SET NUMBER          37         38         39         40       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .2332      .0520      .0526      .2248       .281
           10.00       .2162      .0522      .0525      .2087       .265
           20.00       .1966      .0504      .0516      .1910       .245
           30.00       .1895      .0514      .0522      .1805       .237
           40.00       .1791      .0495      .0509      .1679       .224
           50.00       .1880      .0516      .0528      .1778       .235
           60.00
           70.00       .1943      .0481      .0482      .1809       .236
           80.00       .1801      .0409      .0390      .1620       .211
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AC1296-C01

     TITLE
          COPPER PLATED, SANDBLASTED STAINLESS STEEL USED AS
          LABORATORY STANDARD BY TEXAS INSTRUMENTS, 4 INCHES SQUARE.
          (SAMPLE 1196 REPLATED)
     SUBJECT CODES
          AELC    AMA    CJAG
     DATA SET NUMBERS
           41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
          SOURCE=  DKH    GAMMA(C)=         INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 70.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER        41         42         43         44       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .2204      .0426      .0445      .2157       .262
           10.00      .2580      .0469      .0474      .2532       .303
           20.00      .2885      .0491      .0497      .2880       .338
           30.00      .3167      .0479      .0489      .3221       .368
           40.00      .3481      .0510      .0483      .3621       .405
           50.00      .3780      .0508      .0462      .4303       .453
           60.00      .4237      .0510      .0494      .5659       .545
           70.00      .5658      .0497      .0521      .9073       .787
           80.00      .8204      .0583      .0648      1.251      1.097


DATA SET NUMBER        45         46         47         48       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .2204      .0426      .0445      .2157       .262
           10.00      .1958      .0415      .0429      .1891       .235
           20.00      .1775      .0416      .0435      .1714       .217
           30.00      .1612      .0406      .0421      .1539       .199
           40.00      .1567      .0406      .0429      .1481       .194
           50.00      .1515      .0392      .0402      .1421       .186
           60.00      .1767      .0436      .0460      .1664       .216
           70.00
           80.00      .2192      .0449      .0456      .2228       .266
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AC1332-001

    TITLE
        COPPER-PLATED, SANDBLASTED STAINLESS STEEL, 3 INCHES SQUARE.
    SUBJECT CODES
        AELC    AHA    CJAG
    DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
    PARAMETER INFORMATION
        SOURCE=  DKH     GAMMA(O)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=      0   PHI(I)=     0   WAVELENGTH= 1.060

DATA SET NUMBER            1          2          3          4       COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00        .2122      .0797      .0820      .2061       .290
           20.00        .2128      .0774      .0783      .2071       .288
           30.00        .2212      .0737      .0751      .2150       .292
           40.00        .2271      .0688      .0696      .2197       .293
           50.00        .2367      .0640      .0654      .2321       .299
           60.00        .2375      .0568      .0584      .2350       .294
           70.00        .2412      .0478      .0484      .2391       .288
           80.00        .2526      .0356      .0367      .2565       .291


DATA SET NUMBER            5          6          7          8       COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
=180.0     (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00        .2076      .0768      .0815      .1940       .280
           20.00        .2139      .0723      .0783      .1974       .281
           30.00        .2213      .0690      .0736      .2059       .285
           40.00        .2296      .0648      .0705      .2134       .289
           50.00        .2381      .0593      .0639      .2216       .291
           60.00        .2491      .0522      .0569      .2327       .295
           70.00        .2557      .0447      .0477      .2395       .294
           80.00        .2681      .0318      .0363      .2528       .295
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AC1332-001

     TITLE
         COPPER-PLATED, SANDBLASTED STAINLESS STEEL, 3 INCHES SQUARE.
     SUBJECT CODES
         AELC    AHA     CJAG
     DATA SET NUMBERS
           9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 20.00    PHI(I)=180.00    WAVELENGTH= 1.060

DATA SET NUMBER          9         10         11         12       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .2103      .0745      .0751      .2036        .282
           10.00       .2031      .0747      .0755      .2022        .278
           20.00       .2016      .0719      .0726      .1982        .272
           30.00       .2122      .0703      .0713      .2097        .282
           40.00       .2256      .0654      .0676      .2263        .292
           50.00       .2465      .0580      .0622      .2480        .307
           60.00       .2714      .0497      .0578      .2725        .326
           70.00       .3095      .0416      .0516      .3071        .355
           80.00       .3438      .0282      .0381      .3420        .376


DATA SET NUMBER         13         14         15         16       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .2103      .0745      .0751      .2036        .282
           10.00       .2237      .0757      .0762      .2189        .297
           20.00
           30.00       .2312      .0716      .0728      .2227        .299
           40.00       .2290      .0649      .0681      .2206        .291
           50.00       .2193      .0581      .0614      .2116        .275
           60.00       .2175      .0519      .0537      .2087        .266
           70.00       .2089      .0431      .0451      .2025        .250
           80.00       .2130      .0309      .0337      .2015        .240
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AC1332-001

     TITLE
        COPPER-PLATED, SANDBLASTED STAINLESS STEEL, 3 INCHES SQUARE.
     SUBJECT CODES
        AELC   AHA    CJAG
     DATA SET NUMBERS
         17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 30.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER          17         18         19         20       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

             0.00       .2212      .0724      .0750      .2152       .292
            10.00       .2062      .0718      .0726      .2062       .278
            20.00       .2054      .0711      .0712      .2067       .277
            30.00       .2067      .0694      .0683      .2101       .277
            40.00       .2206      .0667      .0655      .2253       .289
            50.00       .2435      .0639      .0613      .2517       .310
            60.00       .2844      .0575      .0597      .2876       .345
            70.00       .3302      .0503      .0527      .3367       .385
            80.00       .4115      .0432      .0460      .4195       .460


DATA SET NUMBER          21         22         23         24       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

             0.00       .2212      .0724      .0750      .2152       .292
            10.00       .2232      .0710      .0725      .2123       .289
            20.00       .2315      .0711      .0724      .2238       .299
            30.00
            40.00       .2294      .0663      .0659      .2189       .290
            50.00       .2136      .0590      .0606      .2061       .270
            60.00       .2039      .0514      .0517      .1945       .251
            70.00       .1970      .0423      .0430      .1860       .234
            80.00       .1826      .0307      .0305      .1751       .209
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AC1332-001

     TITLE
        COPPER-PLATED, SANDBLASTED STAINLESS STEEL, 3 INCHES SQUARE.
     SUBJECT CODES
        AELD   AHA   CJAG
     DATA SET NUMBERS
         25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(C)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 40.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER         25        26        27        28      COMPUTED
 PHI(R)  THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0   (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

           0.00       .2331     .0642     .0709     .2113       .290
          10.00       .2240     .0648     .0677     .2181       .287
          20.00       .2200     .0640     .0638     .2155       .282
          30.00       .2195     .0632     .0638     .2154       .281
          40.00       .2288     .0593     .0615     .2263       .288
          50.00       .2496     .0561     .0587     .2488       .307
          60.00       .2860     .0504     .0530     .2894       .339
          70.00       .3496     .0444     .0488     .3552       .399
          80.00       .4494     .0348     .0395     .4685       .496


DATA SET NUMBER         29        30        31        32      COMPUTED
 PHI(R)  THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0   (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

           0.00       .2331     .0642     .0709     .2113       .290
          10.00       .2374     .0646     .0720     .2152       .295
          20.00       .2276     .0644     .0691     .2114       .286
          30.00       .2317     .0629     .0688     .2125       .288
          40.00
          50.00       .2126     .0565     .0585     .2027       .265
          60.00       .2023     .0498     .0521     .1893       .247
          70.00       .1856     .0394     .0420     .1736       .220
          80.00       .1786     .0315     .0312     .1645       .203
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AC1332-001

     TITLE
        COPPER-PLATED, SANDBLASTED STAINLESS STEEL, 3 INCHES SQUARE.
     SUBJECT CODES
        AELC    AHA    CJAG
     DATA SET NUMBERS
         33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(C)=      INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER           33         34         35         36      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .2375      .0570      .0572      .2371       .294
           10.00       .2560      .0575      .0577      .2488       .310
           20.00       .2640      .0574      .0583      .2585       .319
           30.00       .2772      .0567      .0571      .2742       .333
           40.00       .2845      .0561      .0559      .2833       .340
           50.00       .2958      .0531      .0537      .3019       .352
           60.00       .3294      .0493      .0502      .3430       .386
           70.00       .3826      .0438      .0462      .4095       .441
           80.00       .5219      .0352      .0437      .5773       .589


DATA SET NUMBER           37         38         39         40      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .2375      .0570      .0572      .2371       .294
           10.00       .2258      .0554      .0566      .2202       .279
           20.00       .2097      .0523      .0545      .2028       .260
           30.00       .2072      .0523      .0544      .1978       .256
           40.00       .2000      .0494      .0515      .1882       .245
           50.00       .2049      .0498      .0524      .1983       .253
           60.00
           70.00       .2134      .0425      .0437      .2050       .252
           80.00       .1833      .0314      .0323      .1764       .212
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AC1332-C01

     TITLE
        COPPER-PLATEC, SANDBLASTEC STAINLESS STEEL, 3 INCHES SCUARE.
     SUBJECT CCDES
        AELC   AHA    CJAG
     CATA SET NUMBERS
        41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATICN
        SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATICN= CLA
        ACCURACY= FIVE PERCENT   NUMBER CF RUNS AVERAGEC= 1
        THETA(I)= 70.C0   PHI(I)=18C.C0   WAVELENGTH= 1.060

                             41          42          43          44      CCMPUTEC
DATA SET NUMBER            RDF(LL)     RCF(PL)     RDF(LP)     RCF(PP)    RCF(OT)
 PHI(R)    THETA(R)        (1/SR)      (1/SR)      (1/SR)      (1/SR)     (1/SR)
 =    0     (DEG)

             C.00           .24CC       .C5C4       .0462       .2394       .288
            1C.00           .2515       .C483       .0449       .2619       .303
            2C.00           .2742       .C484       .0463       .2808       .325
            3C.C0           .2893       .C479       .0470       .2964       .340
            4C.00           .3C66       .C479       .0466       .3237       .362
            5C.00           .3148       .C424       .0426       .3340       .367
            6C.00           .3335       .C4C2       .04C4       .3612       .388
            7C.C0           .3745       .C347       .0356       .4326       .439
            8C.00           .4886       .C329       .0335       .5977       .576


                             45          46          47          48      CCMPUTEC
DATA SET NUMBER            RCF(LL)     RCF(PL)     RDF(LP)     RDF(PP)    RDF(OT)
 PHI(R)    THETA(R)        (1/SR)      (1/SR)      (1/SR)      (1/SR)     (1/SR)
 =180.0     (CEG)

             C.0C           .24CC       .C5C4       .0462       .2394       .288
            1C.CC           .2213       .C448       .0465       .2155       .264
            2C.00           .2079       .C458       .0456       .2066       .253
            3C.C0           .1930       .C439       .0436       .1924       .236
            4C.C0           .1929       .0415       .0439       .1811       .23C
            5C.00           .1815       .C363       .0380       .1670       .211
            6C.C0           .2151       .C410       .0443       .2039       .252
            7C.00
            8C.00           .2298       .C345       .0373       .2081       .255
```

(f)AEM 1

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AC1187-001

      TITLE
         BLACK PAINT (AF3621-73-0000-8730) THINNED 1 TO 1 WITH
         AMYL ACETATE, 2 COATS APPLIED 5 MIN. APART, SPRAYED ON
         120 GAUGE STEEL.
      SUBJECT CODES
         AEM     ECBBL
      DATA SET NUMBERS
            1,  2,  3,  4
      PARAMETER INFORMATION
         SOURCE=  DKI     GAMMA(0)=.90    INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=      0    PHI(I)=      0   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4     COMPUTED
 PHI(R)  THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0   (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .1176      .0000      .0000      .1795       .149
           15.00       .0369      .0000      .0000      .0544       .046
           20.00       .0142      .0000      .0001      .0199       .017
           30.00       .0034      .0001      .0001      .0047       .004
           45.00       .0011      .0001      .0001      .0018       .002
           60.00       .0007      .0001      .0001      .0013       .001
           70.00       .0006      .0001      .0001      .0013       .001
           80.00       .0006      .0002      .0001      .0013       .001
```

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AC1187-001

     TITLE
          BLACK PAINT (AF3621-73-0000-8730) THINNED 1 TO 1 WITH
          AMYL ACETATE, 2 COATS APPLIED 5 MIN. APART, SPRAYED ON
          120 GAUGE STEEL.
     SUBJECT CODES
          AEM    ECBBL
     DATA SET NUMBERS
            5,  6,  7,  8,  9, 10, 11, 12
     PARAMETER INFORMATION
          SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 45.00   PHI(I)= 180.0   WAVELENGTH=  .633

DATA SET NUMBER           5          6          7          8      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =     0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .0006      .0000      .0000      .0007       .001
           15.00        .0013      .0000      .0000      .0022       .002
           35.00        .0297      .0009      .0006      .1370       .084
           45.00        .4146      .0000      .0138      3.975      2.202
           55.00        .0299      .0000      .0031      .7923       .413
           65.00        .0010      .0000      .0005      .0916       .047
           80.00        .0010      .0000      .0000      .0198       .010


DATA SET NUMBER           9         10         11         12      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .0006      .0000      .0000      .0007       .001
           15.00        .0006      .0000      .0000      .0005       .001
           35.00        .0006      .0000      .0000      .0004       .001
           45.00
           55.00        .0005      .0000      .0000      .0004       .000
           70.00        .0005      .0000      .0000      .0004       .000
           80.00        .0005      .0000      .0000      .0004       .000
```

(f)AEM 3

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AC1187-C01

     TITLE
          BLACK PAINT (AF3621-73-CC00-8730) THINNED 1 TO 1 WITH
          AMYL ACETATE, 2 COATS APPLIED 5 MIN. APART, SPRAYED ON
          120 GAUGE STEEL.
     SUBJECT CODES
          AEM    ECBBL
     DATA SET NUMBERS
           13, 14, 15, 16, 17, 18, 19, 20
     PARAMETER INFORMATION
          SOURCE=  DKI     GAMMA(0)=.90   INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 70.00    PHI(I)= 180.0   WAVELENGTH=  .633

DATA SET NUMBER         13         14         15         16      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .0004      .0000      .0000      .0005        .000
           20.00       .0004      .0000      .0000      .0010        .001
           40.00       .0005      .0000      .0001      .0107        .006
           50.00                  .0000                 .0824
           60.00       .0614      .0000      .0050      1.155        .611
           65.00       .8031      .0000      .0371      9.368       5.104
           70.00       8.340      .0000      .2453     64.830      36.708
           75.00       5.446      .0000      .1297     34.154      19.865
           80.00       1.256      .0000      .0193      5.953       3.614


DATA SET NUMBER         17         18         19         20      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .0004      .0000      .0000      .0005        .000
           20.00       .0004      .0000      .0000      .0004        .000
           40.00       .0005      .0000      .0000      .0004        .000
           60.00       .0004      .0000      .0001      .0005        .001
           70.00
           80.00       .0006      .0000      .0001      .0009        .001
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(f)AEM 4

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AC1337-001

     TITLE
          3 COATS 3M BLACK VELVET PAINT COVERING 30 PERCENT OF
          ALUMINUM ALCLAD PANEL IN POLKA-DOTTED PATTERN USED AS
          LABORATORY STANDARD BY TEXAS INSTRUMENTS.
     SUBJECT CODES
          AEM    ECBBL   AELA   CJAG
     DATA SET NUMBERS
            1,  2,  3,  4
     PARAMETER INFORMATION
          SOURCE=  DKH     GAMMA(0)=       INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)=     0    PHI(I)=     0   WAVELENGTH= 1.060

DATA SET NUMBER         1          2       COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .1873      .1701       .179
           20.00       .0404      .0370       .039
           30.00       .0175      .0164       .017
           40.00       .0106      .0102       .010
           50.00       .0084      .0082       .008
           60.00       .0074      .0074       .007
           70.00       .0070      .0071       .007
           80.00       .0097      .0085       .009


DATA SET NUMBER         3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .1884      .1706       .179
           20.00       .0402      .0368       .039
           30.00       .0172      .0165       .017
           40.00       .0110      .0107       .011
           50.00       .0084      .0085       .008
           60.00       .0075      .0076       .008
           70.00       .0072      .0074       .007
           80.00       .0073      .0086       .008
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(f)AEM 5

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AC1337-001

     TITLE
         3 COATS 3M BLACK VELVET PAINT COVERING 30 PERCENT OF
         ALUMINUM ALCLAD PANEL IN POLKA-DOTTED PATTERN USED AS
         LABORATORY STANDARD BY TEXAS INSTRUMENTS.
     SUBJECT CODES
         AEM     ECBBL   AELA   CJAC
     DATA SET NUMBERS
          5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKH     GAMMA(C)=        INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT    NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER          5         6        COMPUTED
 PHI(R)   THETA(R)    RDF(LT)   RDF(PT)    RDF(OT)
 =    0    (DEG)      (1/SR)    (1/SR)     (1/SR)

            0.00       .0073     .0071       .007
           10.00       .0093     .0096       .009
           20.00       .0133     .0142       .014
           30.00       .0245     .0261       .025
           40.00       .0644     .0678       .066
           50.00       .3065     .3216       .314
           60.00      76.047    84.581     80.314
           70.00       .7653     .8295       .797
           80.00       .2339     .2416       .238


DATA SET NUMBER          7         8        COMPUTED
 PHI(R)   THETA(R)    RDF(LT)   RDF(PT)    RDF(OT)
 =180.0    (DEG)      (1/SR)    (1/SR)     (1/SR)

            0.00       .0073     .0071       .007
           10.00       .0065     .0060       .006
           20.00       .0061     .0052       .006
           30.00       .0060     .0049       .005
           40.00       .0053     .0041       .005
           50.00       .0068     .0051       .006
           60.00
           70.00       .0096     .0072       .008
           80.00       .0177     .0161       .017
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AC1338-001

     TITLE
         2 COATS 3M BLACK VELVET PAINT COVERING 64.4 PERCENT OF
         ALUMINUM ALCLAD PANEL IN POLKA-DOTTED PATTERN USED AS
         LABORATORY STANDARD BY TEXAS INSTRUMENTS.
     SUBJECT CODES
         AEM    ECBBL  AELA   CJAG
     DATA SET NUMBERS
           1,  2,  3,  4
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(0)=      INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=     0    PHI(I)=     0   WAVELENGTH= 1.060

DATA SET NUMBER          1          2       COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)    RDF(OT)
 =   0     (DEG)      (1/SR)     (1/SR)     (1/SR)

           0.00
          10.00        .1324      .1195       .126
          20.00        .0409      .0374       .039
          30.00        .0219      .0203       .021
          40.00        .0152      .0144       .015
          50.00        .0120      .0119       .012
          60.00        .0105      .0113       .011
          70.00        .0096      .0114       .011
          80.00        .0088      .0133       .011


DATA SET NUMBER          3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)

           0.00
          10.00        .1427       1266       .135
          20.00        .0409      .0368       .039
          30.00        .0220      .0206       .021
          40.00        .0149      .0147       .015
          50.00        .0116      .0123       .012
          60.00        .0105      .0114       .011
          70.00        .0099      .0120       .011
          80.00        .0093      .0139       .012
```

