(NASA-CR-141680) SL-4 S-190 SPECTRORADIOMETRIC ACCURACY (Lockheed Electronics Co.) 56 p HC $4.25 CSCL 03B

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TECHNICAL MEMORANDUM

SL-4 S-190 SPECTRORADIOMETRIC ACCURACY

By

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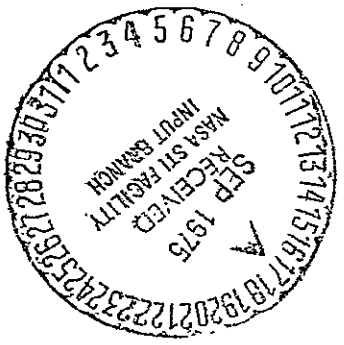

1.0 INTRODUCTION

With the acquisition of the SL-4 film data it became possible to complete the Skylab film data matrix, observe data trends and obtain a larger sampling of data for analysis. There were some gaps in the data matrix due to fogged sensitometry and for rolls 25, 26, 31, 32, 37, 38, 43 and 44 spectral sensitometry could not be used in the computer simulation of the I-B sensitometer since the spectral bandwidths reported in JL12-503 were narrower than those of the I-B sensitometer. Rolls 49, 50, 53, and 54 which were exposed during SL-4 without filters and subsequently processed differently than the rest were not included in the film data matrix. In this report only the SL-4 portion of the film data matrix is examined. An overall summary will be presented in the Skylab final report.

The procedure followed in determining radiometric accuracy consisted of two phases. In the first part, the I-B sensitometer was used as a calibrated radiometric target; while in the second, the moon was employed. Since the moon is a non-homogeneous target whose radiometric signature is not as well-known as the irradiants of the I-B sensitometer, the majority of this effort was directed towards the reduction and analysis of the sensitometric data.

2.0 RADIOMETRIC ACCURACY DETERMINATION

2.1 THEORY

The procedure for determining radiometric accuracy was to compare a known radiometric target to an estimate derived by simulating the photographic process using Van Krevald's Law. If processing and exposure conditions are held constant, the density resulting from an exposure is dependent on the spectral distribution of the irradiant and the spectral sensitivity of the film. Van Krevald's law can be considered as the projection of an irradiant spectral distribution into the exposure domain, by means of the equation

$$E_d = \frac{\Sigma\, M(\lambda)}{\Sigma_\lambda S_d(\lambda)\, M(\lambda)} = \frac{1}{\Sigma_\lambda S_d(\lambda)\, \overline{M}(\lambda)} \qquad (1)$$

where E_d is the energy at the film surface for a given density, d, $S_d(\lambda)$ is the sensitivity of the film, i.e., the inverse of the energy required to produce a given density, d, as a function of wavelength, λ, and $M(\lambda)$ (ergs/cm^2/nm) is the spectral distribution of the exposure and $\overline{M}(\lambda)$ is the normalized spectral distribution.

Since $M(\lambda) = W(\lambda)t$, where $W(\lambda)$ is the irradiant flux distribution (W/cm^2/nm), equation (1) can be written

$$E_d = \frac{1}{\Sigma_\lambda S_d(\lambda)\, \overline{W}(\lambda)} \qquad (1a)$$

Corrected to take into account the attenuation of the camera system, this equation becomes

$$E_d = \frac{4f^2/\P}{\Sigma_\lambda S_d(\lambda)\, T(\lambda)\, \overline{M}(\lambda)} = \frac{4f^2/\P}{\Sigma_\lambda S_d(\lambda)\, T(\lambda)\, \overline{W}(\lambda)} \qquad (2)$$

where $T(\lambda)$ is the total spectral transmission of the camera system, f is the f number of the camera.[1]

Rather than interpolate $S_d(\lambda)$ for a measured density, d, and generate an exposure, E, it was decided to compute exposure values as a function of density and interpolate the exposure corresponding to a measured density. A density vs. exposure function is thus produced which can be considered as a D-log E curve belonging to the input irradiance. Using this function the effect of changes is aperture and shutter speed can be quickly ascertained. Since $S_d(\lambda)$ values are themselves interpolated, the total number of interpolations are reduced and the error contribution due to interpolation is minimized.

[1] For a derivation of these equations see Skylab Program, Earth Resources Experiment Package, Sensor Performance Report, Vol. I (S190A), pg. 5.3ff.

2.2 EASTMAN I-B SENSITOMETER AND DATA SPECTROSENSITOMETER RADIOMETRIC ANALYSIS

The purpose of this effort was to compare the D-Log E curve produced by the Eastman I-B sensitometer to an estimate computed from the spectral sensitometer of the Data Corp. Spectrosensitometer Model 7001. As a repeatable and stable irradiance source, the I-B sensitometer could be used as a means for evaluating the accuracy of the Data Corp. spectrosensitometer. Although there were a few instances of anomalous behaviour on the part of the I-B sensitometer, on the whole it functioned as a reliable irradiance source. The intercomparison between the two instruments and an estimate of their accuracy will be included in the final report.

The D-Log E curve was simulated using equation (1a). The irradiants listed in table 2.1 were used as $W(\lambda)$. Estimates of exposure were generated using the pre- and post-mission spectral sensitometry. These results are summarized in tables 2.2-2.49 along with exposure values interpolated from the absolute D-Log E curve produced by the I-B sensitometer and the calculated error factors.

In the majority of cases, the error factor appears to be within 10%. Where there is a larger error factor it appears to affect rolls which have simila: processing and exposure, as in station 1 and 2 rolls 67, 68, 73, 74, 1A and 2A and all station 5 post-mission sensitometry. In these cases there is a bias of a constant error factor, indicating a miscalibration between the I-B sensitometer and the spectrosensitometer. This effect is being investigated for the final report.

