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INDUCED ENVIRONMENT CONTAMINATION MONITOR  
ASCENT/ENTRY, OPTICAL AND DEPOSITION  
MEASUREMENTS

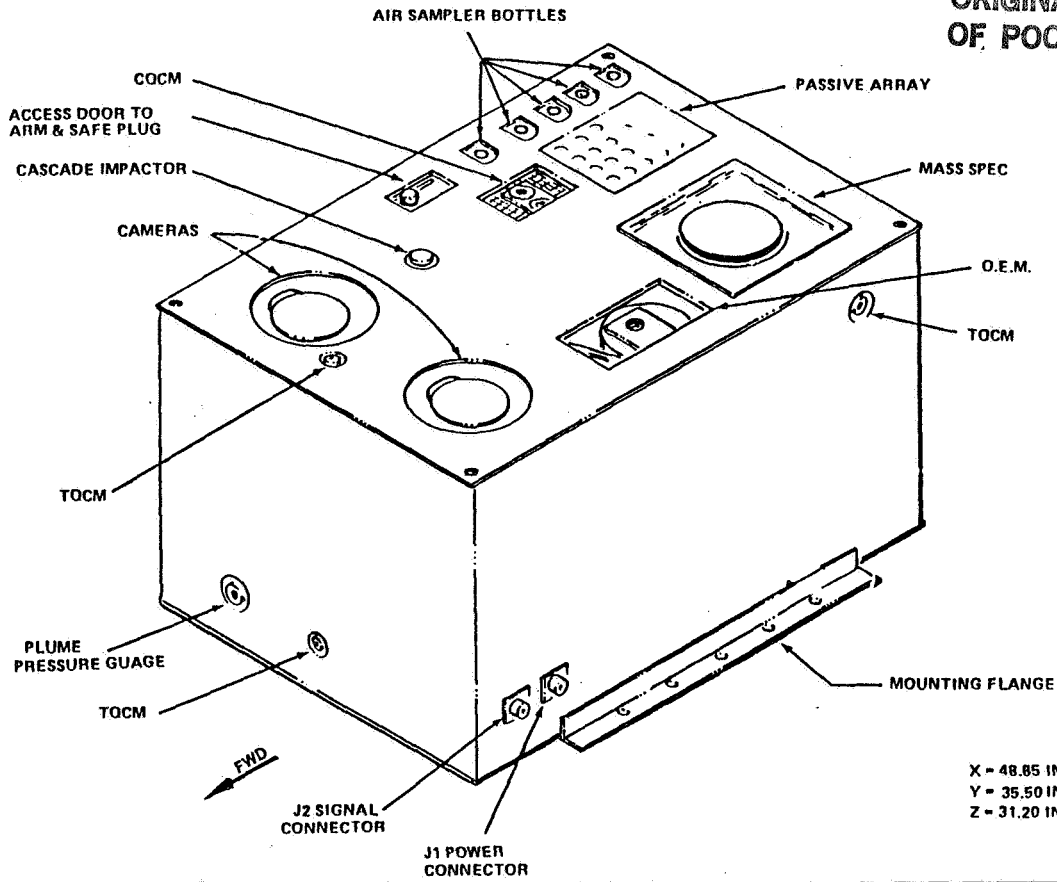
Edgar R. Miller  
Marshall Space Flight Center

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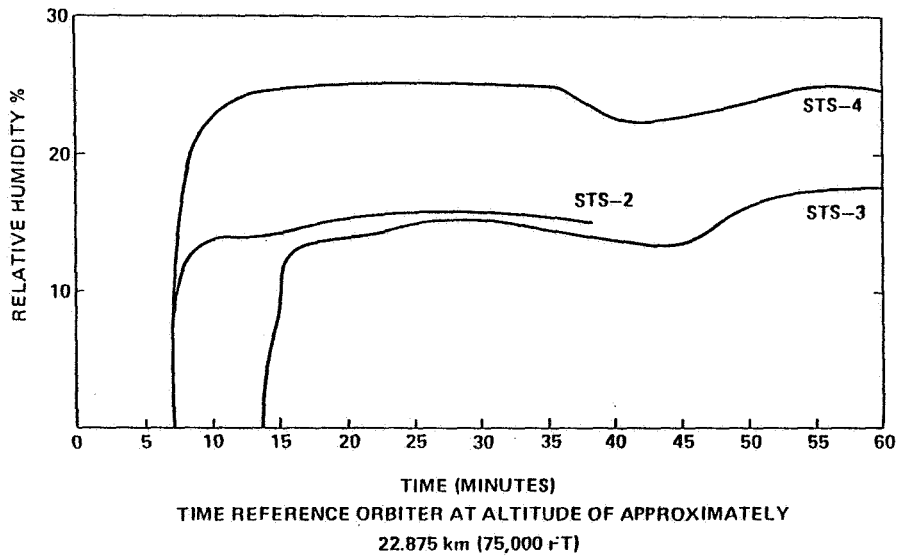