(f)AEM 7

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AD1338-001

     TITLE
         3 COATS 3M BLACK VELVET PAINT COVERING 64.4 PERCENT OF
         ALUMINUM ALCLAD PANEL IN POLKA-DOTTED PATTERN USED AS
         LABORATORY STANDARD BY TEXAS INSTRUMENTS.
     SUBJECT CODES
         AEM    ECBBL  AELA   CJAG
     DATA SET NUMBERS
           5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(D)=        INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER           5          6         COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)      RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)       (1/SR)

            0.00        .0099      .0106         .010
           10.00        .0123      .0142         .013
           20.00        .0167      .0203         .019
           30.00        .0279      .0347         .031
           40.00        .0631      .0760         .070
           50.00        .2567      .2890         .273
           60.00       38.542     46.418       42.480
           70.00        .3650      .4703         .418
           80.00        .1271      .2016         .164


DATA SET NUMBER           7          8         COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)      RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)       (1/SR)

            0.00        .0099      .0106         .010
           10.00        .0090      .0090         .009
           20.00        .0084      .0076         .008
           30.00        .0084      .0072         .008
           40.00        .0076      .0061         .007
           50.00        .0096      .0077         .009
           60.00
           70.00        .0123      .0099         .011
           80.00        .0176      .0178         .018
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AC1339-C01

     TITLE
          3 COATS OF 3M BLACK VELVET PAINT ON ALUMINUM ALCLAD
          PANEL SUBSTRATE USED AS LABORATORY STANDARD BY
          TEXAS INSTRUMENTS.
     SUBJECT CODES
          AEM     ECBBL   CJAG
     DATA SET NUMBERS
            1,  2,  3,  4
     PARAMETER INFORMATION
          SOURCE=  DKH     GAMMA(C)=       INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)=      0    PHI(I)=      0    WAVELENGTH= 1.060

DATA SET NUMBER          1          2         COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00       .0076      .0070        .007
           20.00       .0072      .0072        .007
           30.00       .0069      .0077        .007
           40.00       .0065      .0084        .007
           50.00       .0061      .0095        .008
           60.00       .0057      .0109        .008
           70.00       .0053      .0133        .009
           80.00       .0049      .0173        .011


DATA SET NUMBER          3          4         COMPUTED
 PHI(R)   THETA(R)    RDF(LT)    RDF(PT)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00       .0076      .0069        .007
           20.00       .0072      .0071        .007
           30.00       .0069      .0075        .007
           40.00       .0066      .0084        .008
           50.00       .0062      .0093        .008
           60.00       .0058      .0109        .008
           70.00       .0055      .0133        .009
           80.00       .0055      .0178        .012
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AC1339-001

     TITLE
         3 COATS OF 3M BLACK VELVET PAINT ON ALUMINUM ALCLAD
         PANEL SUBSTRATE USED AS LABORATORY STANDARD BY
         TEXAS INSTRUMENTS.
     SUBJECT CODES
         AEM     ECBBL  CJAG
     DATA SET NUMBERS
           5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00    PHI(I)=180.00    WAVELENGTH= 1.060

DATA SET NUMBER             5          6        COMPUTED
 PHI(R)    THETA(R)      RDF(LT)    RDF(PT)     RDF(OT)
 =    0     (DEG)        (1/SR)     (1/SR)      (1/SR)

             0.00        .0056      .0101        .008
            10.00        .0048      .0120        .008
            20.00        .0041      .0143        .009
            30.00        .0032      .0182        .011
            40.00        .0025      .0238        .013
            50.00        .0023      .0330        .018
            60.00        .0037      .0493        .026
            70.00        .0102      .0819        .046
            80.00        .0322      .1519        .092


DATA SET NUMBER             7          8        COMPUTED
 PHI(R)    THETA(R)      RDF(LT)    RDF(PT)     RDF(OT)
 =180.0     (DEG)        (1/SR)     (1/SR)      (1/SR)

             0.00        .0056      .0101        .008
            10.00        .0062      .0093        .008
            20.00        .0069      .0085        .008
            30.00        .0077      .0083        .008
            40.00        .0074      .0071        .007
            50.00        .0100      .0092        .010
            60.00
            70.00        .0128      .0119        .012
            80.00        .0070      .0191        .013
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(f)AEM 10

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AC129C-001

     TITLE
        3M WHITE VELVET PAINT (TWO COATS) ON ONE COAT ZINC CHROMATE
        PRIMER ON ANODIZED ALUMINUM SUBSTRATE (6 IN. SQ.).
     SUBJECT CODES
        AEMA   ECBBJ  CJAG
     DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(O)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=      0   PHI(I)=      0   WAVELENGTH= 1.060

DATA SET NUMBER          1          2          3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

           0.00
          10.00        .1559      .1330      .1297      .1519        .285
          20.00        .1529      .1323      .1272      .1440        .278
          30.00        .1516      .1317      .1314      .1471        .281
          40.00        .1482      .1288      .1309      .1433        .276
          50.00        .1521      .1304      .1332      .1447        .280
          60.00        .1510      .1293      .1329      .1450        .279
          70.00        .1487      .1279      .1319      .1461        .277
          80.00        .1443      .1226      .1246      .1438        .268


DATA SET NUMBER          5          6          7          8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

           0.00
          10.00        .1580      .1324      .1303      .1489        .285
          20.00        .1551      .1346      .1333      .1483        .286
          30.00        .1515      .1326      .1329      .1471        .282
          40.00        .1502      .1347      .1308      .1504        .283
          50.00        .1457      .1334      .1287      .1496        .279
          60.00        .1427      .1333      .1261      .1493        .276
          70.00        .1363      .1301      .1200      .1478        .267
          80.00        .1283      .1237      .1107      .1454        .254
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AC129C-C01

     TITLE
          3M WHITE VELVET PAINT (TWC CCATS) CN CNE CCAT ZINC CHRCMATE
          PRIMER CN ANCCIZED ALUMINUM SUBSTRATE (6 IN. SC.).
     SUBJECT CCDES
          AEMA    ECBBJ  CJAG
     CATA SET NUMBERS
              9, 1C, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATICN
          SOURCE=  DKH     GAMMA(C)=        INSTRUMENTATICN= CLA
          ACCURACY= FIVE PERCENT   NUMBER CF RUNS AVERAGEC= 1
          THETA(I)= 20.CC    PHI(I)= 18C.C    WAVELENGTH= 1.060

DATA SET NUMBER              9          10          11          12       COMPUTEC
 PHI(R)    THETA(R)      RDF(LL)     RCF(PL)     RDF(LP)     RDF(PP)     RDF(OT)
  =    0     (CEG)        (1/SR)      (1/SR)      (1/SR)      (1/SR)      (1/SR)

              C.CC        .159C       .1286       .1349       .1416        .282
             1C.CO        .1568       .1259       .1376       .1422        .281
             2C.CC        .1513       .1264       .1341       .1405        .276
             3C.CO        .15C9       .1275       .1361       .1430        .279
             4C.00        .148C       .1311       .1348       .1464        .280
             5C.CO        .1458       .1345       .1331       .1496        .281
             6C.CO        .1414       .1331       .1285       .1540        .278
             7C.CO        .1354       .1351       .1262       .1638        .282
             8C.CO        .1354       .1325       .1194       .1699        .279


DATA SET NUMBER             13          14          15          16       COMPUTEC
 PHI(R)    THETA(R)      RDF(LL)     RCF(PL)     RDF(LP)     RCF(PP)     RCF(OT)
 =18C.C     (CEG)         (1/SR)      (1/SR)      (1/SR)      (1/SR)      (1/SR)

              C.CC        .155C       .1286       .1349       .1416        .282
             1C.CO        .1648       .1292       .1363       .1478        .289
             2C.CO
             3C.00        .1676       .1253       .1387       .1457        .289
             4C.CO        .1638       .1282       .139C       .1433        .287
             5C.00        .16C5       .1294       .1372       .1445        .286
             6C.00        .1584       .1338       .1357       .1493        .289
             7C.00        .1552       .1318       .1325       .1486        .284
             8C.00        .15C1       .1275       .1259       .1439        .274
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AC1290-001

     TITLE
        3M WHITE VELVET PAINT (TWO COATS) ON ONE COAT ZINC CHROMATE
        PRIMER ON ANODIZED ALUMINUM SUBSTRATE (6 IN. SQ.).
     SUBJECT CODES
        AEMA   ECBBJ  CJAG
     DATA SET NUMBERS
        33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
        SOURCE=  DKH     GAMMA(O)=        INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 60.00   PHI(I)= 180.0   WAVELENGTH= 1.060

                                                               COMPUTED
DATA SET NUMBER        33         34         35         36       RDF(OT)
  PHI(R)  THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    (1/SR)
  =    0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .1556      .1210      .1400      .1389      .278
           10.00      .1558      .1205      .1428      .1410      .280
           20.00      .1505      .1225      .1404      .1474      .280
           30.00      .1490      .1243      .1404      .1530      .283
           40.00      .1444      .1252      .1359      .1617      .284
           50.00      .1448      .1271      .1339      .1732      .289
           60.00      .1483      .1234      .1326      .1911      .298
           70.00      .1578      .1215      .1295      .2278      .318
           80.00      .1907      .1225      .1286      .3287      .385


                                                               COMPUTED
DATA SET NUMBER        37         38         39         40       RDF(OT)
  PHI(R)  THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    (1/SR)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .1556      .1210      .1400      .1389      .278
           10.00      .1613      .1269      .1431      .1451      .288
           20.00      .1641      .1267      .1432      .1444      .289
           30.00      .1748      .1311      .1460      .1491      .300
           40.00      .1766      .1243      .1428      .1416      .293
           50.00      .2025      .1337      .1543      .1613      .326
           60.00
           70.00      .2314      .1493      .1675      .1814      .365
           80.00      .2231      .1484      .1645      .1740      .355
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AC1290-001

     TITLE
         3M WHITE VELVET PAINT (TWO COATS) ON ONE COAT ZINC CHROMATE
         PRIMER ON ANODIZED ALUMINUM SUBSTRATE (6 IN. SQ.).
     SUBJECT CODES
         AEMA   ECBBJ  CJAG
     DATA SET NUMBERS
          41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(C)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 70.00   PHI(I)= 180.0   WAVELENGTH= 1.060

DATA SET NUMBER        41        42        43        44      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00      .1458     .1174     .1322     .1384       .267
           10.00      .1360     .1165     .1255     .1405       .260
           20.00      .1395     .1173     .1293     .1472       .267
           30.00      .1368     .1165     .1262     .1532       .266
           40.00      .1401     .1174     .1302     .1657       .277
           50.00      .1431     .1151     .1298     .1822       .285
           60.00      .1536     .1138     .1292     .2159       .306
           70.00      .1877     .1171     .1296     .2990       .367
           80.00      .3114     .1161     .1363     .5540       .559


DATA SET NUMBER        45        46        47        48      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00      .1458     .1174     .1322     .1394       .267
           10.00      .1464     .1164     .1305     .1353       .264
           20.00      .1574     .1220     .1376     .1397       .278
           30.00      .1631     .1220     .1388     .1403       .282
           40.00      .1709     .1295     .1416     .1504       .296
           50.00      .1645     .1234     .1300     .1432       .281
           60.00      .2103     .1457     .1539     .1796       .345
           70.00
           80.00      .2668     .1745     .1779     .2226       .421
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AC1292-C01

     TITLE
        3M WHITE VELVET PAINT (TWO COATS) ON ONE COAT ZINC CHROMATE
        PRIMER ON ANODIZED ALUMINUM SUBSTRATE (11 IN. SQ.).
     SUBJECT CODES
        AEMA    ECBBJ   CJAG
     DATA SET NUMBERS
          1,   2,   3,   4,   5,   6,   7,   8
     PARAMETER INFORMATION
        SOURCE=  DKH     GAMMA(C)=        INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=       0   PHI(I)=       0   WAVELENGTH= 1.060

DATA SET NUMBER           1          2          3          4      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .1730      .1508      .1432      .1698       .318
           20.00       .1665      .1502      .1417      .1645       .311
           30.00       .1639      .1528      .1433      .1694       .315
           40.00       .1593      .1475      .1400      .1653       .306
           50.00       .1567      .1478      .1385      .1636       .303
           60.00       .1526      .1457      .1353      .1629       .298
           70.00       .1464      .1397      .1291      .1594       .287
           80.00       .1351      .1269      .1160      .1488       .263


DATA SET NUMBER           5          6          7          8      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .1689      .1491      .1416      .1701       .315
           20.00       .1643      .1489      .1418      .1664       .311
           30.00       .1589      .1462      .1399      .1624       .304
           40.00       .1592      .1467      .1409      .1629       .305
           50.00       .1551      .1452      .1377      .1619       .300
           60.00       .1504      .1427      .1340      .1601       .294
           70.00       .1436      .1384      .1281      .1589       .285
           80.00       .1357      .1298      .1176      .1530       .268
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AC1292-002

     TITLE
         3M WHITE VELVET PAINT (TWO COATS) ON ONE COAT ZINC CHROMATE
         PRIMER ON ANODIZED ALUMINUM SUBSTRATE (11 IN. SQ.).
     SUBJECT CODES
         AEMA   ECBBJ  CJAG
     DATA SET NUMBERS
           1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=      0   PHI(I)=      0   WAVELENGTH= 1.060

DATA SET NUMBER          1         2         3         4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00
           10.00       .1798     .1507     .1503     .1698      .325
           20.00       .1748     .1502     .1479     .1645      .319
           30.00       .1742     .1528     .1524     .1694      .324
           40.00       .1685     .1474     .1487     .1653      .315
           50.00       .1673     .1477     .1463     .1636      .312
           60.00       .1620     .1457     .1442     .1629      .307
           70.00       .1571     .1397     .1373     .1594      .297
           80.00       .1473     .1269     .1278     .1488      .275


DATA SET NUMBER          5         6         7         8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00
           10.00       .1805     .1414     .1510     .1613      .317
           20.00       .1770     .1423     .1517     .1590      .315
           30.00       .1739     .1408     .1513     .1564      .311
           40.00       .1708     .1423     .1511     .1581      .311
           50.00       .1675     .1420     .1483     .1583      .308
           60.00       .1626     .1405     .1439     .1577      .302
           70.00       .1538     .1373     .1358     .1577      .292
           80.00       .1375     .1298     .1164     .1530      .269
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AC1292-C03

     TITLE
         3M WHITE VELVET PAINT (TWO COATS) ON ONE COAT ZINC CHROMATE
         PRIMER ON ANODIZED ALUMINUM SUBSTRATE (11 IN. SQ.).
     SUBJECT CODES
         AEMA    ECBBJ  CJAG
     DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKI     GAMMA(0)=.90    INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=      0    PHI(I)=      0    WAVELENGTH= 1.060

DATA SET NUMBER            1          2          3          4       COMPUTED
 PHI(R)    THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0     (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00        .1860      .1485      .1556      .1679        .329
           20.00        .1770      .1476      .1492      .1626        .318
           30.00        .1736      .1500      .1529      .1663        .321
           40.00        .1681      .1468      .1478      .1623        .313
           50.00        .1656      .1467      .1458      .1623        .310
           60.00        .1625      .1452      .1433      .1625        .307
           70.00        .1559      .1425      .1382      .1607        .299
           80.00        .1484      .1356      .1279      .1578        .285


DATA SET NUMBER            5          6          7          8       COMPUTED
 PHI(R)    THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0     (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00
           10.00        .1822      .1500      .1525      .1693        .327
           20.00        .1776      .1503      .1524      .1666        .323
           30.00        .1732      .1482      .1517      .1635        .318
           40.00        .1721      .1490      .1514      .1640        .318
           50.00        .1684      .1459      .1497      .1614        .313
           60.00        .1659      .1448      .1473      .1630        .310
           70.00        .1577      .1383      .1410      .1563        .297
           80.00        .1430      .1255      .1240      .1463        .269
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AC1292-C02

     TITLE
         3M WHITE VELVET PAINT (TWC CCATS) CN CNE CCAT ZINC CHRCMATE
         PRIMER CN ANCDIZED ALUMINUM SUBSTRATE (11 IN. SC.).
     SUBJECT CCDES
         AEMA    ECBBJ  CJAG
     CATA SET NUMBERS
           9, 1C, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATICN
         SOURCE=  DKI     GAMMA(C)=.9C   INSTRUMENTATICN= CLA
         ACCURACY= FIVE PERCENT   NUMBER CF RUNS AVERAGEC= 1
         THETA(I)= 60.CC    PHI(I)= 18C.C    WAVELENGTH= 1.060

