NASA TECHNICAL MEMORANDUM

NASA TM X-73336

COMPENDIUM OF METEOROLOGICAL DATA FOR THE ATS-F LAUNCH IN MAY 1974

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Marshall Space Flight Center, Alabama

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16. ABSTRACT

All the meteorological data for the 32-hour period before the ATS-F launch from Kennedy Space Center at 0900 EDT on May 30, 1974, are archived at the Marshall Space Flight Center. These data were collected in support of the NASA rocket exhaust effluent prediction and monitoring program. This data set is unique in that soundings were made hourly from T-12 to T-0 hours, providing high temporal resolution. All supporting data, such as synoptic charts and surface data, are also included. This is the third in a series of seven data reports.

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TECHNICAL MEMORANDUM X-73336

COMPENDIUM OF METEOROLOGICAL DATA FOR THE ATS-F LAUNCH IN MAY 1974

I. INTRODUCTION

This report is a compendium of all the meteorological data collected as a function of the Marshall Space Flight Center (MSFC)/Langley Research Center (LaRC)/Kennedy Space Center (KSC) rocket exhaust effluent prediction and monitoring program for the ATS-F launch. The ATS-F was a Titan III C launch from Kennedy Space Center at 0900 EDT on May 30, 1974. The data presented in this compendium were collected largely to support NASA/MSFC diffusion predictions for the deployment of NASA/LaRC monitoring sites. The joint solid rocket motor exhaust prediction (MSFC) and measurement (LaRC and KSC) program evolved in 1972 utilizing the Titan and Delta launches as a source for empirical information that can be employed to more accurately predict the environmental effect of planned Space Shuttle operations.

These data are archived both as an aid in postlaunch analysis and because they represent a unique set of atmospheric soundings with high temporal resolution. Included in the report are the synoptic charts, surface observations, and rawinsonde soundings made during this period. There is no attempt to analyze any of the data presented in this document.

II. DATA

The data are listed in Appendices A through D; page numbers for specific data are given in the Table of Contents. The dates, times, and sources of the data are listed in Table 1.

The synoptic charts are from the series published weekly by the National Oceanographic and Atmospheric Administration (NOAA). The surface data are from the Cape Canaveral Air Force Station (location shown as KSC meteorological station in Figure 1).

The rawinsonde runs were made with an AMQ-9 radiosonde (Fig. 2) using the GMD-4 rather than the NOAA J005B radiosonde system. The

TABLE 1. METEOROLOGICAL DATA SUMMARY FOR ATS-F LAUNCH ON 30 MAY 1974 AT 0900 EDT (1300Z)

Data Type	Date (May 1974)	Time		Source
		EDT	Relative[a]	
Synoptic Charts[b]	29	0800	T-25 hr	NOAA
	30	0800	T- 1 hr	NOAA
	31	0800	T+23 hr	NOAA
Surface Observations[c]	30, 31	0157 (30 May) to 0057 (31 May)	T- 7 hr 3 min to T+15 hr 57 min	USAF
Rawinsonde	29	0115	T-31 hr 45 min	USAF
	29	2300	T-10 hr	USAF
	30	0100	T- 8 hr	USAF
	30	0400	T- 5 hr	USAF
	30	0652	T- 2 hr 8 min	USAF
	30	0904	T+ 4 min	USAF
	30	1100	T+ 2 hr	USAF
PIBAL	29	2100	T-12 hr	USAF
	29	2200	T-11 hr	USAF
	30	0000	T- 9 hr	USAF
	30	0200	T- 7 hr	USAF
	30	0300	T- 6 hr	USAF
	30	0500	T- 4 hr	USAF
	30	0700	T- 2 hr	USAF
	30	0800	T- 1 hr	USAF

[a]Relative to launch time; for example, 0902 EDT = T+2 min.

[b]Charts for surface and 500 mb; also included are precipitation and maximum and minimum temperatures for the preceding 24-hr period.

[c]Location of the base station for upper air and surface observations is illustrated in Figure 1.