INDUCED ENVIRONMENT CONTAMINATION MONITOR

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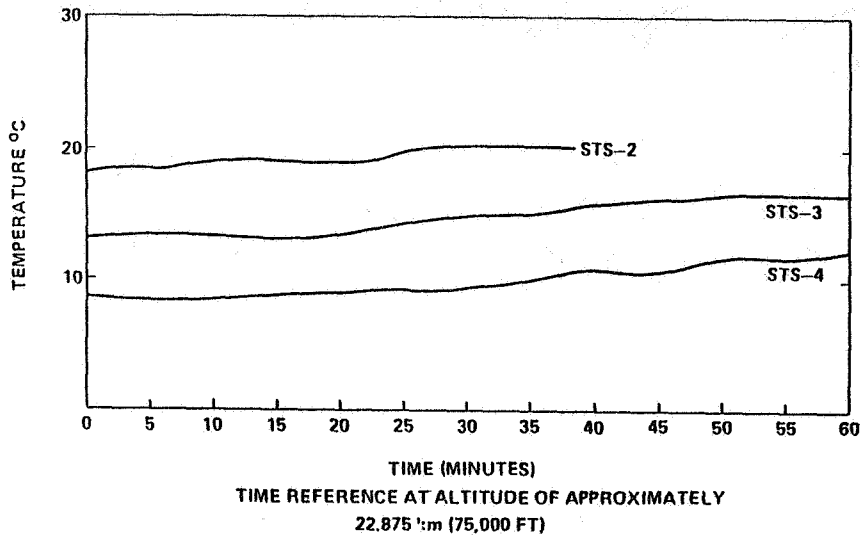
IECM ASCENT/REENTRY  
HUMIDITY MONITOR  
STS-2, STS-3, STS-4



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IECM ASCENT/REENTRY  
TEMPERATURE (IECM AIR SAMPLER)  
STS-2, STS-3, STS-4

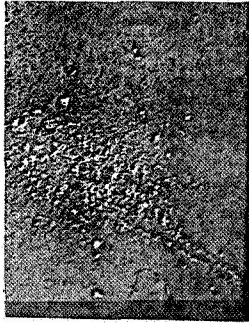
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IECM  
CASCADE IMPACTOR  
PARTICULATE MEASUREMENTS  
SUMMARY - STS-2, 3, 4

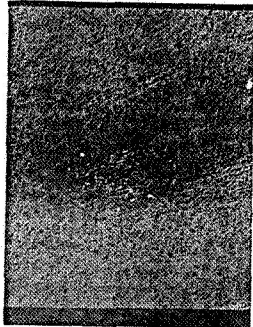
Measurement	Prediction	Flight Results																		
>5 $\mu$ size particulates	<375 $\mu\text{gms}/\text{m}^3$ (assuming $\bar{d}=25\mu$ $\rho=2\text{gms}/\text{cm}^3$ )	<table border="1"> <tr> <td>STS-2</td> <td>Ascent</td> <td><math>\sim 30 \mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td></td> <td>Descent</td> <td><math>\sim 10</math> "</td> </tr> <tr> <td>STS-3</td> <td>Ascent</td> <td><math>\sim 10</math> "</td> </tr> <tr> <td></td> <td>Descent</td> <td><math>\sim 10</math> "</td> </tr> <tr> <td>STS-4</td> <td>Ascent</td> <td>Non functional</td> </tr> <tr> <td></td> <td>Descent</td> <td><math>\sim 20 \mu\text{gms}/\text{m}^3</math></td> </tr> </table>	STS-2	Ascent	$\sim 30 \mu\text{gms}/\text{m}^3$		Descent	$\sim 10$ "	STS-3	Ascent	$\sim 10$ "		Descent	$\sim 10$ "	STS-4	Ascent	Non functional		Descent	$\sim 20 \mu\text{gms}/\text{m}^3$
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	Descent	$\sim 10$ "																		
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STS-4	Ascent	Non functional																		
	Descent	$\sim 20 \mu\text{gms}/\text{m}^3$																		
1 $\mu$ to 5 $\mu$ size particles	<100 $\mu\text{gms}/\text{m}^3$ (assuming $\bar{d}=5\mu$ $\rho=2 \text{gms}/\text{cm}^3$ )	<table border="1"> <tr> <td>STS-2</td> <td>Ascent</td> <td><math>\sim 500 \mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td></td> <td>Descent</td> <td><math>\sim 250^*</math> "</td> </tr> <tr> <td>STS-3</td> <td>Ascent</td> <td>&lt; 10 <math>\mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td></td> <td>Descent</td> <td>&lt; 10 "</td> </tr> <tr> <td>STS-4</td> <td>Ascent</td> <td><math>\sim 300 \mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td></td> <td>Descent</td> <td>&lt; 10 "</td> </tr> </table>	STS-2	Ascent	$\sim 500 \mu\text{gms}/\text{m}^3$		Descent	$\sim 250^*$ "	STS-3	Ascent	< 10 $\mu\text{gms}/\text{m}^3$		Descent	< 10 "	STS-4	Ascent	$\sim 300 \mu\text{gms}/\text{m}^3$		Descent	< 10 "
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0.3 $\mu$ to 1 $\mu$ size particles	<10 $\mu\text{gms}/\text{m}^3$ (assuming $d=1\mu$ $\rho=2 \text{gms}/\text{cm}^3$ )	<table border="1"> <tr> <td>STS-2</td> <td>Ascent</td> <td><math>\sim 250 \mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td></td> <td>Descent</td> <td><math>\sim 125^* \mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td>STS-3</td> <td>Ascent</td> <td>&lt; 10 <math>\mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td></td> <td>Descent</td> <td>&lt; 10 "</td> </tr> <tr> <td>STS-4</td> <td>Ascent</td> <td><math>\sim 90 \mu\text{gms}/\text{m}^3</math></td> </tr> <tr> <td></td> <td>Descent</td> <td>Non functional</td> </tr> </table>	STS-2	Ascent	$\sim 250 \mu\text{gms}/\text{m}^3$		Descent	$\sim 125^* \mu\text{gms}/\text{m}^3$	STS-3	Ascent	< 10 $\mu\text{gms}/\text{m}^3$		Descent	< 10 "	STS-4	Ascent	$\sim 90 \mu\text{gms}/\text{m}^3$		Descent	Non functional
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* Descent values may be largely instrumental (thermal), and should be considered upper limits.																				

