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THE PASSIVE OPTICAL SAMPLE ASSEMBLY (POSA) ON STS-1

By Roger C. Linton
Space Sciences Laboratory

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16. ABSTRACT

The Passive Optical Sample Assembly (POSA), scheduled for flight on Orbital Flight Test 1 (OFT-1), is an instrument to aid in the assessment of contamination hazards to sensitive payloads in the Shuttle cargo bay. It consists of an array of passively deployed samples mounted on the Development Flight Instrumentation (DFI) pallet in the Shuttle cargo bay. This report describes the POSA hardware, the directory of samples together with their intended measurements, and the plan for POSA data analysis.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

NASA TECHNICAL MEMORANDUM

INTRODUCTION

The Passive Optical Sample Assembly (POSA) is a modified version of one of the instruments included in the Induced Environment Contamination Monitor (IECM), an integrated technology payload consisting of 10 individual instruments sharing a common power and data collection system. The IECM, designated for flight on all Orbiter Flight Tests (OFT's) succeeding the first and on Spacelabs 1 and 2, is designed to provide verification measurements of Shuttle contaminant emission and deposit levels during ground operations, ascent, on-orbit, descent, and postlanding. Despite the severe payload constraints of OFT-1 which necessitated removal of the IECM from the mission, consensus substantiated a critical need for at least baseline data pertinent to the evaluation of Shuttle contamination hazards. The POSA, while less ambitious in scope than its parent IECM experiment (Passive Sample Array), is now included on OFT-1 to provide some limited contamination verification of the Shuttle environment so urgently needed by the design and user communities. Figures 1 and 2 show the POSA in the cargo bay of the Shuttle.

As the name implies, the POSA instrument is totally passive. It is a mounted array of five optical samples and three static-charged Teflon sheets (electrets). Table 1 provides a directory of the samples contained in the POSA for OFT-1. All of the samples were subjected to a series of optical and analytical measurements prior to delivery to Kennedy Space Center (KSC). The measurements will be repeated in an identical manner when the POSA is returned to Marshall Space Flight Center (MSFC) following the flight mission. The degradation of the optical properties of the optical samples will constitute the basis for analysis of the severity of the contamination hazards for payloads in the Shuttle cargo bay, while analysis of the electrets will provide a means of identifying and specifying the relative abundances of the contaminants.

DESCRIPTION OF HARDWARE

The POSA consists basically of a sturdy, rectangular holder (Fig. 3). Six cylindrical receptacles (1.09 in. wide, 0.187 in. deep) are bored at equal spacing along the axis of the holder. Smaller (0.75 in. diameter) holes in each of the six sample "slots" are counterbored completely through the holder so that, when the samples are emplaced, effluents can reach front and rear surfaces of the samples directly. This will allow assessment and some comparison of directionality in effluent flow.

A retainer plate with six circular slots is bolted over the sample holder, allowing maximum front-surface exposure of the samples while holding down the outer edges. During the phases of ground handling, transportation, and installation when exposure is not desired, a solid, rectangular cover plate with captive screws is provided to protect the samples. All hardware is 300 series stainless steel.

