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STS-3 INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM) – QUICK-LOOK REPORT

Edited by E. R. Miller and J. A. Fountain
Space Sciences Laboratory

June 1982

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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

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16. ABSTRACT

The STS-3/Induced Environment Contamination Monitor (IECM) mission is described. The IECM system performance is discussed, and IECM mission time events are briefly described. Quick-look analyses are presented for each of the 10 instruments comprising the IECM on the flight of STS-3. Finally, a short summary is presented and plans are discussed for future IECM flights, and opportunities for direct mapping of Orbiter effluents using the Remote Manipulator System.

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STS-3 INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM) – QUICK-LOOK REPORT

I. INTRODUCTION

E. R. Miller

As a result of concern for possible contamination from the induced environment of the Space Shuttle which might place limitations on experiment measurements, goals were established for control of particles and gases that would be emitted by the Space Shuttle. The Induced Environment Contamination Monitor (IECM) (Fig. I-1) was designed to provide measurements of particles and gases during prelaunch, ascent, on-orbit, descent, and postlanding mission phases in order to determine the actual environment relative to the established goals.

The IECM comprises 10 instruments (1) Humidity Monitor, (2) Dew Point Hygrometer, (3) Air Sampler, (4) Cascade Impactor, (5) Passive Sample Array, (6) Optical Effects Module, (7) Temperature-Controlled Quartz Crystal Microbalance (TQCM), (8) Cryogenic Quartz Crystal Microbalance (CQCM), (9) Camera/Photometer, and (10) Mass Spectrometer. A detailed description of the IECM systems and instruments is provided in Reference 1.

The first operational measurements by the full complement of IECM instruments were performed on the second Space Shuttle flight (STS-2) in November 1981 and reported [1-3]. This report provides a summary of the preliminary STS-3 measurement results; a more complete analysis will be provided in a final report to be published later. Section I briefly describes the STS-3 IECM mission. Section III discusses the IECM engineering subsystem performance. Sections IV through X present the preliminary measurement results for the 10 instruments. Sections XI and XII present a summary of the IECM operation on STS-3 and briefly discuss future plans for the IECM.

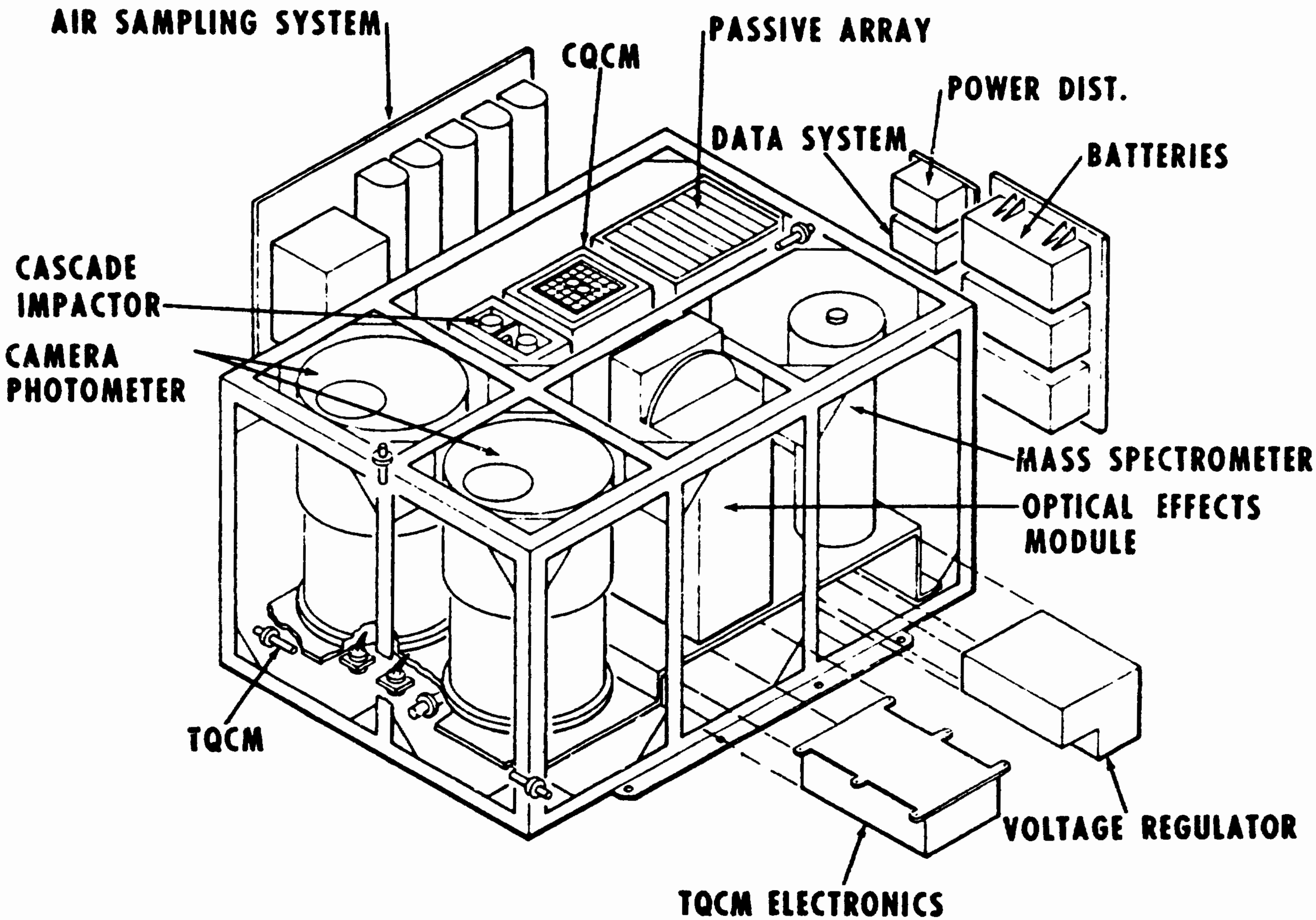

Figure I-1. Induced Environment Contamination Monitor (OFT/DFI and Spacelab VFI unit).

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II. STS-3/IECM MISSION DESCRIPTION

E. R. Miller

The third flight of the Space Shuttle, containing the OSS-1, Development Flight Instrumentation (DFI), and the IECM payloads was launched from the Kennedy Space Center (KSC) at 11:00 a.m. on March 22, 1982 (GMT 81:16:00) and landed at White Sands, New Mexico, on March 30 (GMT 89:16:13). The orbit inclination was 38 deg, and the nominal altitude was 260 km. The mission duration was 192 hr, 13 min.

The IECM was refurbished at MSFC after the STS-2 flight and reinstalled on the Orbiter on January 7, 1982, in the Orbiter Processing Facility (OPF). As on STS-2, the IECM was mounted on top of the DFI pallet located at $X_o = 1179$, $Y_o = 0$, $Z_o = 473.3$ (top center of IECM). At T - 4.5 min on the day of launch, a command through the Multiplexer/Demultiplexer (MDM) turned on the IECM Data Acquisition and Control System (DACS) and Power Distributer. At T - 0 umbilical disconnect, the ascent instruments were activated for timed-sequenced data collection and sampling. At T + 37 min, the stored program command was sent to reconfigure the IECM for on-orbit operations. The IECM remained in the on-orbit mode until the de-orbit command mode was given at 191 hr, 27.5 min. The descent measurement instruments are turned on and sequenced from the de-orbit command as is the final shutdown of the IECM itself, occurring about 45 min after landing.

Figure II-1 shows the Orbiter body coordinate system with the azimuth and co-elevation coordinates associated with the velocity vector, v. Figure II-2 gives the -Z axis co-elevation angle with respect to the velocity vector, v, calculated from the STS-3 as-flown timeline (published April 15, 1982).

In addition to the IECM, DFI, and DFI pallet with a weight totaling 4556 kg, the STS-3 payload consisted of the OSS-1 experiments mounted on an engineering model Spacelab pallet located at $X_o = 922$.

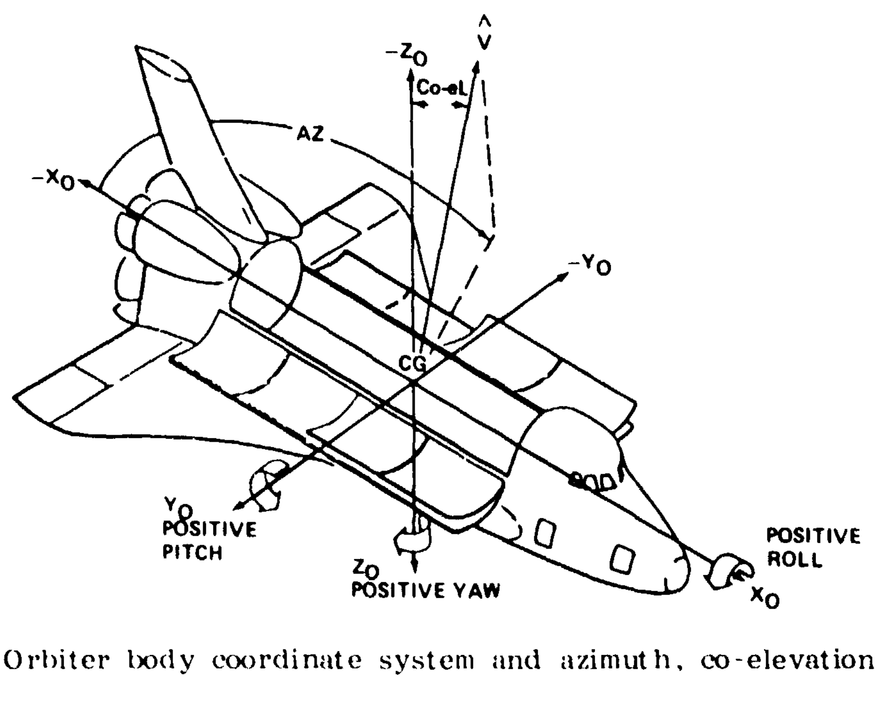

Figure II-1. Orbiter body coordinate system and azimuth, co-elevation coordinates.

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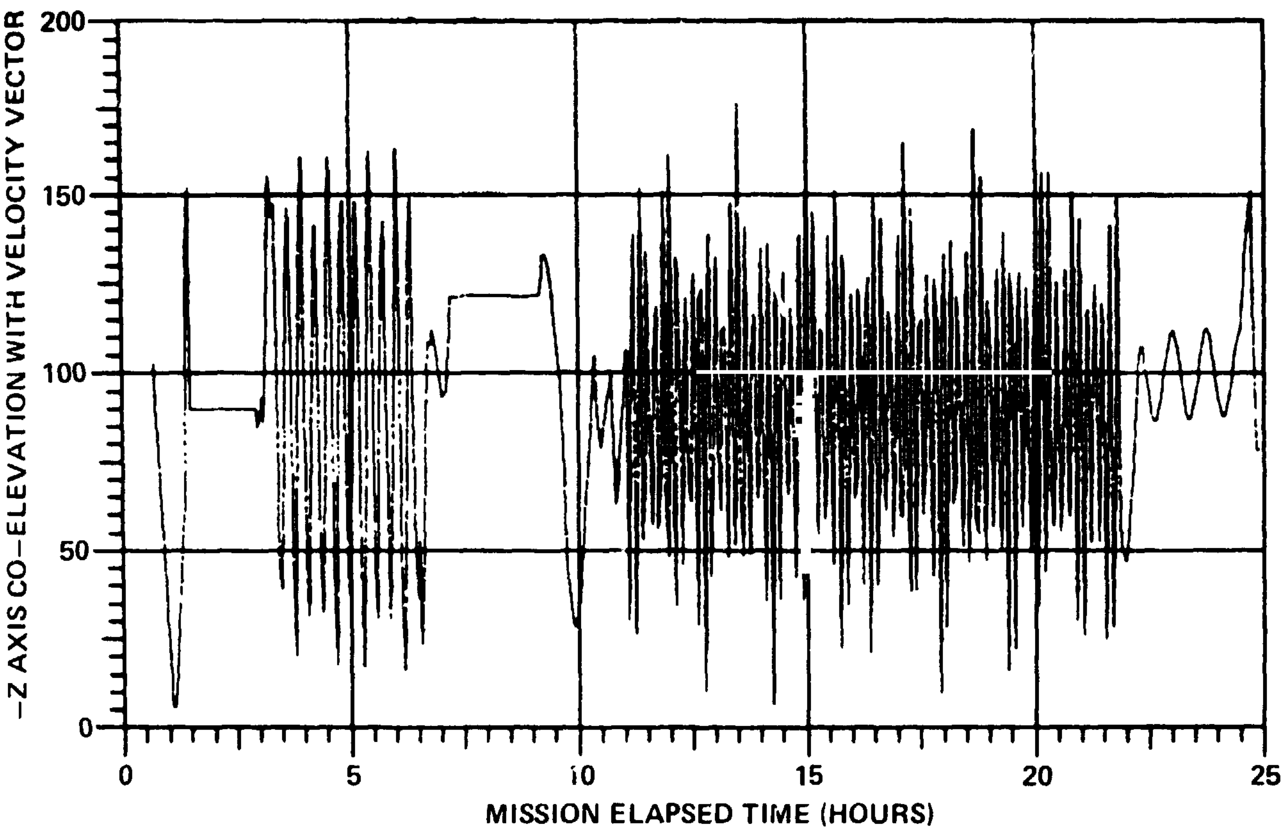

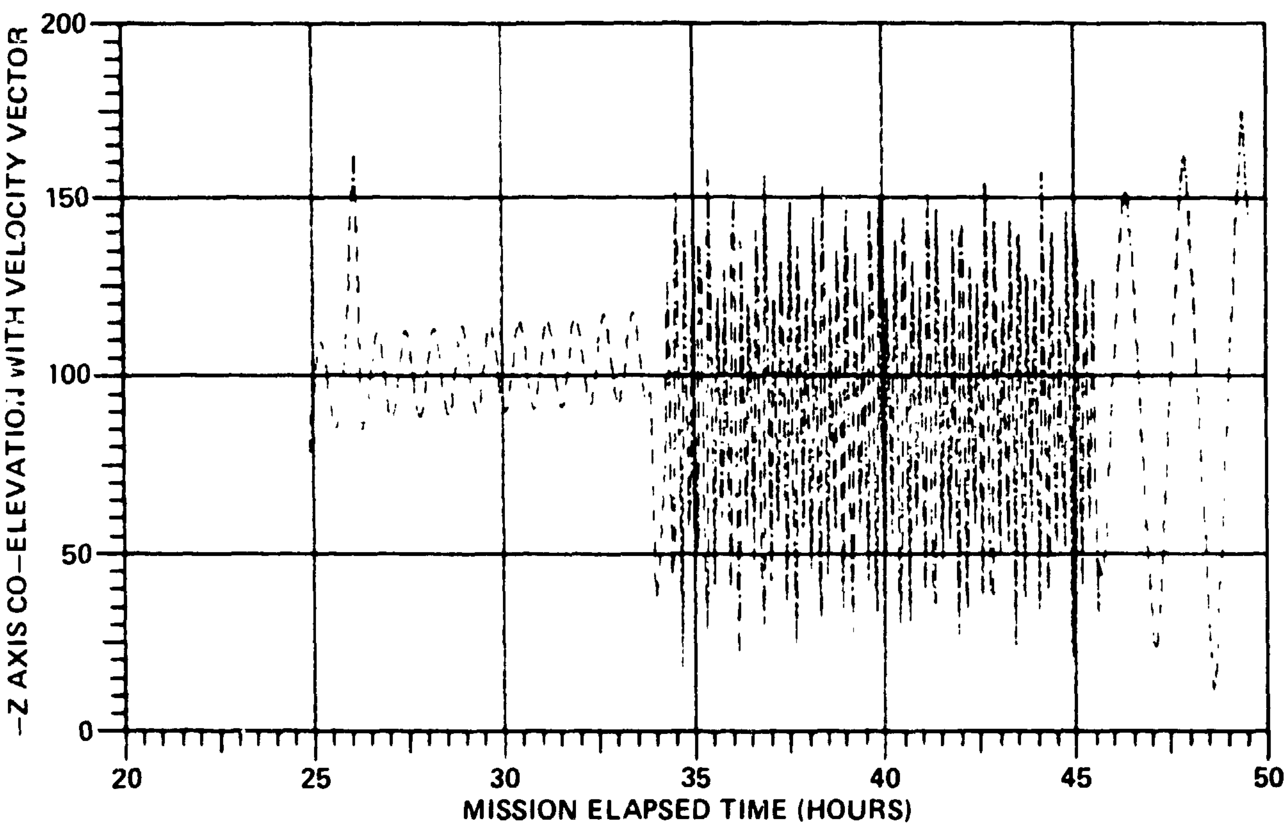

Figure II-2. STS-3 mission -Z axis co-elevation angle with respect to the velocity vector, v.