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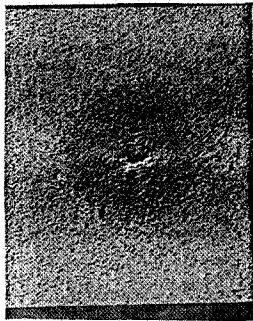


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STS-2, STAGE 2, POSTFLIGHT SENSING CRYSTAL  
SEM PHOTOGRAPH

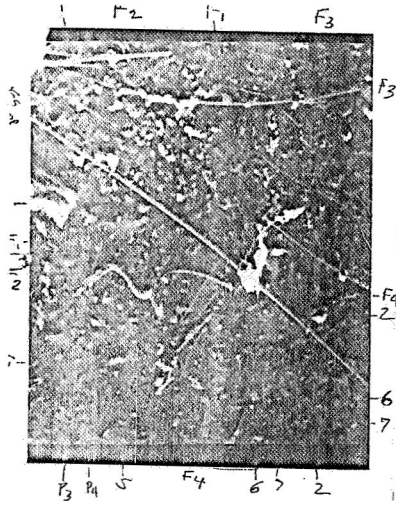


STS-2, STAGE 3, POSTFLIGHT SENSING CRYSTAL  
PHOTOGRAPH WITH SEM

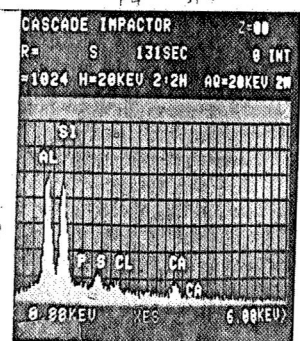
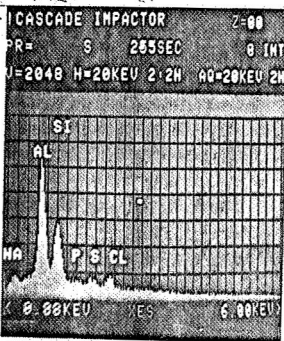
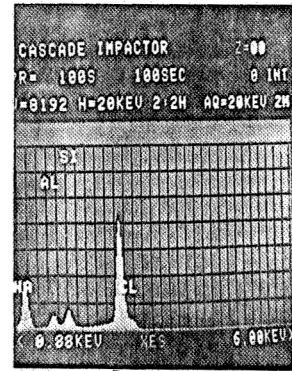
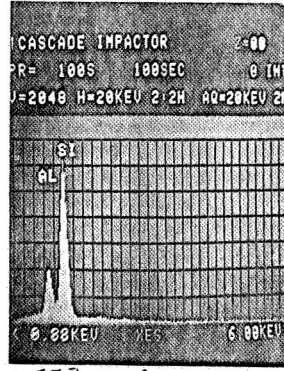


STS-2, STAGE 4, POSTFLIGHT SENSING CRYSTAL  
PHOTOGRAPH USING SEM

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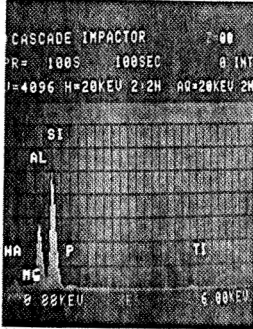
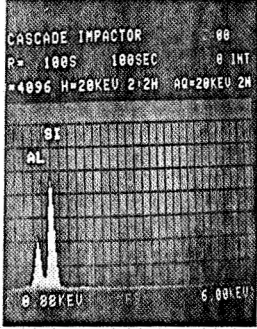
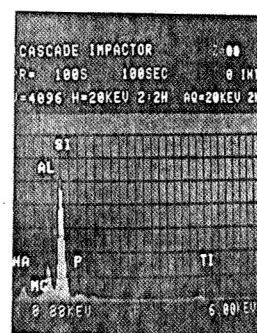
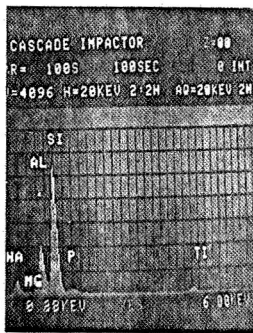
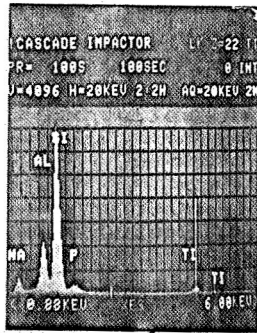


ENLARGEMENT OF AN AREA OF STAGE 3, STS-2, CONTAINING FIBERS, AND SPECTRA OF TYPICAL PARTICLES.