2.3 LUNAR RADIOMETRIC ANALYSIS

In this effort the lunar disc was used as the irradiant, $\overline{W}(\lambda)$ in equation (2). The photographic data used was taken from lunar cal passes 4, rolls 55, 56, 59, 60 frames 001-018 and pass 5, rolls 55, 56, 59, 60 frames 390-407. The lunar phase angle during these two passes varied form 14.54^{o} 15.33^{o} for LC 4 and 13.30^{o} - 14.03^{o} for LC 5.

Two independent estimates of the energy incident to the camera system were computed. In the first, empirical measurement of phase angle dependency, geometric albedo and inverse square correction factors were used to determine the total irradiance for the spectral bandpass of each camera.[1] This estimate is found in column (1) of tables 2.50 and 2.51. The irradiances were converted to exposures, column (2) by multiplying by the shutter interval. The exposure corresponding to a measured density, column (3), is found in columns (4) and (5). These values were generated using Van Krevald's law with pre-mission sensitometry col. (4) and post-mission sensitometry, (5). Columns (6) and (7) contain error estimates using the pre- and post-mission sensitometry respectively.

[1] Lane, Adair P. and Irvine, William M., "Monochromatic Phase Curves and Albedos for the Lunar Disc" Astronomical Journal 78:3, p. 267ff.

In general the estimates of irradiance showed as much variation as the stability of the film between pre- and post-mission sensitometry. This indicates the criticality of the time factor in the calibration of film through sensitometry. It might be possible to correct for the shift in sensitivity by a linear factor. This however can not be ascertained from the Skylab data. Since stability of the film will be a problem also facing the Shuttle it is recommended that this effect be studied in depth.

3.0 CONCLUSIONS

The amount of radiometric accuracy possible in the S190A camera system is a function of the amount of care willing to be assumed in processing and exposing the film. For a radiometric target which is exposed within a short time interval of the sensitometric exposure, the accuracy can be under 10%. If this time interval is increased to 30-60 days as occurred during Skylab, the radiometric accuracy becomes a function of film stability and the error increases to 20% or more.

Some of the more basic problems facing radiometric calibration have been pointed out in this report. These problems need to be addressed before radiometric calibration of the photographic system can be accomplished on a wide scale.

TABLE 2.1 Eastman I-B Sensitometer Irradiants

Wavelength (Nanometers)	Irradiant J Station 1,2 5500° W89B (MW/CM^2/NM)	Irradiant Y Station 5 5500° W25 (MW/CM^2/NM)	Station 6 5500° W57 (MW/CM^2/NM)
460			7.75×10^{-4}
470			3.20×10^{-3}
480			1.46×10^{-2}
490			3.96×10^{-2}
500			7.06×10^{-2}
510			9.13×10^{-2}
520			9.78×10^{-2}
530			9.58×10^{-2}
540			9.07×10^{-2}
550			8.50×10^{-2}
560			8.06×10^{-2}
570			6.43×10^{-2}
580		2.30×10^{-3}	5.13×10^{-2}
590		9.64×10^{-3}	2.84×10^{-2}
600		8.31×10^{-2}	1.70×10^{-2}
610		1.34×10^{-1}	8.84×10^{-3}
620		1.46×10^{-1}	4.05×10^{-3}
630		1.42×10^{-1}	1.65×10^{-3}
640		1.35×10^{-1}	7.10×10^{-4}
650		1.17×10^{-1}	7.10×10^{-4}
660		1.20×10^{-1}	7.35×10^{-4}
670		1.24×10^{-1}	7.60×10^{-4}
680		1.34×10^{-1}	8.25×10^{-4}
690		1.41×10^{-1}	8.65×10^{-4}
700	1.31×10^{-2}	1.43×10^{-1}	8.90×10^{-4}
710	4.48×10^{-2}	1.37×10^{-1}	8.50×10^{-4}
720	8.42×10^{-2}	1.31×10^{-1}	3.20×10^{-3}
730	9.54×10^{-2}	1.20×10^{-1}	8.70×10^{-3}
740	1.03×10^{-1}	1.15×10^{-1}	2.06×10^{-2}
750	1.02×10^{-1}	1.10×10^{-1}	3.80×10^{-2}
760	1.04×10^{-1}	1.09×10^{-1}	5.37×10^{-2}
770	1.01×10^{-1}	1.04×10^{-1}	6.32×10^{-2}
780	1.05×10^{-1}	1.07×10^{-1}	6.90×10^{-2}
790	1.01×10^{-1}	1.04×10^{-1}	7.13×10^{-2}
800	9.74×10^{-2}	9.97×10^{-2}	7.39×10^{-2}
810	9.32×10^{-2}	9.52×10^{-2}	7.04×10^{-2}
820	9.04×10^{-2}	9.23×10^{-2}	6.72×10^{-2}
830	8.73×10^{-2}	8.90×10^{-2}	6.60×10^{-2}
840	8.61×10^{-2}	8.77×10^{-2}	6.52×10^{-2}
850	8.22×10^{-2}	8.37×10^{-2}	6.18×10^{-2}
860	7.80×10^{-2}	7.93×10^{-2}	5.83×10^{-2}
870	7.63×10^{-2}	7.75×10^{-2}	5.76×10^{-2}
880	7.44×10^{-2}	7.57×10^{-2}	5.68×10^{-2}
890	7.01×10^{-2}	7.12×10^{-2}	5.61×10^{-2}
900	6.82×10^{-2}	6.92×10^{-2}	5.54×10^{-2}

TABLE 2.2 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 55, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.6	-1.4625	-1.4467	.0158	1.037
.7	-1.3545	-1.3400	.0148	1.034
.8	-1.2734	-1.2760	-.0026	.994
.9	-1.2045	-1.2120	-.0075	.983
1.0	-1.1419	-1.1443	-.0024	.994
1.2	-1.0248	-1.0087	.0161	1.038
1.4	-.9086	-.9020	.0066	1.0153
1.6	-.7847	-.7900	-.0053	.988
1.8	-.6396	-.6691	-.0295	.934
2.0	-.4649	-.5244	-.0595	.948

