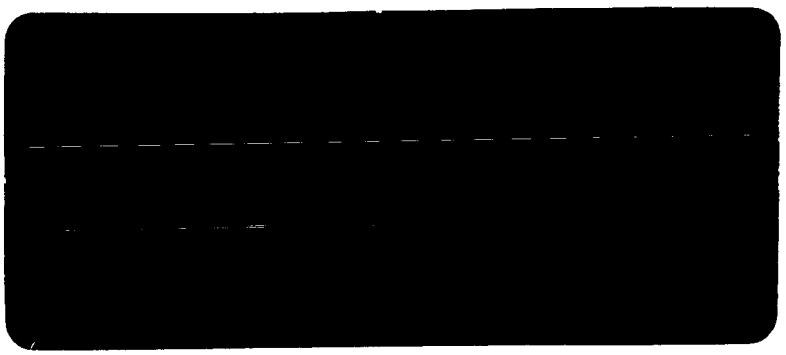

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MICROBIOLOGICAL SAMPLING OF SPACECRAFT CABLING, ANTENNAS, SOLAR PANELS AND THERMAL BLANKETS

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I. SCOPE AND PURPOSE

The sampling procedures and techniques described in this report represent the "state-of-the-art" capability that have resulted from recent Research and Advanced Development (R/AD) and various flight project microbiological monitoring programs of unmanned planetary spacecraft. Concurrent with development of these procedures, compatibility evaluations were effected with the cognizant spacecraft subsystem engineers to assure that degradation factors would not be induced during the monitoring program. Of significance were those areas of the spacecraft configuration possessing a limiting feature (see Table 1) for which special handling precautions and/or non-standard sample gathering techniques were evolved. These spacecraft component areas were: cabling, high gain antenna, solar panels, and thermal blankets.

The compilation of these techniques provides a historical reference for both the qualification and quantification of sampling parameters as applied to the Mariner Spacecraft of the late 1960's and early 1970's. It is expected that with suitable modification as relates to future generation of spacecraft, the inherent features of these procedures and techniques can be utilized.

TABLE I

HARDWARE	LIMITING FEATURE	DEVIATION FROM NASA STANDARD PROCEDURE
Cabling	Impossible to accurately swab the individual strands of wire in flight configuration.	No swabs taken. Submerge portions of cabling and connectors and insonate. No flight cabling will be used. Samples will be exact replicas of flight hardware.
High Gain Antenna	Back of antenna honeycombed with perforations. Extremely thin-skinned hardware. Pressure may produce hardware damage as may moisture if it seeps into the perforations.	Cleaning with isopropyl alcohol must be done immediately after each sample is taken to eliminate all moisture on the antenna. Only light pressure will be applied in the swabbing.
Solar Panels	Solar Cells are very delicate and easily chipped. Wiring on front of panel is extremely fine and easily damaged.	Cleaning with isopropyl alcohol will be done immediately after each sample is taken to eliminate moisture. Vacuum cleaning will follow to eliminate any remaining lint or moisture. Swabbing will be accomplished with only light pressure.
Thermal Blankets	Beta cloth of the blanket absorbs alcohol, with possible damage to the hardware. Moisture must be kept away from science instruments to eliminate possible damage.	A dry-swab technique will be used on the Upper Blanket to eliminate the need for cleaning with isopropyl alcohol. On the other blankets, cleaning with alcohol will be conducted after each swab to eliminate as much moisture as possible from the science instruments.

II. CABLING

PURPOSE

This procedure describes the approach that was utilized to conduct the microbiological assays on the spacecraft cabling.

SCOPE

This procedure was limited to defining the approach and responsibilities required to assay pieces of cable identical to the spacecraft flight cabling.

INTRODUCTION

The flight cables consist of many individual strands of wire which are tied together, enjoined with connectors and in some instances wrapped with Mylar for insulation. The fabrication and subsequent use of the flight cables do not readily lend themselves to direct biological sampling using the swab-rinse technique.

SAMPLE REQUIREMENTS

Six (6) feet of each gauge wire and sixteen (16) connectors of each type used in the spacecraft were obtained from the cognizant cabling engineers.

SAMPLING METHOD

A. Wire

The wire was aseptically cut into eighteen (18) lengths of 4 inches each. Five (5) lengths (of each gauge of wire) were sampled immediately. The remaining lengths of wire were then aseptically placed into a static free plastic bag and held in Quality Assurance Bonded Stores.