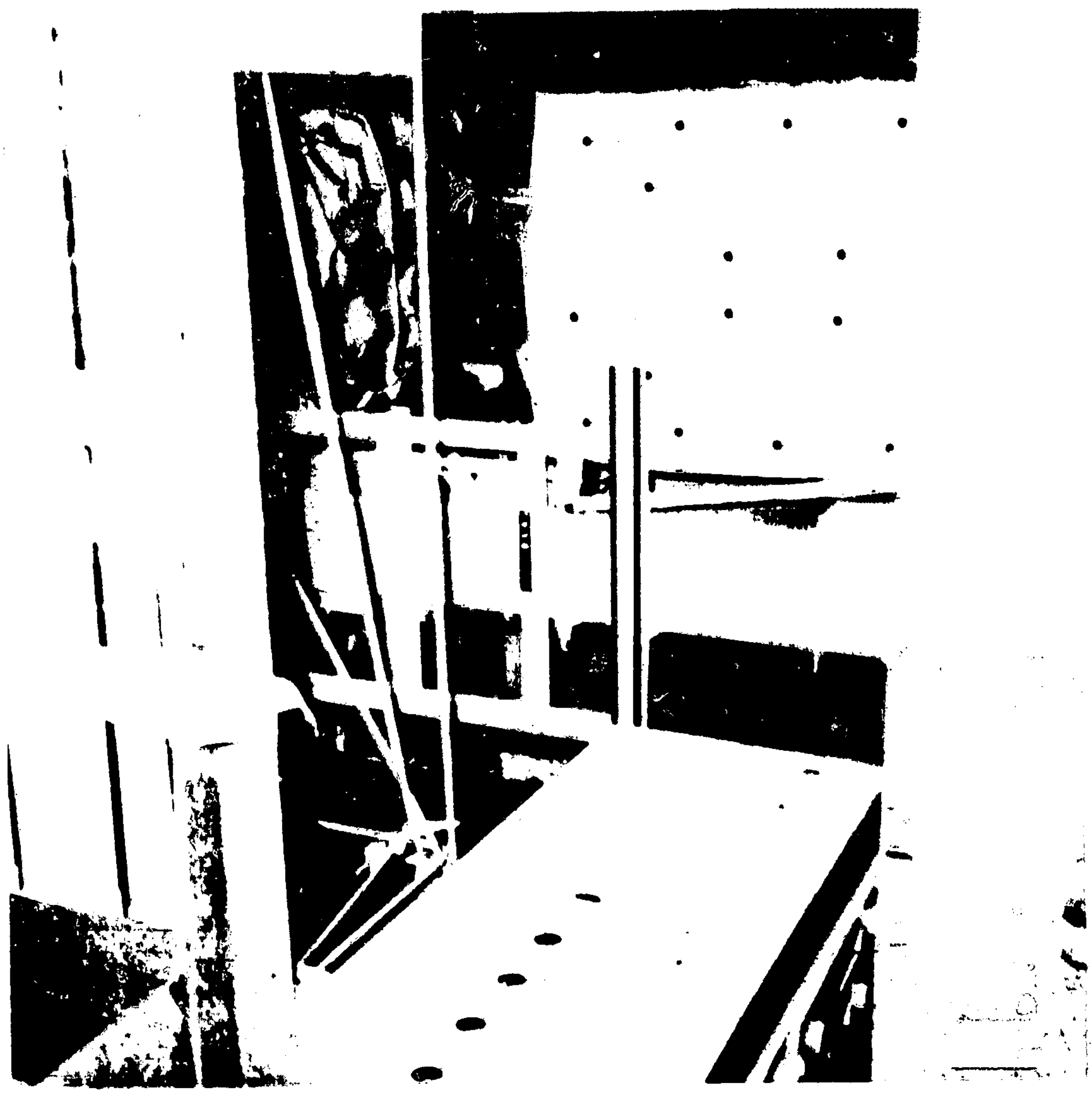

FIGURE 1. POSA mounted on DFI pallet in cargo bay of OFT-1 (POSA in center of photograph).