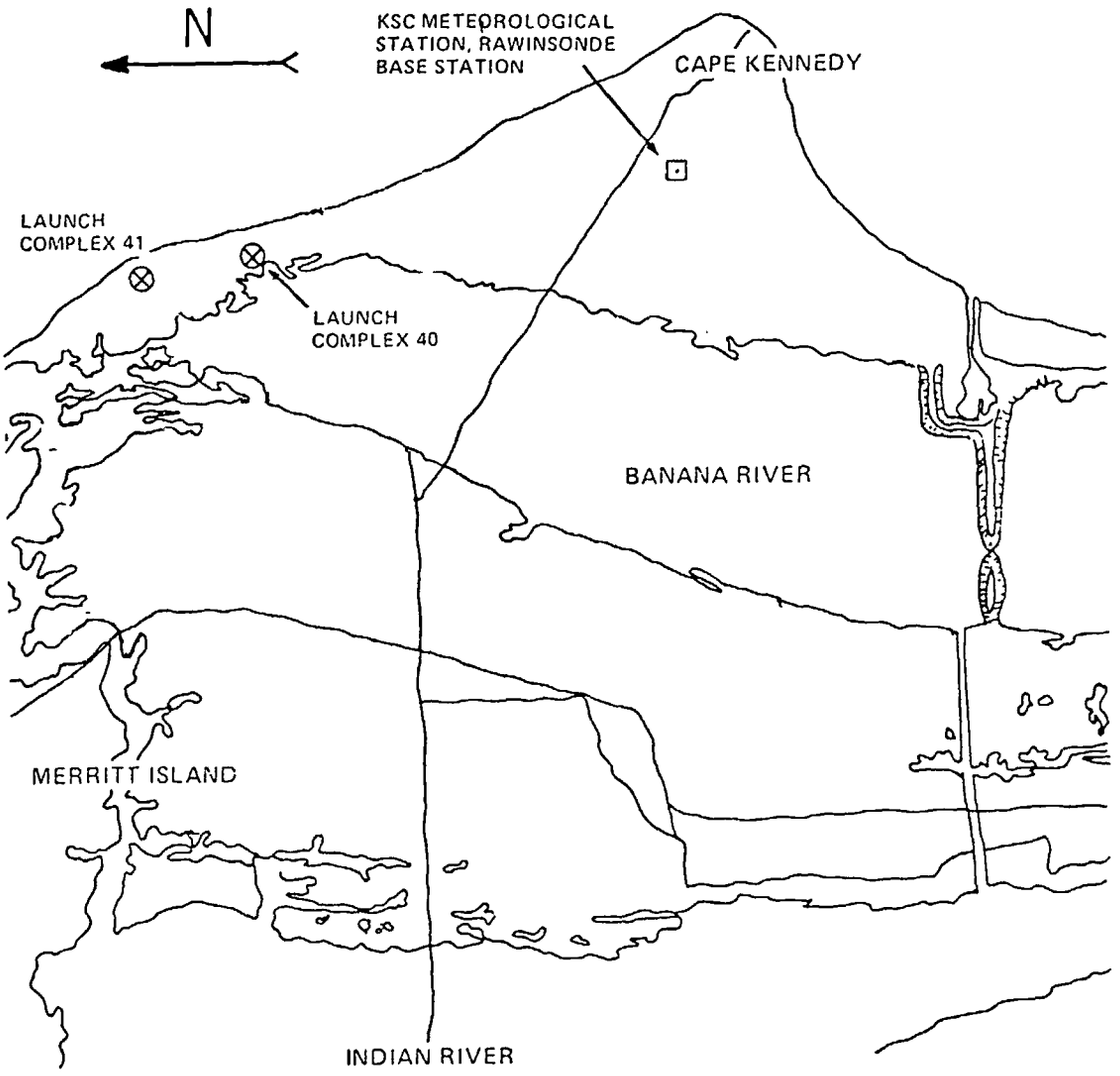


Figure 1. Location of KSC meteorological station for surface and upper air observations.