DATA SET NUMBER           9         10         11         12       COMPUTEC
 PHI(R)   THETA(R)     RDF(LL)    RCF(PL)    RCF(LP)    RCF(PP)    RDF(OT)
 =     0   (CEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            C.CO       .16C3      .1412      .1451      .1602       .303
           1C.00       .1553      .1381      .1423      .1576       .297
           2C.CO       .1517      .1372      .14C1      .1607       .295
           3C.CC       .1508      .1368      .14C7      .1667       .298
           4C.00       .1478      .1349      .1384      .1708       .296
           5C.00       .1483      .1309      .1357      .18C1       .298
           6C.00       .1492      .1285      .1331      .1975       .304
           7C.CO       .1566      .1258      .1295      .2364       .324
           8C.00       .1894      .1246      .1263      .3403       .390


DATA SET NUMBER          13         14         15         16       COMPUTEC
 PHI(R)   THETA(R)     RDF(LL)    RCF(PL)    RCF(LP)    RCF(PP)    RDF(OT)
 =180.0    (CEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            C.CO       .16C3      .1412      .1451      .1602       .303
           1C.00       .1655      .1425      .1478      .1598       .308
           2C.00       .172C      .1454      .1516      .1626       .316
           3C.00       .183C      .15CC      .1546      .1696       .329
           4C.00       .1713      .1352      .1398      .1541       .300
           5C.00       .2152      .1596      .1655      .1878       .364
           6C.00
           7C.00       .2427      .1736      .1779      .2076       .401
           8C.00       .228C      .1679      .1731      .1922       .381
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AC1027-003

    TITLE
        O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 1 COAT APPLIED
        ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
        SAMPLE PREPARED AT U. OF M.
    SUBJECT CODES
        AEMB   ECBBI
    DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
    PARAMETER INFORMATION
        SOURCE=  DKI     GAMMA(O)=.90    INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=      0    PHI(I)=      0   WAVELENGTH=  .633

DATA SET NUMBER           1          2          3          4       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00
          10.00         .1127      .0050      .0042      .1149       .118
          20.00         .0384      .0043      .0039      .0411       .044
          30.00         .0170      .0041      .0039      .0189       .022
          40.00         .0107      .0041      .0039      .0119       .015
          50.00         .0086      .0043      .0038      .0094       .013
          60.00         .0077      .0042      .0036      .0084       .012
          70.00         .0078      .0045      .0037      .0080       .012
          80.00         .0072      .0041      .0035      .0081       .011


DATA SET NUMBER           5          6          7          8       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00
          10.00         .1124      .0052      .0042      .1175       .120
          20.00         .0384      .0042      .0039      .0417       .044
          30.00         .0170      .0035      .0039      .0184       .021
          40.00         .0107      .0039      .0039      .0116       .015
          50.00         .0086      .0042      .0038      .0097       .013
          60.00         .0077      .0042      .0036      .0085       .012
          70.00         .0078      .0045      .0037      .0082       .012
          80.00         .0072      .0044      .0035      .0085       .012
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AC1027-003

TITLE
O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 1 COAT APPLIED
ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
SAMPLE PREPARED AT U. OF M.
SUBJECT CODES
AEMB ECBBI
DATA SET NUMBERS
9, 10, 11, 12, 13, 14, 15, 16
PARAMETER INFORMATION
SOURCE= DKI GAMMA(0)=.90 INSTRUMENTATION= CLA
ACCURACY= FIVE PERCENT NUMBER OF RUNS AVERAGED= 1
THETA(I)= 20.00 PHI(I)=180.00 WAVELENGTH= .633

DATA SET NUMBER PHI(R) = 0	THETA(R) (DEG)	9 RDF(LL) (1/SR)	10 RDF(PL) (1/SR)	11 RDF(LP) (1/SR)	12 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00	.0421	.0041	.0041	.0448	.048
	10.00	.1140	.0051	.0041	.1401	.132
	20.00	.1936	.0054	.0047	.2750	.239
	30.00	.1109	.0053	.0042	.1946	.158
	40.00	.0364	.0005	.0040	.0778	.059
	50.00	.0149	.0049	.0041	.0352	.030
	60.00	.0094	.0049	.0040	.0213	.020
	70.00	.0077	.0049	.0036	.0177	.017
	80.00	.0072	.0045	.0037	.0192	.017

DATA SET NUMBER PHI(R) =180.0	THETA(R) (DEG)	13 RDF(LL) (1/SR)	14 RDF(PL) (1/SR)	15 RDF(LP) (1/SR)	16 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00	.0421	.0041	.0041	.0448	.048
	10.00	.0184	.0046	.0041	.0197	.023
	20.00					
	30.00	.0104	.0047	.0039	.0105	.015
	40.00	.0091	.0046	.0040	.0091	.013
	50.00	.0085	.0046	.0038	.0083	.013
	60.00	.0082	.0047	.0037	.0078	.012
	70.00	.0080	.0046	.0034	.0074	.012
	80.00	.0074	.0045	.0033	.0070	.011

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AC1027-003

     TITLE
        C.D. PAINT USED ON MAZ-200 7 TON TRUCK, 1 COAT APPLIED
        ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
        SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
        AEMB   ECBBI
     DATA SET NUMBERS
         17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
        SOURCE=  DKI     GAMMA(0)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 40.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER         17         18         19         20       COMPUTED
 PHI(R)  THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0   (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

           0.00       .0110      .0039      .0042      .0119        .015
          10.00       .0169      .0041      .0044      .0233        .024
          20.00       .0367      .0046      .0043      .0719        .059
          30.00       .0956      .0062      .0049      .2748        .191
          40.00       .1400      .0079      .0050      .6384        .396
          50.00       .0651      .0076      .0051      .5414        .310
          60.00       .0174      .0063      .0049      .2621        .145
          70.00       .0083      .0059      .0045      .1378        .078
          80.00       .0100      .0057      .0042      .1217        .071


DATA SET NUMBER         21         22         23         24       COMPUTED
 PHI(R)  THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0   (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

           0.00       .0110      .0039      .0042      .0119        .015
          10.00       .0096      .0041      .0043      .0093        .014
          20.00       .0092      .0041      .0041      .0085        .013
          30.00       .0099      .0044      .0044      .0089        .014
          40.00
          50.00       .0105      .0048      .0045      .0089        .014
          60.00       .0100      .0048      .0042      .0080        .014
          70.00       .0094      .0048      .0040      .0073        .013
          80.00       .0086      .0046      .0034      .0067        .012
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AC1027-003

     TITLE
         O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 1 COAT APPLIED
         ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
         SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
         AEMB   ECBBI
     DATA SET NUMBERS
          25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 50.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          25        26        27        28     COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0     (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

             0.00       .0081     .0037     .0038     .0096      .013
            10.00       .0097     .0038     .0039     .0147      .016
            20.00       .0144     .0040     .0041     .0340      .028
            30.00       .0269     .0047     .0057     .1173      .077
            40.00       .0513     .0068     .0047     .4726      .268
            50.00       .0474     .0094     .0052     1.189      .626
            60.00       .0108     .0091     .0051     1.141      .583
            70.00       .0117     .0086     .0045     .6697      .347
            80.00       .0322     .0083     .0042     .5032      .274


DATA SET NUMBER          29        30        31        32     COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

             0.00       .0081     .0037     .0038     .0096      .013
            10.00       .0076     .0039     .0037     .0083      .012
            20.00       .0081     .0040     .0039     .0080      .012
            30.00       .0084     .0042     .0038     .0078      .012
            40.00       .0096     .0045     .0042     .0086      .013
            50.00
            60.00       .0102     .0047     .0040     .0085      .014
            70.00       .0095     .0048     .0036     .0075      .013
            80.00       .0090     .0048     .0036     .0073      .012
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AC1027-003

     TITLE
         C.D. PAINT USED ON MAZ-200 7 TON TRUCK, 1 COAT APPLIED
         ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
         SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
         AEMB   ECBBI
     DATA SET NUMBERS
          33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          33        34        35        36      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00        .0079     .0038     .0042     .0091       .013
           10.00        .0083     .0039     .0045     .0123       .015
           20.00        .0095     .0041     .0045     .0222       .020
           30.00        .0118     .0043     .0048     .0599       .040
           40.00        .0147     .0048     .0050     .2300       .127
           50.00        .0107     .0078     .0057     1.020       .522
           60.00        .0281     .0100     .0074     2.919      1.482
           70.00        .1683     .0102     .0069     3.324      1.755
           80.00        .3516     .0080     .0061     2.578      1.472


DATA SET NUMBER          37        38        39        40      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00        .0079     .0038     .0042     .0091       .013
           10.00        .0077     .0038     .0042     .0075       .012
           20.00        .0079     .0035     .0042     .0070       .011
           30.00        .0085     .0038     .0043     .0071       .012
           40.00        .0091     .0040     .0043     .0075       .012
           50.00        .0107     .0045     .0045     .0085       .014
           60.00
           70.00        .0119     .0048     .0045     .0088       .015
           80.00        .0111     .0047     .0041     .0092       .015
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AC1027-003

     TITLE
        O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 1 COAT APPLIED
        ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
        SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
        AEMB   ECBBI
     DATA SET NUMBERS
         41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 70.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER         41        42        43        44       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
  =    0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00       .0073     .0035     .0042     .0085       .012
           10.00       .0071     .0034     .0042     .0106       .013
           20.00       .0073     .0036     .0043     .0175       .016
           30.00       .0076     .0039     .0045     .0404       .028
           40.00       .0073     .0047     .0045     .1371       .077
           50.00       .0126     .0077     .0048     .6026       .314
           60.00       .1489     .0193     .0060     2.864      1.519
           70.00       1.253     .0468     .0096     9.211      5.260
           80.00       3.601     .0532     .0177    13.430      8.551


DATA SET NUMBER         45        46        47        48       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00       .0073     .0035     .0042     .0085       .012
           10.00       .0072     .0033     .0040     .0066       .011
           20.00       .0076     .0034     .0042     .0068       .011
           30.00       .0080     .0035     .0041     .0061       .011
           40.00       .0090     .0037     .0043     .0069       .012
           50.00       .0101     .0040     .0045     .0074       .013
           60.00       .0121     .0045     .0046     .0093       .015
           70.00
           80.00       .0159     .0058     .0050     .0161       .021
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AC1044-003

     TITLE
        C.D. PAINT USED ON MAZ-200 7 TON TRUCK, 2 COATS APPLIED
        ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
        SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
        AEMB   ECBBI
     DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(C)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=      0    PHI(I)=      0   WAVELENGTH=  .633

DATA SET NUMBER         1          2          3          4       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00      .1156      .0044      .0042      .1159      .120
           20.00      .0405      .0040      .0039      .0417      .045
           30.00      .0186      .0039      .0038      .0196      .023
           40.00      .0113      .0039      .0039      .0123      .016
           50.00      .0089      .0043      .0036      .0099      .013
           60.00      .0078      .0042      .0037      .0090      .012
           70.00      .0072      .0044      .0034      .0085      .012
           80.00      .0071      .0043      .0035      .0090      .012


DATA SET NUMBER         5          6          7          8       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00      .1139      .0042      .0041      .1151      .119
           20.00      .0442      .0041      .0039      .0476      .050
           30.00      .0185      .0042      .0039      .0210      .024
           40.00      .0113      .0043      .0038      .0129      .016
           50.00      .0090      .0043      .0037      .0102      .014
           60.00      .0081      .0045      .0037      .0092      .013
           70.00      .0074      .0045      .0037      .0085      .012
           80.00      .0071      .0046      .0032      .0090      .012
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(f)AEM 27

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AC1044-003

     TITLE
        O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 2 COATS APPLIED
        ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
        SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
        AEMB   ECBBI
     DATA SET NUMBERS
          9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 20.00    PHI(I)=180.00    WAVELENGTH=  .633

DATA SET NUMBER         9         10         11         12       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00      .0447      .0040      .0039      .0483       .050
           10.00      .1091      .0041      .0042      .1276       .122
           20.00      .1565      .0043      .0041      .2076       .186
           30.00      .0987      .0043      .0040      .1559       .131
           40.00      .0366      .0044      .0041      .0732       .059
           50.00      .0155      .0046      .0041      .0354       .030
           60.00      .0096      .0044      .0039      .0215       .020
           70.00      .0077      .0046      .0037      .0179       .017
           80.00      .0070      .0044      .0034      .0192       .017


DATA SET NUMBER        13         14         15         16       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00      .0447      .0040      .0039      .0483       .050
           10.00      .0190      .0044      .0042      .0186       .023
           20.00
           30.00      .0105      .0041      .0041      .0098       .014
           40.00      .0092      .0042      .0040      .0086       .013
           50.00      .0083      .0043      .0037      .0079       .012
           60.00      .0082      .0044      .0037      .0074       .012
           70.00      .0079      .0044      .0033      .0070       .011
           80.00      .0077      .0039      .0033      .0063       .011
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AC1044-003

     TITLE
          C.D. PAINT USED ON MAZ-200 7 TON TRUCK, 2 COATS APPLIED
          ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
          SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
          AEMB   ECBBI
     DATA SET NUMBERS
           17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
          SOURCE=  OKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 40.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER        17         18         19         20      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0111      .0039      .0041      .0123       .016
           10.00      .0169      .0041      .0040      .0249       .025
           20.00      .0370      .0041      .0042      .0771       .061
           30.00      .0857      .0045      .0045      .2630       .179
           40.00      .1084      .0049      .0048      .5032       .311
           50.00      .0531      .0049      .0005      .4465       .252
           60.00      .0159      .0049      .0046      .2407       .133
           70.00      .0079      .0049      .0044      .1298       .074
           80.00      .0091      .0049      .0044      .1170       .068


DATA SET NUMBER        21         22         23         24      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)     (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0111      .0039      .0041      .0123       .016
           10.00      .0095      .0039      .0041      .0090       .013
           20.00      .0092      .0040      .0040      .0084       .013
           30.00      .0101      .0043      .0044      .0091       .014
           40.00
           50.00      .0099      .0044      .0042      .0083       .013
           60.00      .0094      .0047      .0038      .0077       .013
           70.00      .0087      .0046      .0035      .0071       .012
           80.00      .0084      .0041      .0033      .0065       .011
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AC1044-003

     TITLE
         C.D. PAINT USED ON MAZ-200 7 TON TRUCK, 2 COATS APPLIED
         ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
         SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
         AEMB   ECBBI
     DATA SET NUMBERS
          25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 50.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          25        26        27        28      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00       .0085     .0040     .0041     .0100      .013
            10.00       .0102     .0039     .0042     .0150      .017
            20.00       .0135     .0041     .0044     .0356      .029
            30.00       .0301     .0045     .0046     .1286      .084
            40.00       .0536     .0050     .0049     .4691      .266
            50.00       .0442     .0060     .0053     1.005      .530
            60.00       .0118     .0073     .0054     .9560      .490
            70.00       .0123     .0067     .0050     .6029      .313
            80.00       .0333     .0056     .0041     .4739      .258


DATA SET NUMBER          29        30        31        32      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00       .0085     .0040     .0041     .0100      .013
            10.00       .0085     .0038     .0041     .0082      .012
            20.00       .0087     .0038     .0043     .0078      .012
            30.00       .0089     .0039     .0042     .0077      .012
            40.00       .0103     .0044     .0045     .0086      .014
            50.00
            60.00       .0106     .0047     .0042     .0084      .014
            70.00       .0096     .0045     .0038     .0073      .013
            80.00       .0090     .0047     .0034     .0066      .012
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(f)AEM 30

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A01044-003

     TITLE
         O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 2 COATS APPLIED
         ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
         SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
         AEMB   ECBBI
     DATA SET NUMBERS
          33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          33         34         35         36      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .0078      .0038      .0041      .0088       .012
           10.00        .0083      .0038      .0043      .0119       .014
           20.00        .0095      .0040      .0045      .0214       .020
           30.00        .0118      .0042      .0046      .0593       .040
           40.00        .0154      .0046      .0049      .2503       .138
           50.00        .0112      .0060      .0058      1.029       .526
           60.00        .0244      .0084      .0067      2.526      1.283
           70.00        .1501      .0100      .0071      2.913      1.540
           80.00        .3329      .0085      .0060      2.412      1.380


DATA SET NUMBER          37         38         39         40      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .0078      .0038      .0041      .0088       .012
           10.00        .0078      .0037      .0041      .0079       .012
           20.00        .0082      .0036      .0043      .0072       .012
           30.00        .0088      .0037      .0043      .0071       .012
           40.00        .0093      .0039      .0044      .0075       .013
           50.00        .0111      .0044      .0047      .0085       .014
           60.00
           70.00        .0116      .0047      .0044      .0086       .015
           80.00        .0113      .0051      .0044      .0087       .015
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AC1044-003

     TITLE
         O.D. PAINT USED ON MAZ-200 7 TON TRUCK, 2 COATS APPLIED
         ON 2 COATS OF ZINC CHROMATE PRIMER ON ANODIZED ALUMINUM.
         SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
         AEMB   ECBBI
     DATA SET NUMBERS
          41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
         SOURCE=  DKI     GAMMA(0)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 70.00    PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER         41         42         43         44      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0071      .0036      .0042      .0084       .012
           10.00      .0073      .0035      .0042      .0107       .013
           20.00      .0075      .0037      .0044      .0168       .016
           30.00      .0078      .0037      .0046      .0374       .027
           40.00      .0078      .0042      .0049      .1309       .074
           50.00      .0129      .0053      .0053      .6307       .327
           60.00      .1618      .0098      .0073      3.233      1.706
           70.00      1.198      .0182      .0110      9.175      5.201
           80.00      3.475      .0249      .0147     12.929      8.222


DATA SET NUMBER         45         46         47         48      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0071      .0036      .0042      .0084       .012
           10.00      .0072      .0034      .0041      .0072       .011
           20.00      .0076      .0035      .0041      .0068       .011
           30.00      .0083      .0036      .0043      .0066       .011
           40.00      .0091      .0036      .0044      .0068       .012
           50.00      .0098      .0039      .0045      .0072       .013
           60.00      .0120      .0047      .0050      .0087       .015
           70.00
           80.00      .0124      .0057      .0037      .0144       .018
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A01047-003