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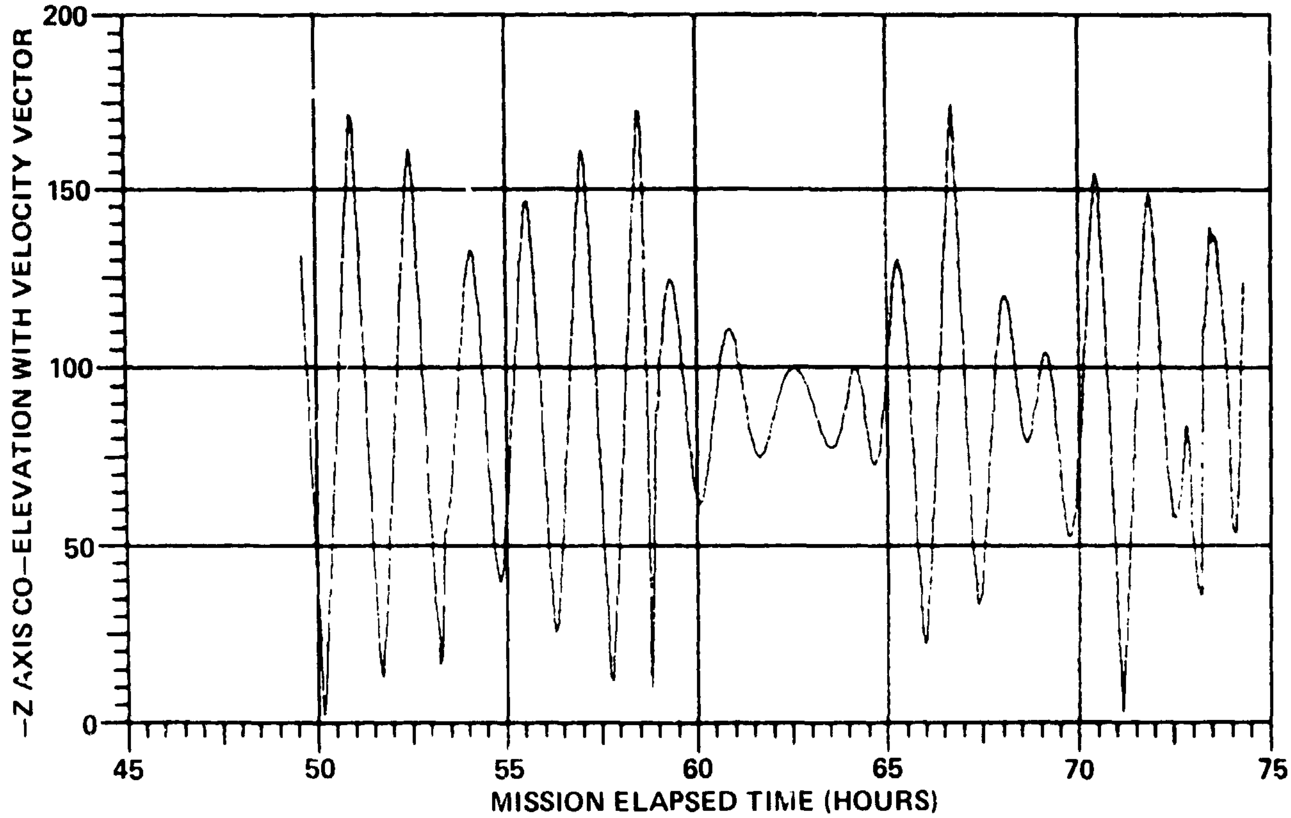

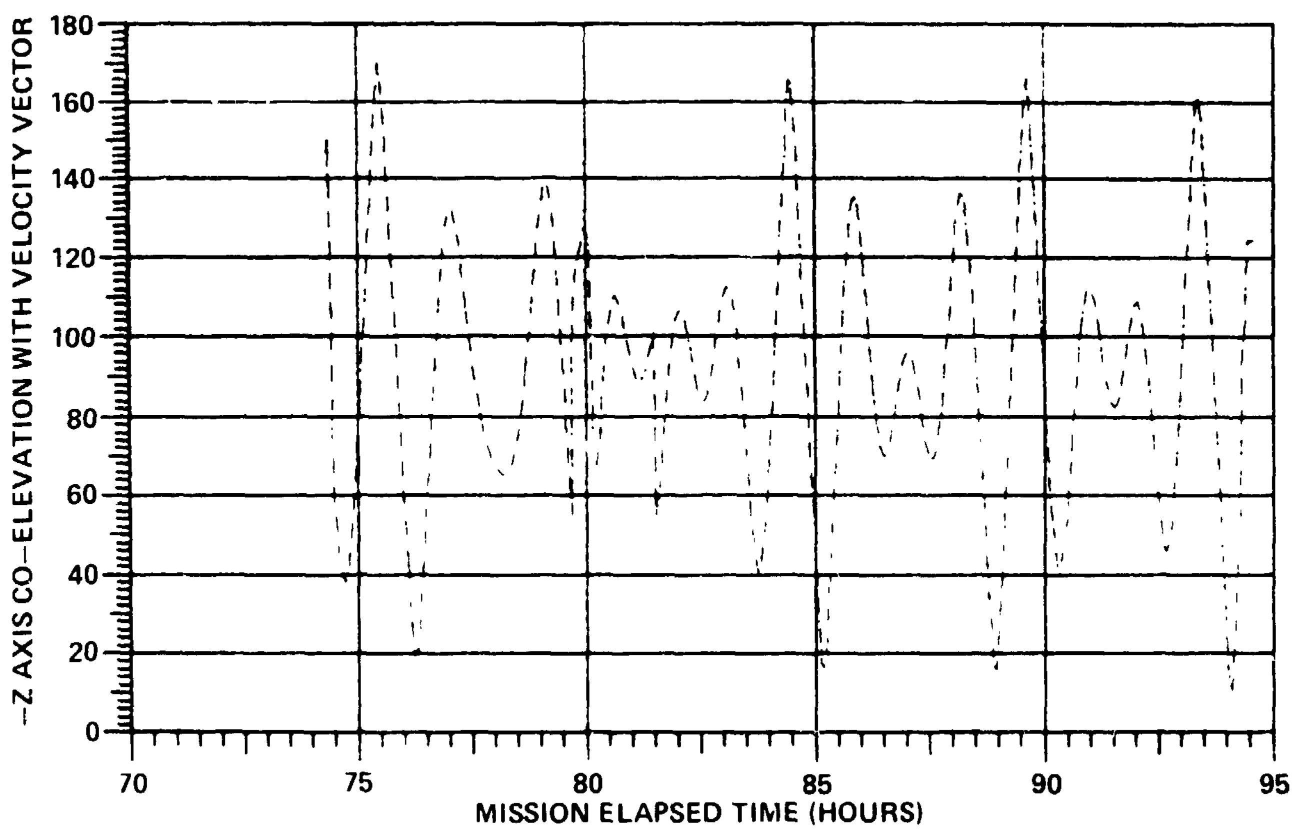

Figure II-2. (Continued)

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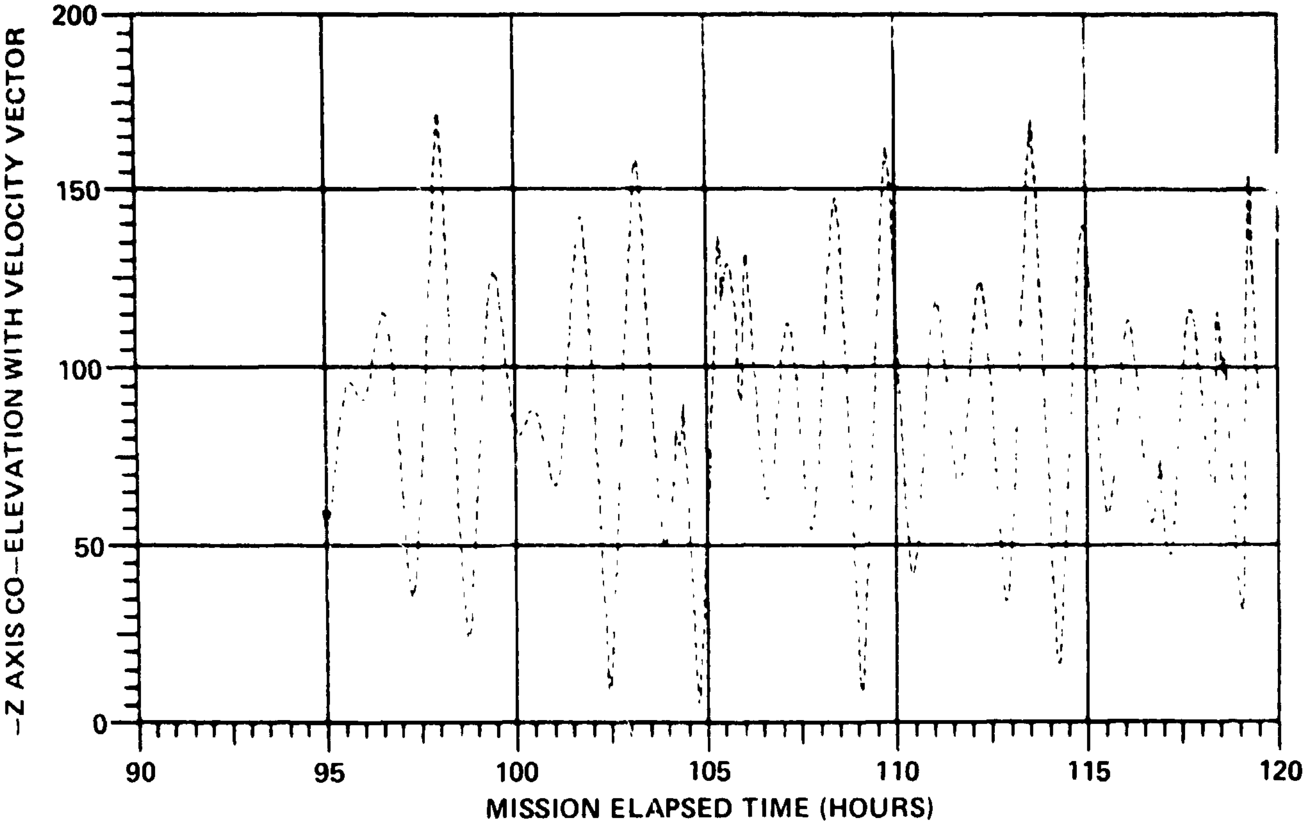

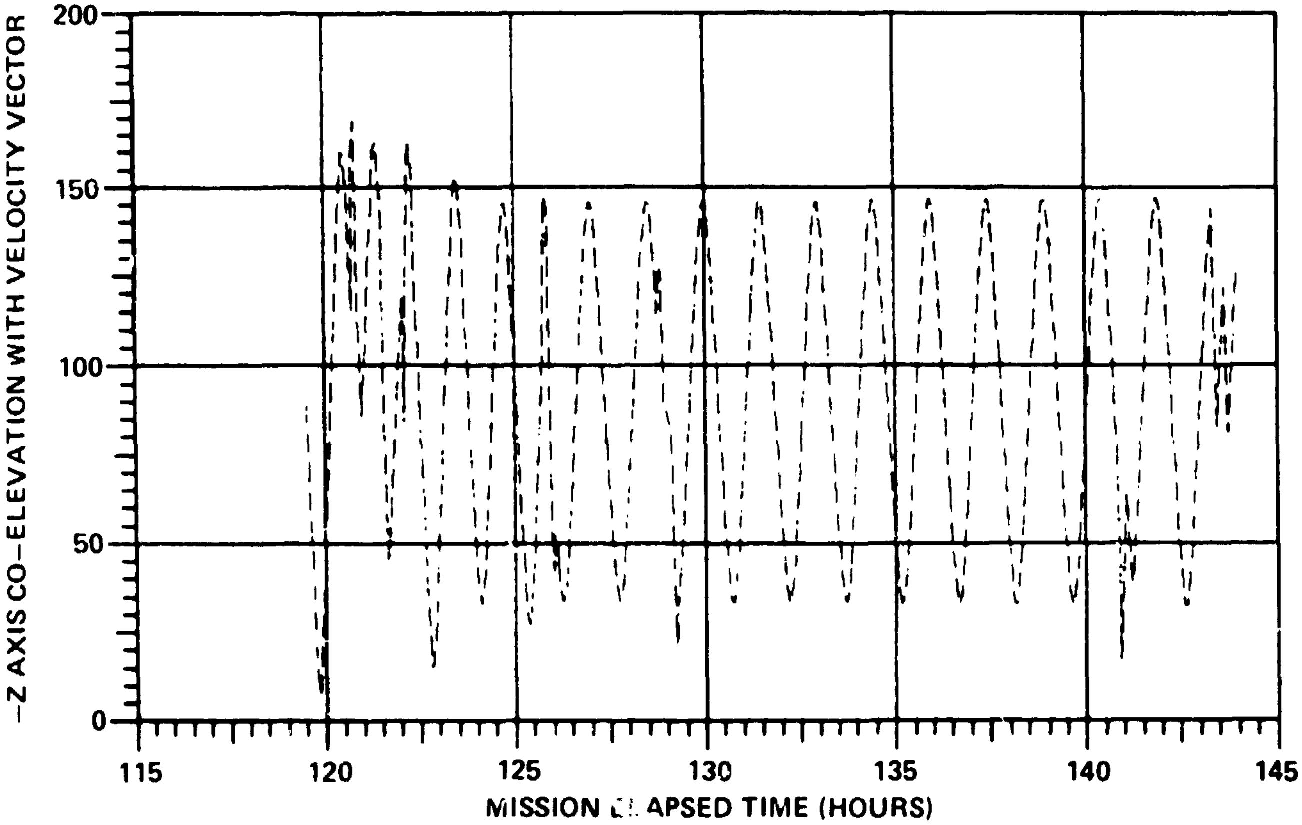

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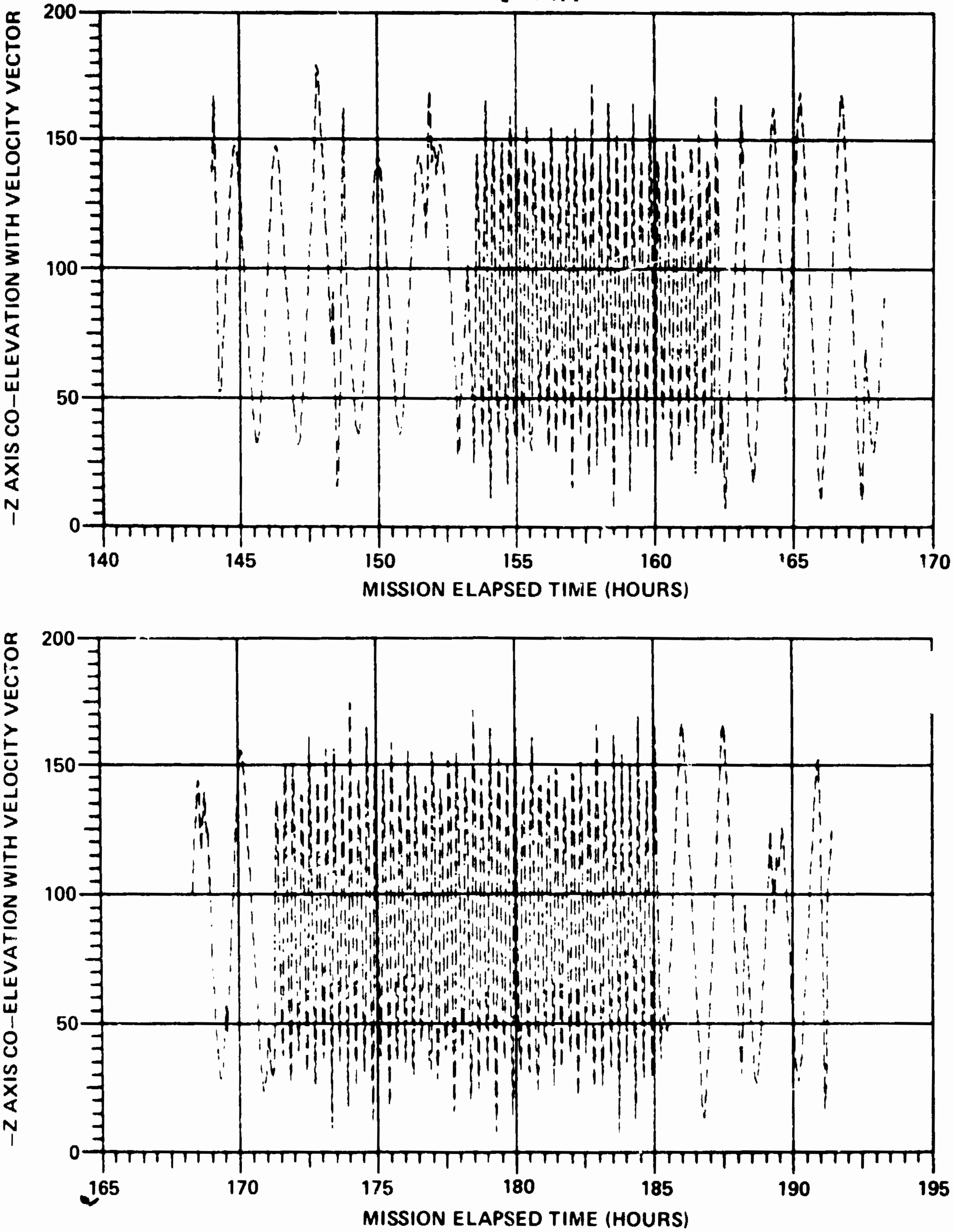

Figure II-2. (Concluded)

III. IECM ENGINEERING SUBSYSTEMS PERFORMANCE ON STS-3

L. W. Russell, W. C. Claunch*, C. W. Davis**, and W. A. Davis***

The IECM engineering subsystems performed as planned during the normal STS-3 mission operations, as well as during the contingency operations, which will be discussed in more detail later. The major components of the engineering subsystems are (1) DACS, (2) Power Distribution and Control Unit (PD&CU), (3) Flight Batteries, and (4) Thermal Control System.