TABLE 2.3 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 55, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.4077	-1.3933	.0144	1.034
.6	-1.2042	-1.1675	.0367	1.088
.7	-1.0665	-1.0425	.0240	1.057
.8	-.9561	-.9500	.0061	1.014
1.0	-.7779	-.7862	-.0083	.985
1.2	-.6332	-.6523	-.0191	.957
1.4	-.4976	-.5333	-.0357	.921
1.6	-.3522	-.4000	-.0478	.896
1.8	-.1955	-.2636	-.0681	.855
2.0	.0295	-.0900	-.1195	.759

TABLE 2.4 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 56, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.6	-1.4382	-1.4429	-.0047	.9892
.7	-1.3318	-1.3320	-.0002	.9995
.8	-1.2499	-1.2520	-.0021	.9952
.9	-1.1795	-1.1740	.0055	1.0127
1.0	-1.1154	-1.1140	.0014	1.0032
1.2	-.9965	-.9957	.0008	1.0018
1.4	-.8781	-.8814	-.0033	.9924
1.6	-.7549	-.7633	-.0084	.9808
1.8	-.6156	-.6413	-.0257	.9425
2.0	-.4470	-.4977	-.0507	.8898

TABLE 2.5 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 56, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.3390	-1.4040	-.0650	.8610
.6	-1.1647	-1.1978	-.0331	.9266
.7	-1.0341	-1.0573	-.0232	.9480
.8	-.9248	-.9626	-.0378	.9166
1.0	-.7470	-.8074	-.0604	.8702
1.2	-.5989	-.6754	-.0765	.8385
1.4	-.4575	-.5600	-.1025	.7898
1.6	-.3043	-.4320	-.1277	.7452
1.8	-.1371	-.2875	-.1504	.7073
2.0	.3289	-.1088		

TABLE 2.6 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: So-022
Roll: 59, Pre Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-.8585	-.8433	.0152	1.0356
.6	-.6402	-.6258	.0144	1.0337
.8	-.4789	-.4796	-.0006	.9986
1.0	-.3485	-.3557	-.0072	.9836
1.3	-.1730	-.1755	-.0025	.9943
1.7	.0669	.0634	.0035	1.0081
2.0	.2710	.2580	.0130	1.0304
2.3	.5085	.4611	.0474	1.1153
2.6	.8360	.7600	.0760	1.1912
2.9	1.2868	1.16	.1268	1.3391

TABLE 2.7 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: So-002
Roll: 59, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-1.1308	-1.0167	.1141	1.3005
.6	-.8890	-.7853	.1037	1.2697
.8	-.7084	-.6227	.0857	1.2181
1.0	-.5599	-.4885	.0714	1.1787
1.3	-.3709	-.3038	.0671	1.1671
1.7	-.1184	-.0800	.0384	1.0924
2.0	+.0930	.1018	.0088	1.0205
2.3	.3623	.3268	-.0355	.9215
2.6	.6764	.6375	-.0389	.9143
2.9	1.2013	1.1038	-.0975	.7989

TABLE 2.8 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 60, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-.7581	-.8467	-.0886	.8154
.6	-.5370	-.6120	-.0750	.8414
.8	-.3740	-.4564	-.0824	.8272
1.0	-.2356	-.3277	-.0921	.8089
1.3	-.0454	-.1384	-.0930	.8072
1.7	.2081	.1177	-.0904	.8121
2.0	.4241	.3100	-.1141	.7690
2.3	.7000	.5294	-.1706	.6751
2.6	1.0599	.8200	-.2399	.5756
2.9	1.4316	1.2567	-.1749	.6685

TABLE 2.9 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 60, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_{c_2} Ergs/cm^2	Log Exposure (Sensitometry) Log E_{s_2} Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s/E_c
.4	-1.0099	- .9800	.0299	1.0713
.6	- .7719	- .7311	.0408	1.0985
.8	- .5998	- .5667	.0331	1.0792
1.0	- .4533	- .4333	.0200	1.0471
1.3	- .2537	- .2408	.0129	1.0301
1.7	.0114	.0038	-.0076	.9827
2.0	.2347	.1908	.0439	.9039
2.3	.5092	.4356	.0736	.8441
2.6	.8886	.7675	.1211	.7567
2.9		1.2525		

TABLE 2.10 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 61, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c	Exposure Ratio E_s / E_c
.6	-1.4774	-1.4893	-.0119	.9730
.7	-1.3657	-1.3827	-.0170	.9616
.8	-1.2814	-1.2964	-.0150	.9661
.9	-1.2098	-1.2236	-.0138	.9687
1.0	-1.1446	-1.1560	-.0114	.9741
1.1		-1.0960		
1.2	-1.0222	-1.0360	-.0138	.9687
1.4	-.9013	-.9214	-.0201	.9548
1.6	-.7743	-.8048	-.0305	.9322
1.8	-.6286	-.6839	-.0553	.8804
2.0	-.4457	-.5506	-.1049	.7854

TABLE 2.11 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 61, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.45703	-1.4360	.021	1.0500
.6	-1.2299	-1.2156	.0143	1.0335
.7	-1.0080	-1.0943	-.0063	.9856
.8	-.9738	-.9924	-.0186	.9581
1.0	-.7842	-.8233	-.0391	.9139
1.2	-.6283	-.6920	-.0637	.8636
1.4	-.4785	-.5720	-.0935	.8063
1.6	-.3325	-.4084	-.0759	.8397
1.8	-.1526	-.2761	-.1235	.7525
2.0	.2178	-.0994		