     TITLE
          2 COATS 529A O.D. PAINT ON 2 COATS ZINC CHROMATE, WET DECKED
          ON ANODIZED ALUMINUM, SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
          AEMB   ECBBI
     DATA SET NUMBERS
             1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
          SOURCE=  DKI     GAMMA(0)=.90   INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)=      0    PHI(I)=      0   WAVELENGTH=  .633

DATA SET NUMBER            1          2          3          4       COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)         (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00
            10.00        .0447      .0025      .0024      .0480       .049
            20.00        .0312      .0023      .0022      .0362       .036
            30.00        .0216      .0021      .0022      .0272       .027
            40.00        .0142      .0025      .0021      .0201       .019
            50.00        .0106      .0025      .0023      .0155       .015
            60.00        .0081      .0026      .0021      .0131       .013
            70.00        .0067      .0029      .0020      .0122       .012
            80.00        .0065      .0026      .0026      .0132       .012


DATA SET NUMBER            5          6          7          8       COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)         (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00
            10.00        .0445      .0025      .0024      .0473       .048
            20.00        .0337      .0024      .0022      .0373       .038
            30.00        .0232      .0024      .0024      .0275       .028
            40.00        .0156      .0025      .0022      .0202       .020
            50.00        .0110      .0025      .0023      .0152       .015
            60.00        .0088      .0026      .0023      .0129       .013
            70.00        .0072      .0027      .0026      .0119       .012
            80.00        .0065      .0026      .0016      .0137       .012
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AC1047-003

     TITLE
         2 COATS 529A G.C. PAINT ON 2 COATS ZINC CHROMATE, WET DECKED
         ON ANODIZED ALUMINUM, SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
         AEMB   ECBBI
     DATA SET NUMBERS
           9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 20.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          9         10         11         12      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0     (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00       .0321      .0023      .0022      .0356       .036
            10.00       .0403      .0026      .0021      .0548       .050
            20.00       .0422      .0023      .0021      .0654       .056
            30.00       .0392      .0024      .0022      .0693       .057
            40.00       .0275      .0024      .0023      .0626       .047
            50.00       .0181      .0027      .0023      .0532       .038
            60.00       .0115      .0027      .0024      .0445       .031
            70.00       .0080      .0030      .0023      .0420       .028
            80.00       .0057      .0025      .0024      .0469       .029


DATA SET NUMBER         13         14         15         16      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RCF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

             0.00       .0321      .0023      .0022      .0356       .036
            10.00       .0242      .0025      .0023      .0240       .026
            20.00
            30.00       .0127      .0027      .0025      .0126       .015
            40.00       .0096      .0026      .0024      .0098       .012
            50.00       .0082      .0026      .0024      .0081       .011
            60.00       .0072      .0024      .0026      .0073       .010
            70.00       .0067      .0025      .0020      .0068       .009
            80.00       .0065      .0023      .0024      .0070       .009
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(f)AEM 34

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AC1047-003

     TITLE
        2 COATS 529A C.C. PAINT ON 2 COATS ZINC CHROMATE, WET DECKED
        ON ANODIZED ALUMINUM, SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
        AEMB   ECBBI
     DATA SET NUMBERS
         17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
        SOURCE=  CKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 40.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER        17        18        19        20       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00      .0140     .0023     .0020     .0188      .019
           10.00      .0202     .0024     .0022     .0328      .029
           20.00      .0267     .0025     .0023     .0592      .045
           30.00      .0320     .0028     .0025     .1043      .071
           40.00      .0310     .0030     .0025     .1585      .098
           50.00      .0225     .0031     .0026     .2078      .118
           60.00      .0114     .0031     .0026     .2249      .121
           70.00      .0058     .0034     .0028     .2384      .125
           80.00      .0087     .0032     .0031     .2734      .144


DATA SET NUMBER        21        22        23        24       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00      .0140     .0023     .0020     .0188      .019
           10.00      .0112     .0024     .0022     .0126      .014
           20.00      .0093     .0024     .0022     .0096      .012
           30.00      .0092     .0027     .0024     .0086      .011
           40.00
           50.00      .0085     .0028     .0026     .0077      .011
           60.00      .0081     .0026     .0025     .0067      .010
           70.00      .0075     .0029     .0025     .0064      .010
           80.00      .0070     .0031     .0018     .0061      .009
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AC1047-003

          TITLE
              2 COATS 529A C.C. PAINT ON 2 COATS ZINC CHROMATE, WET DECKED
              ON ANODIZED ALUMINUM, SAMPLE PREPARED AT U. OF M.
          SUBJECT CODES
              AEMB   ECBBI
          DATA SET NUMBERS
               25, 26, 27, 28, 29, 30, 31, 32
          PARAMETER INFORMATION
              SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
              ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
              THETA(I)= 50.00    PHI(I)=180.00    WAVELENGTH=  .633

DATA SET NUMBER          25         26         27         28       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .0105      .0024      .0021      .0146        .015
           10.00       .0131      .0024      .0022      .0253        .022
           20.00       .0177      .0026      .0024      .0497        .036
           30.00       .0202      .0027      .0024      .0991        .062
           40.00       .0216      .0032      .0028      .1960        .112
           50.00       .0141      .0034      .0029      .3319        .176
           60.00       .0061      .0037      .0030      .4854        .249
           70.00       .0111      .0043      .0034      .6132        .316
           80.00       .0422      .0040      .0032      .7442        .397


DATA SET NUMBER          29         30         31         32       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .0105      .0024      .0021      .0146        .015
           10.00       .0085      .0021      .0022      .0098        .011
           20.00       .0078      .0023      .0023      .0081        .010
           30.00       .0077      .0025      .0024      .0074        .010
           40.00       .0086      .0027      .0026      .0077        .011
           50.00
           60.00       .0090      .0030      .0026      .0076        .011
           70.00       .0084      .0028      .0027      .0069        .010
           80.00       .0080      .0031      .0024      .0072        .010
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AC1C47-CC3

     TITLE
        2 CCATS 529A C.C. PAINT CN 2 CCATS ZINC CHRCMATE, WET DECKED
        CN ANCDIZED ALLMINUM, SAMPLE PREPAREC AT U. CF M.
     SUBJECT CCDES
        AEMB   ECBBI
     CATA SET NUMBERS
         33, 34, 35, 36, 37, 38, 39, 4C
     PARAMETER INFORMATICN
        SOURCE=  DKI    GAMMA(C)=.90   INSTRUMENTATICN= CLA
        ACCURACY= FIVE PERCENT   NUMBER CF RUNS AVERAGEC= 1
        THETA(I)= 60.CC   PHI(I)=18C.CO   WAVELENGTH=  .633

DATA SET NUMBER         33         34         35         36      CCMPUTEC
 PHI(R)   THETA(R)   RDF(LL)    RCF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (CEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            C.CO      .0079      .C023      .0022      .0124       .012
           1C.CO      .CC98      .0023      .C024      .C214       .018
           2C.0C      .C111      .C026      .0025      .0431       .030
           3C.CO      .0124      .C028      .C027      .0931       .056
           4C.0C      .C1C3      .003C      .0030      .2038       .110
           5C.0C      .CC64      .0036      .0031      .4579       .236
           6C.CC      .0140      .C044      .0034      .9055       .464
           7C.0C      .0747      .C048      .0038      1.484       .784
           8C.CO      .2572      .0056      .0043      2.102      1.185


DATA SET NUMBER         37         38         39         40      CCMPUTEC
 PHI(R)   THETA(R)   RCF(LL)    RCF(PL)    RDF(LP)    RCF(PP)    RCF(OT)
 =18C.0    (CEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            C.00      .0079      .C023      .C022      .C124       .012
           1C.00      .0C74      .C023      .0023      .0087       .010
           2C.C0      .CC69      .C023      .C023      .0072       .009
           3C.00      .C07C      .C024      .0024      .0066       .009
           4C.00      .0C76      .0025      .0025      .0065       .010
           5C.C0      .CC9C      .CC3C      .0029      .0080       .011
           6C.00
           7C.00      .C1C1      .C034      .C032      .0085       .013
           8C.00      .0103      .C035      .0033      .0085       .013
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AC1047-003

     TITLE
         2 COATS 529A C.C. PAINT ON 2 COATS ZINC CHROMATE, WET DECKED
         ON ANODIZED ALUMINUM, SAMPLE PREPARED AT U. OF M.
     SUBJECT CODES
         AEMB   ECBBI
     DATA SET NUMBERS
          41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
         SOURCE=  DKI     GAMMA(0)=.90    INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 70.00    PHI(I)=180.00    WAVELENGTH=  .633

DATA SET NUMBER         41         42         43         44       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .0067      .0022      .0023      .0118       .012
           10.00       .0073      .0024      .0024      .0199       .016
           20.00       .0075      .0026      .0025      .0394       .026
           30.00       .0066      .0025      .0025      .0857       .049
           40.00       .0052      .0031      .0029      .2163       .114
           50.00       .0117      .0036      .0031      .5459       .282
           60.00       .0713      .0048      .0036      1.364       .722
           70.00       .4014      .0071      .0054      3.265      1.839
           80.00       1.414      .0095      .0072      6.211      3.821


DATA SET NUMBER         45         46         47         48       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .0067      .0022      .0023      .0118       .012
           10.00       .0064      .0022      .0022      .0084       .010
           20.00       .0064      .0022      .0024      .0068       .009
           30.00       .0066      .0023      .0025      .0061       .009
           40.00       .0073      .0024      .0025      .0062       .009
           50.00       .0082      .0030      .0029      .0070       .011
           60.00       .0100      .0032      .0030      .0090       .013
           70.00
           80.00       .0148      .0046      .0038      .0137       .018
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AC1509-001

     TITLE
        O.D. PAINTED STEEL PLATE, 7-3/4 IN. SQ., TAKEN FROM A U.S.
        18 TON M4A HIGH SPEED TRACTOR.
     SUBJECT CODES
        AEMB   ECBBI
     DATA SET NUMBERS
         1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=     0   PHI(I)=     0   WAVELENGTH=  .633

DATA SET NUMBER           1          2          3          4      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00         .025       .008       .008       .025       .033
           20.00         .022       .008       .007       .024       .031
           30.00         .021       .008       .008       .024       .031
           40.00         .020       .009       .008       .024       .031
           50.00         .019       .009       .009       .026       .032
           60.00         .018       .010       .010       .028       .033
           70.00         .018       .011       .011       .030       .035
           80.00         .019       .012       .012       .033       .038


DATA SET NUMBER           5          6          7          8      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00         .026       .008       .008       .026       .034
           20.00         .024       .008       .008       .025       .033
           30.00         .022       .008       .008       .025       .032
           40.00         .021       .009       .009       .025       .032
           50.00         .019       .009       .009       .026       .032
           60.00         .019       .010       .010       .029       .034
           70.00         .019       .011       .011       .031       .036
           80.00         .019       .012       .012       .033       .038
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AC1509-C01

     TITLE
          C.D. PAINTED STEEL PLATE, 7-3/4 IN. SQ., TAKEN FROM A U.S.
          18 TON M4A HIGH SPEED TRACTOR.
     SUBJECT CODES
          AEMB   ECBBI
     DATA SET NUMBERS
            9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
          SOURCE=  DKH     GAMMA(0)=        INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 45.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER             9         10         11         12      COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            5.00         .019       .009       .009       .026       .032
           15.00         .019       .010       .009       .030       .034
           25.00         .018       .010       .010       .036       .037
           35.00         .018       .011       .011       .044       .042
           45.00         .019       .013       .012       .055       .050
           55.00         .022       .013       .013       .068       .058
           65.00         .027       .015       .015       .084       .071
           75.00         .038       .016       .017       .108       .090
           85.00         .058       .019       .019       .141       .119


DATA SET NUMBER            13         14         15         16      COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            5.00         .020       .009       .008       .024       .031
           15.00         .022       .009       .008       .023       .031
           25.00         .023       .009       .008       .024       .032
           35.00         .027       .010       .009       .026       .036
           45.00
           55.00         .030       .011       .011       .029       .041
           65.00         .029       .011       .011       .029       .040
           75.00         .030       .013       .013       .030       .043
           85.00         .029       .014       .014       .029       .043
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AC1327-001

     TITLE
         MERICN BLUE GRASS SOD FRESHLY OBTAINED, 3 IN. GRASS BLADES,
         SANDY LOAM SOIL NOT VISIBLE
     SUBJECT CODES
         BGCM
     DATA SET NUMBERS
          1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=     0   PHI(I)=     0   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00
          10.00        .0068      .0047      .0038      .0084       .012
          20.00        .0056      .0052      .0035      .0089       .012
          30.00        .0053      .0052      .0035      .0090       .011
          40.00        .0050      .0050      .0035      .0085       .011
          50.00        .0046      .0051      .0034      .0090       .011
          60.00        .0042      .0047      .0031      .0084       .010
          70.00        .0039      .0042      .0031      .0071       .009
          80.00        .0055      .0057      .0043      .0097       .013


DATA SET NUMBER          5          6          7          8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00
          10.00        .0071      .0043      .0042      .0075       .012
          20.00        .0061      .0037      .0037      .0065       .010
          30.00        .0051      .0030      .0034      .0052       .008
          40.00        .0048      .0023      .0033      .0039       .007
          50.00        .0051      .0024      .0035      .0043       .008
          60.00        .0045      .0027      .0033      .0043       .007
          70.00        .0047      .0025      .0036      .0042       .007
          80.00        .0050      .0028      .0039      .0051       .008
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AC1327-001

     TITLE
        MERION BLUE GRASS SOD FRESHLY OBTAINED, 3 IN. GRASS BLADES,
        SANDY LOAM SOIL NOT VISIBLE
     SUBJECT CODES
        BGCM
     DATA SET NUMBERS
          9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
        SOURCE=  DKI     GAMMA(0)=.90    INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT    NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 20.00    PHI(I)=180.00    WAVELENGTH=  .633

DATA SET NUMBER             9        10        11        12      COMPUTED
 PHI(R)    THETA(R)      RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0     (DEG)        (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

              0.00        .0057     .0048     .0035     .0083      .011
             10.00        .0041     .0045     .0028     .0075      .009
             20.00        .0032     .0041     .0024     .0068      .008
             30.00        .0028     .0039     .0022     .0065      .008
             40.00        .0025     .0036     .0019     .0059      .007
             50.00        .0038     .0025     .0031     .0036      .006
             60.00        .0039     .0024     .0030     .0035      .006
             70.00        .0036     .0024     .0027     .0036      .006
             80.00        .0048     .0027     .0034     .0040      .007


DATA SET NUMBER            13        14        15        16      COMPUTED
 PHI(R)    THETA(R)      RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0     (DEG)        (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