The DACS is a programmable, microprocessor-based data system that performs several distinct functions (1) sampling analog and digital data from IECM instruments and subsystems, (2) formatting data for storage on the IECM data recorder, and (3) sequencing and control of IECM instruments and subsystems. The DACS software is developed and tested for each mission in order to optimize the IECM performance for the planned mission timeline and other mission-peculiar operational aspects. The calibration of the DACS analog and digital data channels was verified by testing before the STS-3 mission. The STS-3 IECM flight data, approximately 19 million bits, was time-tagged and stored as a serial bit stream on the IECM flight data recorder. These data were recovered when the IECM was returned to Marshall Space Flight Center (MSFC) to be refurbished for STS-4.

The PD&CU consists of two modules, the power distributor and the voltage regulator. The voltage regulator supplies a constant 28 Vdc to the IECM regardless of whether the input power source is the internal flight batteries (used during ascent and descent operations) or the Orbiter Payload Aft Main B power bus (used during on-orbit operations). The power distributor has two major functions (1) providing switched 28-Vdc power to IECM instruments under control of the DACS and (2) interfacing the IECM with Orbiter MDM commands, the IECM switch (Panel R11A1, switch 2), and the IECM T - 0 umbilical disconnect signal. Additionally, the power distributor monitors the voltage of the IECM batteries and sets a low-battery status signal to the DACS when the batteries discharge to a 23.5-Vdc level. The calibration of this voltage sensing circuit was verified by testing before and after the STS-3 mission. Table III-1 provides a summary of the mission times at which various events were detected by the power distributor. The mission time is given as IECM Clock Time (IECMCT), as Mission Elapsed Time (MET), and as Universal Time (UT) for the STS-3 mission. The IECMCT is an internal elapsed time clock that starts counting when the IECM T - 0 umbilical disconnect signal is detected. This counter is incremented once per minute and is reset any time power to the IECM is lost. In Table III-1, event number 5 was an intentional cycling of IECM Orbiter power, which was done as a precaution to make sure the IECM heaters were functioning in the Orbiter tail-to-Sun thermal attitude. Events 6 and 7 were also intentional cycles of IECM Orbiter power, which were part of a contingency procedure used to by-pass IECM software operations for the IECM/Remote Manipulating System (RMS) activities. The IECM-deployed operations were cancelled because of difficulties with Orbiter equipment. Event number 8 in Table III-1 was an unplanned IECM reset operation, which was most likely caused by a transient on the Orbiter power bus, as indicated by the Orbiter power bus measurements.

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**Data Systems Laboratory, NASA/MSFC.

***Electronics and Control Laboratory, NASA/MSFC.

TABLE III-1. SUMMARY OF IECM MISSION EVENT TIMES

Event	IECM CT	MET	UT
1. IECM Launch Command	0 00:00:00	-0 00:04:30	81 15:55:30
2. T - 0 Disconnect Signal	0 00:00:00	0 00:00:00	81 16:00:00
3. On-Orbit Command	0 00:37:00	0 00:37:00	81 16:37:00
4. IECM Mass Spectrometer On	0 03:28:00	0 03:28:00	81 19:28:00
5. (a) Orbiter Power Off	2 06:59:00	2 06:59:21	83 22:59:21
(b) Orbiter Power On	0 00:00:00	2 07:04:01	83 23:04:01
6. (a) Orbiter Power Off	3 17:15:00	6 00:19:35	87 16:19:35
(b) Orbiter Power On	0 00:00:00	6 00:24:00	87 16:24:00
7. (a) Orbiter Power Off	0 00:08:00	6 00:32:12	87 16:32:12
(b) Orbiter Power On	0 00:00:00	6 00:36:37	87 16:36:37
8. IECM Reset	0 03:20:00	6 03:56:42	87 19:56:42
9. De-Orbit Command	1 19·31:00	7 23:27:27	89 15:27:27

The IECM flight battery subsystem consists of four 18-A-hr lithium carbon monofluoride primary batteries paralleled to form an internal IECM 28-Vdc battery bus with a total energy capacity of 72 A-hr. The batteries supply power to the IECM for ascent, descent, deployed, and postlanding operations. Each battery has two temperature sensors which are monitored by the DACS. During the STS-3 flight, these temperatures varied between 1 and 39°C, which was well within design limits. As mentioned earlier, a battery low-voltage sensing circuit in the power distributor is used to alert the DACS that the batteries have discharged to a 23.5-Vdc level. When the DACS receives this signal, it dumps all data buffers to the tape recorder and then attempts to switch the IECM to the Orbiter 28-Vdc power bus. When the IECM was returned to MSFC, a discharge test was performed on the batteries to determine the actual battery capacity. Using the STS-3 IECM battery loads plus the discharge test data yielded a total battery capacity of 78.5 A-hr, which exceeded the designed 72-A hr capacity.

IECM thermal control is accomplished with a semi-passive system that is designed to reject solar heat input and to provide internal heat to the IECM when required. The top, sides, and bottom of the IECM are isolated from the external environment by radiation panels, which are themselves isolated from each other and the internal IECM structure by low conductance fiberglass spacers. The external coating of the IECM is S 13G LO paint which produces a low solar absorptance surface while providing good radiation coupling to the external environment for heat rejection during hot conditions. Most of the IECM instruments and subsystem components are mounted directly on the thermal baseplate and are designed to operate between 0 and 70°C. The instruments are designed to maximize the thermal conduction coupling to this baseplate. The baseplate has nine temperature sensors which are monitored by the DACS. The lower thermal limit of the baseplate is maintained by nine resistive heaters which are divided into two zones, with zone A providing 115 W of power and zone B providing 69 W. The DACS controls these heaters by sampling the temperatures in each zone. Two temperature sensors in a particular zone must reach 4.4°C before the respective bank of heaters turns on. Turn-off of the heaters occurs when two temperature measurements of a zone reach 10°C. Preflight predictions indicated no problem with the baseplate or components during the mission including two scheduled RMS periods. Both cold and hot environments were flown on STS-3. The cold Orbiter tail-to-Sun attitude resulted in extended baseplate heater operation, and none of the baseplate sensors dropped below 4°C. The hot case Orbiter orientation did not last sufficient time to produce steady-state temperatures; however, the maximum baseplate temperature was 44°C. Table III-2 shows a summary of the component minimum and maximum design limits plus minimum and maximum temperatures experienced during STS-3 for the components that have sensors. These results are all within limits and agreed well with preflight predictions.

TABLE III-2. SUMMARY OF STS 3 IECM COMPONENT TEMPERATURES

Component	Design Limits Minimum (°C)	Design Limits Maximum (°C)	STS-3 Results Minimum (°C)	STS-3 Results Maximum (°C)
Camera	0	60	1	34
Power Distributor	0	70	*	*
TQCM Electronics	0	70	*	*
Voltage Regulator	0	70	*	*
Optical Effects Module	0	70	0	46
Mass Spectrometer	0	70	*	*
Batteries (8 sensors)	0	74	1	39
CQCM Electronics	0	70	*	*
Tape Recorder	0	65	*	*
Cascade Impactor	0	70	*	*
CQCM	200	80	86	33
Passive Sample Array	45	100	25	88
DACS	0	70	*	*
Baseplate (9 sensors)	0	70	3	44

*No flight temperature measurements available for these components. However, most of these items had a baseplate temperature sensor located adjacent to them. These temperatures were all within acceptable limits.

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IV. HUMIDITY MONITOR AND DEW POINT HYGROMETER

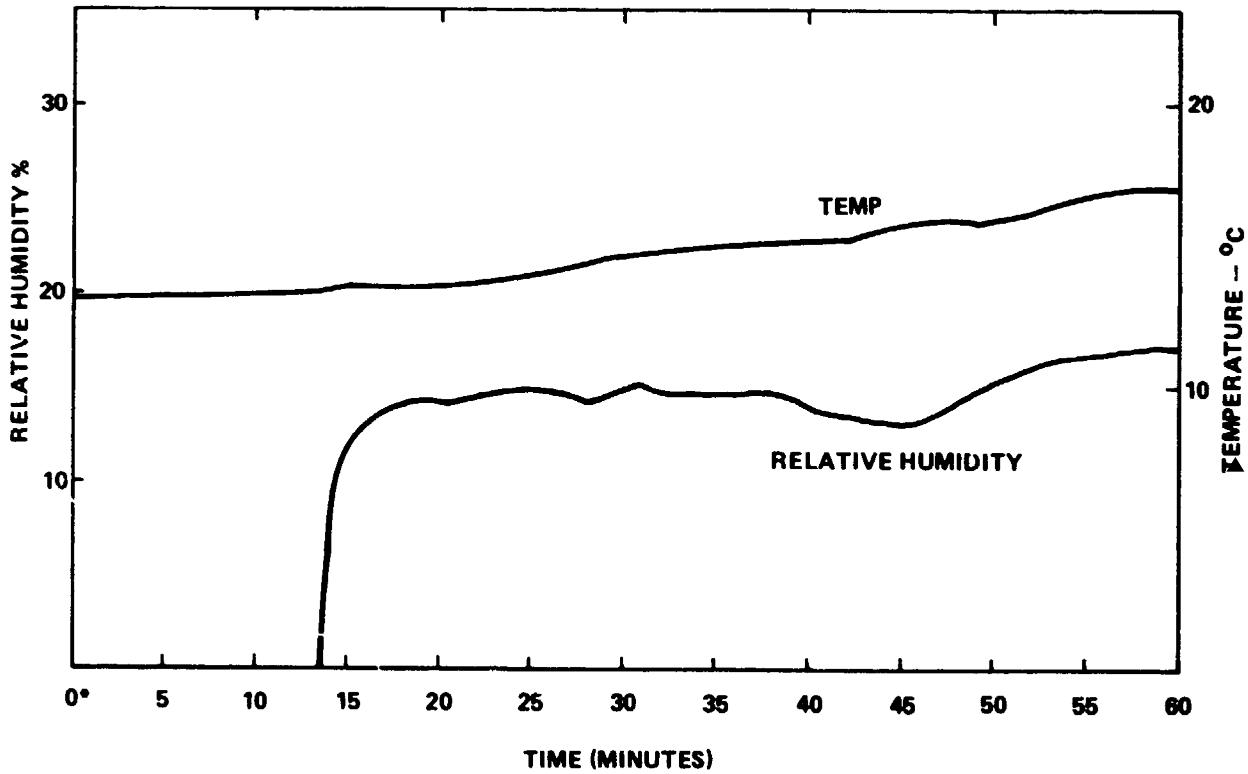
H. W. Parker

The Humidity Monitor operates over a range of 0 to 100 percent relative humidity with an accuracy of ±4 percent. The Dew Point Hygrometer operates over a range of -6.7°C (20°F) to 26.7°C (80°F) with an accuracy of 0.5°C. The temperature is measured over a range of 0 to 100°C with an accuracy of 0.5°C.

The sensors for the Humidity Monitor and Dew Point Hygrometer are located in the air manifold within the Air Sampler system. The air is piped into the manifold at a velocity of 1 liter/min.

The Humidity Monitor measured zero relative humidity during ascent, reflecting the environment provided by the cargo bay dry nitrogen gas prior to launch. The Dew Point Hygrometer correspondingly indicated a dew point below its measuring range of -6.7°C (20°F).

The results of relative humidity and temperature measurements during descent are shown in Figure IV-1. The air pumps were turned on at an altitude of approximately 22.875 km (75,000 ft) and remained on until approximately 44 min after landing. The relative humidity rose to a near constant level of approximately 15 percent at a temperature of 13 to 17°C. The dew point remained below -6.7°C.



*TIME REFERENCED TO 7day:23hr:59min:43sec: WHEN ORBITER WAS AT ALTITUDE OF APPROXIMATELY 22.875 km (75,000 ft).

Figure IV-1. Relative humidity and temperature during descent of STS-3.

V. AIR SAMPLER

P. N. Peters and H. B. Hester

W. Bertsch, H. T. Mayfield, and D. Zatko*
University of Alabama

The Air Sampler acquires the Shuttle cargo bay environment through five bottle locations, as described in previous IECM reports. After ground sampling, bottle 1 is replaced with a flight bottle which has a solenoid valve at each end and which is loaded with adsorbents to collect volatile organics during descent. Bottle 2 has a solenoid valve to initiate sampling at T = 0; pumping occurs during the first minute of ascent, and then two pyro valves are fired to seal the bottle and contain the volatile organics that have been collected on its adsorbents. Bottle 3 is loaded with surfaces sensitive to reaction with HCl and evacuated before flight; firing a pyro valve near solid rocket staging opens the bottle to engulf the high-altitude environment that cannot be sampled by the pumping manifold used on the other bottles; a solenoid valve seals bottle 3 adequately for any HCl to react. Bottle 4, containing the same HCl-sensitive surfaces, is pumped during the first minute of ascent. Bottle 5 contains surfaces sensitive to NO, NO_2, and NH_3, and it is pumped below 25 km during descent. Both bottles 4 and 5 have solenoid valves on each end. The solenoid valves are a bistable latching type with Viton seals.

All programmed sampling operations during flight occurred on schedule. A problem with pyro valve seating (corrected for subsequent flights) allowed bottle 2 to leak its free volume in orbit and refill during descent; since the small free volume is above the adsorbent, little flow through the adsorbent occurred. Since the highest temperature did not exceed 38°C, loss from the adsorbents in orbit has been neglected. The appearance of SO_2 in the bottle may have occurred as described later however.

Residual gas analyses were performed on the contents of all bottles before they were opened to remove the exposed samples. Gas chromatograph/mass spectroscopy (GC/MS) was used to analyze the volatiles, and electron spectroscopy for chemical analysis (ESCA) was used to analyze the reacted species.

The residual gas analyses showed no large concentrations of hydrogen in the bottles (< 0.1 percent). In fact, helium which was used as a purge gas in the welding of the ascent volatile sampling bottle (bottle 2), exceeded the low level of hydrogen observed in that bottle.

Sulfur dioxide on the order of a part per million was indicated in the residual gas of two bottles and supported by analysis of effects on silver oxide films present in bottle 3. The presence of SO_2 in bottle 3 indicates its acquisition at some time after initiation of the grab sampling. Two possible sources for the SO_2 are under investigation (1) although SO_2 was not detected on STS-2, bottles 2 and 3 have pyro valves in common, and tests are being performed to determine if leakage from these valves is a feasible sources; (2) a second source under investigation is a cloud

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*Presently with Sperry Univac, Blue Bell, Pennsylvania.

produced by a volcano. El Chichon (17.33 deg north, 93.20 deg west) erupted on March 28, 1982, and STS-3 landed northwest of this volcano on March 30. Volcanic clouds are known to contain SO_2.