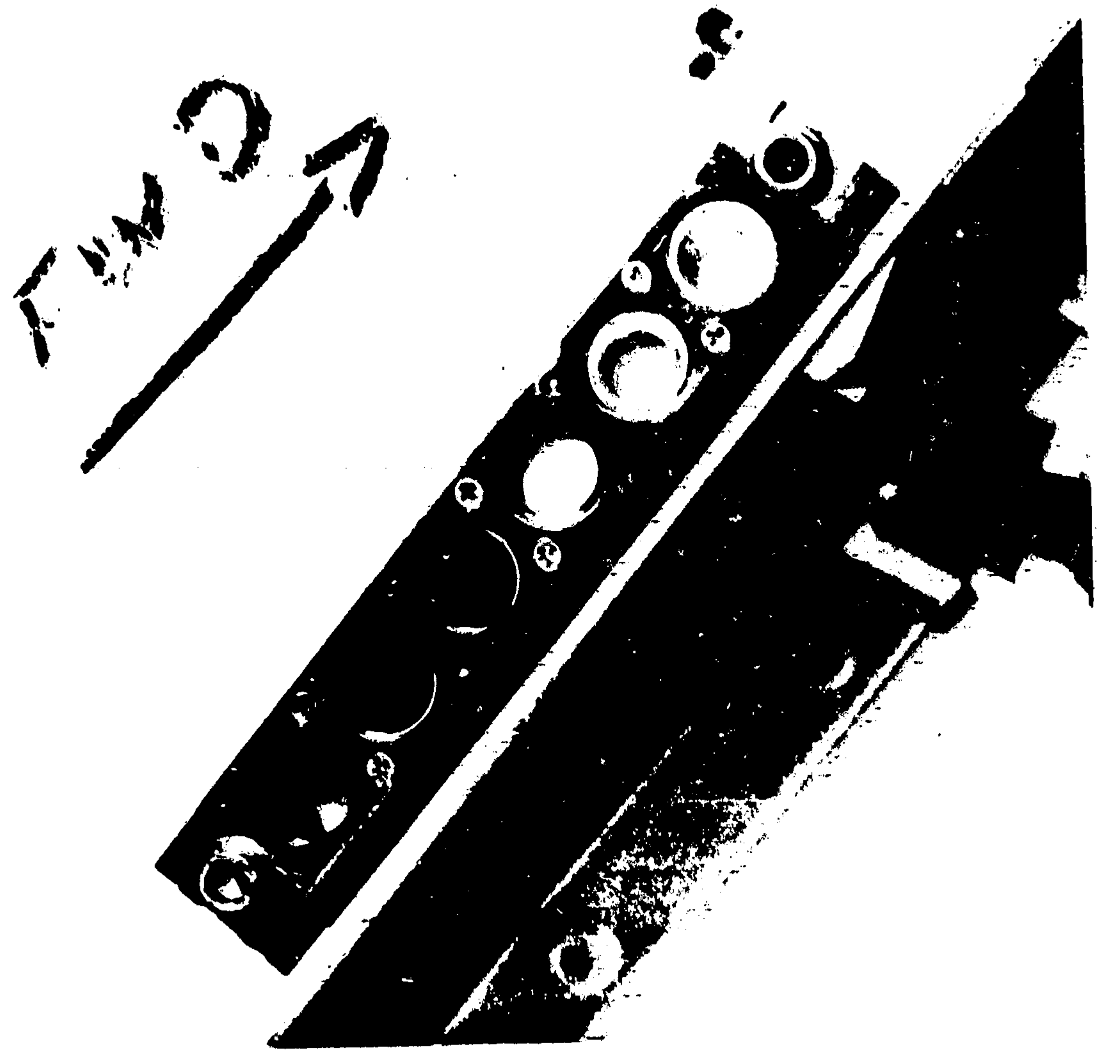

FIGURE 2. Close-up view of POSA in cargo bay. (FWD indicates forward with respect to the Shuttle.)

TABLE 1. PASSIVE OPTICAL SAMPLE ASSEMBLY (POSA)

Tray 012

Sample I.D.	Material
A	MgF_2/Al Mirror
B	Gold Mirror
C	1810 Å Filter
D	CaF_2 Window
E	Top: CaF_2 Window Base: Electret #8
F	Top: Electret #10 Base: Electret #9

The POSA is mounted to the Development Flight Instrumentation (DFI) pallet in the Shuttle cargo bay by means of two bolts, one at each end of the holder; these bolts mate to existing captive nuts under the IECM mounting rails of the DFI pallet.

The samples are subject to chipping, breaking, or cracking if not adequately protected. Therefore, Teflon gaskets are placed in each slot of the holder prior to installation of the samples and, in some cases, on top of the samples as well. Qualification testing of the Passive Sample Array/IECM and analytical calculations for the POSA have proved satisfactory mechanical integrity.

Identification of the POSA hardware and the individual samples is provided by means of stamped numbers and letters on the front surface of the retainer plate.

Assembly of the POSA for flight (with all components having been properly cleaned, double-bagged, and brought into a designated clean room) is straightforward. A Teflon gasket is deposited into each depression (slot) of the holder. Into each of the first four sample positions is deposited an optical sample, front surface up. Two electrets are placed in positions (slots) E and F. A third electret is added to slot F. The electrets are placed so that particles are attracted from above or below the POSA. The fifth optical sample (CaF_2) is added on top of the electret in slot E. Additional Teflon gaskets are added as needed to fill, but not overfill, the sample slot depressions. The retainer plate is then placed over the sample holder, the six (6-32 Phillips-head) bolts dropped into place, lock nuts added, and all tightened uniformly to 10 to 12 in. lbs. (torque). Finally, the cover plate, with two captive bolts, is placed over the assembly and