TABLE 2.12 COMPARISON OF EXPOSURE GENERATED BY VAN KRAVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 62, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.6	-1.4890	-1.4542	.0348	1.0834
.7	-1.3756	-1.3400	.0356	1.0854
.8	-1.2912	-1.2733	.0179	1.0421
.9	-1.2203	-1.2067	.0136	1.0318
1.0	-1.1565	-1.1440	.0125	1.0292
1.2	-1.0387	-1.0244	.0143	1.0334
1.4	-.9237	-.9141	.0096	1.0223
1.6	-.8020	-.7962	.0058	1.0134
1.8	-.6697	-.6740	-.0043	.9901
2.0	-.5130	-.5500	-.0370	.9183

TABLE 2.13 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 62, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.4723	-1.4200	.0523	1.1280
.6	-1.2540	-1.2156	.0384	1.0924
.7	-1.1115	-1.0942	.0173	1.0406
.8	-.9979	-.9963	.0016	1.0037
1.0	-.8141	-.8336	-.0196	.9561
1.2	-.6639	-.6913	-.0274	.9389
1.4	-.5235	-.5663	-.0428	.9061
1.6	-.3743	-.4333	-.0590	.8730
1.8	-.2166	-.2929	-.0763	.8389
2.0	-.0029	-.1182	-.1153	.7668

TABLE 2.14 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 65, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-1.1432	-1.0300	.1132	1.2978
.6	- .9093	- .7947	.1146	1.3020
.8	- .7463	- .6300	.1163	1.3071
1.0	- .5941	- .4946	.0995	1.2575
1.3	- .3997	- .3130	.0867	1.2210
1.7	- .1463	- .0800	.0663	1.1649
2.0	.0626	.1078	.0452	1.1097
2.3	.3239	.3317	.0078	1.0181
2.6	.6653	.6375	-.0278	.9380
2.9	1.1903	1.1171	-.0732	.8449

TABLE 2.15 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY

Film: SO-022

Roll: 66, Pre-Mission Sensitometry

D Density	Log Exposure (Calculated) Ergs/cm^2	Log Exposure (Sensitometry) Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s/E_c
.40	-.8710	-.8564	.0146	1.0342
.60	-.6419	-.6200	.0219	1.0517
.80	-.4710	-.4581	.0129	1.0301
1.00	-.3312	-.3277	.0035	1.0081
1.30	-.1458	-.1431	.0027	1.0062
1.70	.1020	.0992	-.0028	1.9936
2.00	.3063	.2900	-.0163	.9632
2.30	.5524	.4986	-.0538	.8835
2.60	.8746	.7871	-.0875	.8175
2.90	1.3213	1.1963	-.1250	.7499

TABLE 2.16 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY

Film: SO-022

Roll: 66, Post-Mission Sensitometry

D Density	Log Exposure (Calculated) Ergs/cm^2	Log Exposure (Sensitometry) Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s/E_c
.40	-1.1704	-1.1189	.0515	1.1259
.60	- .9272	- .8700	.0572	1.1408
.80	- .7487	- .7033	.0454	1.1102
1.00	- .5954	- .5700	.0254	1.0602
1.30	- .4028	- .3715	.0310	1.0740
1.70	- .1561	- .1356	.0205	1.0483
2.00	.0485	.0480	-.0005	.9988
2.30	.3062	.2753	-.0309	.9313
2.60	.6358	.5875	-.0483	.8947
2.90	1.1631	1.0529	-.1102	.7759

TABLE 2.17 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 67, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.6	-1.4573	-1.1693	.2880	1.9409
.7	-1.3540	-1.0621	.2919	1.9584
.8	-1.2736	-.9791	.2945	1.9702
.9	-1.2043	-.9064	.2979	1.9856
1.0	-1.1411	-.8404	.3007	1.9985
1.2	-1.0229	-.7219	.3010	1.9999
1.4	-.9063	-.6169	.2894	1.9472
1.6	-.7808	-.5046	.2962	1.8889
1.8	-.6415	-.3804	.2611	1.8243
2.0	-.4720	-.2500	.2220	1.6672

TABLE 2.18 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 67, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.39243	-1.4200	-.0276	.9384
.6	-1.1992	-1.2000	-.0008	.9982
.7	-1.0644	-1.0762	-.0118	.9732
.8	-.95272	-.9795	-.0268	.9402
1.0	-.7646	-.8213	-.0567	.8776
1.2	-.6072	-.6850	-.0778	.8360
1.4	-.4664	-.5600	-.0936	.8061
1.6	-.3222	-.4320	-.1098	.7766
1.8	-.1683	-.2977	-.1294	.7423
2.0	.1309	-.1200	-.2509	.5612

TABLE 2.19 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY

Film: 2424
Roll: 68, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5		-1.3200		
.6	-1.4310	-1.1550	.2760	1.8880
.7	-1.3309	-1.0300	.3009	1.9994
.8	-1.2508	-.9573	.2935	1.9656
.9	-1.1807	-.8845	.2962	1.9779
1.0	-1.1165	-.8226	.2939	1.9674
1.2	-.9963	-.7050	.2913	1.9557
1.4	-.8776	-.6050	.2726	1.8733
1.6	-.7509	-.4993	.2516	1.7848
1.8	-.6022	-.3870	.2152	1.6413
2.0	-.4235	-.2565	.1670	1.4689

TABLE 2.20 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 68, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4		-2.46		
.5	-1.3631	-1.3857	-.0226	.9493
.6	-1.1759	-1.1978	-.0219	.9500
.7	-1.0407	-1.0762	-.0355	.9215
.8	-.9294	-.9767	-.0473	.8968
.9		-.8878		
1.0	-.7494	-.8167	-.0673	.8564
1.2	-.6023	-.6860	-.0837	.8247
1.4	-.4647	-.5660	-.1013	.7920
1.6	-.3179	-.4384	-.1205	.7577
1.8	-.1584	-.3045	-.1461	.7143
2.0	.1684	-.1220	-.2904	.5124