Figure 2. AMQ-9 radiosonde.

temperature and humidity sensor data are transmitted ten times per minute in the AMQ-9 by a clock-actuated switch rather than the aneroid barometer switch used in the NOAA radiosonde. Both systems measure azimuth and elevation with the directional receiver in the GMD. A transponder in the AMQ-9 is used to obtain the slant range to the radiosonde, enabling the calculation of altitude. The pressure is then calculated according to the hypsometric equation. The equations used in the computer program to calculate various thermodynamic quantities from the basic altitude, temperature, and relative humidity data are given in Appendix E.

Since it is envisioned that use of the rawinsonde data will be restricted to studies of the stabilized Space Shuttle rocket booster cloud, an altitude limit of 6.8 km (20 000 ft) was chosen; all data beyond that altitude are not included in this report. The excluded data are archived at MSFC and are available.

Winds aloft were also measured by tracking an ascending pilot balloon (PIBAL) with a single theodolite. The height of the balloon is estimated by assuming a constant ascent rate. The horizontal distance from the theodolite to the point below the balloon at a specified time is a function of the elevation angle measured with the theodolite and the height of the balloon. The azimuth, or bearing, of the balloon is also measured with the theodolite. Successive theodolite readings separated by standardized time intervals are used for calculation of the horizontal trajectory of the balloon. The wind speed and direction in the layer through which the balloon has passed are obtained from the vector drawn between successive horizontal projections of the balloon position.

The data contained in this report cover a time period that is sufficient for most anticipated meteorological analyses. The chronology of the data relative to the time of launch is given in Figure 3. In most studies, data within 1.5 hours of launch time are sufficient. To facilitate retrieval of these data, an index is provided in Table 2 which gives the page number of data obtained within 1.5 hours of launch. It is understood that for dynamic situations, such as the onset of a sea breeze or the passage of a front within 1.5 hours of launch, the selection of data would have to be narrowed to a more appropriate period.

III. LAUNCH CONDITIONS

At launch, the sky was overcast with high thin cirrus, the visibility was 10 miles, and the winds at the surface and aloft were generally from the