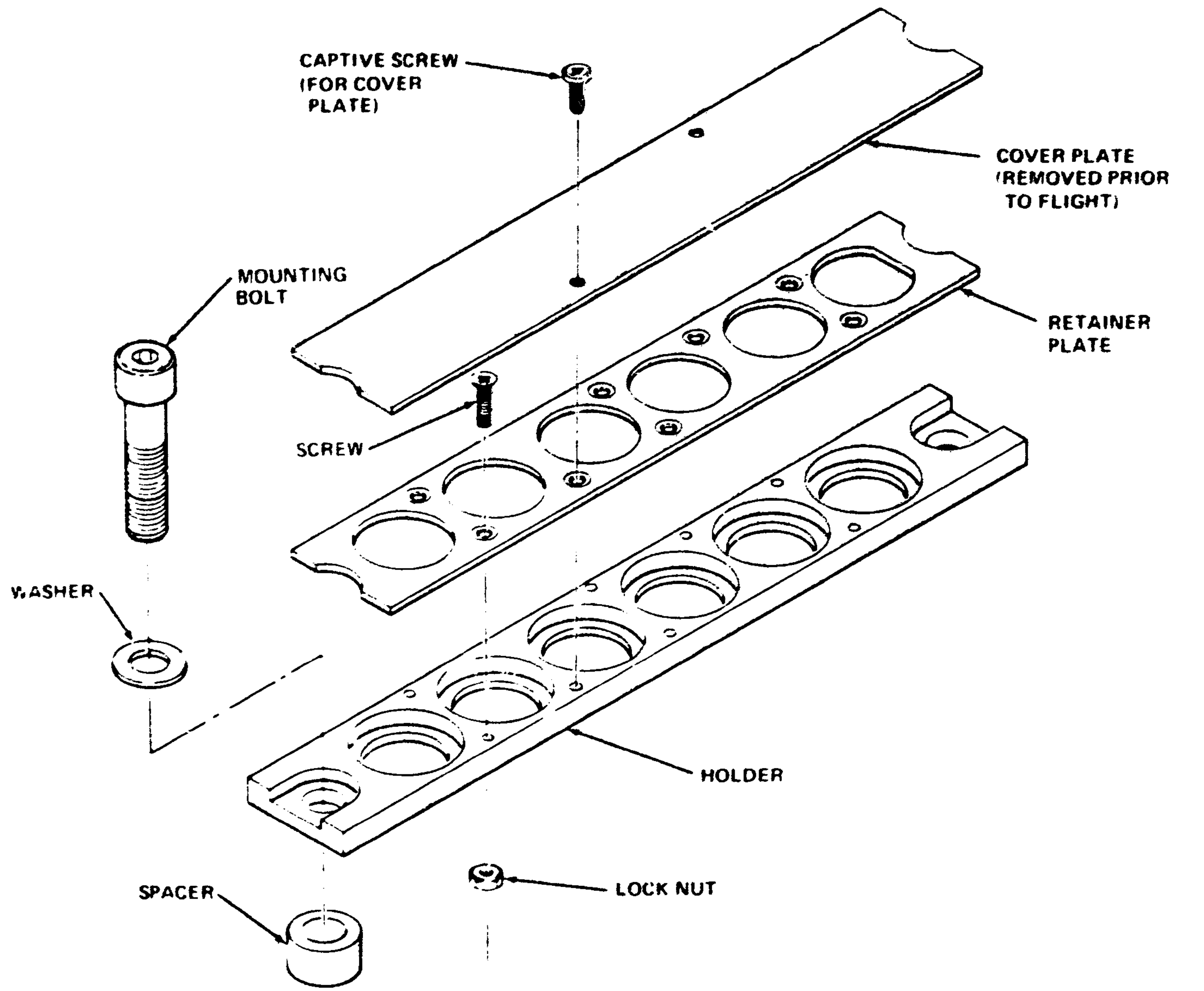

FIGURE 3. POSA configuration.

bolted into position. The POSA was delivered to KSC with the mounting hardware (bolts, washers, spacers) separately bagged. At KSC, the washers were added to the two mounting bolts, the bolts placed through the designated holes of the POSA, the spacers added, and the POSA tightened down to the DFI pallet. The cover plate was removed, as scheduled, at the last cargo bay access on March 17, 1981.