              0.00        .0057     .0048     .0035     .0083      .011
             10.00        .0072     .0050     .0039     .0092      .013
             20.00
             30.00        .0092     .0057     .0050     .0107      .015
             40.00        .0102     .0050     .0058     .0092      .015
             50.00        .0113     .0055     .0064     .0104      .017
             60.00        .0126     .0067     .0071     .0132      .020
             70.00        .0135     .0078     .0080     .0164      .023
             80.00        .0177     .0123     .0109     .0282      .035
```

AC1327-C01

TITLE
MERION BLUE GRASS SOD FRESHLY OBTAINED, 3 IN. GRASS BLADES,
SANDY LOAM SOIL NOT VISIBLE
SUBJECT CODES
BGCM
DATA SET NUMBERS
17, 18, 19, 20, 21, 22, 23, 24
PARAMETER INFORMATION
SOURCE= DKI GAMMA(0)=.90 INSTRUMENTATION= CLA
ACCURACY= FIVE PERCENT NUMBER OF RUNS AVERAGED= 1
THETA(I)= 40.00 PHI(I)=180.00 WAVELENGTH= .633

DATA SET NUMBER		17	18	19	20	COMPUTED
PHI(R)	THETA(R)	RDF(LL)	RDF(PL)	RDF(LP)	RDF(PP)	RDF(OT)
= 0	(DEG)	(1/SR)	(1/SR)	(1/SR)	(1/SR)	(1/SR)
	0.00	.0046	.0032	.0033	.0055	.008
	10.00	.0036	.0026	.0027	.0042	.007
	20.00	.0025	.0021	.0021	.0033	.005
	30.00	.0019	.0025	.0016	.0035	.005
	40.00	.0017	.0022	.0014	.0031	.004
	50.00	.0017	.0023	.0014	.0031	.004
	60.00	.0021	.0026	.0016	.0039	.005
	70.00	.0023	.0028	.0017	.0044	.006
	80.00	.0029	.0029	.0020	.0045	.006

DATA SET NUMBER		21	22	23	24	COMPUTED
PHI(R)	THETA(R)	RDF(LL)	RDF(PL)	RDF(LP)	RDF(PP)	RDF(OT)
=180.0	(DEG)	(1/SR)	(1/SR)	(1/SR)	(1/SR)	(1/SR)
	0.00	.0046	.0032	.0033	.0055	.008
	10.00	.0058	.0036	.0036	.0066	.010
	20.00	.0074	.0041	.0044	.0073	.012
	30.00	.0101	.0049	.0051	.0094	.015
	40.00					
	50.00	.0141	.0082	.0068	.0176	.023
	60.00	.0139	.0075	.0068	.0158	.022
	70.00	.0130	.0083	.0067	.0179	.023
	80.00	.0126	.0094	.0069	.0200	.024

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AC1327-001

     TITLE
        MERION BLUE GRASS SOD FRESHLY OBTAINED, 3 IN. GRASS BLADES,
        SANDY LOAM SOIL NOT VISIBLE
     SUBJECT CODES
        BGCM
     DATA SET NUMBERS
         25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
        SOURCE=  OKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 50.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          25        26        27        28      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00        .0036     .0025     .0027     .0042      .006
           10.00        .0029     .0020     .0022     .0032      .005
           20.00        .0021     .0025     .0017     .0039      .005
           30.00        .0016     .0018     .0014     .0024      .004
           40.00        .0017     .0016      0013     .0024      .003
           50.00        .0015     .0017     .0011     .0024      .003
           60.00        .0015     .0020     .0010     .0030      .004
           70.00        .0023     .0022     .0016     .0035      .005
           80.00        .0054     .0049     .0032     .0093      .011


DATA SET NUMBER          29        30        31        32      COMPUTED
 PHI(R)    THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00       .0036     .0025     .0027     .0042      .006
            10.00       .0042     .0028     .0028     .0046      .007
            20.00       .0057     .0036     .0037     .0059      .009
            30.00       .0086     .0046     .0047     .0081      .013
            40.00       .0101     .0058     .0052     .0114      .016
            50.00
            60.00       .0128     .0079     .0064     .0162      .022
            70.00       .0145     .0080     .0078     .0155      .023
            80.00       .0193     .0086     .0109     .0157      .027
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AC1327-001

     TITLE
         MERION BLUE GRASS SOD FRESHLY OBTAINED, 3 IN. GRASS BLADES,
         SANDY LOAM SOIL NOT VISIBLE
     SUBJECT CODES
         BGCM
     DATA SET NUMBERS
          33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER         33         34         35         36       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0016      .0021      .0012      .0030       .004
           10.00      .0018      .0020      .0013      .0029       .004
           20.00      .0017      .0014      .0012      .0020       .003
           30.00      .0012      .0012      .0009      .0018       .003
           40.00      .0011      .0011      .0008      .0018       .002
           50.00      .0010      .0011      .0008      .0017       .002
           60.00      .0010      .0015      .0007      .0022       .003
           70.00      .0040      .0039      .0024      .0070       .009
           80.00      .0046      .0049      .0026      .0092       .010


DATA SET NUMBER         37         38         39         40       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0016      .0021      .0012      .0030       .004
           10.00      .0026      .0023      .0019      .0035       .005
           20.00      .0034      .0028      .0023      .0046       .007
           30.00      .0064      .0045      .0038      .0077       .011
           40.00      .0088      .0059      .0047      .0106       .015
           50.00      .0121      .0069      .0058      .0129       .019
           60.00
           70.00      .0302      .0124      .0126      .0230       .039
           80.00      .0471      .0173      .0207      .0323       .059
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(f)BGCM 6

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AC1327-001

     TITLE
         MERION BLUE GRASS SOD FRESHLY OBTAINED, 3 IN. GRASS BLADES,
         SANDY LOAM SOIL NOT VISIBLE
     SUBJECT CODES
         BGCM
     DATA SET NUMBERS
          41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(C)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 70.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          41         42         43         44       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00        .0013      .0015      .0010      .0024        .003
           10.00        .0012      .0013      .0009      .0020        .003
           20.00        .0010      .0011      .0007      .0018        .002
           30.00        .0009      .0010      .0006      .0016        .002
           40.00        .0008      .0010      .0006      .0022        .002
           50.00        .0009      .0011      .0006      .0017        .002
           60.00        .0037      .0024      .0020      .0046        .006
           70.00        .0041      .0021      .0020      .0041        .006
           80.00        .0024      .0019      .0014      .0036        .005


DATA SET NUMBER          45         46         47         48       COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00        .0013      .0015      .0010      .0024        .003
           10.00        .0016      .0013      .0012      .0021        .003
           20.00        .0026      .0020      .0017      .0036        .005
           30.00        .0038      .0028      .0024      .0052        .007
           40.00        .0099      .0053      .0050      .0103        .015
           50.00        .0159      .0081      .0075      .0152        .023
           60.00        .0130      .0087      .0080      .0175        .027
           70.00
           80.00        .0517      .0287      .0237      .0688        .086
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AC1324-001

     TITLE
         MATURE MULBERRY LEAF, 2 HOURS OLD, PICKED FROM THE SOUTHEAST
         SIDE OF THE BUSH, IN AUGUST 1967
     SUBJECT CODES
         BGDV
     DATA SET NUMBERS
            1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKI     GAMMA(0)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=     0   PHI(I)=      0   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .0625      .0043      .0042      .0817       .076
           20.00       .0308      .0039      .0038      .0337       .036
           30.00       .0172      .0040      .0040      .0169       .021
           40.00       .0104      .0042      .0040      .0106       .015
           50.00       .0079      .0041      .0039      .0093       .013
           60.00       .0071      .0046      .0032      .0087       .012
           70.00       .0071      .0042      .0038      .0089       .012
           80.00       .0059      .0056      .0034      .0093       .012


DATA SET NUMBER          5          6          7          8       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00       .0644      .0040      .0039      .0773       .075
           20.00       .0348      .0041      .0038      .0348       .039
           30.00       .0166      .0038      .0035      .0157       .020
           40.00       .0093      .0040      .0040      .0105       .014
           50.00       .0083      .0040      .0038      .0092       .013
           60.00       .0072      .0043      .0041      .0087       .012
           70.00       .0070      .0045      .0038      .0084       .012
           80.00       .0052      .0040      .0037      .0091       .011
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AC1324-001

     TITLE
        MATURE MULBERRY LEAF, 2 HOURS OLD, PICKED FROM THE SOUTHEAST
        SIDE OF THE BUSH, IN AUGUST 1967
     SUBJECT CODES
        BGDV
     DATA SET NUMBERS
         9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 20.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER            9         10         11         12      COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00          .0333      .0036      .0038      .0347       .038
          10.00          .0536      .0040      .0040      .0822       .072
          20.00          .0610      .0041      .0043      .1315       .100
          30.00          .0474      .0042      .0041      .1121       .084
          40.00          .0269      .0041      .0040      .0645       .050
          50.00          .0154      .0045      .0045      .0323       .028
          60.00          .0094      .0047      .0043      .0208       .020
          70.00          .0102      .0055      .0041      .0141       .017
          80.00          .0067      .0051      .0042      .0211       .019


DATA SET NUMBER           13         14         15         16      COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

           0.00          .0333      .0036      .0038      .0347       .038
          10.00          .0172      .0040      .0042      .0150       .020
          20.00
          30.00          .0089      .0041      .0038      .0083       .013
          40.00          .0075      .0039      .0041      .0074       .011
          50.00          .0066      .0042      .0035      .0070       .011
          60.00          .0065      .0042      .0041      .0065       .01
          70.00          .0066      .0047      .0037      .0068       .011
          80.00          .0050      .0035      .0029      .0061       .009
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(f)BGDV 3

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AC1324-C01

     TITLE
         MATURE MULBERRY LEAF, 2 HOURS OLD, PICKED FROM THE SOUTHEAST
         SIDE OF THE BUSH, IN AUGUST 1967
     SUBJECT CODES
         BGDV
     DATA SET NUMBERS
          17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 40.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER        17         18         19         20      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0104      .0034      .0042      .0105       .014
           10.00      .0161      .0036      .0039      .0207       .022
           20.00      .0278      .0042      .0042      .0603       .048
           30.00      .0416      .0050      .0047      .1683       .110
           40.00      .0397      .0052      .0049      .2990       .174
           50.00      .0266      .0057      .0051      .3667       .202
           60.00      .0132      .0057      .0052      .2618       .143
           70.00      .0072      .0062      .0054      .1454       .082
           80.00      .0135      .0062      .0059      .1050       .065


DATA SET NUMBER        21         22         23         24      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .0104      .0034      .0042      .0105       .014
           10.00      .0081      .0039      .0038      .0082       .012
           20.00      .0075      .0037      .0038      .0071       .011
           30.00      .0076      .0042      .0041      .0073       .012
           40.00
           50.00      .0074      .0045      .0041      .0068       .011
           60.00      .0074      .0041      .0037      .0060       .011
           70.00      .0073      .0047      .0035      .0061       .011
           80.00      .0065      .0041      .0035      .0065       .010
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AC1324-001

     TITLE
         MATURE MULBERRY LEAF, 2 HOURS OLD, PICKED FROM THE SOUTHEAST
         SIDE OF THE BUSH, IN AUGUST 1967
     SUBJECT CODES
         BGDV
     DATA SET NUMBERS
          25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(C)=.50    INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 50.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER         25         26         27         28       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .0076      .0035      .0038      .0091        .012
           10.00       .0099      .0035      .0042      .0135        .016
           20.00       .0158      .0044      .0046      .0312        .028
           30.00       .0220      .0044      .0043      .1014        .066
           40.00       .0264      .0059      .0052      .3399        .189
           50.00       .0193      .0070      .0064      .6731        .353
           60.00       .0112      .0065      .0067      .7692        .397
           70.00       .0227      .0075      .0068      .6634        .350
           80.00       .0623      .0060      .0059      .5051        .290


DATA SET NUMBER         29         30         31         32       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .0076      .0035      .0038      .0091        .012
           10.00       .0068      .0038      .0038      .0072        .011
           20.00       .0066      .0038      .0038      .0069        .011
           30.00       .0072      .0037      .0038      .0066        .011
           40.00       .0077      .0043      .0042      .0069        .012
           50.00
           60.00       .0082      .0043      .0042      .0072        .012
           70.00       .0077      .0040      .0048      .0066        .012
           80.00       .0068      .0046      .0040      .0070        .011
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AC1324-C01

     TITLE
         MATURE MULBERRY LEAF, 2 HOURS OLD, PICKED FROM THE SOUTHEAST
         SIDE OF THE BUSH, IN AUGUST 1967
     SUBJECT CODES
         BGDV
     DATA SET NUMBERS
         33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
         SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 60.00   PHI(I)=180.00   WAVELENGTH=  .633

DATA SET NUMBER          33        34        35        36      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00      .0065     .0036     .0041     .0081       .011
            10.00      .0073     .0038     .0047     .0136       .014
            20.00      .0094     .0046     .0045     .0200       .019
            30.00      .0118     .0050     .0050     .0593       .041
            40.00      .0131     .0053     .0056     .2020       .113
            50.00      .0110     .0065     .0064     .6920       .358
            60.00      .0298     .0083     .0077     1.581       .813
            70.00      .1369     .0092     .0081     2.411      1.283
            80.00      .4272     .0113     .0105     2.788      1.618


DATA SET NUMBER          37        38        39        40      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00      .0065     .0036     .0041     .0081       .011
            10.00      .0064     .0036     .0039     .0071       .011
            20.00      .0068     .0034     .0040     .0068       .010
            30.00      .0067     .0037     .0038     .0064       .010
            40.00      .0071     .0041     .0042     .0066       .011
            50.00      .0080     .0047     .0041     .0072       .012
            60.00
            70.00      .0097     .0050     .0040     .0079       .013
            80.00      .0090     .0035     .0027     .0065       .011
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AC1324-C01

TITLE
MATURE MULBERRY LEAF, 2 HOURS OLD, PICKED FROM THE SOUTHEAST
SIDE OF THE BUSH, IN AUGUST 1967
SUBJECT CODES
BGDV
DATA SET NUMBERS
41, 42, 43, 44, 45, 46, 47, 48
PARAMETER INFORMATION
SOURCE= OKI GAMMA(0)=.90 INSTRUMENTATION= CLA
ACCURACY= FIVE PERCENT NUMBER OF RUNS AVERAGED= 1
THETA(I)= 70.00 PHI(I)=180.00 WAVELENGTH= .633

DATA SET NUMBER PHI(R) = 0	THETA(R) (DEG)	41 RDF(LL) (1/SR)	42 RDF(PL) (1/SR)	43 RDF(LP) (1/SR)	44 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00	.0062	.0036	.0041	.0082	.011
	10.00	.0065	.0038	.0042	.0108	.013
	20.00	.0072	.0048	.0044	.0191	.018
	30.00	.0081	.0046	.0051	.0367	.027
	40.00	.0093	.0050	.0058	.1258	.073
	50.00	.0202	.0097	.0068	.5335	.285
	60.00	.1146	.0089	.0081	2.037	1.084
	70.00	.5954	.0122	.0107	5.514	3.066
	80.00	2.287	.0180	.0147	11.131	6.725

DATA SET NUMBER PHI(R) =180.0	THETA(R) (DEG)	45 RDF(LL) (1/SR)	46 RDF(PL) (1/SR)	47 RDF(LP) (1/SR)	48 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00	.0062	.0036	.0041	.0082	.011
	10.00	.0058	.0036	.0038	.0070	.010
	20.00	.0061	.0037	.0036	.0065	.010
	30.00	.0066	.0038	.0039	.0064	.010
	40.00	.0070	.0041	.0044	.0065	.011
	50.00	.0082	.0041	.0045	.0068	.012
	60.00	.0099	.0038	.0053	.0069	.013
	70.00					
	80.00	.0136	.0052	.0050	.0128	.018

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AC1190-001

     TITLE
         SMOKED MAGNESIUM OXIDE ON ALUMINUM PLATE
         (APPROXIMATELY 1.75 TO 2 MM DEPOSIT).
     SUBJECT CODES
         CJAAA
     DATA SET NUMBERS
           1,  2,  3,  4,  5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DXI    GAMMA(O)=.90   INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=     0    PHI(I)=     0   WAVELENGTH=  .633

DATA SET NUMBER          1         2         3         4     COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)   RDF(OT)
 =    0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

            0.00
           10.00       .1751     .1310     .1352     .1663      .304
           20.00       .1746     .1307     .1402     .1636      .305
           30.00       .1750     .1320     .1409     .1659      .307
           40.00       .1691     .1272     .1389     .1594      .297
           50.00       .1625     .1246     .1365     .1600      .292
           60.00       .1526     .1187     .1298     .1612      .281
           70.00       .1425     .1082     .1270     .1484      .263
           80.00       .1280     .1023     .1120     .1561      .249


DATA SET NUMBER          5         6         7         8     COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)   RDF(OT)
 =180.0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

            0.00
           10.00       .1760     .1434     .1380     .1806      .319
           20.00       .1737     .1373     .1387     .1731      .311
           30.00       .1696     .1366     .1365     .1728      .308
           40.00       .1654     .1330     .1349     .1651      .299
           50.00       .1560     .1277     .1298     .1645      .289
           60.00       .1472     .1236     .1247     .1642      .280
           70.00       .1322     .1089     .1158     .1487      .253
           80.00       .1165     .1024     .1019     .1552      .238
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AC119C-CC1

     TITLE
         SMOKED MAGNESIUM CXIDE CN ALUMINUM PLATE
         (APPRCXIMATELY 1.75 TC 2 MM CEPOSIT).
     SUBJECT CCDES
         CJAAA
     CATA SET NUMBERS
          9, 1C, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATICN
         SOURCE=  DKI    GAMMA(O)=.9C   INSTRUMENTATICN= CLA
         ACCURACY= FIVE PERCENT   NUMBER CF RUNS AVERAGEC= 1
         THETA(I)= 20.CC   PHI(I)= 18C.0   WAVELENGTH=  .633

DATA SET NUMBER          9         10         11         12      CCMPUTEC
 PHI(R)   THETA(R)    RCF(LL)    RCF(PL)    RDF(LP)    RCF(PP)    RCF(OT)
 =    0    (CEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            C.CO       .1538      .1514      .1222      .1844       .306
           1C.CC       .1540      .1531      .1232      .1885       .309
           2C.00       .1493      .1491      .1237      .1850       .304
           3C.00       .1458      .1474      .1236      .1872       .302
           4C.00       .1387      .1450      .1207      .1839       .294
           5C.00       .1346      .143C      .1177      .188C       .292
           6C.00       .1281      .1341      .1135      .1928       .284
           7C.CC       .1182      .1230      .1042      .1935       .269
           8C.C0       .1132      .1C72      .0965      .1932       .255


DATA SET NUMBER         13         14         15         16      CCMPUTEC
 PHI(R)   THETA(R)    RCF(LL)    RCF(PL)    RCF(LP)    RCF(PP)    RCF(OT)
 =180.0    (CEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            C.00       .1538      .1514      .1222      .1844       .306
           1C.00       .1625      .1499      .1247      .1838       .310
           2C.CC
           3C.00       .1693      .1485      .1270      .1867       .316