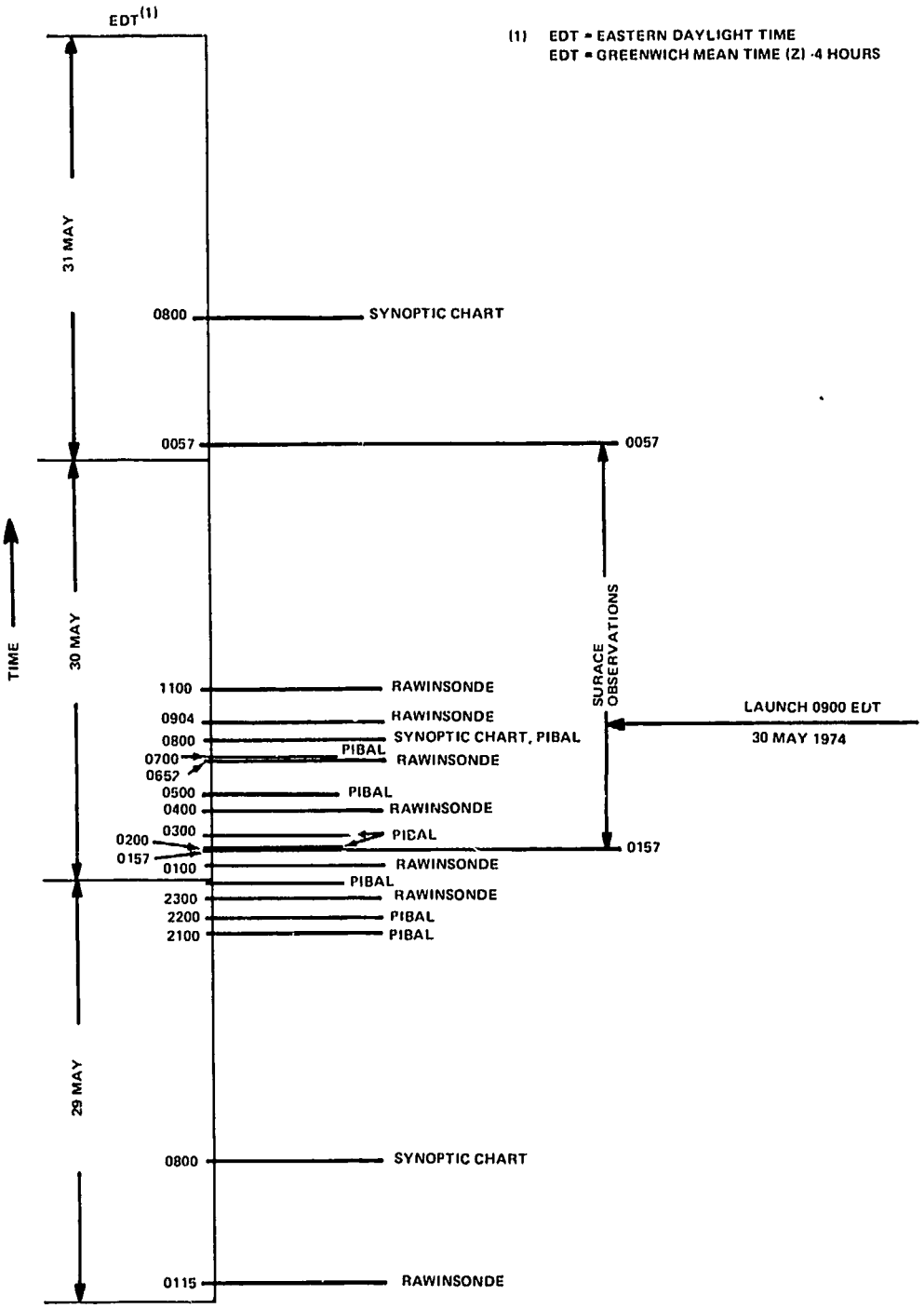


Figure 3. Data chronology.

TABLE 2. METEOROLOGICAL DATA OBTAINED WITHIN 1.5 HOURS OF T-0 (0900 EDT, 30 MAY 1974)

Time	Data Type	Page
T-1 hr 30 min (0730 EDT)	Surface Observation	14
T-1 hr 2 min (0758 EDT)	Surface Observation	14
T-1 hr (0800 EDT)	Synoptic Charts	11
T-1 hr (0800 EDT)	PIBAL	25
T- 50 min (0810 EDT)	Surface Observation	14
T- 4 min (0856 EDT)	Surface Observation	14
T- 0	Surface Observation	14
T+ 4 min (0904 EDT)	Rawinsonde	21
T+ 56 min (0956 EDT)	Surface Observation	14