F3 STS

6 ST 3



SPECTRA OF VARIOUS  
FIBRES ON STAGE 3, STS-2

INDUCED ENVIRONMENT CONTAMINATION MONITOR

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Air Sampler Results  
Contaminant Totals for Representative  
STS Ground, Ascent, and Descent Phases

LOCATION	SPECIES	LEVELS EXPECTED, SPEC.	DETECTION* METHOD	OBSERVED
Ground	Volatile Hydrocarbonst	<15 PPM, <15 PPM in Purge Gas	A	<3 PPM by Wt. <1 PPM by Volumet
Ascent	Volatile Hydrocarbonst	Unknown, no Spec	A	~50 PPM by Wt. ~10 PPM by Volumet
Ascent	Reactive HCl	Unknown, no Spec	B	None detected to PPM sensitivity
Descent	Reactives NO, NO <sub>2</sub> , NH <sub>3</sub>	Unknown, no Spec	C	None detected to PPM sensitivity
Descent	Volatile Hydrocarbonst	Unknown, no Spec	A	~20 PPM by Wt. ~ 4 PPM by Volumet

\* A - Concentration on adsorbent; postflight GC/MS analysis.

B - Reaction with silver oxide/hydroxide surfaces; postflight analyses by ESCA.

C - Reaction with ruthenium trichloride surfaces; postflight analyses by ESCA.

† Covers C<sub>9</sub> to C<sub>24</sub> range and uses ~C<sub>12</sub> as average molecular weight to obtain PPM by volume.

IECM OPTICAL MEASUREMENTS

PASSIVE SAMPLE ARRAY

- AVERAGE CHANGE IN OPTICAL PROPERTIES:

PRE-LAUNCH ENVIRONMENT ----- ≤ 2%

FLIGHT MISSION ----- ≤ 1%

FERRY-FLIGHT ----- ≤ 1%

(MEASURED UNCERTAINTY ≈ 1%)

- NO MOLECULAR CONTAMINANT FILMS DETECTED
- MEASURED OPTICAL DEGRADATION ATTRIBUTED TO PARTICULATES

TECH OPTICAL MEASUREMENTS  
 PASSIVE SAMPLE ARRAY  
 FLIGHT MISSION RESULTS: STS-2, STS-3, STS-4

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Sample	Wavelength $\lambda$ (nm)	Range of AR ( $\pm 0.01$ uncertainty)	Average % Change
MgF <sub>2</sub> /Al (22 samples)	120	-0.07 to +0.03	+0.7%
	160	-0.01 to +0.04	+1.8%
	200	-0.03 to +0.02	+0.1%
	240	-0.04 to +0.01	-0.3%
	280	-0.06 to +0.01	-2.3%
Gold (18 samples)	120	-0.03 to +0.04	-1.7%
	160	-0.01 to +0.03	+0.9%
	200	-0.01 to +0.03	+4.2%
	240	-0.02 to +0.04	+0.9%
	280	-0.03 to +0.02	-0.1%

- MEASUREMENT UNCERTAINTY  $\pm 1\%$  (ABSOLUTE).
- MOST OF THE OBSERVED DEGRADATION ATTRIBUTED TO EFFECTS OF PARTICULATES.
- NO EVIDENCE FOUND FOR MOLECULAR FILM DEPOSITS.

TECH OPTICAL MEASUREMENTS  
 PASSIVE SAMPLE ARRAY

AVERAGED  
 PRE-FLIGHT EXPOSURE RESULTS

CONTAMINATION SPECIFICATION:

PARTICLE DENSITY - OPTICAL SURFACES

$\leq$  CLASS 300

- ORBITER PROCESSING FACILITY (OPF) AT KSC SUBJECTED TO CLEAN-UP FOLLOWING ROLL-OUT OF STS-2.
- DURING OPF OPERATIONS, SAMPLES AND INSTRUMENTS OF THE TECH DESIGNATED FOR FLIGHT WERE PROTECTED BY COVERS UNTIL FINAL ACCESS PRIOR TO ROLL-OUT.

STS-2	19 DAYS EXPOSURE: OPF $\rho = 1.4 \times 10^4$ PARTICLES/CM <sup>2</sup> CLASS 750 TO 1500
STS-3	19 DAYS EXPOSURE: OPF $\rho = 6.5 \times 10^3$ PARTICLES/CM <sup>2</sup> CLASS 500 TO 1500
STS-4	5 DAYS EXPOSURE: OPF $\rho = 1.3 \times 10^3$ /CM <sup>2</sup> CLASS 500 IN-TRANSIT OPF-PCR (26 DAYS) $\rho = 6.7 \times 10^2$ /CM <sup>2</sup> CLASS 200 16 DAYS EXPOSURE IN PCR $\rho = 5 \times 10^2$ /CM <sup>2</sup> CLASS 300 SAMPLES EXPOSED FROM 1ST ACCESS OPF + LAST ACCESS PCR $\rho = 2.7 \times 10^3$ /CM <sup>2</sup> CLASS 750



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IECM OPTICAL MEASUREMENTS  
 PASSIVE SAMPLE ARRAY  
 FLIGHT MISSION RESULTS: STS-2, STS-3, STS-4  
 AVERAGED

CONTAMINATION SPECIFICATION:

PARTICLE DENSITY - OPTICAL SURFACES

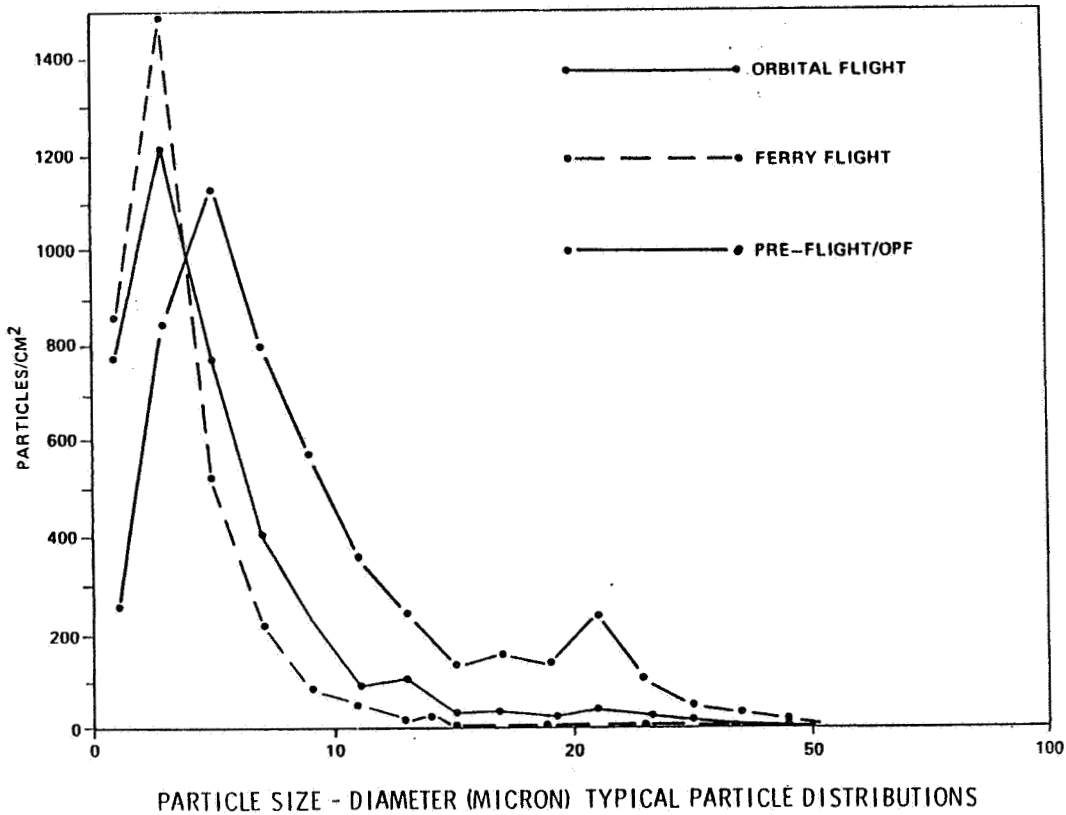
≤ CLASS 300

- MEASUREMENTS PERFORMED WITH OMNICON OPTICAL IMAGING PARTICLE COUNTING FACILITY.
- RESULTS SHOWN INDICATE DIFFERENCE IN LEVELS MEASURED ON SAMPLES EXPOSED TO ENTIRE MISSION VERSUS LEVELS IN SAMPLES EXPOSED ONLY ON FERRY-FLIGHT.

FLIGHT MISSION RESULTS

STS-1	$\rho = 1.7 \times 10^3$ PARTICLES/CM <sup>2</sup> <u>≤ CLASS 300</u>
STS-2	$\rho = 3.8 \times 10^3$ PARTICLES/CM <sup>2</sup> <u>≈ CLASS 300</u>
STS-3	$\rho = 2.7 \times 10^3$ PARTICLES/CM <sup>2</sup> <u>≈ CLASS 300</u>
STS-4	$\rho = 0.5 \times 10^3$ PARTICLES/CM <sup>2</sup> <u>&lt; CLASS 300</u>

IECM OPTICAL MEASUREMENTS



## IECM OPTICAL MEASUREMENTS

## OPTICAL EFFECTS MODULE

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SUMMARY OF RESULTS: STS-2, STS-3, STS-4

MISSION PHASE	AVERAGE CHANGE IN TRANSMITTANCE (253.7 nm)				
	EXPOSED SAMPLES			UNEXPOSED SAMPLES	
	<u>LiF<sub>2</sub></u>	<u>CaF<sub>2</sub></u>	<u>MgF<sub>2</sub></u>	<u>SAPPHIRE</u>	<u>QUARTZ</u>
● KSC/OPF: GROUND OPERATIONS	0%	0%	-1%	-1%	0%
● GROUND TO ORBIT	0%	-2%	-1%	0%	0%
● ON-ORBIT	0%	+1%	+1%	-3%	0%
● DESCENT/LANDING FERRY FLIGHT	-1%	-1%	0%	-1%	-1%
● TOTAL	-1%	-1%	-2%	-3%	-1%

- OEM SAMPLES LABELED "EXPOSED" REMAIN EXTERNAL TO OEM HOUSING 95% OF MISSION DURATION.
- FLIGHT DATA - SCATTER CHANNEL INDICATE NO ACCUMULATIONS OF PARTICLES GREATER THAN CLASS 300 SURFACE LEVELS.
- POST-FLIGHT PARTICLE COUNTS ON OEM SAMPLES INDICATE LEVELS NO GREATER THAN CLASS 300.
- EFFECTS OF DISCRETE SHUTTLE EVENTS NOT DETECTABLE DUE TO LIMITED MAGNITUDE OF MEASURED OPTICS VARIATIONS.