TABLE 2.21 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 71, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	- .8490	- .8331	.0159	1.0372
.5		- .7100		
.6	- .6322	- .6211	.0111	1.0259
.8	- .4755	- .4665	.0090	1.0209
1.0	- .3459	- .3367	.0092	1.0214
1.3	- .1724	- .1580	.0144	1.0337
1.7	.0651	.0800	.0149	1.0349
2.0	.2683	.2726	.0043	1.0100
2.3	.5066	.4860	-.0206	.9537
2.6	.8110	.7800	-.0310	.9311
2.9	1.2885	1.1814	-.1071	.7814

TABLE 2.22 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 71, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-1.1368	-1.0167	.1201	1.3186
.6	- .8975	- .7853	.1122	1.2948
.8	- .7194	- .6227	.0967	1.2494
.9		- .5500		
1.0	- .5733	- .4885	.0848	1.2156
1.3	- .3872	- .3038	.0834	1.2117
1.7	- .1451	- .0738	.0713	1.1784
2.0	.0554	.1148	.0594	1.1466
2.3	.3151	.3525	.0374	1.0899
2.6	.6348	.6423	.0075	1.0174
2.9	1.1434	1.1225	-.0209	.9530

TABLE 2.23 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 72, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio $E_s - E_c$
.3		-1.0600		
.4	- .8462	- .8564	-.0102	.9768
.6	- .5981	- .6200	-.0219	.9508
.8	- .4270	- .4581	-.0311	.9309
1.0	- .2874	- .3277	-.0403	.9114
1.3	- .0943	- .1474	-.0531	.8849
1.7	.1687	.0869	-.0818	.8283
1.9		.2100		
2.0	.3665	.2796	-.0869	.8187
2.3	.5919	.4914	-.1005	.7934
2.6	.9071	.7764	-.1307	.7401
2.9	1.3653	1.1900	-.1753	.6679

TABLE 2.24 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 72, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio $E_s - E_c$
.4	-1.1726	-1.0280	.0846	1.2151
.6	- .8329	- .7629	.0700	1.1749
.8	- .6555	- .5884	.0671	1.1671
1.0	- .5098	- .4478	.0620	1.1535
1.3	- .3146	- .2538	.0608	1.1503
1.7	- .0598	- .0167	.0431	1.1043
2.0	.1482	.1652	.0170	1.0499
2.3	.3926	.3965	.0039	1.0090
2.6	.7168	.6936	-.0232	.9480
2.9	1.2360	1.1614	-.0746	.8422

TABLE 2.25 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 73, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5		-1.3933		
.6	-1.4629	-1.1978	.2651	1.8412
.7	-1.3510	-1.0762	.2748	1.8828
.8	-1.2657	-.9795	.2862	1.9329
.9	-1.1932	-.8953	.2979	1.9856
1.0	-1.1279	-.8213	.3066	2.0258
1.2	-1.0089	-.6860	.3229	2.1033
1.4	-.8931	-.5660	.3271	2.1237
1.6	-.7718	-.4278	.3440	2.208
1.8	-.6308	-.2857	.3451	2.2136
2.0	-.4626	-.1088	.3538	2.2584

TABLE 2.26. COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 73, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.4349	-1.0227	.4122	2.5834
.6	-1.2334	-.9718	.2616	1.8264
.7	-1.0971	-.8773	.2198	1.6588
.8	-.9851	-.8203	.1648	1.4615
.9		-.7652		
1.0	-.8008	-.7100	.0908	1.2325
1.2	-.6497	-.6100	.0397	1.0957
1.3		-.5600		
1.4	-.5072	-.5067	.0005	1.0012
1.6	-.3534	-.4000	-.0466	.8983
1.8	-.185[illegible]	-.2696	-.0838	.8245
2.0	.087[illegible]	-.1140	-.2017	.6285

TABLE 2.27 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 74, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.6	-1.4684	-1.1300	.3384	2.1797
.7	-1.3554	-1.0148	.3406	2.1908
.8	-1.2707	-.9386	.3321	2.1483
.9	-1.1990	-.8636	.3354	2.1647
1.0	-1.1341	-.7996	.3345	2.1602
1.2	-1.0140	-.6800	.3340	2.1577
1.4	-.8972	-.5800	.3172	2.0759
1.6	-.7731	-.4576	.3155	2.0678
1.8	-.6364	-.3340	.3024	2.0063
2.0	-.4722	-.1935	.2787	1.8998

TABLE 2.28 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 74, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4		-2.1300		
.5	-1.5070	-1.3400	.1670	1.4689
.6	-1.2664	-1.1586	.1078	1.2817
.7	-1.1170	-1.0514	.0656	1.1631
.8	-.9976	-.9547	.0429	1.1038
.9		-.8633		
1.0	-.8076	-.7967	.0109	1.0254
1.2	-.6565	-.6680	-.0115	.9739
1.4	-.5167	-.5461	-.0294	.9345
1.6	-.3690	-.4070	-.0380	.9162
1.8	-.2121	-.2761	-.0640	.8630
2.0	.0044	-.0900	-.0856	.8211

TABLE 2.29 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 77, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio $E_s - E_c$
.3		-1.03		
.4	- .8542	- .8300	.0242	1.0573
.6	- .6342	- .6174	.0168	1.0394
.8	- .4705	- .4700	.0005	1.0012
1.0	- .3399	- .3408	-.0009	.9979
1.3	- .1643	- .1550	.0093	1.0216
1.7	.0771	.0800	.0029	1.0067
2.0	- .2843	.2726	-.0117	.9734
2.3	.5304	.5029	-.0275	.9386
2.6	.8782	.7985	-.0797	.8323
2.9	1.4227	1.2100	-.2127	.6128