The analysis of silver oxide films by ESCA verified that the discoloration observed on samples from bottle 3 was a sulfide rather than a sulfite, and no unreacted silver was observable, indicating saturation occurred. No discoloration was observed on silver oxide samples from bottle 4, and no sulfur was detected by ESCA on the same samples (bottle 4 has the environment continuously pumped through it for the first minute of ascent then closes with solenoid valves – the solenoid valve seals were rather good with a partial vacuum retained at the time of analysis). No evidence of reaction with HCl was found on any of the silver oxide films. Analyses of ruthenium trichloride surfaces produced no evidence of reaction with nitrogen compounds (NO, NO_2, and NH_3) from descent sampling.

Partial analyses of the STS-3 ascent volatiles indicate approximately 180 μg of total hydrocarbons from 220 standard cm^3 of sampled volume. This compares to 338 μg for an equivalent volume analyzed from STS-3; however, the appearance of unexpectedly large quantities of some of the same species in five control samples requires that the totals will have to be reduced for both flights. Breakage of GC column at the last stage of analysis on the STS-2 samples delayed analyses on controls and STS-3 samples. Analyses of the controls since repairs on the instrument were completed have produced high background levels of several solvents in particular. We are still trying to determine the source of these species in our controls, which were sealed at all times after preparation, but were shipped and stored with the other samples. The earlier quick-look results are now being corrected peak for peak utilizing the results from the controls. It is apparent that the total hydrocarbons will be significantly reduced by these corrections.

CONCLUSIONS

Residual gas analyses indicated low levels of hydrogen. The reactive species of concern, HCl, NO, NO_2, and NH_3, were not detected; instead, an unexpected appearance of SO_2 was indicated by residual gas analysis and ESCA. The total volatile hydrocarbon quantities analyzed on STS-2 and STS-3 will have to be corrected downward as a result of unexpectedly large quantities of some of the species found in control samples.

VI. CASCADE IMPACTOR

B. J. Duncan

The Cascade Impactor is one of the complement of instruments constituting the IECM which flew in the payload bay area of STS-3, as it had previously on STS-2. The instrument measures the aerosol particulate environment in three size ranges during ascent and descent, and nonvolatile residue cumulated throughout the flight at ambient temperature.

Plots of the instantaneous mass concentrations as a function of mission elapsed time are shown in Figure VI-1 for each of the three stages for both the ascent and descent phases of the mission. As was the case with STS-2, concentrations of the larger size particulates (5 micrometers in diameter) were not very great during either ascent or descent. Indicated concentrations are of the order of 10 $\mu g/m^3$ or less. The notably high concentrations of the smaller size particles during STS-2 ascent were not evidenced on STS-3. In both cases, concentrations of less than 10 $\mu g/m^3$ are indicated, compared with 250 $\mu g/m^3$ for the 0.3- to 1.0-micron particles, and 500 $\mu g/m^3$ of particles between 1 and 5 microns on STS-2. Postflight photographs of the sensing crystals of each of the particulate stages are shown in Figure VI-2, made with the aid of a scanning electron microscope (SEM). The relative sparsity of particles and larger nozzle size required a mosaic of photographs to display the collected sample for the larger particulates ($> 5\ \mu$) at the same magnification for comparison with the other two stages. As was the case with STS-2, a great number of fiber-type particles are evident on stage 3, and to a lesser extent, on stage 4. These are almost pure silicon as determined by X-ray elemental analysis on the SEM. In all cases, the number of particles collected on each individual stage is less than the number on the corresponding stage for the earlier flight.

The nonvolatile residue measurement functioned throughout the flight with maximum indications of less than 4×10^{-6} g/cm^2 collected on the sensor surface, compared with a recommended Contamination Requirements Definition Group limit of 10^{-5} g/cm^2.

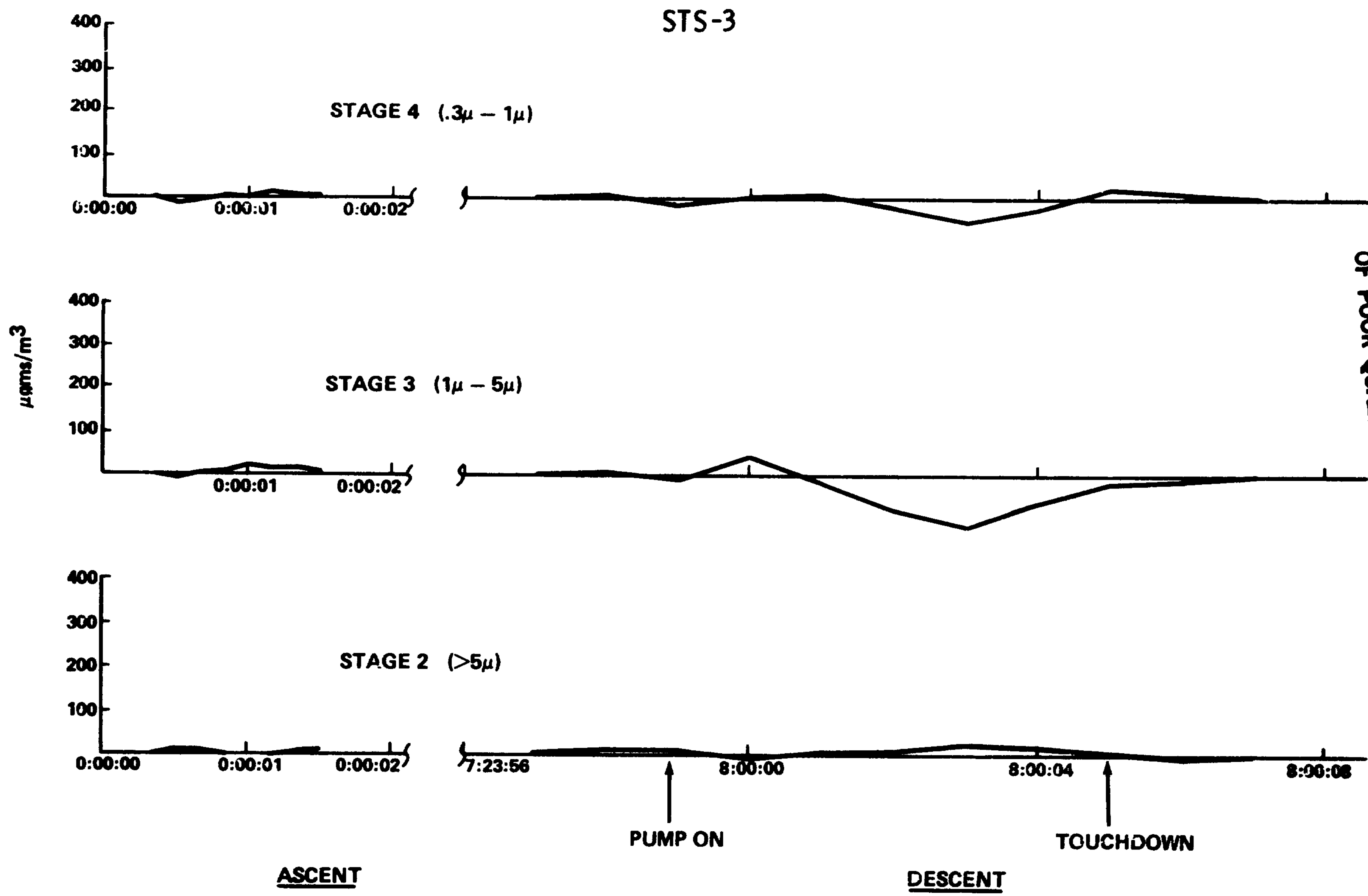
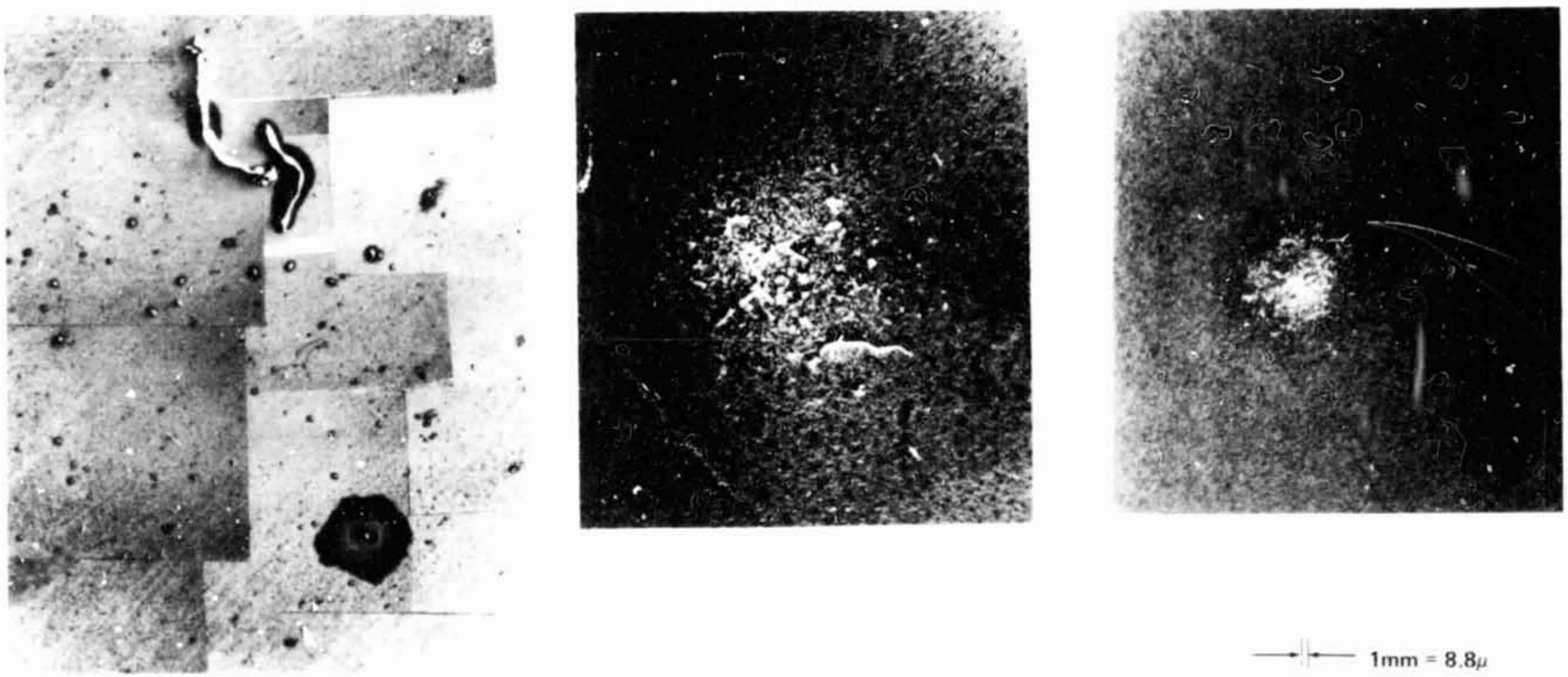


Figure VI-1. Mass concentrations as a function of mission time (day:hr:min).



1mm = 8.8μ

STAGE 2

(·5μ)

STAGE 3

(1μ – 5μ)

STAGE 4

(0.3μ = 1.0μ)

Figure VI-2. Cascade sensor crystal.

VII. OPTICAL EFFECTS MODULE AND PASSIVE SAMPLE ARRAY

R. C. Linton

A. Optical Effects Module (OEM)

The OEM is an active monitor of monochromatic (253.7 nm) ultraviolet transmittance and scatter, operating during the orbital phase of the mission. Five ultraviolet transmitting "witness samples" are mounted on the periphery of a carousel that rotates in the Shuttle X-Z plane. A sixth, empty, sample holder is included for self-calibration of the transmittance measurements during each operational sequence.

A complete OEM sequence includes approximately 8 min of static exposure, followed by a measurement phase lasting 77 sec. In the measurement phase, the samples are sequentially "stepped" through the internal light-beam-detector path by rotation of the carousel. The initial sequence for STS-3 (triggered by the IECM power-on command) was recorded at approximately 46 min MET.

A summary of the OEM results for the STS-3 mission, based on the transmittance measurements, is included in Figure VII-1. The uncertainty in these OEM transmittance measurements is about ±1 percent ΔT, or ±2 percent $\Delta T/T_0$ (percent change in transmittance). Therefore, the indicated changes in transmittance (Fig. VII-1) are generally within this range of uncertainty for each of the mission phases. The ground-to-orbit and postlanding mission phase results for sample I_1 are not completely analyzed at this time, so that the listed uncertainties for I_1 in Figure VII-1 are correspondingly larger. Preliminary analysis indicates that the changes for I_1 during these mission phases will be comparable in magnitude to values for the other OEM samples.

With the exception of the sapphire sample (I_1), most of the inflight optical change recorded for OEM samples on STS-3 was positive (increasing), as indicated in Figure VII-2. During the first several hours of the orbital mission, there was effectively no change in the recorded transmittance ratios for these samples. There were frequent intervals throughout this mission when the OEM carousel failed to rotate on command, leading to the gaps in the data of Figure VII-2.

The range of uncertainty for OEM transmittance measurements, it will be recalled, is about ±1 percent. Most of the indicated changes in transmittance of Figure VII-2 are within this uncertainty range.

While the analysis is incomplete, the OEM scatter data for STS-3 provide little, if any, indication of significant accumulations of particulates on the samples during the orbital mission. Increased diffuse reflection, or scatter, from the samples would indicate an increase in particulates on the surface. The results for STS-3 appear to indicate, basically, no overall change, with intermediate decreases in the number of particulates. However, the uncertainty associated with the OEM scatter measurements is much greater than for the transmittance measurements (±10 percent versus ±2 percent relative change).

B. Passive Sample Array (PSA)

The PSA contains a number of materials, primarily optical, exposed as "witness samples." The PSA is mounted on the top (-Z) surface of the IECM, in the Shuttle X-Y plane. The PSA has no protective covers in place during ascent, orbit, or descent.

For the ferry-flight phase of the mission, a Passive Optical Sample Assembly (POSA) unit of additional "witness samples" was mounted in the Shuttle payload bay (X_o = 750), postflight, at the White Sands Test Facility (WSTF). The POSA ferry-flight unit provides a means of estimating the contributions of the ferry-flight environment on the condition of samples exposed through the entire mission.

The PSA for STS-3 (designated PSA03) contained 42 optical samples, 2 KRS-5 crystals, and 8 "electrets."[1] Two of the eight PSA03 trays, containing the KRS-5 crystals were supplied as guest experimenter hardware;[2] no results for these guest samples are presented in this report.

Samples of the PSA flown on the orbital phase of the STS-3 mission indicate an average change in specular reflectance (ΔR) and transmittance (ΔT) of about ±0.01; most of the measured change is positive, possibly indicating that the samples were exposed to an environment whose overall effect was to simply improve the optical efficiency of the individual samples.

In the vacuum to the near ultraviolet spectral region (120 to 290 nm), the average change in specular spectral reflectance and transmittance (Fig. VII-3) is about +0.01 for gold mirrors and transmissive samples, and +0.02 for magnesium-fluoride protected aluminum (MgF_2/Al) mirrors.

The postflight diffuse spectral reflectance and transmittance measurements[3] in the range 250 to 2500 nm are presently being analyzed. These data indicate either no change or slight increases in optical properties at wavelengths up to 500 nm.

These results, indicating generally increased reflectance and transmittance, are in basic agreement with the OEM results, considering the measurement uncertainty.

Results for the POSA unit mounted in the Shuttle payload bay can be seen by inspection of Figure VII-4 compared to Figure VII-3. Considering the measurement uncertainty, the ultraviolet optical changes measured for the STS-3 POSA samples are basically negligible. Although the analysis of diffuse reflectance and specular transmittance of the POSA for STS-3 in the range 250 to 2500 nm is presently incomplete, these preliminary results also indicate no measureable change.