INDUCED ENVIRONMENT CONTAMINATION MONITOR  
OPTICAL MEASUREMENT CAMERA/PHOTOMETER

## TYPICAL QUESTIONS

WHAT IS THE SIZE DISTRIBUTION OF PARTICLES?

WHAT IS THE VELOCITY DISTRIBUTION OF PARTICLES?

WHAT OPTICAL EFFECTS, IF ANY, ARISE FROM A MOLECULAR CLOUD?

WHAT ARE THE SOURCES OF CONTAMINATION?

DO ALL MANEUVERS RESULT IN INCREASED CONTAMINATION?

HOW DOES THE CONTAMINATION VARY WITH MET?

HOW LONG AFTER LAUNCH DOES THE SPACECRAFT ENVIRONMENT CLEAR?

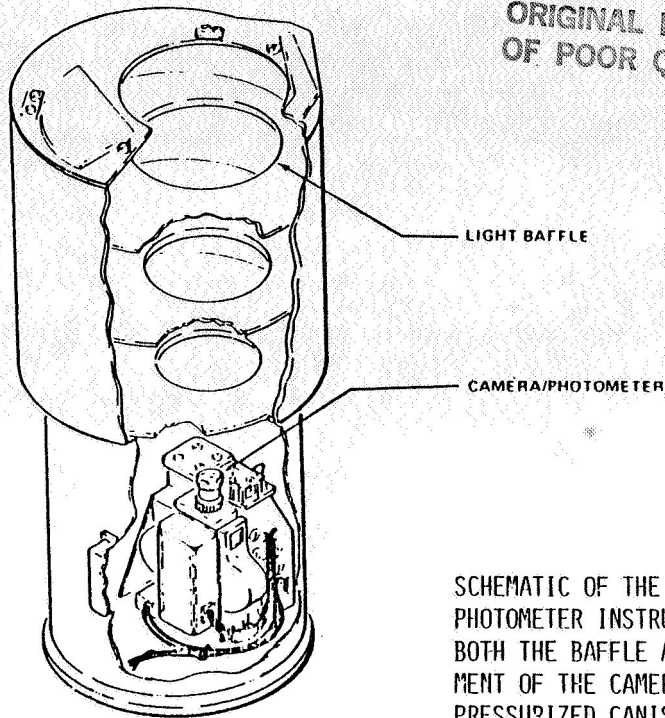
WHAT IS THE DECAY TIME OF CONTAMINATION DUE TO WATER DUMPS?

WHAT IS BRIGHTNESS BACKGROUND DUE TO CONTAMINATION?

1. TYPICAL QUESTIONS WHICH HOPEFULLY WILL BE ANSWERED BY THE CAMERA/  
PHOTOMETER EXPERIMENT ON THE IECM.

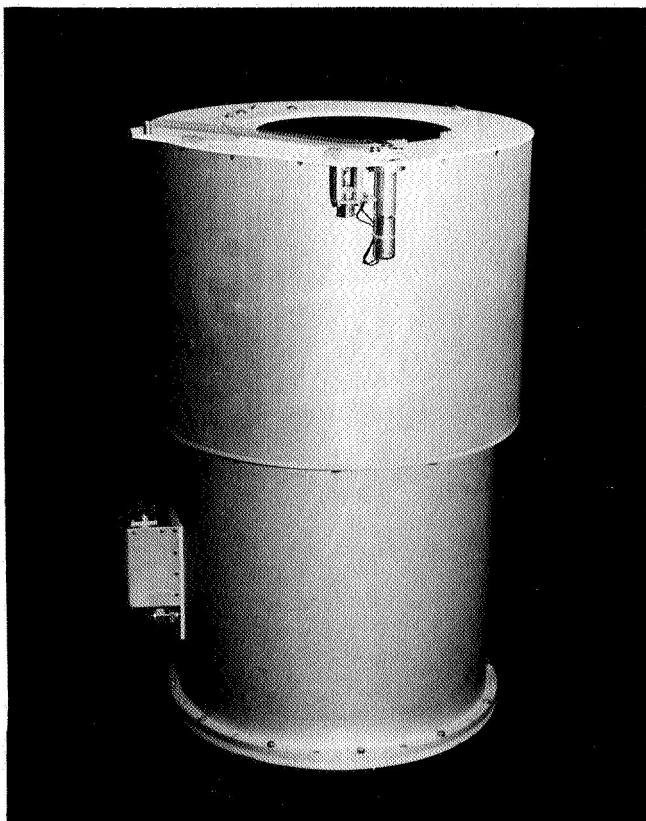
INDUCED ENVIRONMENT CONTAMINATION MONITOR  
OPTICAL MEASUREMENT CAMERA/PHOTOMETER