TABLE 2.30 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 77, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio $E_s - E_c$
4	-1.1333	-1.0033	.1300	1.3490
.5		- .8700		
.6	- .8959	- .7500	.1459	1.3992
.8	- .7202	- .6082	.1120	1.2942
1.0	- .5699	- .4732	.0967	1.2494
1.3	- .3767	- .2893	.0874	1.2229
1.4		- .2300		
1.7	- .1245	- .0062	.1183	1.3131
2.0	.0844	.1357	.0513	1.1254
2.3	.3479	.3650	.0171	1.0402
2.6	.7042	.6885	-.0157	.9645
2.9	1.3175	1.2100	-.1075	.7807

TABLE 2.31 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 78, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	- .7583	- .8273	-.0690	.8531
.6	- .5370	- .6000	-.0630	.8650
.8	- .3736	- .4429	-.0693	.8525
1.0	- .2327	- .3154	-.0827	.8266
1.3	- .0366	- .1308	-.0942	.8050
1.7	.2208	.1300	-.0908	.8113
2.0	.4248	.3124	-.1124	.7720
2.3	.6800	.5388	-.1412	.7224
2.6	1.0401	.8300	-.2101	.6165
2.9	1.4317	1.2600	-.1717	.6734

TABLE 2.32 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 78, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-1.0526	- .9711	.0815	1.2064
.6	- .8000	- .7222	.0778	1.1962
.8	- .6107	- .5522	.0585	1.1442
1.0	- .4613	- .4138	.0475	1.1156
1.3	- .2704	- .2304	.0400	1.0965
1.7	- .0068	.0080	.0148	1.0347
2.0	.2193	.2033	-.0160	.9638
2.3	.4888	.4450	-.0438	.9041
2.6	.8751	.7755	-.0996	.7951
2.9	1.3562	1.2686	-.0876	.8173

TABLE 2.33 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 1A, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5		-1.4467		
.6	-1.5107	-1.1800	.3307	2.1414
.7	-1.3769	-1.0550	.3219	2.0984
.8	-1.2824	-.9690	.3134	2.0578
.9	-1.2036	-.8929	.3107	2.0450
1.0	-1.1328	-.8252	.3076	2.0305
1.2	-1.0026	-.6997	.3029	2.0086
1.4	-.8773	-.5962	.2811	1.9102
1.6	-.7454	-.4768	.2686	1.8561
1.8	-.6007	-.3478	.2529	1.7902
2.0	-.4186	-.2029	.2157	1.6432

TABLE 2.34 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 1A, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.5697	-1.6600	-.0903	.8123
.6	-1.2882	-1.2867	.0015	1.0035
.7	-1.1357	-1.1371	-.0014	.9968
.8	-1.0192	-1.0300	-.0108	.9754
.9		-.9458		
1.0	-.8346	-.8630	-.0284	.9367
1.2	-.6778	-.7239	-.0461	.8993
1.4	-.5326	-.6020	-.0694	.8523
1.6	-.3788	-.4655	-.0867	.8190
1.8	-.2158	-.3175	-.1017	.7912
2.0	.0025	-.1146	-.1171	.7637

TABLE 2.35 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 2A, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5		-1.4600		
.6	-1.5028	-1.2000	.3028	2.0082
.7	-1.3695	-1.0675	.3020	2.0045
.8	-1.2755	-.9767	.2988	1.9898
.9	-1.1977	-.9005	.2972	1.9824
1.0	-1.1282	-.8316	.2966	1.9797
1.2	-1.0013	-.7046	.2967	1.9802
1.4	-.8787	-.5975	.2812	1.9107
1.6	-.7479	-.4830	.2649	1.8403
1.8	-.6027	-.3591	.2436	1.7523
2.0	-.4260	-.2144	.2116	1.6278

TABLE 2.36 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 2A, Post-Mission Senstiometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.7172	-1.6067	.1105	1.2897
.6	-1.3268	-1.2867	.0401	1.0967
.7	-1.1588	-1.1527	.0061	1.0141
.8	-1.0351	-1.0845	-.0494	.8925
.9		-.8700		
1.0	-.8365	-.8215	.0150	1.0351
1.2	-.6769	-.7245	-.0476	.8962
1.4	-.5257	-.6080	-.0823	.8274
1.6	-.3749	-.4765	-.1016	.7914
1.8	-.2200	-.3325	-.1125	.7718
2.0	-.0100	-.1540	-.1440	.7178

TABLE 2.37 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 5A, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	- .8690	- .8577	.0113	1.0264
.6	- .6307	- .6347	-.0040	.9908
.8	- .4856	- .4767	.0089	1.0207
1.0	- .3556	- .3500	.0056	1.0130
1.3	- .1822	- .1760	.0062	1.0143
1.7	.0587	.0622	-.0035	.9920
2.0	.2694	.2605	-.0089	.9797
2.3	.5161	.4780	-.0381	.9160
2.6	.8481	.7738	-.0743	.8428
2.9	1.3367	1.2163	-.1204	.7579

TABLE 2.38 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 5A, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-1.1154	-1.0154	.1000	1.2589
.5		- .8700		
.6	- .8804	- .7700	.1104	1.2894
.8	- .7059	- .6033	.1026	1.2665
1.0	- .5511	- .4700	.0011	1.2054
1.3	- .3551	- .2854	.0697	1.1741
1.7	- .1095	.0030	.1125	1.2957
2.0	.0947	.1309	.0362	1.0869
2.3	.3510	.3525	.0015	1.0035
2.6	.6952	.6538	.0414	.9091
2.9	1.2672	1.16	.1072	.7813

TABLE 2.39 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 6A, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio $E_s - E_c$
.3		-1.0600		
.4	- .8016	- .8680	-.0664	.8582
.6	- .5694	- .6271	-.0577	.8756
.8	- .4051	- .4709	-.0658	.8594
1.0	- .2674	- .3400	-.0726	.8461
1.3	- .0762	- .1554	-.0792	.8333
1.7	.1814	.0833	-.0981	.7978
2.0	.3868	.2833	-.1035	.7880
2.3	.6286	.4975	-.1311	.7394
2.6	.9589	.7800	-.1789	.6624
2.9	1.4107	1.2066	-.2041	.6250