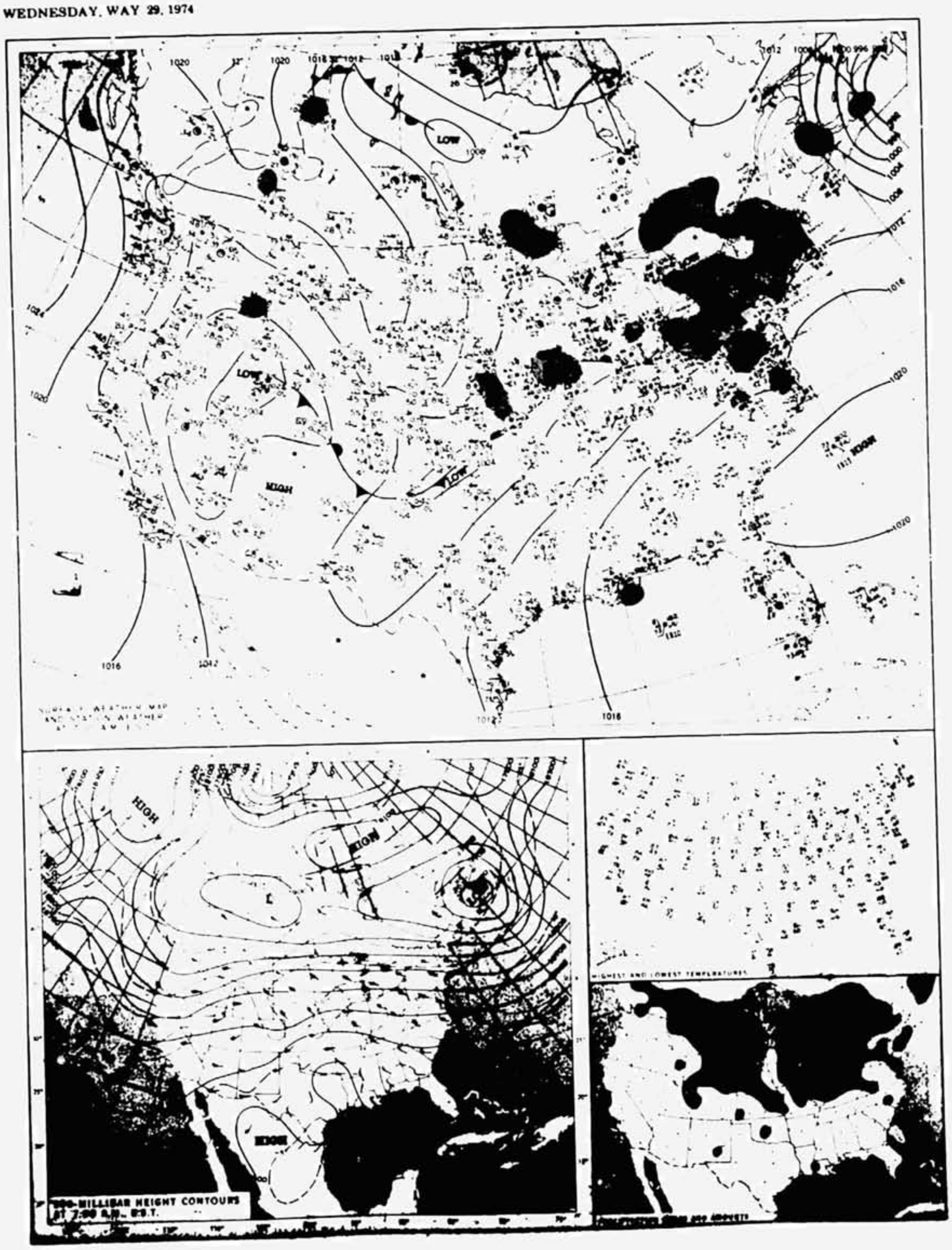
northwest. The northwest flow was responsible for the offshore transport of the exhaust cloud.