For a measure of the effects of contamination caused by the Shuttle ground operating environment, two trays of optical samples in the PSA were exposed without covers in the OPF at KSC from January 11 to January 30, 1982. These trays were removed and replaced by flight sample trays on January 30. These 19 days of OPF exposure are about the same duration exposure of samples in the OPF as for similar

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1. Thin sheets of teflon with a relatively permanent surface polarization of charge. Investigator: Mr. M. Susko, ES84, MSFC.
2. Investigator: Mr. E. N. Borson, The Aerospace Corporation.
3. Contributed by Mr. D. R. Wilkes, ES64, MSFC.

trays prior to the STS-2 mission. The measured ultraviolet optical changes of the exposed samples are shown in Figure VII-5; these results are very similar to results for samples exposed to the pre-STS-2 launch OPF environment at KSC. The optical change not attributable to measurement uncertainty is probably due to the presence of particles accumulated on the sample surfaces in the OPF.

A comparative summary of measured surface particle counts[4] for samples of the PSA and POSA for STS-2 and STS-3 is shown in Table VII-1. The difference in the particle counts for samples exposed for equal intervals (19 days) in the OPF prior to STS-2 and STS-3 is attributed to a clean-up of the OPF prior to the STS-3 mission. The relative size distributions of particles on one type of sample common to exposed sample trays in each of the three different environments are shown in Figure VII-6. In all cases, as for STS-1 and STS-2, the distribution of particle sizes is heavily concentrated in the size range <10 μm diameter.

A scanning electron microscope, with X-ray microprobe capability, was used to determine the relative abundance of elements detected on the surface of the electrets included on both the PSA03 and POSA/FF03. That analysis indicated measureable accumulations for the elements chlorine, silicon, calcium, and sulfur on flight electrets of STS-3. However, similar results were obtained for the electrets included in the ferry-flight POSA unit, so that the origin of the detected species of the flight electrets may not be attributable to the Shuttle Orbiter environment.

Several of the optical samples (including ones exposed to the total STS-3 mission environment and the ferry-flight environment) along with control samples were subjected to an elemental analysis using Auger spectroscopy.[5] The elements detected as contaminants were carbon, oxygen, and nitrogen, with traces of sulfur and chlorine. It is probable from analysis of the Auger results that there were no contaminant accumulations of monolayer thickness or more, attributable to the general Shuttle payload bay environment.

C. Summary

These preliminary results for both the PSA and the OEM indicate minimally measureable effects of exposure to the combined environments of the STS-3 mission. While no particular source or mechanism (other than general environment) for the recorded optical changes of the OEM samples has been determined at this time, the magnitudes of changes are small – considerably less than, for example, the analytical predictions of degradation (~10 percent) associated with the accumulation on an optical surface of a single monolayer of a contaminant such as volatized DC-704 pump oil (at 253.7 nm). Most of the degradation of the samples of the passive arrays is probably due to the effects of adhering particles and fibers. Most of the particulate accumulation can be attributed to the landing (WSTF) and ferry-flight environments. Preliminary results of the particle size distribution measurements indicate level 500 to level 1000 distributions on the flight samples, equivalent to the results for STS-2. The effects of the clean-up operation in the OPF at KSC, following the STS-2 mission, are to reduce, by about a factor of 2, the number of particulates on samples exposed during preflight operations there.

4. Contributed by Mr. W. K. Witherow, ES74, MSFC.
5. Contributed by Dr. P. Peters, ES63, MSFC, and Mr. Jack Swann, University of Alabama, Tuscaloosa.

TABLE VII-1. PARTICLE COUNTS COMPARATIVE SUMMARY

SAMPLE TYPE	STS–2 ORBITAL MISSION (PARTICLES/cm^2)	STS–2 FERRY–FLIGHT (PARTICLES/cm^2)
MgF_2/AL	2.5×10^3	2.3×10^3
GOLD	3.1×10^3	1.0×10^3
SAMPLE TYPE	STS–2 PRE–FLIGHT/ OPF/KSC (PARTICLES/cm^2)	STS–3 PRE–FLIGHT OPF/KSC (PARTICLES/cm^2)
MgF_2/AL	1.3×10^4	5.1×10^3
GOLD	1.5×10^4	7.9×10^3
SAMPLE TYPE	STS–3 ORBITAL MISSION (PARTICLES/cm^2)	STS–3 FERRY–FLIGHT (PARTICLES/cm^2)
MgF_2/AL	3.3×10^3	3.3×10^3
GOLD	3.9×10^3	1.9×10^3

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SAMPLE LISTING:

POSITION	MATERIAL
I_0	OPEN APERTURE
I_1	SAPPHIRE
I_2	LITHIUM FLUORIDE
I_3	CALCIUM FLUORIDE
I_4	MAGNESIUM FLUORIDE
I_5	QUARTZ

MEASURED CHANGE IN TRANSMITTANCE
(2537 ANGSTROMS)

MISSION PHASE	I_1	I_2	I_3	I_4	I_5
PRE-FLIGHT GROUND-OPS	−1.3%	+1.1%	0	0	+1.1%
GROUND TO ORBIT	<4%	+1.1%	−2.4%	−2.2%	0
IN-FLIGHT	−4.1%	0	+1.2%	+1.1%	+1.1%
POST-LANDING (INCLUDING FERRY FLIGHT)	<5%	0	0	0	0
TOTAL CHANGE	−1.3%	+2.3%	−1.2%	−1.1%	+2.3%

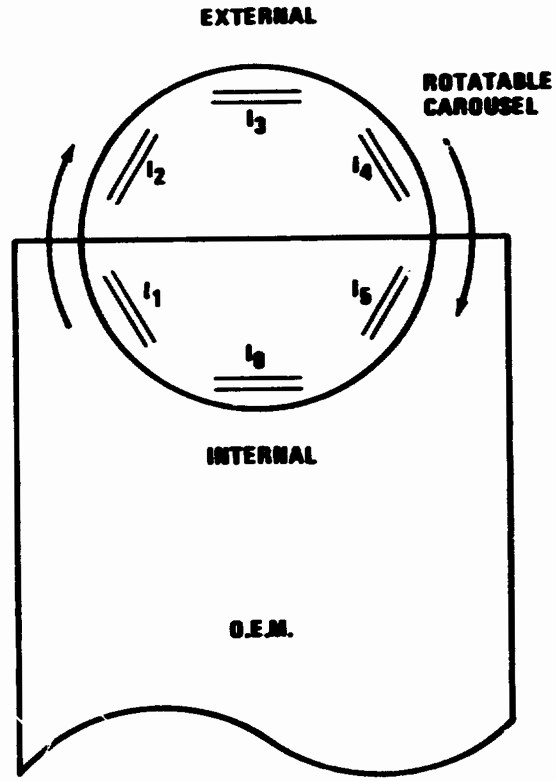

Figure VII-1. Optical effects module summary results: STS-3.

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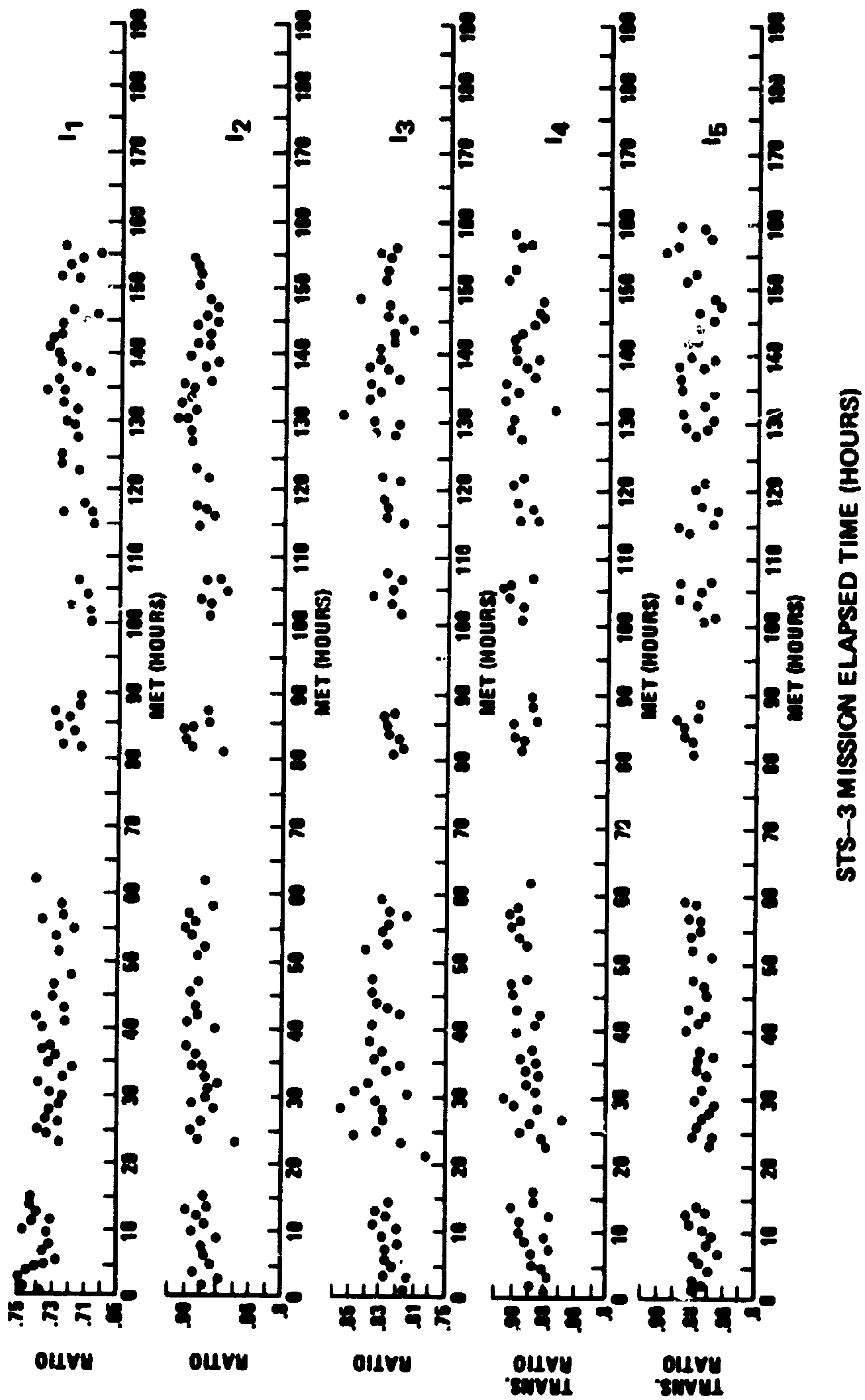

Figure VII-2. OEM transmission channel total mission summary.

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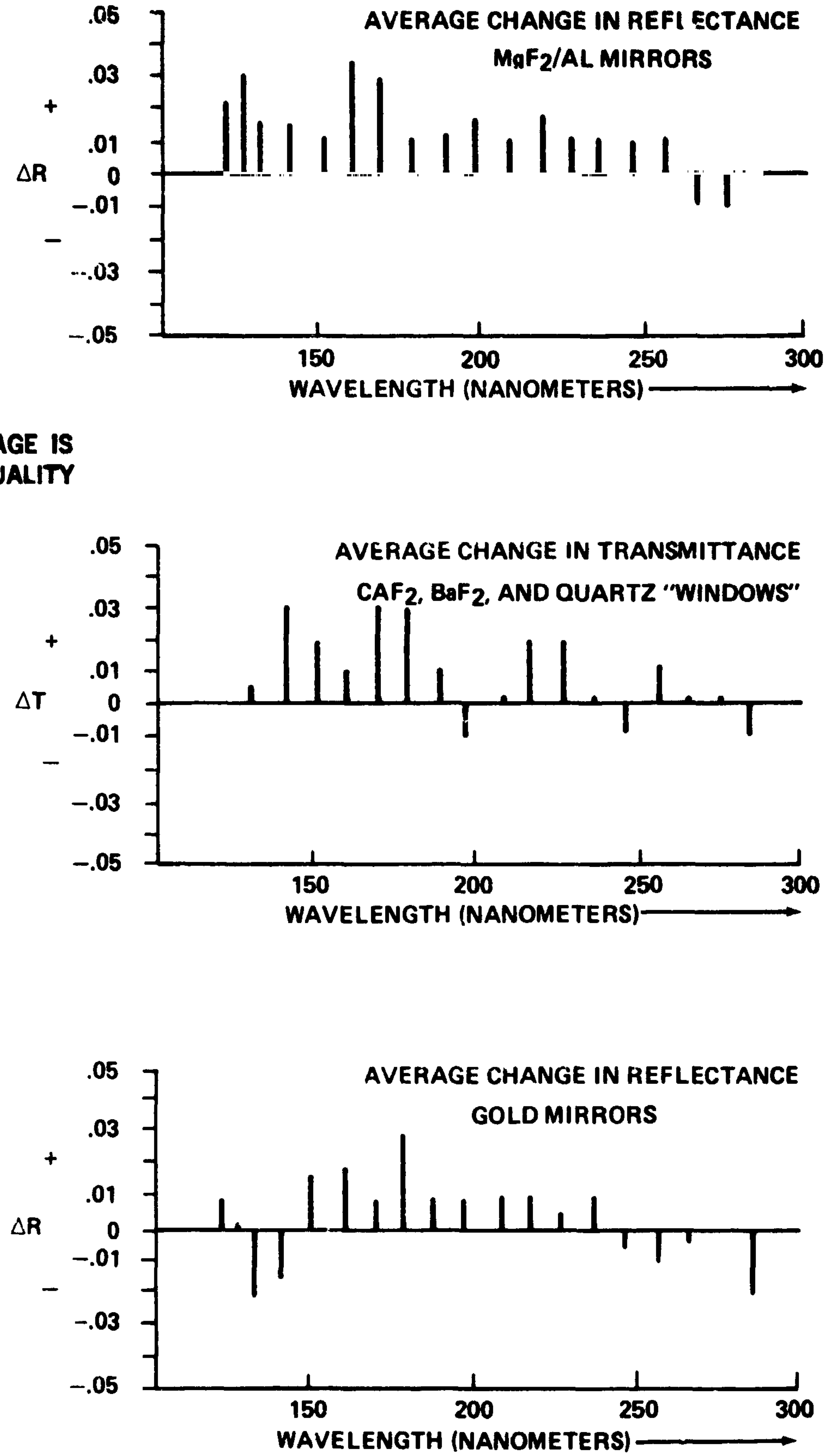

Figure VII-3. PSA/IECM preliminary STS-3 optical effects.

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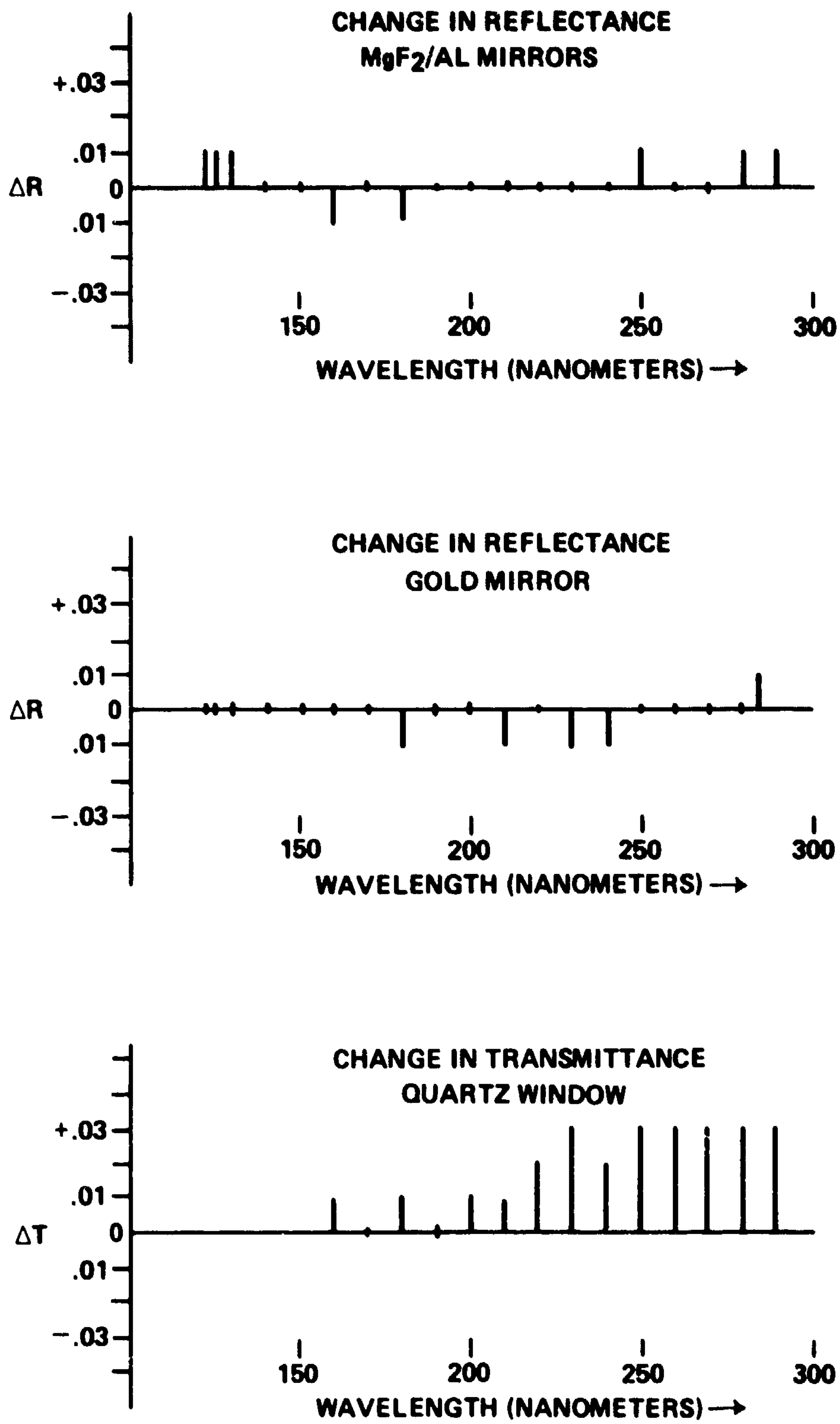

Figure VII-4. POSA for STS-3 ultraviolet optical effects of STS-3 ferry-flight environment.