Each of the 4-inch lengths of wire was aseptically placed into a flask containing 50 ml of 0.1% peptone water. The flasks were then insonated for 12 minutes and four 5 ml aliquots from each flask were plated with Trypticase Soy Agar (TSA). Following incubation, the resultant established the vegetative bio-burden. From the remaining liquid in the flask, four 5 ml aliquots were placed in test tubes and heat shocked for 18 minutes at 80°C. These samples were plated with TSA, incubated and counted for establishing the spore bio-burden.

Thirty days after the original samples were taken, 4 lengths of wire were aseptically removed and sampled in the manner described above. An additional 4 length were taken out and sampled one hundred (100) days after the original sampling date with the remaining 5 lengths being sampled on the day of launch.

B. Connector

Four of each type of connector were sampled simultaneously with the lengths of wire. The remaining connectors were aseptically placed into static free plastic bags and held in Quality Assurance Bonded Stores.

Each of the connectors were aseptically placed into a flask containing 100 ml* of 0.1 peptone water. The flasks were then insonated for 12 minutes. Four (4) 10 ml aliquots were poured on TSA; then incubated and counted to establish the vegetative bio-burden. From the remaining liquid, four (4) 10 ml aliquots were poured in test tubes; heat shocked at 80°C for 18 minutes; plated on TSA, then incubated and counted to establish the spore bio-burden.

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*100 ml volume required for total submergence.

Subsequent sampling of the remaining connectors was scheduled at the following milestones: 1) four each type 30 days after initial sampling; 2) four each type 100 days after initial sampling; 3) four each type on the day of launch. Each milestone sampling used the procedure described above.

MONITORING AND CLEANING RESPONSIBILITY

All the sampling was accomplished in the microbiological laboratory and no hardware cleaning was involved. The Planetary Quarantine Group of Section 294 (Environmental Requirements) was responsible for obtaining all the samples.

QUALITY ASSURANCE RESPONSIBILITY

The Planetary Quarantine Bioassays were considered flight project milestones and as such required QA's presence as well as a QA sign off. This sign off ensured and documented the performance of the assay.

SCHEDULING RESPONSIBLITY

The cognizant Planetary Quarantine Engineer, in coordination with the respective hardware and quality assurance engineer, developed the schedule.

III. HIGH GAIN ANTENNA

PURPOSE

This procedure describes the approach that was utilized to conduct the microbiological assays on the spacecraft high gain antenna.

SCOPE

This procedure was limited to defining the approach and the responsibilities required to assay the high gain antenna.

INTRODUCTION

The complexity of the material composition, shape, size and configuration of the high gain antenna necessitated the adoption of specific monitoring techniques and procedures for assessing the microbial contamination.

SAMPLE REQUIREMENTS

The number of microbiological samples from the high gain antenna were established pro rata of its exposed area to the total exposed area of the spacecraft. This resultant proportion applied to each milestone and was allocated in equal amounts for both the front and rear area samples.

An example for computation:

Total Spacecraft Samples per Milestone	250
Total Spacecraft Surface Area	X units
Total Surface Area High Gain Antenna (Front and Back)	Y units
Percent of High Gain Antenna Surface	$\frac{Y}{X}$ %
Area to Total Spacecraft Surface Area	
Allocation of Sampling to High Gain Antenna	$\frac{Y}{X}$ % x 250 = No.

SAMPLING METHOD

General

Each sample site covered an area of four (4) square inches. The sample sites were randomly selected and followed a distribution pattern to provide equitable representation of the total surface for both the front and rear of the high gain antenna.

Samples were taken at each sample site by the standard swab-rinse technique. This technique consisted of:

a. Moistening a sterile cotton-tipped swab in a tube of sterile water.

b. Swabbing the sample site with a linear and rotating motion; reversing the direction three (3) times.

c. Depositing the swab into the tube of sterile water; breaking the swab handle carefully below the point held by the sampler.

d. Plugging or capping the test tube to maintain the sample true condition.

Limitations

1. Due to the material sensitivity, the sampling technique involved using a minimum of pressure in swabbing to prevent hardware damage.
2. The rear portion of the high gain antenna consisted of a honeycombed skin; sampling thereon must exclude the deposition of moisture into the honeycomb perforations.

CLEANING OF SAMPLED AREA

Immediately after a swab sample was taken from the antenna surface, the sample site was cleaned with isopropyl alcohol and a clean lint-free cloth. The determination of acceptable cleanliness was made by the cognizant hardware engineering personnel or representative. Care was exercised with regard to the forestated limitations.