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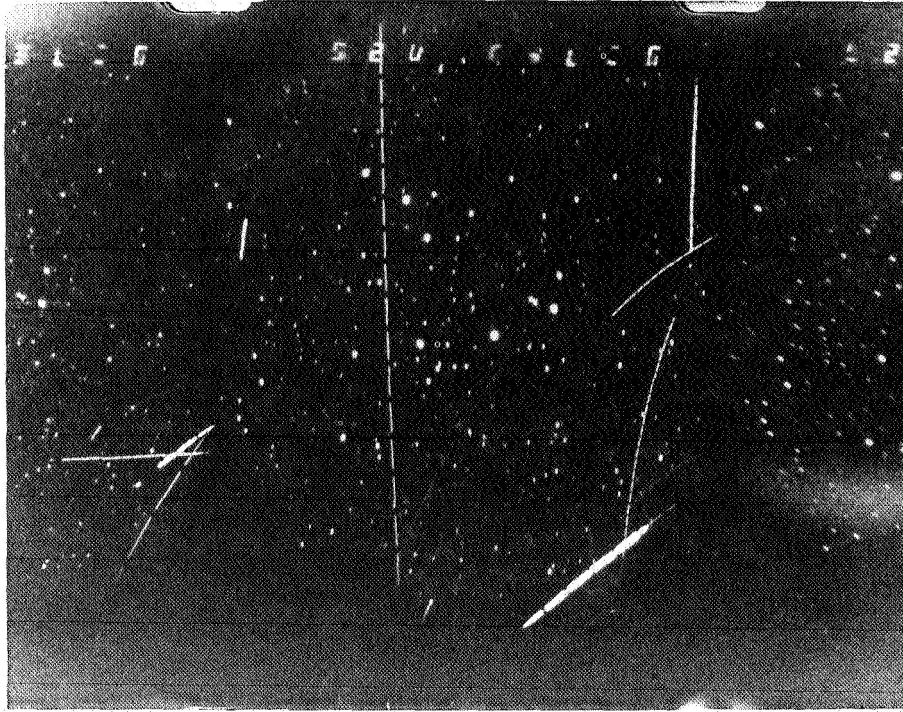
SCHEMATIC OF THE CAMERA/  
PHOTOMETER INSTRUMENT SHOWING  
BOTH THE BAFFLE AND THE PLACE-  
MENT OF THE CAMERA ON THE  
PRESSURIZED CANISTER.

Induced Environment Contamination Monitor Optical Measurement Camera/Photometer



Picture of the camera/  
photometer showing baffle  
and pressurized canister.  
A solar shutter to protect  
the instrument from high  
temperatures during solar  
orientation is seen at the  
top of the baffle.

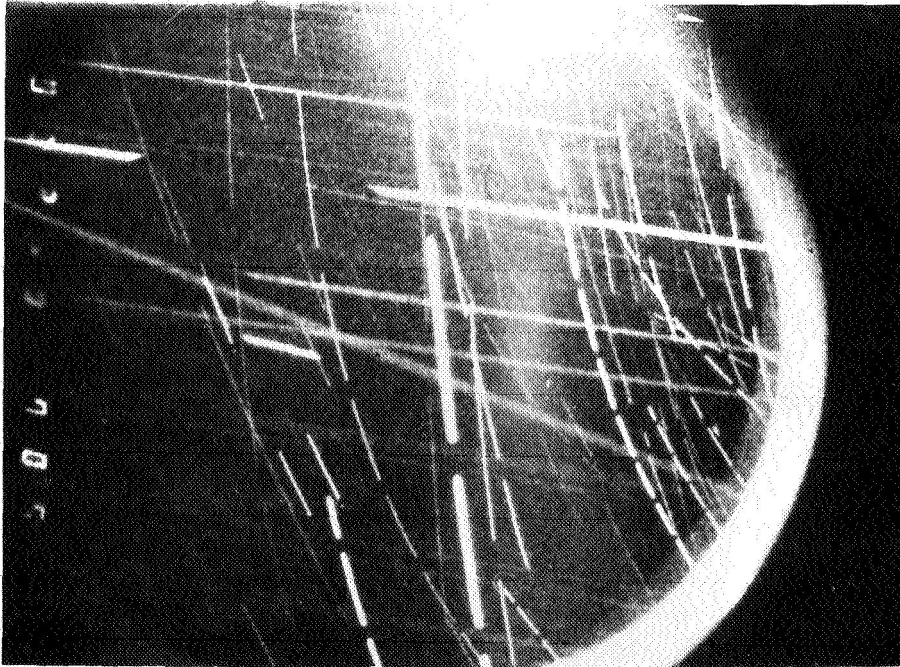
Induced Environment Contamination Monitor Optical Measurement Camera/Photometer



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One of the star fields observed during camera/photometer operation. Stars to the 10th magnitude were recorded by such observations during sunlit conditions.

Induced Environment Contamination Monitor Optical Measurement Camera/Photometer



"Snowstorm" of contaminant particles seen during the early portion of STS-2. The chopping action of the shutter can be seen from the segmented tracks of the particles. This allows the determination of particle velocity.

INDUCED ENVIRONMENT CONTAMINATION MONITOR  
OPTICAL MEASUREMENT CAMERA/PHOTOMETER

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Number of Events per Frame	Mission Elapsed Time								
	2-7h	7-12h	12-17h	17-22h	22-27h	27-32h	32-37h	37-42h	42-48h
x > 20	81%	25%	10%	3%	2%	0%	2%	0%	10%
20 > x > 10	8	12	4	6	3	2	2	0	0
10 > x > 5	6	16	5	1	2	5	0	0	5
5 > x > 2	0	32	11	5	11	10	2	0	10
1	5	9	22	14	12	12	7	3	5
0	0	6	48	71	70	71	87	97	70
Total Contamination	100	94	52	29	30	29	13	3	30

Data frames as a percentage of potential contamination frames as seen in the first 48 hours during STS-2, 3, and 4.