DIRECTORY OF SAMPLES

There are six sample positions in the POSA tray to be flown (Fig. 4). The selected directory of samples for STS-1, as shown in Table 1, includes:

A. Mirror - Thin film aluminum overcoated with magnesium fluoride

B. Mirror - Thin film gold

C. Filter - Thin film multilayered metallic vacuum ultraviolet filter

D. Window - Calcium fluoride (CaF_2), transparent to 1216 Å

E. Window - Calcium fluoride (CaF_2), uv grade

F. Electret - Electrically charged Teflon sheet

The basic philosophy of selection was determined by the relative sensitivity of the surfaces selected and the relevance of concern for similar materials as components of future STS payloads sensitive to contamination. In particular, the following measurements apply for the samples in the order previously listed:

A. An optically flat ($\lambda/10$) fused silica substrate is coated with 1000 Å thickness aluminum which is, in turn, overcoated with a protective and reflective-enhancing 250 Å thick layer of magnesium fluoride. The sample is designated as MgF_2/Al. The substrate thickness is 32 mm (0.125 in.). This particular composition of thin film mirror provides the highest reflectance in the vacuum ultraviolet spectral range through, or down to, 1216 Å wavelength (Lyman α).

Measurements of specular, spectral reflectance are performed in the wavelength range 1200 to 3000 Å in a reflectometer at the exit slit of a Seya-Namioka monochromator. A hydrogen discharge lamp is utilized as the source. Additionally, the measurements are extended through 2.5 μ wavelength by measuring the diffuse reflectance in a Gier-Dunkle integrating sphere facility.

B. The gold mirror consists of a 400 Å thickness layer of pure gold on a fused silica substrate. The substrates of all mirrors selected for use in the POSA are identical. This sample is designated as the Au mirror. Both gold and MgF_2/Al mirrors are standard components of space optical instrumentation. In the spectral range of