PROCESSING SAMPLES

Samples were processed in accordance with procedures stated in NHB 5340.A "NASA Standard Procedures for Microbiological Examination of Space Hardware."

RESPONSIBILITIES

Planetary Quarantine Engineer - responsible for providing the sampling equipment, personnel contact, taking of samples, and the processing of samples.

Quality Assurance Engineer - responsible for sample documentation and certification for completion at each required milestone.

Spacecraft Hardware Engineer - responsible for the hardware readiness; the acceptance of hardware cleanliness after cleaning operations.

SCHEDULING AND SAFETY

These were fully coordinated and concurred in by the respective PQ, QA, and S/C Hardware Engineers.

IV. SOLAR PANELS

PURPOSE

This procedure described the approach that was utilized to conduct the microbiological assays on the spacecraft solar panels.

SCOPE

This procedure was limited to defining the approach and the responsibilities required to assay the solar panels.

INTRODUCTION

The spacecraft flight solar panels comprised the major surface areas of the spacecraft total configuration for exposure to microbial contamination. The complexity of structural differences, surface qualities, and geometry in relation to the total spacecraft configuration necessitated the adoption of specific monitoring techniques and procedures for assessing the microbial contamination.

SAMPLE REQUIREMENTS

The number of microbiological samples were determined pro rata of the total solar panels surface area A_{SP} (front and rear) to the spacecraft total surface area $A_{S/C}$. This resultant percentage was applied to each scheduled milestone and allocated to the respective sides of the solar panels in accordance with its determined ratio:

$$\frac{A_{FSP}}{A_{SP}} \times \frac{A_{SP}}{A_{S/C}} \times 250 = \text{No. for front solar panel}$$

$$\frac{A_{RSP}}{A_{SP}} \times \frac{A_{SP}}{A_{S/C}} \times 250 = \text{No. for rear of solar panel}$$

Where:

$A_{S/C}$ = Total exposed spacecraft surface area

A_{SP} = Total exposed solar panel area

A_{RSP} = Total exposed rear solar panel area

A_{FSP} = Total exposed front solar panel area

The distribution of sampling sites for the solar panels was randomly selected to ensure representative coverage. Affecting this distribution were factors expressed by the Quality Assurance and the Cognizant Hardware Engineers; namely, after effects of the sampling that would induce degradations to adjacent subsystems.

Example of computation: Mariner '71 S/C

Total Spacecraft Samples per Milestone	250
Total Spacecraft Surface Area	X units
Total Surface Area Solar Panels (Front and Rear)	Y units
Percent of Solar Panels Surface Area to Total Spacecraft Surface Area	$\frac{Y}{X}$ units %
Allocation of Sampling for Solar Panels	$\frac{Y}{X}$ % x 250 = No.
Front Panel Allocation	$= \frac{3.5}{7.5}$ x No.
Rear Panel Allocation	$= \frac{4.0}{7.5}$ x No.

B

SAMPLING METHOD

Each sample site covered an area of four (4) square inches. The sample was taken by the standard swab-rinse technique. This technique consisted of:

a. Moistening a sterile cotton-tipped swab in a tube of sterile water.

b. Swabbing the sample site with a linear and rotating motion; reversing the direction three (3) times.

c. Depositing the swab into the tube of sterile water; breaking the swab handle carefully below the point held by the sampler.

d. Plugging or capping the test tube to maintain the sample true conditions.

LIMITATIONS

The front surface of the solar panels required delicate handling during the sampling operation. Only mild pressure was applied in taking the sample.

CLEANING OF SAMPLED AREA

Immediately after a swab sample was taken from the solar cell surface, isopropyl alcohol was applied to the area with a clean cotton swab. Thorough cleaning of the area with alcohol swab was required; following the cleaning the area will be vacuumed until no evidence of lint or moisture is present.

The cleaning of the rear portion of the solar panels was identical for alcohol swabbing. However, the final cleaning and drying was with a lint-free cloth, excluding the vacuuming.

PROCESSING SAMPLES

Samples were processed in accordance with procedures stated in NHB 5340.A "NASA Standard Procedures for Microbiological Examination of Space Hardware."

RESPONSIBILITIES

Planetary Quarantine Engineer - responsible for providing the sampling equipment, personnel control, taking of samples, and the processing of samples.

Quality Assurance Engineer - responsible for the sample documentation and the certification for completion at each required milestone.

Spacecraft Hardware Engineer - responsible for the hardware readiness; the acceptance of hardware cleanliness after cleaning operations.