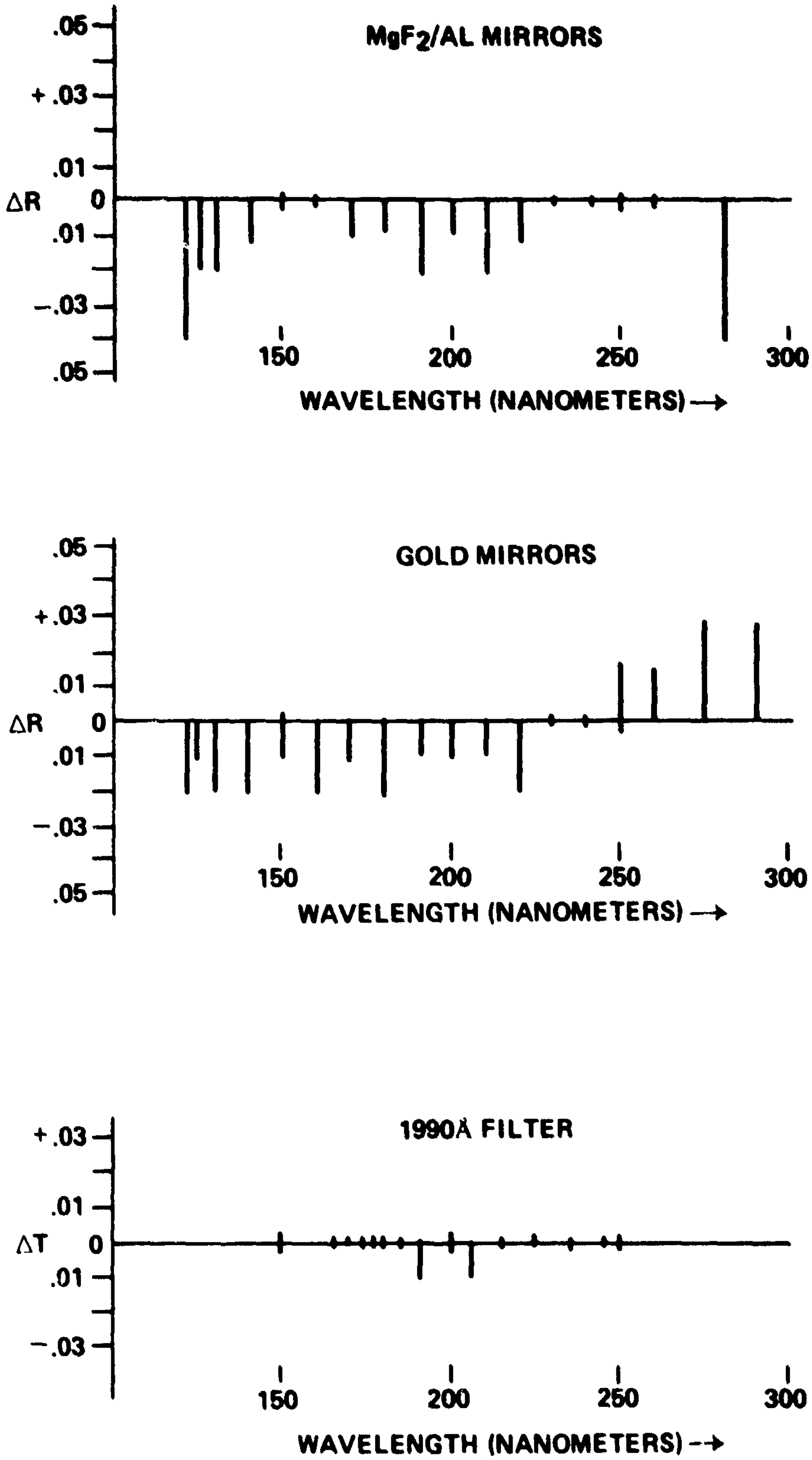

Figure VII 5. PSA/IECM optical effects of STS-3 pre-launch/OPF environment.

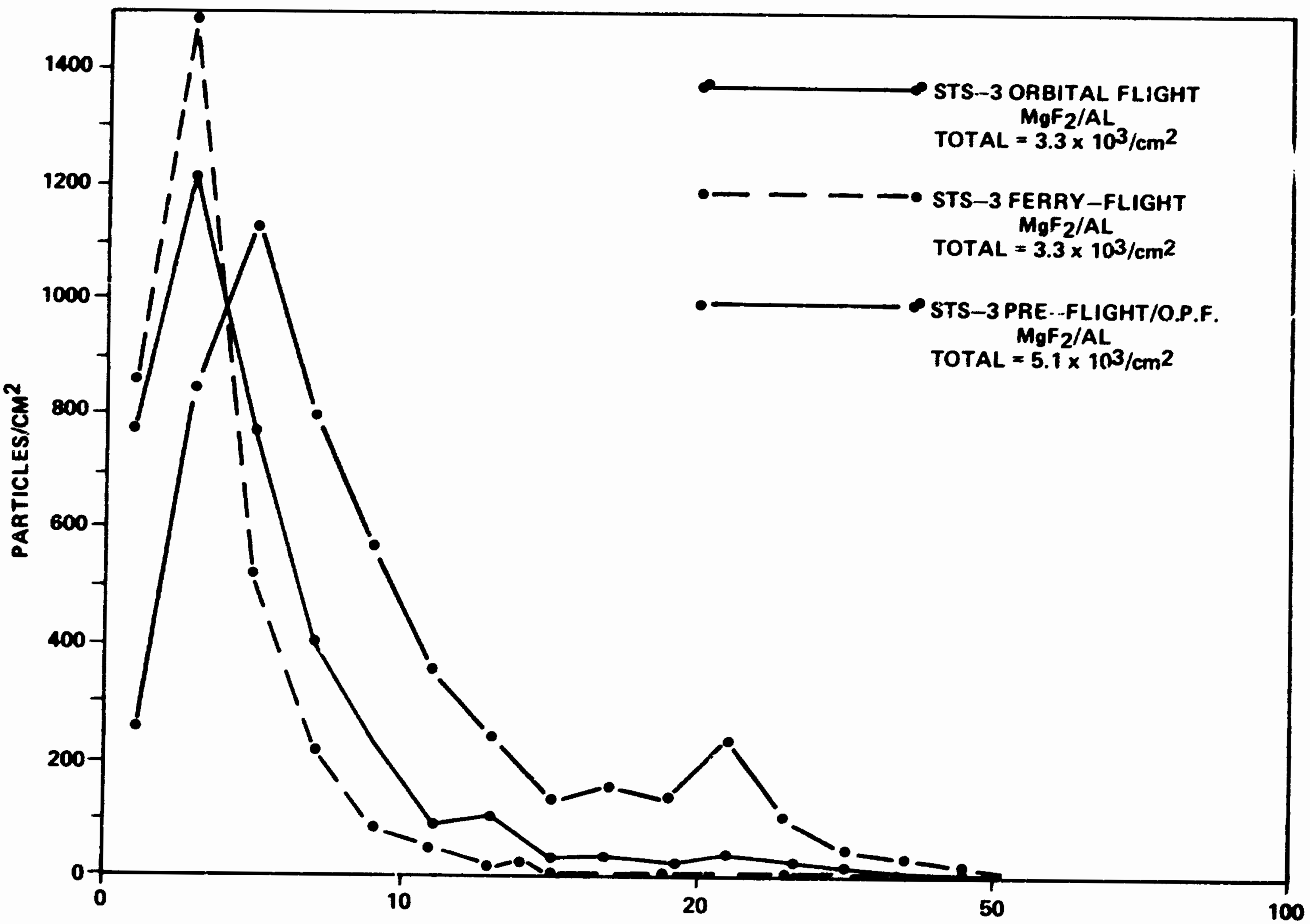

Figure VII-6. Particle size-diameter (microns) STS-3 particle distributions.

VIII. TEMPERATURE-CONTROLLED QUARTZ CRYSTAL MICROBALANCE AND CRYOGENIC QUARTZ CRYSTAL MICROBALANCE

J. A. Fountain

A. Temperature-Controlled Quartz Crystal Microbalance (TQCM)

The TQCM system measures condensible molecular deposition in the payload bay of the Space Shuttle Orbiter as a function of temperature, direction, and time [1,2]. There are five TQCM sensors, one pointing in each of the Orbiter axes (except +Z). The temperature of each sensor is controlled by a thermoelectric device so molecular accumulation can be measured at four preset temperatures: +30, 0, -30, and -60°C. The measuring procedure is as follows. During ascent and for the first 2 hr of orbital flight, the sensors are not controlled but make measurements at ambient temperatures. At 2 hr, 37 min MET, the sensors are commanded to +80°C to desorb the contaminants present on the crystal surfaces and establish a base frequency. The command cycle is similar to STS-2 (review Ref. 1, Figure VIII-1) with the following differences: the +80°C setting is reduced to 20 min, the +30 and 0°C collection periods are reduced to 100 min, and the -30 and -60°C collection periods are extended to 255 min. The signal output from the TQCM sensors are (1) a frequency which is proportional to mass adsorption per unit area at a sensitivity of 1.56×10^{-9} g cm^{-2} Hz^{-1} and (2) the temperature of the sensor in degrees Celsius. During the ascent and descent phases of the mission, the frequencies and temperatures of each sensor are read out at a rate of 10 times per minute, and during the orbital phase, the rate is once per minute.

For this quick-look report, results will be given on the general behavior of the TQCM sensors at several critical times during the mission: ascent, payload bay door opening, and the time during which the Orbiter was in the tail-to-Sun attitude hold period. Other parts of the mission will be analyzed later.

During the ascent phase, the TQCM sensors recorded frequency increases of up to 145 ng cm^{-2} in the first minute. During the second minute of flight, this initial buildup decreased back to the zero level and for the next 35 min continued to decrease at a slow rate. An exception to this behavior was seen on the -X sensor which recorded a 195 ng cm^{-2} increase at 12 min MET. A tabular summary of the mass adsorption/desorption for the ascent phase is given in Table VIII-1. The values given are referenced to readings at lift-off and are given in nanograms per square centimeter.

During orbital phase, the TQCMs remained at ambient temperature until 2 hr, 37 min MET. The payload bay doors were opened in this time period. At 1 hr, 57 min MET, the doors began to open and the TQCMs recorded a momentary decrease in frequency followed by an increase over the next 32 to 37 min. These results are given in Table VIII-2. The TQCM command cycle began at 2 hr, 37 min MET. The first command given was the initial +80°C temperature setting. As a result of this temperature and the simultaneous reduction in ambient pressure caused by the opening of the bay doors, all TQCM sensors exhibited mass desorption which continued through the first +30°C temperature setting (2 hr, 59 min to 4 hr, 38 min MET). At 4 hr, 57 min, the first 0°C command is given and during this time the desorption trend stops, and for the next 100 min, small increases in mass deposition are recorded.

TABLE VIII-1. ASCENT PHASE

Sensor Axis	Mission Elapsed Time (min)					
	0.7	2	10	20	30	37
+Y	+87	-2	-45	-58	-69	-72
+X	+109	-16	-47	-67	-76	-81
-Z	+111	-9	-16	-20	-25	-25
-X	+145	-9	-61	+75	+70	+75
-Y	+145	+8	0	+2	-12	-27
Averages	119	-6	-34	-14	-22	-25

TABLE VIII-2. PERIOD OF PAYLOAD BAY DOOR OPENING

Sensor Axis	Total Mass Deposition $ng\ cm^{-2}$	Time Interval minutes	Mass Deposition Rate $ng\ cm^{-2}\ min^{-1}$
+Y	168	36	5
+X	345	36	10
-Z	211	37	6
-X	117	35	3
-Y	70	32	2

The first major attitude position held for a significant length of time was the tail-to-Sun position from 10 hr, 45 min to 34 hr, 0 min MET, a period of 23 hr, 15 min, with only a few brief interruptions for maneuvers such as inertial measurement unit alignment. The TQCM command cycle beginning at 20 hr, 43 min and ending at 33 hr, 52 min was included in this tail-to-Sun period, and the results are given in Table VIII-3. The values are calculated from the difference between the minimum and maximum frequencies attained during the measurement period and averaged over the time interval between the two. This procedure averages over specific events and effects that will be taken into account in later detailed data analyses. While in the tail-to-Sun attitude, the payload bay is cold, so the accumulation rates are low. Table VIII-3 indicates that most of the accumulation occurred on the +X sensor, that is, the sensor looking forward over the payload bay.

Yet to be analyzed are (1) the long period in which the Orbiter was in a nose-to-Sun attitude, and (2) the period from 126 to 153.5 hr MET in which the Orbiter was in the bay-to-Sun attitude. However, visual inspection of the data plots indicates that for the nose-to-Sun case, deposition rates are at similar low levels as in the tail-to-Sun case. As expected, the bay-to-Sun attitude showed significant increases in mass accumulation. Directional effects are evident with the most accumulation occurring in the -X and +X directions. Also quite significant are the effects of time

TABLE VIII-3. TAIL-TO-SUN ATTITUDE

Sensor Axis	Mass Accumulation $ng\ cm^{-2}$	Time Interval minutes	Mass Accumulation Rate $ng\ cm^{-2}\ min^{-1}$
A. +30°C Measurement Setting (Total time - 100 min)			
+Y	6	31	0.2
+X	154	55	2.8
-Z	48	58	0.8
-X	48	55	0.9
-Y	12	11	1.1
B. 0°C Measurement Setting (Total time - 100 min)			
+Y	132	97	1.4
+X	276	97	2.8
-Z	48	96	0.5
-X	103	97	1.1
-Y	51	135	0.4
C. -30°C Measurement Setting (Total time - 255 min)			
+Y	53	231	0.2
+X	250	251	1.0
-Z	62	229	0.3
-X	34	121	0.3
-Y	47	32	1.5
D. -60°C Measurement Setting (Total time - 255 min)			
+Y	335	214	1.6
+X	384	240	1.6
-Z	181	207	0.9
-X	73	200	0.4
-Y	215	166	1.3

in sunlight and shadow. A good example of this effect appears on the -X (aft-facing sensor) at -60°C at 133 hr, 43 min to 135 hr, 13 min MET. Figure VIII-1 shows this period. The frequency increase is 693 Hz in 63 min due to solar heating. This corresponds to an accumulation rate of 17.1 ng cm^{-2} min^{-1}. When the Orbiter goes into the Earth's shadow, the contamination continues to increase for 13 min, then dissipates by -456 Hz in 27 min, which corresponds to a rate of -26.4 ng cm^{-2} min^{-1}. Since the time in sunlight is longer than the time in shadow, there is an overall increase of contamination of 368 ng cm^{-2} during the 90-min orbit.

At 147 hr, 56 min MET, the TQCM system ceased operation because of the unintentional power reset caused by the transient on the Orbiter power bus (mentioned in Section III) and did not restart. Therefore, no TQCM data are available on the descent phase of the mission.