           4C.00       .1699      .1462      .1264      .1870       .315
           5C.00       .1681      .1432      .1242      .1850       .310
           6C.00       .1581      .1373      .1192      .1847       .300
           7C.00       .14C6      .1277      .1090      .1752       .276
           80.00       .1345      .1186      .1041      .1689       .263
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AC119C-C01

     TITLE
          SMOKED MAGNESIUM OXIDE ON ALUMINUM PLATE
          (APPROXIMATELY 1.75 TO 2 MM DEPOSI...
     SUBJECT CODES
          CJAAA
     DATA SET NUMBERS
           17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
          SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CL4
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 40.00   PHI(I)= 180.0   WAVELENGTH=  .633

DATA SET NUMBER          17         18         19         20      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .1625      .1276      .1331      .1600       .292
           10.00        .1566      .1300      .1342      .1679       .294
           20.00        .1504      .1285      .1338      .1700       .291
           30.00        .1516      .1297      .1314      .1760       .294
           40.00        .1522      .1286      .1294      .1865       .298
           50.00        .1463      .1268      .1233      .1977       .297
           60.00        .1457      .1217      .1173      .2073       .296
           70.00        .1511      .1121      .1112      .2019       .288
           80.00        .1586      .1030      .0999      .2400       .301


DATA SET NUMBER          21         22         23         24      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .1625      .1264      .1331      .1587       .290
           10.00        .1649      .1333      .1295      .1680       .298
           20.00        .1709      .1297      .1291      .1633       .296
           30.00        .1741      .1263      .1226      .1607       .292
           40.00
           50.00        .1846      .1233      .1207      .1715       .300
           60.00        .1777      .1210      .1140      .1690       .291
           70.00        .1716      .1116      .1113      .1568       .276
           80.00        .1567      .1054      .0991      .1571       .259
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AC1190-001

     TITLE
          SMOKED MAGNESIUM OXIDE ON ALUMINUM PLATE
          (APPROXIMATELY 1.75 TO 2 MM DEPOSIT).
     SUBJECT CODES
          CJAAA
     DATA SET NUMBERS
           25, 26  27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
          SOURCE=  DKI    GAMMA(C)=.90    INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 60.00   PHI(I)= 180.0   WAVELENGTH=  .633

DATA SET NUMBER         25          26          27          28      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)     RDF(PL)     RDF(LP)     RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)      (1/SR)      (1/SR)      (1/SR)      (1/SR)

            0.00       .1479       .1229       .1272       .1633        .281
           10.00       .1452       .1248       .1289       .1706        .285
           20.00       .1387       .1268       .1251       .1797        .285
           30.00       .1443       .1246       .1232       .1929        .292
           40.00       .1531       .1237       .1230       .2095        .305
           50.00       .1770       .1212       .1200       .2438        .331
           60.00       .2251       .1201       .1176       .3078        .385
           70.00       .2600       .1137       .1123       .3349        .410
           80.00       .3352       .1077       .1038       .4152        .481


DATA SET NUMBER         29          30          31          32      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)     RDF(PL)     RDF(LP)     RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)      (1/SR)      (1/SR)      (1/SR)      (1/SR)

            0.00       .1479       .1229       .1272       .1633        .281
           10.00       .1555       .1149       .1257       .1586        .277
           20.00       .1630       .1135       .1222       .1533        .276
           30.00       .1751       .1123       .1216       .1534        .281
           40.00       .1822       .1085       .1173       .1510        .279
           50.00       .1922       .1059       .1134       .1533        .282
           60.00
           70.00       .2077       .0969       .1029       .1643        .286
           80.00       .1938       .0862       .0907       .1519        .261
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AC1317-C01

     TITLE
        MAGNESIUM OXIDE, PRESSED AT 4200 PSI, AGAINST INK
        BLOTTER PAPER.
     SUBJECT CODES
        CJAAB
     DATA SET NUMBERS
          1,  2,  3,  4
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=      0    PHI(I)=      0    WAVELENGTH=  .633

DATA SET NUMBER            1          2          3          4      COMPUTED
 PHI(R)   THETA(R)      RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00         .1908      .1437      .1385      .1822       .328
           20.00         .1794      .1421      .1361      .1799       .319
           30.00         .1764      .1407      .1400      .1733       .315
           40.00         .1696      .1416      .1366      .1754       .312
           50.00         .1623      .1399      .1342      .1763       .306
           60.00         .1568      .1378      .1316      .1743       .300
           70.00         .1525      .1376      .1317      .1722       .297
           80.00         .1451      .1361      .1279      .1744       .2[illegible]
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AC1317-001

     TITLE
        MAGNESIUM OXIDE, PRESSED AT 4200 PSI, AGAINST INK
        BLOTTER PAPER.
     SUBJECT CODES
        CJAAB
     DATA SET NUMBERS
          5,  6,  7,  8,  9, 10, 11, 12
     PARAMETER INFORMATION
        SOURCE=  DKI    GAMMA(0)=.90   INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 40.00   PHI(I)= 180.0   WAVELENGTH=  .633

DATA SET NUMBER          5         6         7         8      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00       .1763     .1454     .1424     .1813       .323
           10.00       .1701     .1420     .1432     .1827       .319
           20.00       .1604     .1424     .1384     .1827       .312
           30.00       .1603     .1391     .1425     .1812       .312
           40.00       .1519     .1410     .1398     .1928       .313
           50.00       .1515     .1386     .1351     .1938       .309
           60.00       .1491     .1338     .1335     .1920       .304
           70.00       .1472     .1302     .1268     .1958       .300
           80.00       .1565     .1320     .1220     .2147       .313


DATA SET NUMBER          9        10        11        12      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00       .1763     .1454     .1424     .1813       .323
           10.00       .1813     .1453     .1468     .1827       .328
           20.00       .1923     .1458     .1435     .1861       .334
           30.00       .1985     .1460     .1374     .1913       .337
           40.00
           47.00       .2157     .1544     .1407     .2108       .361
           50.00       .2081     .1501     .1415     .2031       .351
           60.00       .2014     .1531     .1379     .1995       .346
           70.00       .1924     .1524     .1385     .1943       .339
           80.00       .1785     .1459     .1307     .1883       .322
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AC1192-001

        TITLE
           FLOWERS OF SULPHUR, MANUALLY PRESSED INTO PLASTIC CONTAINER
           APPROXIMATELY 2.5 X 2.5 X .25 IN.
        SUBJECT CODES
           CJAC
        DATA SET NUMBERS
              1,  2,  3,  4
        PARAMETER INFORMATION
           SOURCE=  DKI    GAMMA(O)=.90   INSTRUMENTATION= CLA
           ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
           THETA(I)=      0   PHI(I)=     0   WAVELENGTH=  .633

DATA SET NUMBER          1          2          3          4      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
           10.00      .1498      .1390      .1345      .1453       .284
           20.00      .1487      .1397      .1352      .1457       .285
           30.00      .1467      .1398      .1350      .1460       .284
           40.00      .1415      .1346      .1290      .1409       .273
           50.00      .1386      .1320      .1261      .1391       .268
           60.00      .1290      .1252      .1202      .1313       .253
           70.00      .1194      .1184      .1105      .1267       .237
           80.00      .1031      .1006      .0918      .1109       .203
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AC1191-C01

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
         (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE
     DATA SET NUMBERS
           1,  2
     PARAMETER INFORMATION
         SOURCE=  DKH     GAMMA(O)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=      0   PHI(I)=      0   WAVELENGTH=  .425

DATA SET NUMBER          1          2       COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)

            0.00
            7.00        .3296      .3296       .330
           10.00        .3264      .3264       .326
           15.00        .3268      .3268       .327
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AC1191-C01

     TITLE
          FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
          (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
          CJAE
     DATA SET NUMBERS
             3,  4,  5,  6
     PARAMETER INFORMATION
          SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 80.00   PHI(I)= 180.0   WAVELENGTH=  .425

DATA SET NUMBER           3         4        COMPUTED
 PHI(R)    THETA(R)    RDF(LT)   RDF(PT)    RDF(OT)
 =     0    (DEG)      (1/SR)    (1/SR)     (1/SR)

              0.00      .2646     .3699      .317
             20.00      .3357     .3970      .366
             40.00      .5775     .6817      .630
             60.00      .3680     1.791     1.079
             80.00


DATA SET NUMBER           5         6        COMPUTED
 PHI(R)    THETA(R)    RDF(LT)   RDF(PT)    RDF(OT)
 =180.0     (DEG)      (1/SR)    (1/SR)     (1/SR)

              0.00      .2646     .3699      .317
             20.00      .2346     .3937      .314
             40.00      .2533     .3541      .304
             60.00      .2822     .4933      .388
             70.00      .3352     .5769      .456
             80.00
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AC1191-001

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
         (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE
     DATA SET NUMBERS
           7,  8,  9, 10
     PARAMETER INFORMATION
          SOURCE=  DKH     GAMMA(O)=        INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 80.00   PHI(I)= 180.0   WAVELENGTH=  .550

 DATA SET NUMBER           7          8       COMPUTED
  PHI(R)   THETA(R)     RDF(LT)    RDF(PT)    RDF(OT)
  =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)

             0.00        .0739      .2362       .155
            20.00        .2673      .2962       .282
            40.00        .4372      .4955       .466
            60.00       1.051      1.271       1.161
            80.00


 DATA SET NUMBER           9         10       COMPUTED
  PHI(R)   THETA(R)     RDF(LT)    RDF(PT)    RDF(OT)
  =180.0    (DEG)       (1/SR)     (1/SR)     (1/SR)

             0.00        .0739      .2362       .155
            20.00        .1319      .2334       .182
            40.00        .2186      .2350       .227
            60.00        .3842      .2362       .310
            70.00        .6264      .3120       .469
            80.00
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AC1191-C01

     TITLE
          FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
          (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
          CJAE
     DATA SET NUMBERS
           11, 12, 13, 14
     PARAMETER INFORMATION
          SOURCE=  DKH    GAMMA(O)=        INSTRUMENTATION= CLA
          ACCURACY- FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 80.00   PHI(I)= 180.0   WAVELENGTH=  .750

DATA SET NUMBER          11         12        COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)     RDF(OT)
  =    0    (DEG)       (1/SR)     (1/SR)      (1/SR)

             0.00       .2173      .2137       .215
            20.00       .2592      .2709       .265
            40.00       .4181      .4480       .433
            60.00       1.017      1.148      1.082
            80.00       4.321      5.447      5.134


DATA SET NUMBER          13         14        COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)     RDF(OT)
 =180.0     (DEG)       (1/SR)     (1/SR)      (1/SR)

             0.00       .2173      .2137       .215
            20.00       .2044      .2008       .203
            40.00       .1963      .2069       .202
            60.00       .2160      .2199       .218
            70.00       .2227      .2480       .235
            80.00
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AC1191-C01

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
         (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE
     DATA SET NUMBERS
          15, 16, 17, 18
     PARAMETER INFORMATION
         SOURCE=  DKH     GAMMA(O)=        INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 80.00    PHI(I)= 180.0    WAVELENGTH= 1.100

DATA SET NUMBER          15         16        COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)     RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)      (1/SR)

            0.00        .2166      .2281        .222
           20.00        .2677      .2829        .275
           40.00        .4239      .4628        .443
           60.00        1.087      1.224       1.155
           80.00        3.000      6.269       4.634


DATA SET NUMBER          17         18        COMPUTED
 PHI(R)   THETA(R)     RDF(LT)    RDF(PT)     RDF(OT)
 =180.0    (DEG)       (1/SR)     (1/SR)      (1/SR)

            0.00        .2166      .2281        .222
           20.00        .2039      .2081        .206
           40.00        .2033      .2102        .207
           60.00        .2014      .2242        .213
           70.00        .2069      .2490        .228
           80.00
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AC1191-002

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
         (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE
     DATA SET NUMBERS
          1,  2,  3,  4
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(O)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=      0   PHI(I)=      0   WAVELENGTH=  .550

DATA SET NUMBER           1          2          3          4      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)       (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
            7.00        .2142      .1474      .1404      .2063       .354
           10.00        .2031      .1486      .1415      .2045       .349
           15.00        .2025      .1515      .1443      .2059       .352
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AC1191-002

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
         (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE
     DATA SET NUMBERS
          5,  6,  7,  8
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(O)=      INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=     0   PHI(I)=     0   WAVELENGTH=  .750

DATA SET NUMBER          5          6          7          8      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(CT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
            7.00       .1990      .1455      .1400      .1931       .339
           10.00       .1951      .1429      .1394      .1908       .334
           15.00       .1951      .1466      .1422      .1945       .339
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AC1191-002

          TITLE
              FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
              (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
          SUBJECT CODES
              CJAE
          DATA SET NUMBERS
                9, 10, 11, 12
          PARAMETER INFORMATION
              SOURCE=  DKH     GAMMA(C)=       INSTRUMENTATION= CLA
              ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
              THETA(I)=     0   PHI(I)=      0   WAVELENGTH= 1.100

DATA SET NUMBER            9          10          11          12       COMPUTED
 PHI(R)    THETA(R)      RDF(LL)     RDF(PL)     RDF(LP)     RDF(PP)    RDF(OT)
 =    0     (DEG)        (1/SR)      (1/SR)      (1/SR)      (1/SR)     (1/SR)

              0.00
              7.00       .1952       .1469       .1390       .1962        .339
             10.00       .1905       .1443       .1395       .1910        .333
             15.00       .1914       .1484       .1417       .1904        .336
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AC1191-002

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
         (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE
     DATA SET NUMBERS
          13, 14, 15, 16
     PARAMETER INFORMATION
         SOURCE=  DKH     GAMMA(C)=        INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)=      0    PHI(I)=      0    WAVELENGTH= 1.100

DATA SET NUMBER         13         14         15         16      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 = 90.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00
            7.00      .1978      .1416      .1408      .1919       .336
           10.00      .1971      .1389      .1402      .1856       .331
           15.00      .1980      .1409      .1429      .1846       .333
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AC1191-002

     TITLE
        FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
        (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
        CJAE
     DATA SET NUMBERS
         17, 18, 19, 20, 21, 22, 23, 24
     PARAMETER INFORMATION
        SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)=     0   PHI(I)=     0   WAVELENGTH=  .633

DATA SET NUMBER        17        18        19        20      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00
           10.00      .1851     .1270     .1234     .1803      .308
           20.00      .1757     .1245     .1252     .1709      .298
           30.00      .1671     .1249     .1245     .1584      .287
           40.00      .1561     .1201     .1193     .1505      .273
           50.00      .1456     .1180     .1107     .1476      .261
           60.00      .1389     .1084     .1037     .1375      .244
           70.00      .1323     .1001     .0953     .1326      .230
           80.00      .1181     .0848     .0799     .1185      .201


DATA SET NUMBER        21        22        23        24      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00
           10.00      .1932     .1326     .1316     .1902      .324
           20.00      .1817     .1333     .1301     .1792      .312
           30.00      .1694     .1276     .1266     .1655      .295
           40.00      .1596     .1263     .1218     .1585      .283
           50.00      .1463     .1217     .1121     .1505      .265
           60.00      .1410     .1132     .1054     .1461      .253
           70.00      .1319     .0982     .0949     .1313      .228
           80.00      .1194     .0840     .0817     .1183      .202
```

```
AC1191-002

      TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT,
         (CARBORUNDUM CO.), ON 1/4 IN. PLYWOOD BACKING.
      SUBJECT CODES
         CJAE
      DATA SET NUMBERS
          25, 26, 27, 28, 29, 30, 31, 32
      PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 40.00   PHI(I)= 180.0   WAVELENGTH=  .633

DATA SET NUMBER       25        26        27        28       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)   RDF(OT)
 =    0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

            0.00      .1543     .1180     .1198     .1532      .273
           10.00      .1610     .1234     .1236     .1600      .284
           20.00      .1687     .1243     .1275     .1676      .294
           30.00      .1817     .1312     .1309     .1855      .315
           40.00      .1949     .1356     .1324     .2056      .334
           50.00      .2162     .1317     .1298     .2286      .353
           60.00      .2405     .1287     .1204     .2556      .373
           70.00      .2775     .1177     .1150     .2907      .400
           80.00                .1051               .3344


DATA SET NUMBER       29        30        31        32       COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)   RDF(OT)
 =180.0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)    (1/SR)

            0.00      .1543     .1180     .1198     .1532      .273
           10.00      .1536     .1186     .1197     .1520      .272
           20.00      .1532     .1147     .1141     .1480      .265
           30.00      .1494     .1109     .1101     .1493      .260
           40.00
           50.00      .1380     .1031     .1021     .1427      .243
           60.00      .1327     .0987     .0955     .1332      .230
           70.00      .1200     .0896     .0862     .1210      .208
           80.00      .1007               .0712
```