TABLE 2.40 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 6A, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio $E_s - E_c$
.3		- .9000		
.4	-1.10127	- .6964	.4049	2.5404
.6	- .8326	- .4733	.3593	2.2872
.8	- .6364	- .3267	.3097	2.0403
.9		- .2600		
1.0	- .4813	- .2007	.2806	1.9081
1.3	- .2874	- .0188	.2686	1.8561
1.7	- .0353	.2300	.2653	1.8420
2.0	.1797	.4314	.2517	1.7853
2.3	.4479	.6560	.2081	1.6147
2.6	.7977	.9671	.1694	1.4771
2.9	1.3264	1.4213	.0949	1.2442

TABLE 2.41 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 1B, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s - Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5		-2.1300		
.6	-1.5427	-1.5533	-.0106	.9759
.7	-1.3986	-1.4086	-.0100	.9772
.8	-1.2997	-1.3044	-.0047	.9892
.9	-1.2195	-1.2156	.0039	1.0090
1.0	-1.1484	-1.1390	.0094	1.0219
1.2	-1.0188	-1.0087	.0101	1.0235
1.4	-.8936	-.9020	-.0084	.9808
1.6	-.7610	-.7804	-.0194	.9563
1.8	-.6129	-.6513	-.0384	.9154
2.0	-.4265	-.5035	-.0770	.8375

TABLE 2.42 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 1B, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.7981	-1.8200	-.0219	.9508
.6	-1.4495	-1.3933	+.0562	1.1382
.7	-1.2725	-1.2236	+.0489	1.1192
.8	-1.1412	-1.1144	+.0268	1.0637
.9		-1.0230		
1.0	-.9336	-.9535	-.0199	.9552
1.2	-.7639	-.8167	-.0528	.8855
1.4	-.6058	-.6814	-.0756	.8402
1.6	-.4384	-.5360	-.0976	.7987
1.8	-.2584	-.3775	-.1191	.7602
2.0	-.0180	-.2157	-.1977	.6343

TABLE 2.43 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 2B, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) $\text{Log } E_c$ Ergs/cm^2	Log Exposure (Sensitometry) $\text{Log } E_s$ Ergs/cm^2	$\text{Log } E_s - \text{Log } E_c$ Ergs/cm^2	Exposure Ratio E_s / E_c
.5		-1.7000		
.6	-1.5001	-1.4631	.0370	1.0889
.7	-1.3659	-1.3400	.0259	1.0615
.8	-1.2711	-1.2600	.0111	1.0259
.9	-1.1927	-1.1800	.0127	1.0297
1.0	-1.1229	-1.1200	.0029	1.0067
1.2	-.9959	-1.0014	-.0055	.9874
1.4	-.8740	-.8871	-.0131	.9703
1.6	-.7442	-.7729	-.0287	.9361
1.8	-.5990	-.6513	-.0523	.8865
2.0	-.4224	-.5035	-.0811	.8297

TABLE 2.44 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: 2424
Roll: 2B, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.5	-1.6507	-1.5533	.0974	1.2514
.6	-1.3213	-1.2867	.0346	1.0829
.7	-1.1542	-1.1371	.0171	1.0402
.8	-1.0322	-1.0300	.0022	1.0051
.9		-.9500		
1.0	-.8453	-.8700	-.0247	.9447
1.2	-.6890	-.7367	-.0477	.8960
1.4	-.5450	-.6057	-.0607	.8696
1.6	-.3937	-.4696	-.0759	.8397
1.7		-.4000		
1.8	-.2363	-.3167	-.0804	.8310
2.0	-.0273	-.2348	-.2075	.6202

TABLE 2.45 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 58, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.3		-1.0300		
.4	-.8544	- .8264	.0280	1.0666
.6	-.6260	- .6033	.0227	1.0537
.8	-.4621	- .4567	.0054	1.0125
.9		- .3900		
1.0	-.3320	- .3307	.0013	1.0030
1.3	-.1568	- .1488	.0080	1.0186
1.7	.0881	.1000	.0119	1.0278
2.0	.2971	.3014	.0043	1.0100
2.3	.5456	.5260	.0196	1.0462
2.6	.9038	.8371	.0667	1.1660
2.9		1.2913		

TABLE 2.46 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 5B, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.4	-1.1275	- .9864	.1411	1.3839
.6	- .8784	- .7500	.1284	1.3440
.8	- .6994	- .5820	.1174	1.3104
1.0	- .5486	- .4476	.101	1.2618
1.3	- .3579	- .2656	.0923	1.2368
1.7	- .1101	.0308	.1409	1.3832
2.0	.1028	.1635	.0607	1.1500
2.3	.3705	.4000	.0295	1.0703
2.6	.7356	.7291	-.0065	.9851
2.9	1.3386	1.2457	-.0929	.8074

TABLE 2.47 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 6B, Pre-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio E_s / E_c
.3		-1.06		
.4	- .7730	- .8418	-.0688	.8535
.6	- .5514	- .6013	-.0499	.8915
.8	- .3896	- .4360	-.0464	.8987
1.0	- .2493	- .3133	-.0640	.8630
1.3	- .0585	- .1308	-.0723	.8466
1.7	.1886	.1357	-.0529	.8853
2.0	.3963	.3233	-.0730	.8453
2.3	.6519	.5600	-.0919	.8093
2.6	1.0011	.8567	-.1444	.7171
2.9	1.4303	1.2900	-.1403	.7239

TABLE 2.48 COMPARISON OF EXPOSURE GENERATED BY VAN KREVALD'S LAW AND BROADBAND SENSITOMETRY.