B. Cryogenic Quartz Crystal Microbalance (CQCM)

The CQCM is a system with two -Z axis sensors similar to the TQCM sensors, except that their temperatures are not controlled. Instead, they are thermally coupled to a passive optical radiator which reflects and radiates heat away, and thus provides sensor temperatures which are cooler than their surroundings. The radiator system operated well; the minimum temperature reached was -101°C at 28 hr, 6 min MET when the Orbiter was in the tail-to-Sun attitude. The CQCM sensors never went over 35°C even in the bay-to-Sun attitude.

The CQCM data have not been analyzed, but a summary is presented based on a cursory examination of the frequency plots in Table VIII-4.

Table VIII-4 was developed by taking the difference between sensor frequency minima and maxima which occurred during each period shown and averaging over the time interval between the two. The contamination which was recorded within the first minute of ascent dissipated during the remainder of the ascent phase. Thus, a negative deposition or clean-up was seen as a result of the pressure decrease as orbital altitude was attained. During the early part of the orbital phase, a frequency minimum was reached at 3 hr, 30 min MET. A generally increasing trend was observed over the rest of the orbital phase with the maxima of the two sensors being reached some 31 hr apart, which is the reason for the different time periods seen in Table VIII-4. The Orbiter was in the tail-to-Sun and nose-to-Sun attitudes during most of this time, and the contamination accumulation rates are quite small.

TABLE VIII-4. CQCM MISSION SUMMARY

	Mass Deposition ng cm^{-2}	Time Interval minutes	Mass Deposition Rate ng cm^{-2} min^{-1}
Ascent Phase (first minute)			
$-Z_1$	36	0.7	51.4
$-Z_2$	34	0.7	48.6
Ascent Phase (entire phase)			
$-Z_1$	-4.7	37	-0.1
$-Z_2$	-28	37	-0.8
Period of Payload Bay Door Opening			
$-Z_1$	144	19	7.6
$-Z_2$	163	18	9.0
Orbital Phase			
$-Z_1$	635	9,401	0.07
$-Z_2$	454	11,272	0.04
Descent Phase			
$-Z_1$	53	38	1.4
$-Z_2$	17	36	0.5

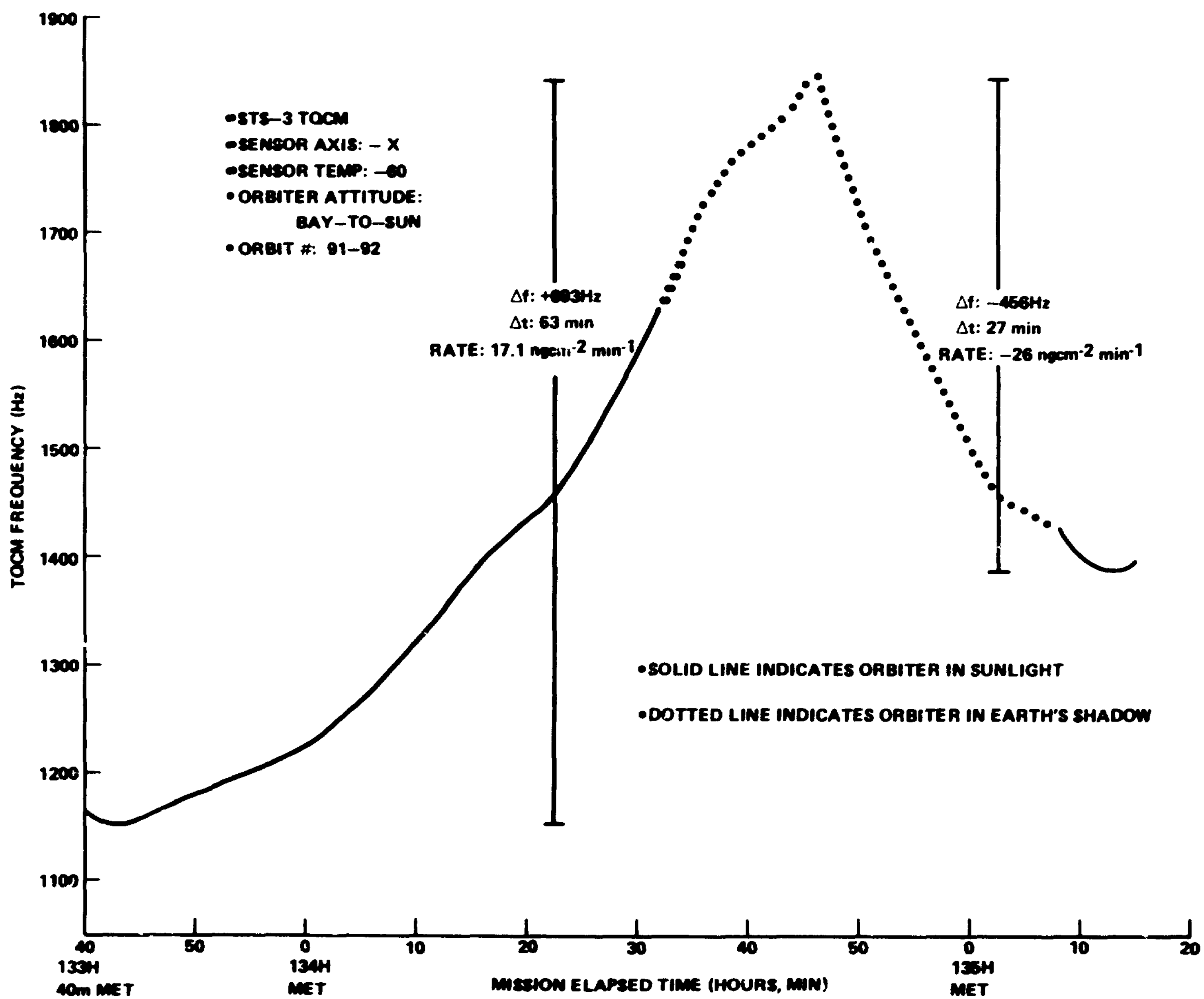

Figure VIII-1. -X TQCM contamination rates in sunlight and shadow, bay-to-Sun attitude.

IX. CAMERA/PHOTOMETERS

K. S. Clifton and J. K. Owens

Optical measurements of background brightness and the size and velocity distributions of contaminant particles were undertaken by the Camera/Photometer experiment on the STS-3 mission. As during the STS-2 Shuttle flight, these measurements were conducted stereoscopically with two 16-mm motion picture cameras operating continuously throughout the on-orbit phase of the mission. Simultaneous exposures were made every 150 sec with exposure durations determined from the amount of background illumination recorded by integrating photometers. The cameras were equipped with 18-mm f/0.9 lenses which subtended overlapping fields of view. Kodak Double X film, Type 7222, was used to record the data.

The Camera/Photometers operated nominally throughout the first 48 hr of the mission, at which time a failure occurred in the master timing circuitry causing a halt in the operations of both systems. Investigations of the camera system have since indicated that the most likely source for the malfunction is from an electromagnetic interferrence-induced transient on the Orbiter's AFT Main B power bus.

Over 1100 exposures were made by each camera during its operational period on STS-3. Of these, over 400 potential contamination frames were recorded, a four-fold increase over the results of STS-2. Such frames are obtained under conditions suitable for the recording of contamination, and at the same time they are sufficiently free of light reflected from nearby surfaces to allow the detection of particle tracks. The conditions for recording contamination require a sunlit Orbiter environment against a dark stellar or terrestrial background, the latter achieved during terminator crossings. Nearly 120 frames were found to contain particle tracks. Table IX-1 shows the contamination data with the number of particle tracks recorded per frame. Column 3 in the table relates the number of frames of a given particle number density as a percentage of overall potential contamination frames. Thus, for example, 1 percent of all the exposures capable of yielding contamination data contained a particle number density of 20 particles/frame or greater.

TABLE IX-1. BREAKDOWN OF CONTAMINATION WITH THE NUMBER OF PARTICLES DETECTED PER FRAME

Number of Particles/Frame	Number of Frames (N)	Percentage of Frames (N/ΣN)
$x \geq 20$	5	1
$20 > x \geq 10$	5	1
$10 > x \geq 5$	15	4
$5 > x \geq 2$	40	10
$x = 1$	54	13
$x = 0$	284	70
Total Contamination	119	30

The number of contamination frames with heavy particle densities ($\geq$ 20) recorded during the STS-3 mission is a factor of five less than that recorded during the STS-2 flight. This, however, may be due less to a cleaner Orbiter environment than to the lower number of potential contamination frames recorded during the earliest part of the STS-3 mission when heavier particle concentrations are expected. The incidence of large amounts of reflected light has reduced this number on STS-3 considerably. A breakdown of the contamination data with MET is shown in Table IX-2. In this table, MET is grouped into 5-hr periods beginning with the first opportunity to record contamination when the bay doors open at 2 hr MET.

The overall trend of the data is as expected and similar to that observed with the STS-2 mission. Between 2 hr and approximately 13.5 hr MET, contamination is recorded on well over 50 percent of the potential contamination frames. After that time, the figure is well under 50 percent. The isolated cases in which heavy particle number densities are observed after MET = 30 hr are probably due to activities aboard the spacecraft. However, no specific events have as yet been identified to account for any activities which might cause increases in contamination events. In addition, the data are being correlated with spacecraft orientation in order to determine spacecraft shadowing characteristics and the subsequent effect on the observed contamination.

Since the exposure time for each frame of data is determined by the photometer measurement, the observed background brightness distribution may be inferred from the distribution of exposure times for the mission. This is done in Figure IX-1 for exposures made in the daylight portion of the orbits and in Figure IX-2 for the night-side exposures. Exposures made during passage through the day/night interface have been omitted from these figures, since the percentage of the exposure made on a given side is uncertain.

The average exposure time during daylight periods was 9.28 sec. An examination of Figure IX-1 shows clearly that the daylight portion of an orbit is characterized by high background brightness levels. However, it must be remembered that the brightness here is a strong function of spacecraft orientation and that significant reflections occurred from the Orbiter tail and objects aboard the spacecraft. A similar dependence of brightness on orientation during the daylight side was also indicated by STS-2 data when the payload bay was directed toward the sunlit Earth.

For the frames exposed on the night side of the orbit, the average exposure time is 28.79 sec. As expected, the exposures are generally longer on the night side. It is interesting, however, to note the significant number of short-exposure frames recorded during nighttime observations. These are believed to be due to engine firings or activities taking place in the payload bay for which the bay lights were turned on.

The actual brightness level for the average daytime exposure (9.28 sec) is about 6×10^{-13} $B_\odot$ where $B_\odot$ indicates solar brightness. For the average nighttime exposure (28.79 sec), the brightness is about 2×10^{-13} $B_\odot$; for the longest exposure recorded (82 sec) the approximate brightness is 7×10^{-14} $B_\odot$.

TABLE IX-2. PRELIMINARY STS-3 CORRELATION OF CONTAMINATION WITH MISSION ELAPSED TIME

Met (hours)	2-7	7-12	12-17	17-22	22-27	27-32	32-37	37-42	42-48
Particles/Frame									
$x \geq 20$	2	0	1	0	0	0	1	0	1
$20 > x \geq 10$	1	3	0	0	0	0	1	0	0
$10 > x \geq 5$	0	14	1	0	0	0	0	0	0
$5 > x \geq 2$	0	26	10	1	2	0	1	0	0
$x = 1$	1	7	21	11	9	2	3	0	0
Total Contamination	4	50	33	12	11	2	6	0	1
Number of Frames without Contamination	0	5	42	49	64	67	27	14	16
Percent Frames with Contamination	100	91	44	19	15	3	18	0	6

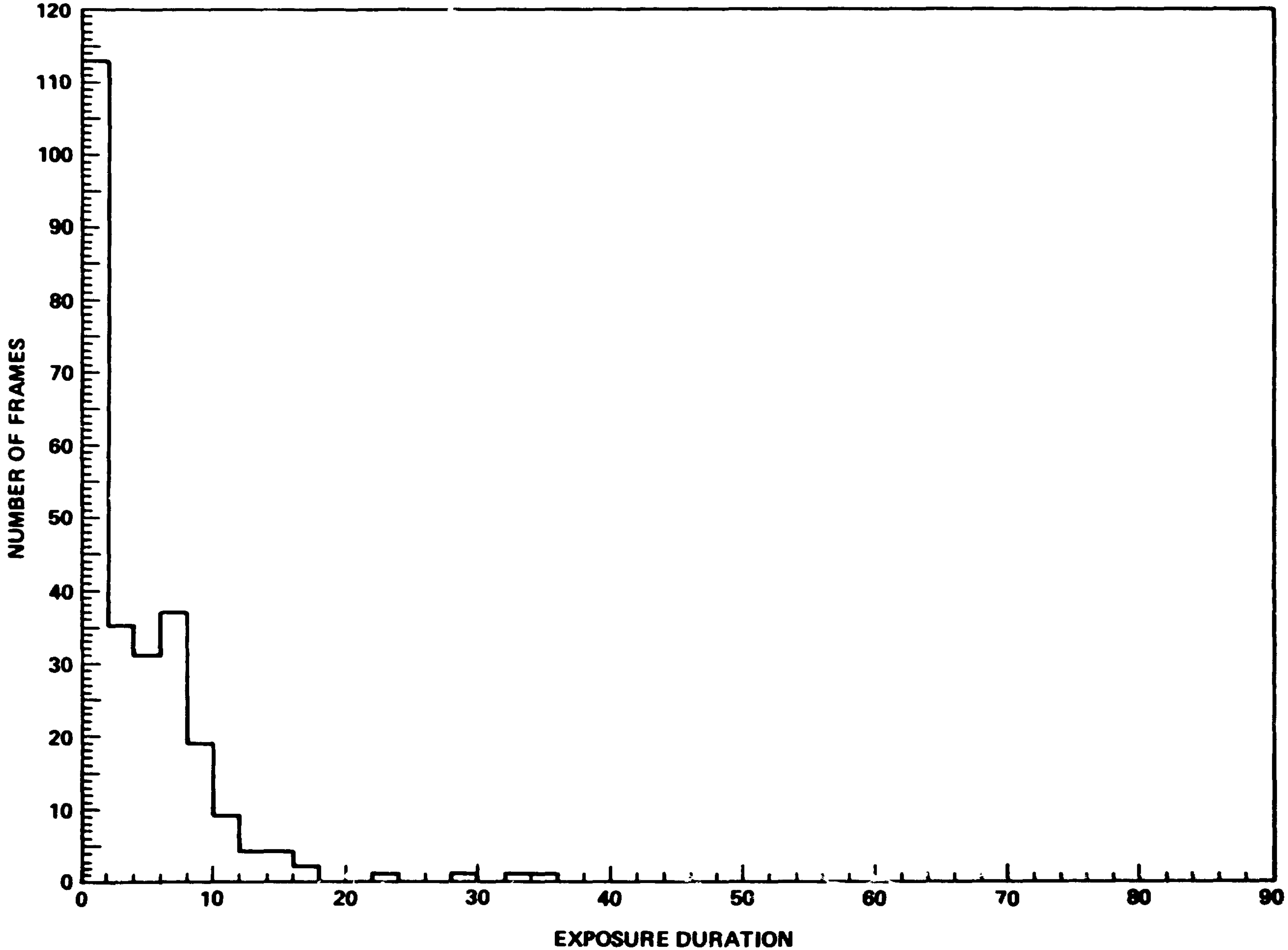

Figure IX-1. Daytime exposures.