6. THE NUMBER OF FRAMES WITH X NUMBER OF EVENTS AS A PERCENTAGE OF POTENTIAL CONTAMINATION FRAMES. THE DATA IS A SUMMARY OF THE STS-2, 3, AND 4 MISSIONS DURING THE FIRST 48 HOURS OF THE RESPECTIVE MISSIONS.

INDUCED ENVIRONMENT CONTAMINATION MONITOR OPTICAL MEASUREMENT CAMERA/PHOTOMETER

ONBOARD SPACECRAFT EVENT	MISSION ELAPSED TIME (MET) HRS : MINS	ΔT TIME UNTIL OPPORTUNITY TO OBSERVE CONTAM	NUMBER OF POTENTIAL CONTAM. FRAMES RECORDED AT ΔT	NUMBER OF CONTAM. FRAMES	AMOUNT OF CONTAM. (PART/FR)
MANEUVERS PAYLOAD BAY DOOR TESTS	02:30	7			
	02:32	5	33	13	> 30
		60	1	1	> 30
		96	1	1	> 30
MANEUVER	04:15	45	1	1	> 15
		75	1	1	5
		135	2	2	5, 1
		165	1	1	> 15
OMS BURN	07:45 07:50	12	1	1	> 20
OMS BURN	08:33	1	1	1	20
MANEUVER	09:10	20	1	1	3
		55	1	1	10
		110	1	1	3
MANEUVER	11:00	34	1	1	1
H <sub>2</sub> O DUMP	11:53- 12:53	-	6	6	> 30

TABLE 3. CORRELATION OF OBSERVED CONTAMINATION WITH ON-BOARD SPACECRAFT EVENTS.

7. CORRELATION OF OBSERVED CONTAMINATION WITH ON-BOARD SPACECRAFT ACTIVITIES, SUCH AS MANEUVERS, WATER DUMPS, ENGINE BURNS, ETC. THE DATA WAS RECORDED DURING THE STS-2 MISSION.

INDUCED ENVIRONMENT CONTAMINATION MONITOR OPTICAL MEASUREMENT CAMERA/PHOTOMETER

ONBOARD SPACECRAFT EVENT	MISSION ELAPSED TIME (MET) HRS : MINS	ΔT TIME UNTIL OPPORTUNITY TO OBSERVE CONTAM.	NUMBER OF POTENTIAL CONTAM. FRAMES RECORDED AT ΔT	NUMBER OF CONTAM. FRAMES	AMOUNT OF CONTAM. (PART/FR)
MANEUVER	12:35	7	1	0	0
		75			
		150	1	0	0
		180	1	2	2
		240	1	0	0
		270	1	0	0
		330	1	0	0
MANEUVER	21:55	5	1	1	2
MANEUVER	22:18	40	1	0	0
RMS TESTS	23:00- 27:00	--	4	1	1
		150	1	0	0
		210	1	1	3
		240	2	0	0
		270	1	0	0
MANEUVER	32:05	25	1	0	0
		50	1	0	0

CONTINUED

8. CORRELATION OF OBSERVED CONTAMINATION WITH ON-BOARD SPACECRAFT ACTIVITIES, SUCH AS MANEUVERS, WATER DUMPS, ENGINE BURNS, ETC. THE DATA WAS RECORDED DURING THE STS-2 MISSION.

INDUCED ENVIRONMENT CONTAMINATION MONITOR OPTICAL MEASUREMENT CAMERA/PHOTOMETER

ONBOARD SPACECRAFT EVENT	MISSION ELAPSED TIME (MET) HRS : MINS	ΔT TIME UNTIL OPPORTUNITY TO OBSERVE CONTAM.	NUMBER OF POTENTIAL CONTAM. FRAMES RECORDED AT ΔT	NUMBER OF CONTAM. FRAMES	AMOUNT OF CONTAM. (PART/FR)
MANEUVER	38:55	4	1	0	0
		90	1	0	0
		150	2	0	0
		180	2	0	0
		240	1	0	0
		330	2	0	0
		360	2	0	0
		420	2	0	0
		450	2	0	0
		510	2	0	0
MANEUVER	45:51	6	1	1	1
MANEUVER	46:07	50	2	0	0
MANEUVER	47:21	6	2	0	0
		21	3	3	9, 2, 2
APU TEST	47:48- 47:52	1	4	4	1, 3 - > 30
		30	1	0	0
PAYLOAD BAY DOOR CLOSING	49:37	72	15	7	1, 2
		0	2	2	2

CONTINUED

9. CORRELATION OF OBSERVED CONTAMINATION WITH ON-BOARD SPACECRAFT ACTIVITIES, SUCH AS MANEUVERS, WATER DUMPS, ENGINE BURNS, ETC. THE DATA WAS RECORDED DURING THE STS-2 MISSION.

ORIGINAL PAGE IS  
OF POOR QUALITY

IECM OPTICAL MEASUREMENTS

CAMERA/PHOTOMETER

PRELIMINARY RESULTS

BACKGROUND BRIGHTNESS:  $\left\{ \begin{array}{l} \text{STS-2, 3: } 10^{-13} - 10^{-14} \text{ } \text{B}\theta \\ \text{STS-4 } 10^{-13} - 10^{-15} \text{ } \text{B}\theta \end{array} \right\}$  IN VISIBLE SPECTRUM

PARTICULATES: 0.01 25  $\mu\text{m}$  PARTICLE/ $1.5 \times 10^{-5}$  SR/ORBIT