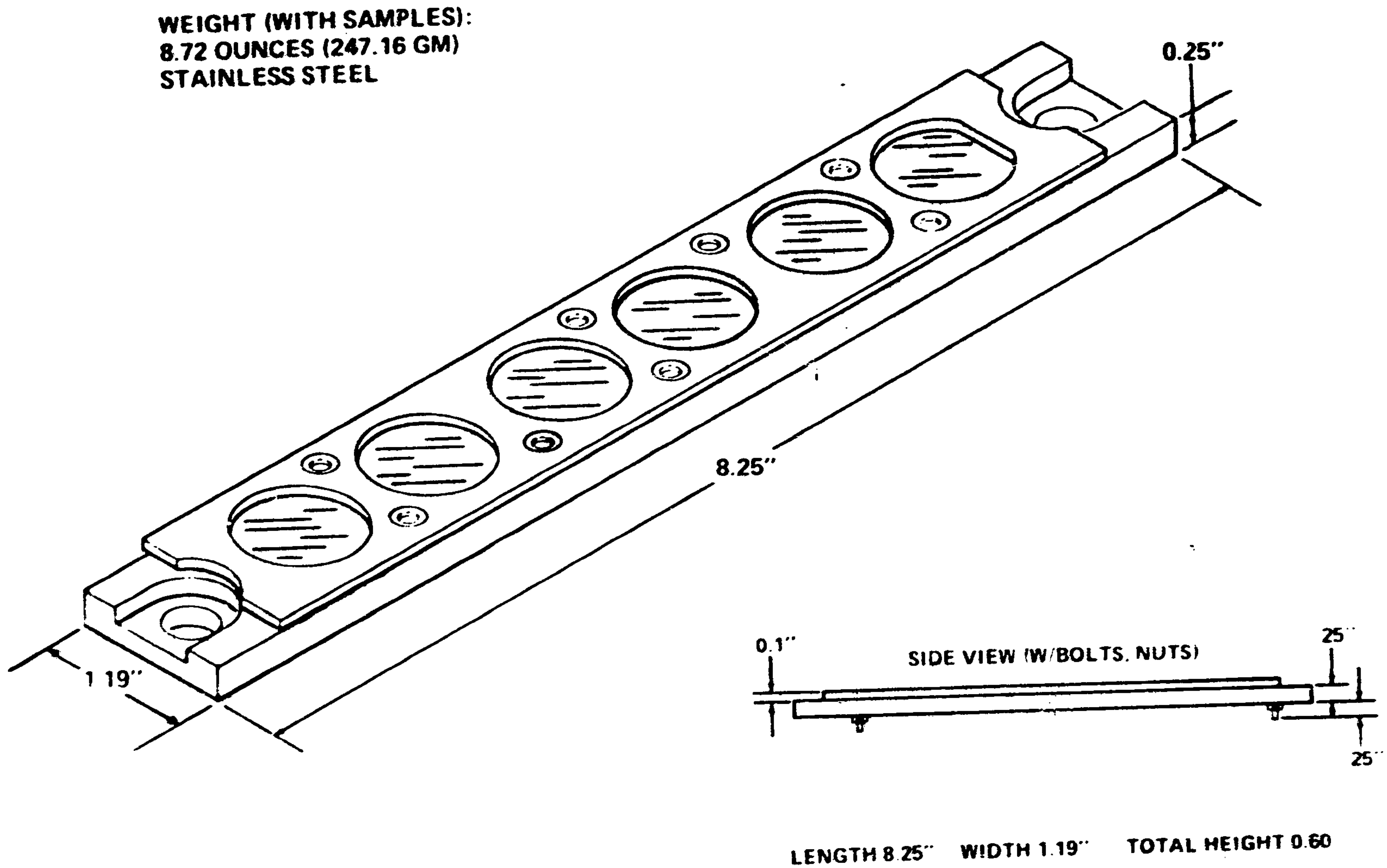

FIGURE 4. Passive Optical Sample Assembly.

measurements selected, the degradation due to deposition of contaminants is detectable for the presence of as little as one monolayer of contamination.

Specular, spectral reflectance of the gold mirror is measured in the range 1200 to 3000 Å and is extended, for diffuse reflectance and backscatter measurements, through 2.5 μ with the Gier-Dunkle facility.

C. The vacuum ultraviolet filter is composed of a multilayer thin film composition deposited on a magnesium fluoride substrate. The filter transmits a 225 Å bandwidth of light centered at 1810 Å wavelength. Peak transmission at 1810 Å is 21 percent. Such filters are common components of vacuum ultraviolet instruments flown in space. The transmission is highly sensitive to contamination. The filter is opaque to all wavelengths of light in the range 0.12 to 2.5 μ except, of course, for the "narrow" bandwidth, as designed.

Measurements of the filter include front-surface specular, spectral reflectance and direct transmission in the wavelength range 1200 to 3000 Å.

D. The calcium fluoride "window" is dimensionally identical to the mirror substrates; both sides are optically polished. Transmission extends through the ultraviolet. Such windows are commonly used as components in spaceborne optical instruments, and the degradation of optical performance due to contamination can severely degrade the performance of the elements they are emplaced to protect.

Measurements of front-surface specular, spectral reflectance and direct transmission are performed in the wavelength range 1200 to 3000 Å. In addition, the samples of this type are subjected to backscatter measurements in the Gier-Dunkle facility.

E. The CaF_2 sample is optically polished on both sides (2.54 cm diameter, 2.5 mm thick). This sample is transparent to light through the vacuum ultraviolet to a magnitude decreasing to zero below 1216 Å.

Because of hardness, resistance to water, uv-induced damage, and, of course, favorable transmission properties in the vacuum ultraviolet, calcium fluoride windows are commonly used as components of spaceborne optical instrumentation (particularly as windows for environmentally sensitive detectors).

Measurements of front-surface specular, spectral reflectance and direct transmission are performed in the wavelength range 1200 to 3000 Å.

F. The electrets are made of Teflon-polytetrafluorethylene, $(C_2H_4)_n$. Electrets are dielectrics with a permanent surface charge that gives them properties analogous to magnets by attracting charged particles and ions to their surface. From X-ray microprobe analysis of the effluents collected on the Teflon electrets, energy measurements are made in the X-ray energy range from 0.707 to 30 keV ±0.170 keV (i.e., fluorine to silver). Thus, an elemental analysis and an estimate of the abundance of the elements are obtained.