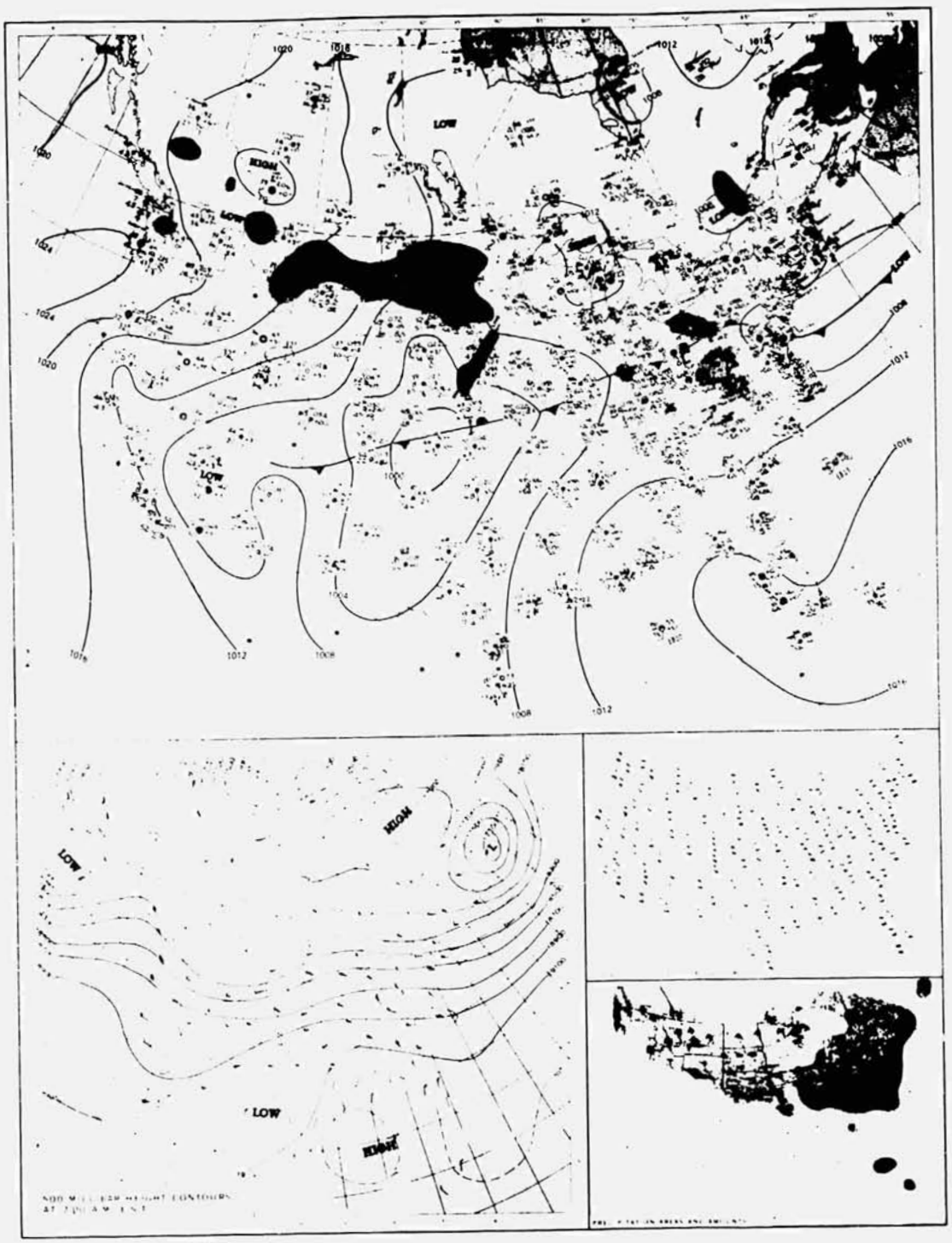
Although there was significant convective activity beginning 2 hours after launch, there was no evidence of rainfall in the vicinity of KSC that would have interacted with the exhaust cloud.