AC1293-C01

TITLE
FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT ON
1/4 IN. PLYWOOD BACKING.
SUBJECT CODES
CJAE ECBBJ
DATA SET NUMBERS
1, 2, 3, 4, 5, 6, 7, 8
PARAMETER INFORMATION
SOURCE= DKH GAMMA(0)= INSTRUMENTATION= CLA
ACCURACY= FIVE PERCENT NUMBER OF RUNS AVERAGED= 1
THETA(I)= 0 PHI(I)= 0 WAVELENGTH= 1.060

DATA SET NUMBER PHI(R) = 0	THETA(R) (DEG)	1 RDF(LL) (1/SR)	2 RDF(PL) (1/SR)	3 RDF(LP) (1/SR)	4 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00					
	10.00	.2068	.1386	.1497	.1939	.344
	20.00	.1983	.1369	.1460	.1780	.330
	30.00	.1918	.1376	.1467	.1721	.324
	40.00	.1811	.1263	.1421	.1615	.306
	50.00	.1775	.1222	.1369	.1542	.295
	60.00	.1703	.1154	.1293	.1472	.281
	70.00	.1615	.1044	.1170	.1399	.261
	80.00	.1432	.0897	.1010	.1263	.230

DATA SET NUMBER PHI(R) =180.0	THETA(R) (DEG)	5 RDF(LL) (1/SR)	6 RDF(PL) (1/SR)	7 RDF(LP) (1/SR)	8 RDF(PP) (1/SR)	COMPUTED RDF(OT) (1/SR)
	0.00					
	10.00	.2090	.1365	.1488	.1917	.343
	20.00	.1997	.1353	.1480	.1785	.331
	30.00	.1921	.1334	.1458	.1717	.321
	40.00	.1847	.1320	.1412	.1641	.311
	50.00	.1772	.1254	.1341	.1605	.299
	60.00	.1700	.1202	.1266	.1547	.286
	70.00	.1582	.1084	.1133	.1455	.263
	80.00	.1411	.0916	.0962	.1305	.230

```
AC1293-001

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT ON
         1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE   ECBBJ
     DATA SET NUMBERS
          9, 10, 11, 12, 13, 14, 15, 16
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 20.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER          9         10         11         12      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =     0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .1949      .1291      .1434      .1664       .317
           10.00       .1946      .1390      .1470      .1763       .328
           20.00       .1891      .1370      .1442      .1756       .323
           30.00       .1898      .1398      .1463      .1787       .327
           40.00       .1864      .1324      .1437      .1716       .317
           50.00       .1876      .1283      .1406      .1730       .315
           60.00       .1885      .1213      .1307      .1725       .306
           70.00       .1908      .1144      .1229      .1759       .302
           80.00       .1868      .1002      .1092      .1739       .285


DATA SET NUMBER         13         14         15         16      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00       .1949      .1291      .1434      .1664       .317
           10.00       .1900      .1305      .1423      .1735       .318
           20.00
           30.00       .1814      .1248      .1379      .1654       .305
           40.00       .1734      .1223      .1324      .1555       .292
           50.00       .1637      .1154      .1258      .1441       .274
           60.00       .1552      .1079      .1179      .1369       .259
           70.00       .1412      .0984      .1064      .1266       .236
           80.00       .1252      .0853      .0912      .1140       .208
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AC1293-001

          TITLE
              FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT ON
              1/4 IN. PLYWOOD BACKING.
          SUBJECT CODES
              CJAE   ECBBJ
          DATA SET NUMBERS
              17, 18, 19, 20, 21, 22, 23, 24
          PARAMETER INFORMATION
              SOURCE=  DKH    GAMMA(C)=       INSTRUMENTATION= CLA
              ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
              THETA(I)= 30.00    PHI(I)=180.00    WAVELENGTH= 1.060

DATA SET NUMBER         17         18         19         20       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .1668      .1313      .1296      .1663        .297
           10.00       .1700      .1367      .1325      .1737        .306
           20.00       .1744       1428      .1355      .1811        .317
           30.00       .1819      .1445      .1407      .1880        .328
           40.00       .1848      .1443      .1386      .1954        .332
           50.00       .1913      .1411      .1350      .2024        .335
           60.00       .2016      .1378      .1321      .2147        .343
           70.00       .2116      .1273      .1226      .2260        .344
           80.00       .2220      .1132      .1116      .2336        .340


DATA SET NUMBER         21         22         23         24       COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)     RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)      (1/SR)

            0.00       .1668      .1313      .1296      .1663        .297
           10.00       .1638      .1269      .1241      .1607        .288
           20.00       .1599      .1258      .1224      .1660        .287
           30.00
           40.00       .1529      .1212      .1155      .1627        .276
           50.00       .1487      .1191      .1129      .1527        .267
           60.00       .1408      .1132      .1075      .1430        .252
           70.00       .1321      .1048      .0996      .1345        .235
           80.00       .1176      .0942      .0876      .1232        .211
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AC1293-C01

     TITLE
         FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT ON
         1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
         CJAE   ECBBJ
     DATA SET NUMBERS
          25, 26, 27, 28, 29, 30, 31, 32
     PARAMETER INFORMATION
         SOURCE=  DKH    GAMMA(O)=       INSTRUMENTATION= CLA
         ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
         THETA(I)= 40.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER        25        26        27        28      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00      .1620     .1325     .1284     .1655      .294
           10.00      .1671     .1370     .1307     .1758      .305
           20.00      .1751     .1402     .1340     .1828      .316
           30.00      .1873     .1432     .1389     .1978      .334
           40.00      .1996     .1435     .1394     .2117      .347
           50.00      .2211     .1442     .1390     .2332      .369
           60.00      .2456     .1400     .1333     .2591      .389
           70.00      .2804     .1333     .1264     .2917      .416
           80.00      .3270     .1197     .1134     .3221      .439


DATA SET NUMBER        29        30        31        32      COMPUTED
 PHI(R)   THETA(R)   RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0    (DEG)     (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

            0.00      .1620     .1325     .1284     .1655      .294
           10.00      .1607     .1305     .1262     .1631      .290
           20.00      .1567     .1236     .1205     .1570      .279
           30.00      .1524     .1235     .1173     .1621      .278
           40.00
           50.00      .1449     .1169     .1091     .1568      .264
           60.00      .1396     .1124     .1030     .1475      .251
           70.00      .1274     .1026     .0936     .1357      .230
           80.00      .1148     .0926     .0817     .1245      .207
```

```
AC1293-001

     TITLE
        FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT ON
        1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
        CJAE    ECBBJ
     DATA SET NUMBERS
         33, 34, 35, 36, 37, 38, 39, 40
     PARAMETER INFORMATION
        SOURCE=  DKH     GAMMA(C)=        INSTRUMENTATION= CLA
        ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
        THETA(I)= 5[illegible].00    PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER           33         34         35         36      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .1632      .1239      .1296      .1589       .288
           10.00        .1728      .1268      .1352      .1671       .301
           20.00        .1863      .1323      .1407      .1834       .321
           30.00        .2015      .1372      .1438      .2047       .344
           40.00        .2291      .1435      .1456      .2417       .380
           50.00        .2678      .1464      .1548      .2912       .430
           60.00        .3356      .1466      .1491      .3545       .493
           70.00        .4043      .1406      .1396      .4426       .564
           80.00        .5176      .1315      .1305      .5596       .670


DATA SET NUMBER           37         38         39         40      COMPUTED
 PHI(R)   THETA(R)     RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)        (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00        .1632      .1239      .1296      .1589       .288
           10.00        .1544      .1194      .1237      .1506       .274
           20.00        .1540      .1179      .1217      .1486       .271
           30.00        .1501      .1141      .1153      .1461       .263
           40.00        .1480      .1108      .1122      .1489       .260
           50.00
           60.00        .1431      .1040      .1050      .1475       .250
           70.00        .1374      .0974      .0979      .1357       .234
           80.00        .1258      .0853      .0862      .1235       .210
```

```
AC1293-001

     TITLE
          FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT ON
          1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
          CJAE   ECBBJ
     DATA SET NUMBERS
           41, 42, 43, 44, 45, 46, 47, 48
     PARAMETER INFORMATION
          SOURCE= DKH    GAMMA(0)=       INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 60.00    PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER         41         42         43         44      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =    0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .1455      .1115      .1139      .1447       .258
           10.00      .1569      .1192      .1184      .1619       .278
           20.00      .1734      .1231      .1245      .1815       .301
           30.00      .1989      .1302      .1297      .2140       .336
           40.00      .2402      .1372      .1344      .2671       .389
           50.00      .3081      .1442      .1389      .3503       .471
           60.00      .4220      .1488      .1414      .4806       .596
           70.00      .5859      .1475      .1413      .6731       .774
           80.00      .8577      .1414      .1370      .9745      1.055


DATA SET NUMBER         45         46         47         48      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)    RDF(PL)    RDF(LP)    RDF(PP)    RDF(OT)
 =180.0    (DEG)      (1/SR)     (1/SR)     (1/SR)     (1/SR)     (1/SR)

            0.00      .1455      .1115      .1139      .1447       .258
           10.00      .1407      .1092      .1121      .1404       .251
           20.00      .1371      .1058      .1072      .1331       .242
           30.00      .1361      .1045      .1056      .1331       .240
           40.00      .1341      .1031      .0999      .1337       .235
           50.00      .1342      .1024      .0986      .1452       .240
           60.00
           70.00      .1315      .0958      .0900      .1489       .233
           80.00      .1305      .0888      .0835      .1408       .222
```

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AC1293-C01

     TITLE
          FIBERFRAX, TYPE 970 JH CERAMIC INSULATING FELT ON
          1/4 IN. PLYWOOD BACKING.
     SUBJECT CODES
          CJAE   ECBBJ
     DATA SET NUMBERS
           49, 50, 51, 52, 53, 54, 55, 56
     PARAMETER INFORMATION
          SOURCE=  DKH    GAMMA(0)=       INSTRUMENTATION= CLA
          ACCURACY= FIVE PERCENT   NUMBER OF RUNS AVERAGED= 1
          THETA(I)= 70.00   PHI(I)=180.00   WAVELENGTH= 1.060

DATA SET NUMBER          49        50        51        52      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =    0     (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00      .1366     .1035     .1033     .1399       .242
            10.00      .1455     .1046     .1061     .1508       .253
            20.00      .1691     .1121     .1133     .1766       .286
            30.00      .2028     .1180     .1182     .2180       .328
            40.00      .2605     .1262     .1249     .2872       .399
            50.00      .3686     .1338     .1351     .4070       .522
            60.00      .5592     .1423     .1406     .6247       .733
            70.00      .8992     .1445     .1468     1.023      1.107
            80.00      1.529     .1460     .1439     1.695      1.757


DATA SET NUMBER          53        54        55        56      COMPUTED
 PHI(R)   THETA(R)    RDF(LL)   RDF(PL)   RDF(LP)   RDF(PP)    RDF(OT)
 =180.0     (DEG)      (1/SR)    (1/SR)    (1/SR)    (1/SR)     (1/SR)