SCHEDULING AND SAFETY

These matters were fully coordinated and concurred in by the respective PQ, QA, AND S/C hardware Engineers.

V. THERMAL BLANKETS

PURPOSE

This procedure described the approach that was utilized to conduct the microbiological assays on the spacecraft thermal blankets.

SCOPE

This procedure was limited to defining the approach and the responsibilities required to assay the thermal blankets.

INTRODUCTION

The spacecraft thermal blankets provided protective shrouds for the Propulsion Module, the Planetary Scan Platform, the Rocket Engine, and the Lower Spacecraft Bus. These blankets, when mounted in the flight configuration, provided a large surface area for exposure to microbial contamination. The complexity of each blanket material composition, shape, and configuration as a part of the spacecraft geometry necessitated the adoption of specific monitoring techniques and procedures for assessing the microbial contamination.

SAMPLE REQUIREMENTS

The number of microbiological samples were determined pro rata of the total thermal blankets surface area A_{TB} to the spacecraft total surface area $A_{S/C}$. This resultant percentage was applied to each scheduled milestone

and allocated to each respective thermal blanket in accordance with its determined ratio:

$$\frac{A_i}{A_{TB}} \times \frac{A_{TB}}{A_{S/C}} \times 250 = \text{No. for i-th thermal blanket}$$

Where:

$A_{S/C}$ = Total exposed spacecraft surface area

A_{TB} = Total exposed thermal blanket surface area

A_i = Exposed surface area of i-th thermal blanket, i = 1, 2, 3, ...; e.g., propulsion module blanket, lower spacecraft bus blanket, planetary scan platform blanket

Example of computation: Mariner '71 S/C

Total Spacecraft Sample per Milestone	-250
Total Spacecraft Surface Area	- X units
Sum of Surface Area for Propulsion Module, Planetary Scan Platform, Lower Spacecraft Bus, Rocket Engine Blankets	- Y units
Percentage of ALL blankets surface area to total spacecraft surface area	$\frac{X}{Y}$ %
Allocation of Sampling to ALL Blankets	= $\frac{X}{Y}$ % x 250

SAMPLING METHODS

General

Each sample site covered an area of four (4) square inches. The sample sites were randomly selected and followed a distribution pattern to provide equitable representation of the total surface area for each blanket.

Propulsion Module Blanket

Samples were taken with a sterile dry cotton-tipped swab. The swab path was linear and with the head rotating; coverage of the sample site was accomplished by reversing the path three (3) times.

The collected sample was deposited into a tube of sterile water; the handle of the swab was broken at a point below that held by the samplers; and, the tube capped to maintain the sample true conditions.

Lower Bus, Rocket Engine, Planetary Scan Platform Blankets

Samples were taken at each sample site by the standard swab-rinse technique. This technique consisted of:

a. Moistening a sterile cotton-tipped swab in a tube of sterile water.

b. Swabbing the sample site with a linear and rotating motion; reversing the direction three (3) times.

c. Depositing the swab into the tube of sterile water; breaking the swab as previously described.

d. Plugging or capping the test tube as previously described.

LIMITATIONS

1. Due to material sensitivity the sampling technique involved using a minimum of pressure in swabbing to prevent blanket perforation.

2. The dry-swab technique was necessary for the Propulsion Module Blanket as moisture penetration would induce undesirable electric-discharge characteristics and thereby abort mission operations.

CLEANING OF SAMPLED AREA

Immediately after a swab sample was collected from the Planetary Scan Platform, Rocket Engine, and Lower Bus Blankets, the sample site was cleaned with isopropyl alcohol and a clean lint-free cloth.

For the Propulsion Module Blanket the sample site, noted with residual fibers from the dry swab, was vacuum cleaned.

The determination of acceptable cleanliness was made by the cognizant hardware engineering personnel.

PROCESSING SAMPLES

Samples were processed in accordance with procedures stated in NHB 5340.A "NASA Standard Procedures for Microbiological Examination of Space Hardware."

RESPONSIBILITIES

Planetary Quarantine Engineer - responsible for providing the sampling equipment, personnel control, taking of samples, and the processing of samples.

Quality Assurance Engineer - responsible for sample documentation and certification for completion at each required milestone.

Spacecraft Hardware Engineer - responsible for the hardware readiness; the acceptance of hardware cleanliness after cleaning operations.

SCHEDULING AND SAFETY

These matters were fully coordinated and concurred in by the respective PQ, QA, and S/C Hardware Engineers.