Film: SO-022
Roll: 6B, Post-Mission Sensitometry

Density	Log Exposure (Calculated) Log E_c Ergs/cm^2	Log Exposure (Sensitometry) Log E_s Ergs/cm^2	Log E_s -Log E_c Ergs/cm^2	Exposure Ratio $E_s - E_c$
.3		-1.2200		
.4	-1.0423	- .9600	.0823	1.2086
.6	- .7906	- .7133	.0773	1.1948
.8	- .6092	- .5436	.0656	1.1631
1.0	- .4604	- .4015	.0589	1.1452
1.3	- .2648	- .2185	.0463	1.1125
1.5		- .1000		
1.7	- .0068	.0250	.0318	1.0760
2.0	.2087	.2245	.0158	1.0371
2.3	.46766	.4638	-.0039	.9911
2.6	.8124	.7925	-.0199	.9552
2.9	1.3510	1.2713	-.0797	.8323

TABLE 2.40 LUNAR IRRADIANCE CALCULATIONS LC4

Frames Averaged Over	(1) Lunar Irradience W/cm^2	(2) Lunar Exposure $ergs/cm^2$	(3) Measured density	(4) Estimate based on Pre-mission	(5) Estimate based on post-mission	(6) Error Factor Pre-	(7) Error Factor Post-		
55,1-3	------	------	------	------	-----	------	-------		
56,1-3	1.74×10^{-2}	-1.42	.45	-1.51	-1.38	.81	1.09		
59,1-3	1.16×10^{-2}	-1.06	.30	-1.01	-1.15	1.12	.81		
60,1-3	--------	-------	-------	--------	---------	--------	-------		
55,4-6	5.18×10^{-3}	-1.36	.45	-1.40	-1.35	.91	1.02		
56,4-6	3.49×10^{-2}	-1.112	.80	-1.18	-1.03	.87	1.23		
59,4-6	2.32×10^{-2}	-.75	.56	-.78	-.85	.93	.79		
60,4-6	-------	-------	--------	--------	--------	---------	--------		
55,7-9	1.04×10^{-2}	-1.06	.93	-1.115	- .95	.81	1.29		
56,7-9	6.98×10^{-2}	-.82	1.06	-1.08	-.81	.55	1.02		
59,7-9	4.64×10^{-2}	-.45	.99	-.49	-.44	.91	1.02		
60,7-9	2.92×10^{-2}	-.61	.58	-.58	-.75	1.07	.72		
55,10-12	6.08×10^{-2}	-.88	1.27	-.87	-.66	1.02	1.66		
56,10-12	6.51×10^{-2}	-.85	1.12	-1.03	-.65	.66	1.58		
59,10-12	2.11×10^{-2}	-.34	1.19	-.22	-.35	1.32	.98		
60,10-12	3.26×10^{-1}	-.15	1.38	-.08	-.20	1.17	.89		
55,13-15	3.04×10^{-2}	-1.18	.79	-1.35	-1.01	.68	1.48		
56,13-15	3.26×10^{-2}	-1.15	.82	-1.20	-1.12	.89	1.07		
59,10-13	1.05×10^{-1}	-.94	.69	-.66	-.88	.95	.57		
60,10-13	1.63×10^{-1}	-.45	.88	-.38	-.38	1.34	1.17		
55,16-18	1.52×10^{-2}	-1.48	.62	-1.60	-1.25	.76	1.69		
56,16-18	1.62×10^{-2}	-1.45	.60	-1.49	-1.39	.91	1.15		
59,16-18	5.27×10^{-3}	-.94	.43	-.89	-1.01	1.12	.85		
60,16-18	8.16×10^{-2}	-.75	.44	-.74	-.95	1.02	.63		

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TABLE 2.50 LUNAR IRRADIANCE CALCULATIONS, LC5

Frames Averaged Over	(1) Lunar Irradiance W/cm^2	(2) Lunar Exposure $ergs/cm^2$	(3) Measured Density	(4) Estimate based on Pre-mission	(5) Estimate based on Post-mission	(6) Error Factor Pre-	(7) Error Factor Post-		
55,390-393	--------	--------	--------	-------	-------	-------	-------		
56,390-393	1.90×10^{-2}	-1.48	.55	-1.48	-1.22	.95	1.74		
59,390-393	1.27×10^{-2}	-1.10	.51	-.93	-1.10	1.48	.98		
60,390-393	--------	--------	--------	--------	-------	---------	---------		
55,393-395	---------	--------	---------	---------	--------	----------	--------		
56,393-395	3.81×10^{-2}	-1.16	.86	-1.18	-.96	.95	1.58		
59,393-395	2.54×10^{-2}	- .79	.82	-.60	-.71	1.54	1.23		
60,393-395	1.60×10^{-2}	-.35	.40	-.38	-.40	.93	.89		
55,396-398	1.13×10^{-2}	-1.10	.64	-1.20	-1.09	.79	1.02		
56,396-398	7.63×10^{-2}	-.86	1.32	-.90	-.83	.91	1.07		
59,396-398	5.09×10^{-2}	-.49	1.27	-.42	-.49	1.17	1.00		
60,396-398	3.20×10^{-2}	-.65	.79	-.58	-.63	1.17	1.05		
55,399-401	6.63×10^{-2}	-.84	1.27	-.97	-.65	.74	1.55		
56,399-401	7.14×10^{-2}	-.81	1.34	-.91	-.85	.79	.91		
59,399-401	2.31×10^{-1}	-.30	1.93	-.29	-.31	1.02	.98		
60,399-401	3.57×10^{-1}	-.11	1.23	-.13	-.09	.95	1.05		
55,399-401	3.31×10^{-2}	-1.14	.74	-1.20	-1.01	.87	1.35		
56,399-401	3.57×10^{-2}	-1.11	.82	-1.20	-1.07	.81	1.10		
59,399-401	1.15×10^{-1}	-.60	1.22	-.59	-.58	1.02	1.05		
60,399-401	1.79×10^{-1}	-.41	.66	-.49	-.44	.83	.93		

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