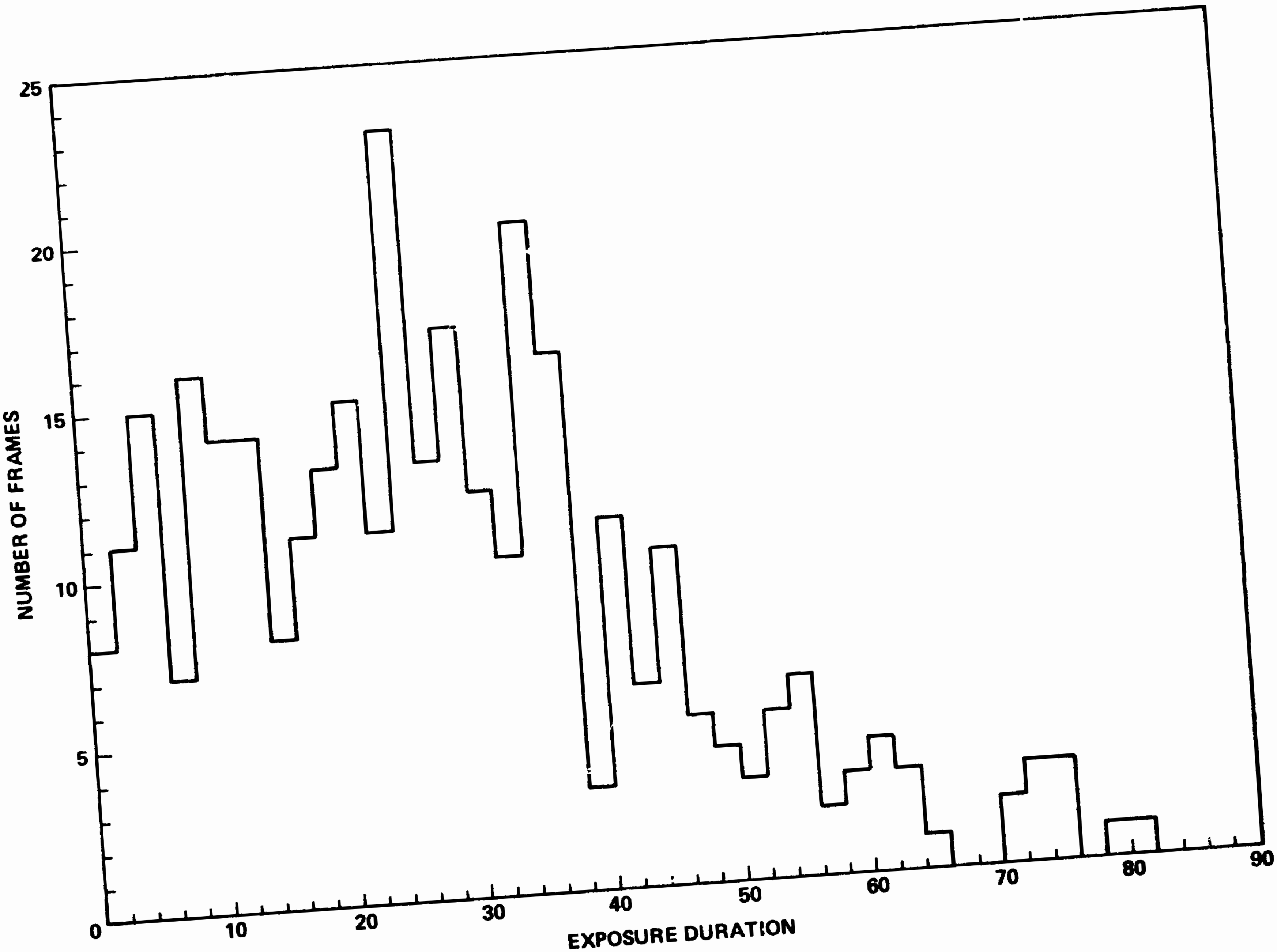

Figure IX-2. Nighttime exposures.

X. MASS SPECTROMETER

E. R. Miller and G. R. Carignan*

The IECM Mass Spectrometer, developed by the University of Michigan, Space Physics Research Laboratory, is a quadrupole design operating from 2 to 150 amu. Mass collimation is provided by sintered Zirconium getter pumps to 0.1 sr. The dynamic range of the instrument is approximately 10^8 to 10^{16} molecules or atoms/cm^2/sec/0.1 sr. In the normal IECM operation, each amu pulse count is integrated for 2 sec, requiring 300 sec for a full 150 amu sweep. Alternately, an equal number of steps are taken on the water peak (amu 18). Thus the full cycle requires about 10 min. This cycle is normally repeated throughout the on-orbit phase of the mission.

The Mass Spectrometer performed normally on the flight of STS-3. However, the planned in-flight release of ^{22}Ne, $H_2{}^{18}O$ gas mixture for the purpose of determining differential molecular collision cross section was started, but an unexplained power reset of the IECM caused termination after 40 sec of the 1 hr required for this experiment.

The H_2O peak (amu 18), Figure X-1, rose from an initial value of about 1×10^3 counts/2 sec at turn on (3.5 hr MET) to about 4×10^3 counts/2 sec after instrument warm-up (approximately 7 hr MET) and to about 2×10^3 counts/2 sec at 20 hr and stayed near that value except for brief intervals until top-to-Sun attitude at 126 hr MET.

The value of 2×10^3 counts/2 sec corresponds to an ion source density of 1.19×10^6 molecules/cm^3, and it is believed to be almost entirely instrument background. The value of 2×10^3 counts/2 sec establishes an upper bound of $< 1 \times 10^{12}$/cm^2/sec/sr return flux for H_2O. The conclusion that H_2O is instrument background is supported by the observation that little or no modulation is seen as the spacecraft is oriented with the payload bay (-Z axis) pointed into and away from the velocity vector (Fig. II-2). Considerable angle of attack effects were seen on H_2O return flux during the STS 2 flight [1].

The H_2O column density for STS-3 is probably much less than 3×10^{12}/cm^2 except for brief periods attributable to specific events shown in Figure X-1: at 31.2 to 32.3 hr MET the port payload bay door was closed; between about 48 and 52 hr MET the IECM was operated in a faster mode, integrating for 1 sec instead of 2 sec for each amu; unknown event at 80 hr MET; at 95 hr MET the 875-lb thrust left rear upward (L2U) primary reaction control system engine was fired; at 124.4 to 125.25 hr MET the payload bay doors were cycled; at 143.7 hr MET the number 3 auxilliary power unit was fired; at 151 to 151.5 and 166.7 to 170.6 hr MET the payload doors were cycled and finally closed in preparation for re-entry at 188.2 hr MET.

Significantly, nine water dumps (at a rate of 68 kg/hr) during the course of the mission with duration of 5 min each are not observed in Figure X-1.

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Included in Figure X-1 are times of major attitude acquisitions and IECM power cycles. During the approximate 3 hr of closed payload bay doors beginning at 166.7 hr MET (mostly top-to-Sun attitude), the pressure increased and did not recover to initial background levels for the rest of the mission. During this time, the partial pressure of H_2O reached 1.7×10^{-7} torr, N_2 rose to a partial pressure of 6×10^{-6} torr, argon to about 4×10^{-8} torr, and helium to 7.5×10^{-7} torr.

Of particular interest is the presence of amu 16, Figure X-2, which is predominantly CH_4 (methane). Although the source of methane return flux has not been determined at this time, there is evidence of oxygen atom oxidation of organic materials producing hydrogen, carbon monoxide, and methane [4]. Also unexplained is the increased amu 16 count rates and subsequent slow decay associated with the L2U engine firing at 95 hr MET.

The significant mass count rates occur at amu 2, 4, 12, 13, 14, 15, 16, 17, 18, 25, 26, 27, 28, 29, 30, 32, 39, 40, 41, 42, 43, and 44 for lighter masses and 55, 52, 57, 60, 64, and 78 for heavier masses. These results are similar to those obtained on STS-2 [1].

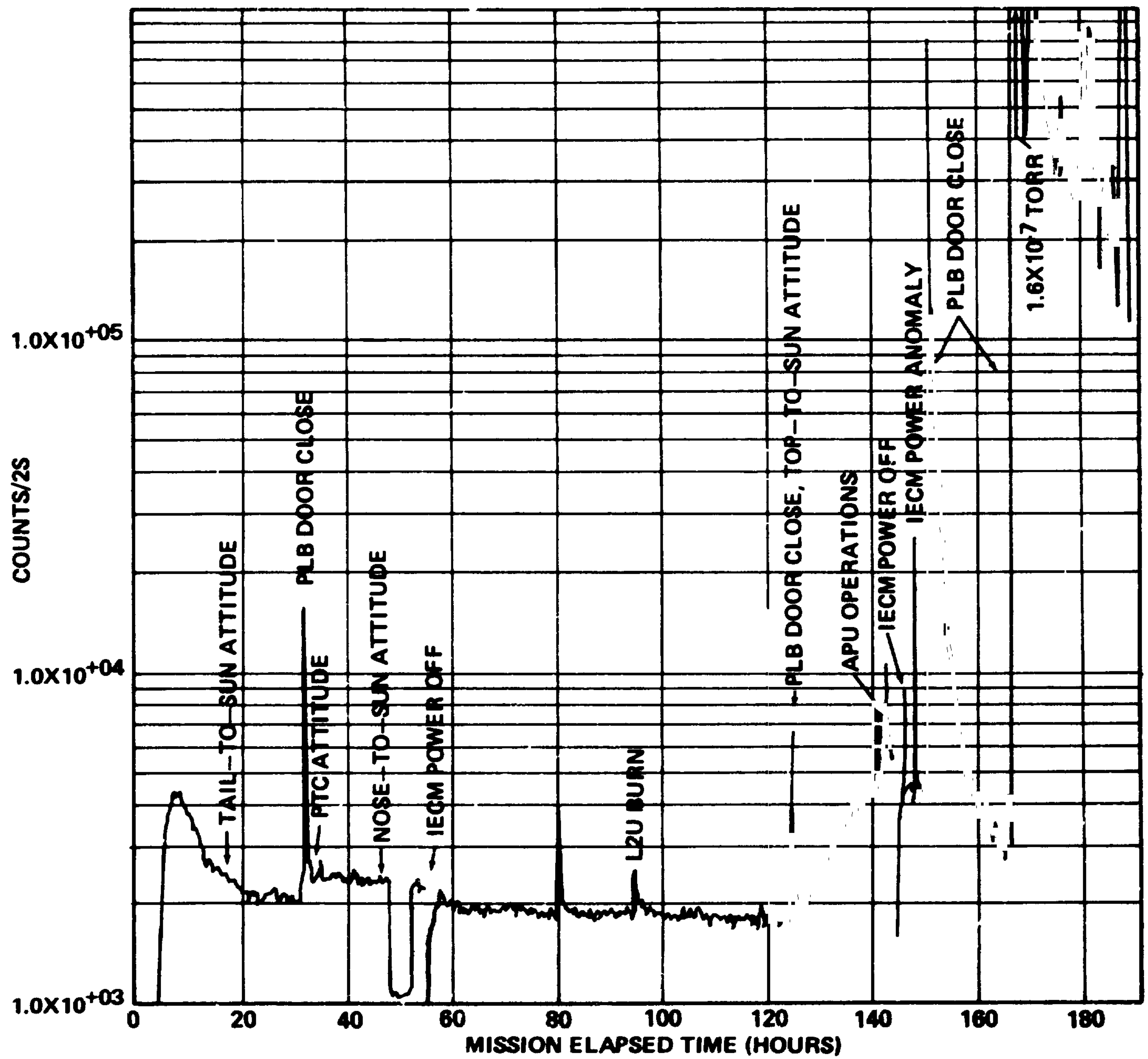
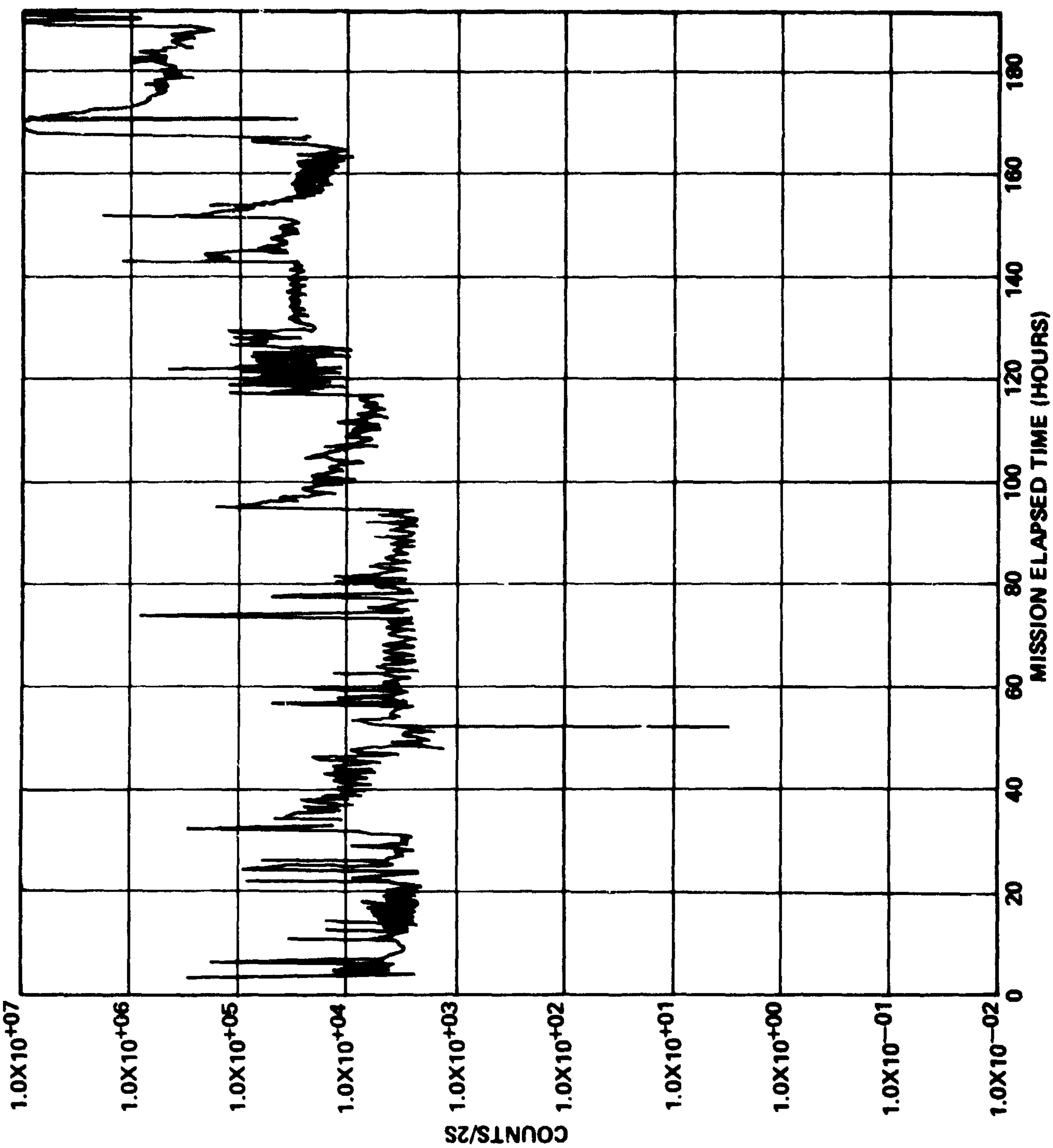


Figure X-1. IECM mass spectrometer flight STS-3 mass counts versus time at amu 18.



Figur^ X-2. IECM mass spectrometer flight STS-3 mass counts versus time at amu 16.

XI. SUMMARY

E. R. Miller

The overall results of the induced contamination environment remains encouraging. As on STS-2, low levels of humidity were detected, and there is no evidence of ingestion of combustion products into the payload bay on ascent or descent. Less dustfall was seen in the OPF, and the excessive particles <5 micrometers diameter detected on ascent and descent on the STS-2 mission were reduced to acceptable levels on STS-3. Again, there was no evidence of optical surface contamination, other than particulates, for the entire STS-3 mission. On-orbit particulates, as on STS-2, decreased rapidly during the first few hours and indicate periods of low frequency of occurrence. The Quartz Crystal Microbalances indicated generally low levels of mass accumulation, and the Mass Spectrometer measured much lower water molecule return flux than on STS-2. The presence of methane may be a result of atmospheric atomic oxygen reaction with hydrocarbons.

These quick-look results provide a general assessment of the contamination environment and its affects and do not take into account all of the activities which may contribute to IECM results. For example, the extensive use of the RMS and the unknown use of cargo bay lights may have contributed to the light background. In addition, the Orbiter maneuvers were calculated from an early postflight report and could contain errors. Also, the contamination contributions from the DFI and OSS-1 payloads and pallets are unknown.

XII. FUTURE PLANS

E. R. Miller

The IECM was refurbished after the STS-3 flight and mounted in the Columbia on May 5, 1982, in preparation for STS-4. The planned 7-day flight of STS-4 will provide further in-bay measurements of particles and gases. The gas release/maneuver is planned for STS-4. It is planned to perform the contamination mapping and engine plume surveys during the STS-4 mission.

After STS-4, the IECM will be integrated into the Spacelab 1 payload and will later make its final scheduled flight on Spacelab 2, measuring experiment-laden STS environments for a long Spacelab Module-plus-pallet and a pallet-only case, respectively.

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APPROVAL

STS-3 INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM) – QUICK-LOOK REPORT

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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.

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