             0.00      .1366     .1035     .1033     .1399       .242
            10.00      .1276     .1000     .0986     .1293       .228
            20.00      .1273     .0997     .1002     .1281       .228
            30.00      .1249     .0965     .0966     .1242       .221
            40.00      .1273     .0980     .0959     .1290       .225
            50.00      .1209     .0878     .0870     .1217       .209
            60.00      .1338     .0942     .0922     .1448       .232
            70.00
            80.00      .1565     .0952     .0935     .1746       .260
```

5
RADAR (ACTIVE MICROWAVE) DATA

The active microwave data in the TSAC compilation consists of averaged radar cross sections as a function of aspect angle with frequency as a parameter, and cumulative probability distribution vs. radar cross section. The latter data appear only in the classified supplement.

Each radar data curve has been digitized by the same technique as used for the optical data, and the curves are reproduced on uniform grids. Normalized radar cross section σ_0 in decibels is plotted along the ordinate, and the abscissa represents the angle measured from the normal (aspect angle) in degrees. The header information for each curve, which includes the curve's identification number, title, a coded designation for the type of terrain covered, and parameter information, is also supplied by computer.

5.1. DATA FORMAT

A numerical code is used to identify the radar curves. The number of digits in the code is variable, depending on the number of descriptors required for a particular target or background. Table 5-1 contains the key for interpreting this code. The first digit, always a 3, identifies the curve as being radar data. The second digit, either a 1, 2, or 3, indicates that the curve is for a background, target, or combination of terrain and target, respectively. Third, fourth, and fifth digits, when used, represent successively finer subdivisions of the material class involved. Thus, 31312 represents clay, a subset of soil (3131), which in turn is a subset of terrain (313), which is a background material (31) being measured by radar (3). Table 5-1 also indicates which material classes require still additional descriptors. These are designated by the letters A, B, C, C_1, C_2, C_3, etc., as defined in table 5-2. Table 5-3 explains the parameter information appearing in the curve header. In section 5.3 the radar data are grouped according to the first four digits of the curve identification number.

TABLE 5-1. RADAR DATA NUMERICAL CODE

31	BACKGROUND AND TERRAIN
311	Sky
312	H_2O States
3122 □ *$C_1C_2C_3C_4$	Ice
3123 □ AB	Water
313	Terrain
3131	Soil
31311$C_1C_2C_3C_4$	Sand
31312$C_1C_2C_3C_4$	Clay
31313$C_1C_2C_3C_4$	Loam, cultivated
31314$C_1C_2C_3C_4$	Loam, uncultivated
31315$C_1C_2C_3C_4$	Rock
31316$C_1C_2C_3C_4$	Salt
3132	Trees
31321$C_1C_2C_3C_4$	Leaves, laboratory sample
31322$C_1C_2C_3C_4$	Bark, laboratory sample
31323$C_1C_2C_3C_4$	Broad-leaf trees
31324$C_1C_2C_3C_4$	Narrow-leaf trees
31325$C_1C_2C_3C_4$	Broad-leaf shrubs
31326$C_1C_2C_3C_4$	Narrow-leaf shrubs
3133	Crops
31331$C_1C_2C_3C_4$	Grain
31332$C_1C_2C_3C_4$	Broad-leaf crops
31333$C_1C_2C_3C_4$	Grass
31334$C_1C_2C_3C_4$	Mosses, ferns, and fungi
3134X$C_1C_2C_3C_4$	Forest, where X is the percentage of cover
3135 □ $C_1C_2C_3C_4$	Farmland (including farm buildings, etc.)
3136 □ $C_1C_2C_3C_4$	Marsh
3137 □ $C_1C_2C_3C_4$	Desert
314	Space
315	Combinations of Ice, H_2O, and Land
3151A$C_1C_{2_I}C_{3_I}C_{4_I}$	Ice and H_2O
3152A$C_1C_2C_3C_4$	H_2O and land
3153 □ $C_1C_2C_3C_4C_{2_I}$	Ice and land
3154A$C_1C_2C_3C_4C_{2_I}$	Ice, H_2O, and land

---

*The symbol □ indicates a blank space.

TABLE 5-1. RADAR DATA NUMERICAL CODE (Continued)

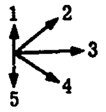
32	TARGET
320	Composite areas
3201 □ $C_1C_2C_3C_4$	Industrial area
3202 □ $C_1C_2C_3C_4$	Residential area
3203 □ $C_1C_2C_3C_4$	Rural town area
321	Buildings and building materials
3211	Materials
32111$C_1C_2C_3C_4$	Painted lumber
32112$C_1C_2C_3C_4$	Brick and tile
32113$C_1C_2C_3C_4$	Asphalt
32114$C_1C_2C_3C_4$	Glass
3212 □ $C_1C_2C_3C_4$	Concrete buildings
3213 □ $C_1C_2C_3C_4$	Frame buildings
3214 □ $C_1C_2C_3C_4$	Camouflage, decoys, and temporary structures
3215 □ $C_1C_2C_3C_4$	Steel buildings
322 □ □C_1□ □C_4	Personnel
323 □ □C_1□ □C_4	Surface vehicles
3231 □C_1□ □C_4	Trucks, armor, and painted vehicles
324 □ □C_1□ □C_4	Aircraft
325 □ □C_1□ □C_4	Missiles
328 □ □$C_1C_2C_3C_4$	Airfields
3290D$C_1C_2C_3C_4$	Pavement, where D is (1) Asphalt (4) Concrete (7) Cinder and gravel (2) Brick (5) Gravel (8) Concrete and gravel (3) Cinder (6) Stone (9) Cinder and dirt
33	COMBINATIONS OF TERRAIN AND TARGETS
3301 □$C_1C_2C_3C_4$	Orchard with paved highway
3302 □$C_1C_2C_3C_4$	Desert, highway, and bridges
3303A$C_1C_{2_L}C_{3_I}C_4C_{2_I}$	Water, ice, land, and small buildings

TABLE 5-2. SCALES OF ADDITIONAL DESCRIPTORS FOR RADAR DATA

Scale A: Douglas Sea Scale

Code No.	Description	Wave Height (ft)	Wind Speed (knots)
0	Calm	0	0
1	Smooth	<1	<6.5
2	Slight	1 to 3	6.5 to 12
3	Moderate	3 to 5	12 to 14.5
4	Rough	5 to 8	14.5 to 18
5	Very rough	8 to 12	18 to 23
6	High	12 to 20	23 to 30
7	Very high	20 to 40	30 to 40
8	Mountainous	>40	>40
9	Confused		

Scale B: Wind-Direction Scale



1 indicates antenna direction.

Scale C_1: Season When Measurements Taken

1	Summer: June, July, August
2	Fall: September, October, November
3	Winter: December, January, February
4	Spring: March, April, May

Scale C_2: Small-Scale Roughness

1	Roughness = <0.01λ
2	Roughness = 0.01λ to 0.05λ
3	Roughness = 0.05λ to 0.10λ
4	Roughness = 0.10λ to 0.50λ
5	Roughness = 0.50λ to 1.00λ
6	Roughness = 1.00λ to 5.00λ
7	Roughness = 5.00λ to 10.00λ
8	Roughness = 10.00λ to 50.00λ
9	Roughness = >50.00λ

Scale C_3: Large-Scale Roughness

1	Flat
2	Rolling
3	Hilly
4	Mountainous

Scale C_4: Wetness or Snow

1	Dry ground
2	Wet ground (rain)
3	Partially flooded or swampy
4	Snow, <3λ deep
5	Snow, 3 to 10λ deep
6	Snow, 10 to 20λ deep
7	Snow, 20 to 50λ deep
8	Snow, 50 to 100λ deep
9	Snow, >100λ deep

TABLE 5-3. RADAR DATA PARAMETERS

BAND	Frequency interval of measurement coded as follows:	
	B	Low frequency
	P	0.225 to 0.390 GHz
	L	0.390 to 1.55
	S	1.55 to 3.90
	C	3.90 to 6.20
	X	6.20 to 10.9
	KU	10.9 to 20.9
	KA	20.9 to 36.0
	Q	36.0 to 46.0
	V	46.0 to 56.0
FREQ	Exact frequency of measurement (gigahertz)	
POL	Polarization of transmitted signal and polarization of received signal, coded as follows:	
	VV	Vertical × vertical
	HV	Horizontal × vertical
	RL	Right circular × left circular
	RR	Right circular × right circular
	AV	Average
	HH	Horizontal × horizontal
	VH	Vertical × horizontal
	LR	Left circular × right circular
	LL	Left circular × left circular
LAT	Latitude of measurement	
LONG	Longitude of measurement	
DATE	Date of measurement (day, month, and year)	
RADAR TYPE	Coded as follows:	
	ACC	Airborne cw, coherent
	ACN	Airborne cw, noncoherent
	APC	Airborne pulse, coherent
	APN	Airborne pulse, noncoherent
	GCC	Ground cw, coherent
	GCN	Ground cw, noncoherent
	GPC	Ground pulse, coherent
	GPN	Ground pulse, noncoherent
BEAMWIDTH	Beamwidth between half-power points (degrees)	
RANGE	Range in thousands of feet followed by an R for slant range or an H for altitude.	
AREA	Total sampling area per average point (square feet)	
AVERAGING	Degree of averaging, scaled from 1 (instantaneous) to 9 (very heavily averaged)	
VARIANCE	Variance about curves (decibels)	

5.2. SUMMARY OF EXPERIMENTS YIELDING RADAR DATA

The documents from which the radar data have been extracted are briefly summarized below. These summaries are included to facilitate use of the data presented in section 5.3. Information on the experimental platform, instrumentation, reflectance standards, and other related matters has been included. The code consisting of the letter B and five digits at the beginning of each entry is the accessions number assigned to the document by the Target Signature Analysis Center. All curves extracted from the document carry this accessions number plus a number from 001 to 999 which is an arbitrary designation assigned to specific curves. The two numbers together constitute a curve's identification number. Bibliographical information on each of the documents is included, and the user is referred to the original source if more detailed information is required.

B-03337. Campbell: Backscattering Characteristics of Land and Sea at X-Band, General Precision Laboratory, Inc., Pleasantville, N. Y., May 1958.

Instrumentation
System 1: airborne pulsed radar
Antenna: 18-in.-diameter paraboloid
Polarization: horizontal
Frequency: X-band ($\lambda = 3.4$ cm)
Antenna beamwidth: unspecified
Pulse-repetition frequency: 20 kHz
Pulse duration: 1/4 μsec

System 2: airborne pulsed radar
Antenna: a pair of paraboloids, 18-in. diameter
Polarization: vertical, horizontal, cross
Frequency: X-band ($\lambda = 3.4$ cm)
Antenna beamwidth (both azimuth and elevation): 5 1/2°
Pulse-repetition frequency: 50 kHz
Pulse duration: 1 μsec
Comments: One antenna was arranged to transmit vertically polarized radiation, and the other was arranged to transmit horizontally polarized radiation. For the cross-polarization measurements, the horizontally polarized antenna was used for transmission and the vertically polarized antenna for reception. The antennas were mounted on a servo-controlled platform within a radome on the underside of the C-46 test aircraft. Platform azimuth was adjusted during each run so that the direction of propagation (except for normal incidence) was forward, approximately along the ground track of the aircraft. The platform tilt angle, which determined the radiation incidence angle, was stabilized against aircraft motion about the tilt axis by means of a vertical gyroscope mounted on the platform.

Targets and Backgrounds Observed: wooded land (Connecticut), cultivated land (Virginia), Atlantic Ocean, dry pine forests and grasslands (northern Arizona), irrigated farm land (Chandler, Ariz.), desert and dry lake bed (Amboy, Calif.)

Test Procedure (Property Measured): scattering cross section per unit area

Data
Output form: curves of scattering cross section, 10 log σ_0 vs. incidence angle; curves are averages of several measurements

B-03539. Measurements of Terrain Backscattering with Airborne X-Band Radar (Final Report), Goodyear Aerospace Corp., Litchfield Park, Ariz., 30 September 1959, AD 229 104.

Instrumentation System: airborne side-looking pulsed radar
  Antenna: designed to provide uniform ground illumination angles of incidence from 10° to 70°
  Polarization: horizontal
  Frequency: 9375 MHz (X-band)
  Antenna beamwidths: 4° azimuth, 9.2° elevation
  Pulse-repetition frequency: 800 pps
  Pulse duration: 0.78 μsec
  Transmitter output power: 50 kw

Targets and Backgrounds Observed: wooded land (New Jersey, Connecticut), cultivated land (Virginia), wooded land with occasional residential and cleared areas (Long Island, N. Y.), water (Long Island Sound, N. Y.)

Test Procedure (Property Measured): ratio of received-to-transmitted rf power levels at X-band

Experimental Parameters Specified
  Aspect angle: $10^\circ < \theta < 70^\circ$
  Others: altitude, terrain clearance, slant range

Data
  Output form: tables and curves of backscattering coefficient σ_0 vs. aspect angle
  Data processing: averages, data spread, probability density function for σ_0
  Errors: σ_0 accurate to 1 dB

B-03553. Hagn: An Investigation of the Direct Backscatter of High-Frequency Radio Waves from Land, Sea Water, and Ice Surfaces (Final Report II), Stanford Research Institute, Menlo Park, Calif., May 1962, AD 278 138.

Instrumentation System: airborne high-frequency pulsed radar (a cw mode was also available)
  Antenna: a crossed Yagi array was secured to the nose of the aircraft and a dipole under the tail; the two antennas were matched to have a VSWR of less than 1.4:1 when airborne
  Polarization: horizontal, vertical, cross
  Frequency: 32.8 MHz
  Antenna beamwidth
    Nose antenna vertical: 140° azimuth, 20° elevation
    Nose antenna horizontal: 50° azimuth, 10° elevation
    Tail antenna horizontal: 40° azimuth, 5° elevation
  Pulse-repetition frequency: variable from 10 to 10,000 pps
  Pulse duration: variable from 1 μsec to 10 msec
  Transmitter output power: variable from 4 w to 4 kw

Targets and Backgrounds Observed: ocean, polar sea ice, selected land surfaces

Test Procedure (Property Measured): backscatter reflection coefficient as a function of incidence angle

Data
  Output form: plots of backscatter reflection coefficient ρ vs. angle of incidence

  Data processing: averages, data spread computed

B-04333. Grant, Yaplee: Backscattering from Water and Land at Centimeter and Millimeter Wavelengths, Naval Research Laboratory, Washington, D. C., 20 March 1957.

Instrumentation System: 2-antenna, zero-intermediate frequency superheterodyne cw Doppler
Antenna: spun aluminum parabolas
Polarization: vertical
Frequency: 3.2 cm at X-band, 1.25 cm at K-band, 8.6 mm at Q-band
Antenna beamwidth (both azimuth and elevation): 3.1° for X-band; 3.4° for K-band, 2.4° for Q-band
Transmitter: low-power klystron transmitting tubes: 2K25 at X-band. 2K50 at K-band, QK-291 at Q-band

Comments in the water-surface measurements, the difference in frequency between the transmitted and received signals was provided by the Doppler shift due to the motion of the water. The frequency response of the audio amplifier was linear down to 20 Hz. A radial velocity of about 0.6 knot on the X-band system and less than 0.2 knot on the Q-band system was necessary to give a 20-Hz Doppler frequency. Only in the case of extremely calm water were velocities lower than this encountered. For calm water and all the land-terrain measurements the difference in frequency between transmitted and received signals was provided by frequency modulating the klystron transmitter.

Targets and Backgrounds Observed: water surfaces, tree-covered terrain, tall dry weeds, wet terrain covered with tall green weeds or flags, short dry grass, green grass, nonhomogeneous terrain

Comments: Water-surface data were taken on the Potomac River Bridge, Newburg, Md., where a catwalk 150 ft high provided an unobstructed view of the water at all angles from normal incidence to the horizon. Terrain data were taken from bridges that had approaches at least 100 ft above relatively flat land. The bridges used were the Neches River Bridge, Port Arthur, Tex., the Huey P. Long Bridge, New Orleans, La., and the Eugene Talmadge Bridge, Savannah, Ga.

Test Procedure (Property Measured): readings of the ratio of received power were made every 5° from 0° to 40° and every 10° from 40° to 80°

Experimental Parameters Specified
Wind velocity: 0-25 knots

Data
Output form: curves of average radar cross section of water or land echo per unit area of surface σ_0 vs. angle of incidence

B-04434. MacDonald, Ament, Ringwalt: Terrain Clutter Measurements, Naval Research Laboratory, Washington, D. C., 21 January 1958, AD 156 184.

Instrumentation System: airborne pulsed radar
Antenna: unspecified
Polarization: horizontal, cross
Frequency: X-band, S-band, L-band
Antenna beamwidth: unspecified
Pulse-repetition frequency: 175 Hz
Pulse duration: 1/2 μsec

Targets and Backgrounds Observed: rural terrain, urban terrain

Test Procedure (Property Measured): radar ground clutter

Experimental Parameters Specified
Altitude: 2000, 3000, 6000 ft
Depression angle: $1.5^\circ < \theta < 90^\circ$
Aircraft ground speed: 140 knots
Date: February 1956
Location: Annapolis, Baltimore (Md.)

Data
Output form: charts of normalized radar cross section (dB), 10 log σ_0 vs. depression angle

B-04435. Peake, Taylor: Radar Back-Scattering Measurements from "Moon-Like" Surfaces, Antenna Laboratory, Ohio State University Research Foundation, Columbus, 1 May 1963.

Instrumentation System: single-antenna cw Doppler
  Antenna: high-gain pyramidal horns and zoned dielectric lenses designed to give an optimum pattern at operating range of 20 ft
  Polarization: horizontal, vertical
  Frequency: 10 GHz at X-band, 15.5 GHz at K_u-band, 35 GHz at K_a-band
  Transmitter: low-power klystrons, X-12 at X-band and K_u-band, QK-291 at K_a-band
  Detector: 1N23 crystals at X-band, 1N26 crystals at K_u-band, 1N53 crystals at K_a-band

Targets and Backgrounds Observed: sand, gravel, stone

Test Procedure (Property Measured): radar backscatter (dB)

Data
  Output form: curves of radar backscatter vs. grazing angles of 20^o to 80^o
  Data processing: curves of radar return, $10 \log \gamma$ vs. normalized roughness

B-04436. Cosgriff, Peake, Taylor: Terrain Scattering Properties for Sensor System Design: Terrain Handbook No. 2, sponsored by contracts between U. S. Air Force (ARDC) and U. S. Army Signal Corps and Ohio State University Research Foundation, Columbus, May 1960.

Instrumentation System: single-antenna cw Doppler
  Antenna: high-gain pyramidal horns with zoned dielectric lenses designed to give an optimum pattern at operating range of 20 ft
  Polarization: horizontal, vertical
  Frequency: 10 GHz at X-band, 15.5 GHz at K_u-band, 35 GHz at K_a-band
  Transmitter: low-power klystrons, X-13 at X-band, X-12 at K_u-band, QK-291 at K_a-band
  Detector: 1N23 crystals at X-band, 1N26 crystals at K_u-band, 1N53 crystals at K_a-band

Targets and Backgrounds Observed: smooth terrain, vegetation, snow- and rain-covered terrain, sea

Test Procedure (Property Measured): radar cross section per unit area of terrain (normalized echo area)

Experimental Parameters Specified
  Incidence angle: measurements made at 5^o or 10^o intervals for incidence angles from 10^o to 80^o ($\pm 1^o$)
  Slant range: 20 ft
  Effective illuminated area (normal to line of sight): 2.41 ft^2 at X-band, 2.36 ft^2 at K_u-band, 0.67 ft^2 at K_a-band

Data
  Output form: curves of radar cross section per unit area of terrain vs. angle of incidence and frequency
  Error: measurements accurate to ±1 dB

Insert Radar Data Sheets Here

6

PASSIVE MICROWAVE DATA

The passive microwave data in this compilation are apparent temperatures (antenna or target) as a function of aspect or depression angle. These data are processed in a manner similar to that used for the optical data in section 3, i.e., each curve is digitized and assigned subject codes (table 1-1), and the parameter information describing the experimental conditions (see table 6-1) is listed. However, the system used to process the microwave data is actually an expanded version of that used with the optical data. It has been designed to handle not only passive microwave data, but also, eventually, both directional and bidirectional reflectance data. Thus, many of the parameters defined in table 6-1 do not apply to the data now in this section, but were included for future data accessions.

There is also a major difference in printed-out format between the curve headers for the optical data and those for the microwave data in this section. For the optical data, all the parameter designations are printed as part of each header whether or not there is specific information on the parameter. For the microwave data, only those parameters for which there are specific entries will appear; parameters that are not applicable or not specified are not included. The data are arranged by subject codes and alphabetically cross-indexed in section 2.

TABLE 6-1. GENERALIZED PARAMETERS FOR PASSIVE MICROWAVE DATA

	TIME
MONTH	Month of measurement
DAY	Day of measurement
YEAR	Year of measurement
TIME	Time of measurement (24-hour clock), Greenwich Standard Time (GMT)
	TARGET
LAT	Latitude (degrees) of measurement (field measurement) or of location at which specimen was collected (laboratory measurement)
LATNS	Latitude, North (N) or South (S)
LONG	Longitude (degrees) of measurement or of location at which specimen was collected, as with LAT
LONG EW	Longitude, East (E) or West (W)
TARALT	Altitude of target above ground (kilometers)
TARZEN	Zenith angle (degrees) of target normal with respect to vertical
TARAZ	Azimuth angle (degrees) of target normal with respect to a $\phi = 0$ reference line defined for a given target
TARUNF	Surface uniformity coded as UNIFRM (uniform) or NONUNF (nonuniform); in radar applications, use subject codes from table 1-1 or the Douglas Sea Scale codes (table 5-2).
TAROPQ	Target opaqueness coded as OPAQUE (opaque), TRANSP (transparent), or TRANSL (translucent)
TARTEM	Target temperature (degrees Kelvin)
TH2OES	Qualitative estimate of free water content coded as DRY, DAMP, WET or PTFL (partially flooded). Indicate snow under TARCS1 or TARCS2.

TABLE 6-1. GENERALIZED (PASSIVE MICROWAVE) DATA PARAMETERS (Continued)

TH2OME	Quantitative measure (percent) of free water content; W indicates percentage by weight, V percentage by volume
HRSREM	Number of hours sample has been removed from its natural environment
TARCS1	Target coating or substrate 1 coded using up to a five-letter code from the Target Signature Subject-Code List (table 1-1) preceded by a C (coating) or S (substrate); snow coatings are indicated using the following letter code at the end of subject code BHBD: A Incomplete cover B Depth 0 to 5 cm C Depth 5 to 20 cm D Depth over 20 cm
TARCS2	Target coating or substrate 2 (see TARSC1)
TARCON	Target contaminant coded using up to a six-letter subject code from table 1-1
TARSRD	Availability of data on the target's surface roughness, coded by AVAIL
TARDCN	Availability of the target's dielectric constant, coded by DC; its index of refraction, coded by N; or both, coded by BOTH
TARINF	Availability of other descriptive information about the target, coded by AVAIL

BACKGROUND

BKGTYP	Predominant background type coded using up to a six-letter subject code from table 1-1
BKGUNF	Background uniformity (see TARUNF)
BKGOPQ	Background opaqueness (see TAROPQ)
BKGTEM	Background temperature (see TARTEM)
BH2OES	Qualitative estimate of free water content (see TH2OES)
BH2OME	Quantitative measure of free water content (see TH2OME)
BKGCS1	Background coating or substrate 1 (see TARCS1)
BKGCS2	Background coating or substrate 2 (see TARCS2)
BKGCON	Background contaminant (see TARCON)
BKGSRD	Availability of data on the background's surface roughness (see TARSRD)
BKGDCN	Availability of the backgrounds dielectric constant, index of refraction, or both (see TARDCN)
BKGINF	Availability of other descriptive information about the background (see TARINF)

METEOROLOGY

Note: These parameters are applicable to field experiments only.

AIRTEM	Ambient or air temperature (^{o}K)
BARPRS	Barometric pressure (millibars)
RELHUM	Relative humidity
VISBIL	Visibility (kilometers)
WINDSP	Wind speed (miles per hour)
WINDIR	Wind direction (N, NNE, NE, ENE, etc.); for radar, indicate relative bearing with 0^{o} being from target to receiver and angle measured counterclockwise
OBST	Obstructions in the air preventing a clear view of the target, coded as NONE, FOG, DRIZZL, RAIN, SNOW, HAZE, SMOKE, DUST, or OTHER
PRAMT	Ground accumulation of precipitation in the preceding 24-hour period (centimeters)
CLDCOV	Total cloud cover (percent)

TABLE 6-1. GENERALIZED (PASSIVE MICROWAVE) DATA PARAMETERS (Concluded)

SOURCE

Note: These parameters are not applicable to passive-microwave measurement systems.

SORTYP	Type of source coded using table 1-1
SGAMMA	The real part of the coherence function of the source, i.e., the visibility function or $\|\gamma_0\|$; for radar, 1.0 = coherent, 0.0 = noncoherent
SORPOL	Type of source polarization coded using table 1-1
SORDP	Degree of polarization at the source (percent)
ZENINC	Zenith angle of incidence (degrees)
AZINC	Azimuth angle of incidence (degrees)
SRANGE	Range (distance) from source to target (kilometers)
SORINF	Availability of other descriptive information about the source, coded by AVAIL

RECEIVER

MINST	Measuring instrument coded using table 1-1
ROMEGA	Mean reflected solid angle (steradians)
RRANGE	Range from target to receiver (kilometers)
ZENOBS	Zenith angle of observation (degrees)
AZOBS	Azimuth angle of observation (degrees)
RECPOL	Type of receiver polarization coded using table 1-1
LAMDA	Operating center wavelength λ_c (centimeters)
IFBAND	Intermediate frequency bandwidth or spectral resolution expressed as $\Delta\lambda/\lambda_c$
TIMEC	Time constant for integration time of the receiver (seconds)
INSENS	Availability of data on instrument sensitivity, coded by AVAIL
SYSACC	System accuracy expressed in units of the dependent variable
ANT3DB	3-db antenna beamwidth (degrees)
AVESLL	Average side-lobe level of the antenna (decibels)
RECINF	Availability of other descriptive information about the receiver, coded by AVAIL

GENERAL

PLATF	Experimental platform coded using table 1-1
RELABS*	Dependent variable is indicated as relative (REL) or absolute (ABS)
STAND	Standard used coded using table 1-1
NAVE	Number of curves or measurements averaged to make up this curve
VARNCE	Variance about curves in units of ordinate dimensions

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*If ABS (absolute) appears along with an entry for STAND (standard), the measurement was originally done on a relative basis using the indicated standard and later converted to absolute values.

Insert Passive Microwave Data Sheets Here

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13. ABSTRACT

This supplement to the Target Signature Analysis Center: Data Compilation augments an ordered, indexed compilation of reflectances, radar cross sections, and apparent temperatures of target and background materials. The Data Compilation includes spectral reflectances and transmittances in the optical region from 0.3 to 15 μ and normalized radar cross sections (active) and apparent temperatures (passive), plotted as functions of aspect or depression angle, at millimeter wavelengths. When available, the experimental parameters associated with each curve are listed to provide the user with a description of the important experimental conditions.

This supplement contains the initial addition of reflectance distribution function data to the unclassified compilation. The data are presented in tabular form as a function of reflection angle for fixed incidence angles and discrete wavelengths in the visible and near-infrared spectral regions. These data were obtained from the Laboratory Measurements Phase of the Target Signature Measurements Program conducted at The University of Michigan and sponsored by the Air Force Avionics Laboratory. The unclassified compilation, including these data, consists of about 4300 curves and 112 tables (in general, each table is the equivalent of four unique curves).

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Targets Backgrounds Reflectance Optical spectrum Radar Passive microwaves Infrared						