Three electrets are included in the POSA for OFT-1. One is placed under Sample E, the calcium fluoride "window." For this electret, the ion-attracting charged surface is oriented 180 degrees from the direction the CaF_2 samples faces, providing a measure of the directionality of effluent flow. The other two electrets are placed in sample slot "F" of the POSA holder (one facing "up" and the other facing "down") for directionality analysis.

The preceding measurements were performed on the samples prior to installation in the Shuttle, and they will be repeated in an identical manner after the flight to assess the contamination hazards of the STS cargo-bay environment.

DATA ANALYSIS PLAN

The inclusion of a variety of optical surfaces and electrets in the POSA for STS-1 offers a corresponding variety of "sticking" probabilities for contaminants. Each of the samples in the POSA was chosen for its relative sensitivity to optical degradation by deposition of contaminants as well as inherent relevance to future STS payloads. Measurements of the optical properties of the samples made prior to installation of the POSA on OFT-1 will be compared to identical measurements on the samples after the flight. Analysis will be directed toward understanding the mechanisms of degradation as well as identification of the contaminants themselves. The inclusion of electrets in the POSA will enhance the probability of collecting and retaining contaminants and, further, will provide a basis for chemical identification by estimating elemental abundance.

The plan for POSA data analysis is subdivided into the following major phases:

1. During pre-installation measurements of the optical properties of the five optical samples and background microprobe measurements of the three electrets, personnel will handle the samples with clean-room procedures, including gloves.

2. Following retrieval of the POSA from the Shuttle cargo bay after the flight mission, the unit will be double-bagged and returned (hand-carried) to MSFC for analysis.

3. At MSFC, in a laminar-flow class 10,000 clean-bench environment, the protective cover will be removed and a thorough visual inspection of the samples in the POSA tray will be performed. Personnel handling POSA hardware will wear clean-room garments and use clean-room gloves in all phases of handling.

4. Photographs of the POSA will be taken for comparison with those taken prior to KSC delivery.

5. The five optical samples and the three electrets will be removed from the POSA hardware.

6. Individual, close-up photographs of the samples themselves will be taken.

7. The electrets will be subjected to X-ray microprobe analysis.

8. The optical samples will be subjected to measurements of reflectance, transmittance, and backscattering efficiency in a manner identical to that used in the pre-installation sequence.

9. The optical degradation will be determined by computing the percentage change in each of the optical properties, computed as a percentage of the measured difference, if any, divided by the original value--all as a function of wavelength.

10. The microprobe analysis of the electrets is expected to reveal information concerning the nature of the collected contaminants. A measurement of the relative elemental abundance will be performed. An excellent opportunity for assessing at least one aspect of the directionality of cargo bay effluents will be presented through analysis of the relative abundances from electrets oriented 180 degrees apart in the POSA.

11. A final analytical tool available for this analysis of the optical samples will be the scanning electron microscope (SEM) facility in the Space Sciences Laboratory at MSFC. It is necessary that this be the final phase of measurement because of the necessity of depositing a conductive paste to the samples for analysis with this instrument.

Table 2 summarizes a projected schedule for data analysis of the POSA.

A "quick-look" report of the initial results obtained will be available within 2 weeks of delivery of the POSA to MSFC. The extended analysis, with conclusions, will be available for distribution (in NASA Technical Memorandum format) within 6 weeks.

TABLE 2. PROJECTED SCHEDULE FOR POSA DATA ANALYSIS

Task	Estimated Time Required	Location/Facility
Retrieval of POSA, installation of cover plate, double-bagging, shipment to MSFC	2 days	KSC
Initial postflight inspection (visual), including photographs	1 day	SSL/MSFC Laminar-flow clean bench
Optical measurements and X-ray microprobe analysis of samples	2 weeks	ES64/MSFC Seya/Namioka monochromator; Beckman DK-2 integrating sphere
Electron microscope photograph, microprobe analysis of samples	3 days	SEM Facilities: EC43/MSFC ES73/MSFC

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APPROVAL

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By Roger C. Linton

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

EDGAR R. MILLER
Chief, Optics Physics Branch

RUDOLF DECHER
Chief, Space Physics Division

CHARLES A. LUNDQUIST
Director, Space Sciences Laboratory

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