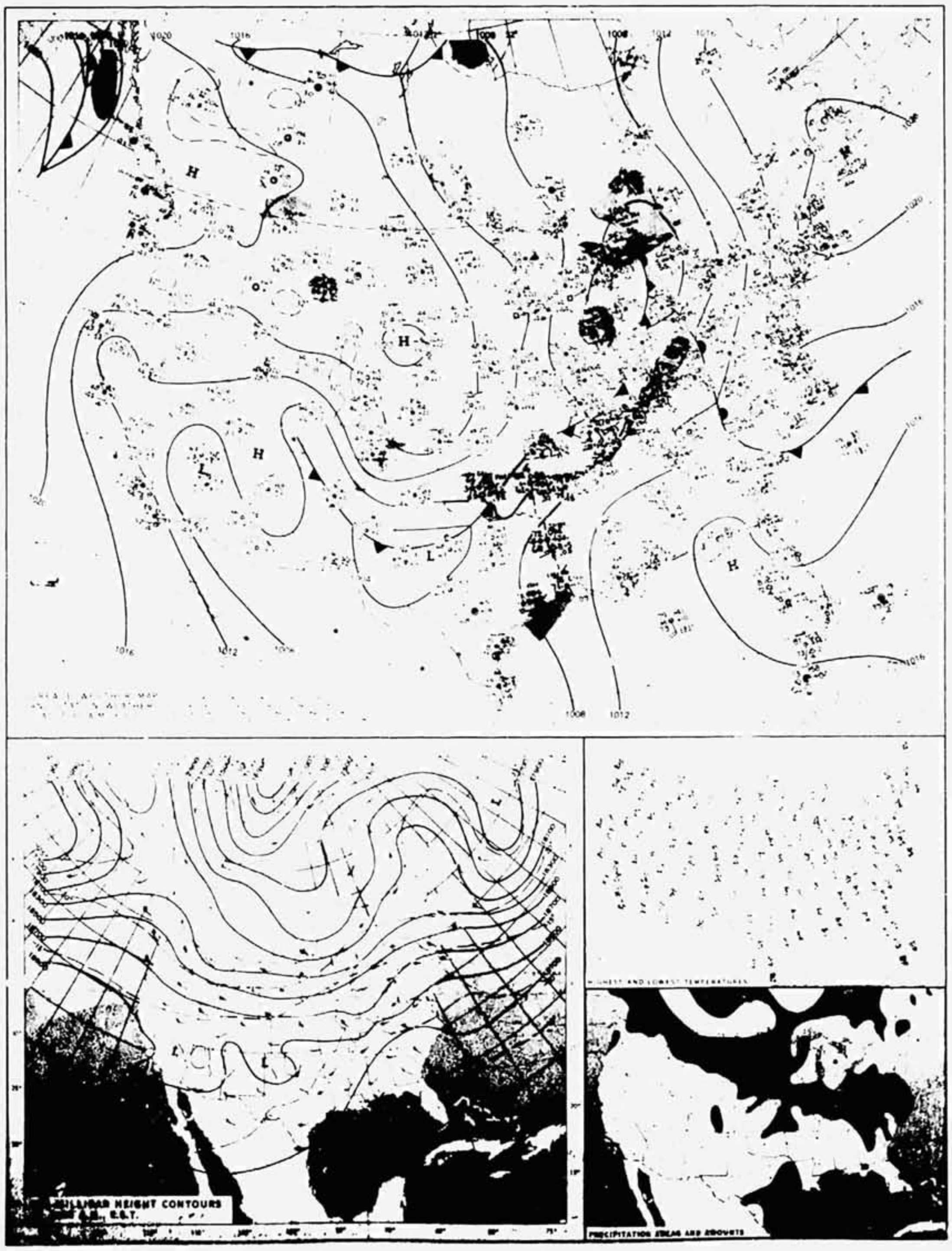
APPENDIX A

SYNOPTIC CHARTS
(1974)

WEDNESDAY, WAY 29, 1974




LOW
HIGH
1020
1016
1012
1008
1004
1000
1024
LOW
HIGH
LOW
LOW
LOW
HIGH


HEIGHT CONTOURS
PRECIPITATION AREAS AND AMOUNTS

APPENDIX B

SURFACE OBSERVATIONS
(KSC, 1974)

FEDERAL METEOROLOGICAL FORM 1-10 SURFACE WEATHER OBSERVATIONS
(ABRIDGED FORM FOR USE AT A...)

Latitude	Longitude	Station Elevation	Time Conversion	Mag to True	Day	Month	Year	Station and State or Country
28°	[illegible]	[illegible]	+5	0	30	MAY	1974	CAPE CANAVERAL AFS, FLA.

Time (LST)	Sky Condition	Sea Level Press (mb)	Temp (°F)	Dew Point (°F)
[illegible]	E50 ①	152	75	70
57	50 ①	146	73	70
57	①	142	72	69
57		142	70	69
59		146	69	69
57	230 ①			
30	310 ①	152	70	68
58	310 - ①			
30	280 - ①	159	75	71
58	80 ① 280 - ①			
10	260 - ①	159	79	72
56	260 - ①	159	79	72
56	260 - ①	159	83	70
56	240 ① 260 ①	159	83	66
57				
30	25 ① 260 ①	159	85	72
28		156	86	72
30		152	83	72
58	25 ① 260 ①			
38	25 ① 260 ①	141	84	71
30		129	85	73
57		135	82	72
58		132	82	72
57		132	80	73
56		135	79	73
57	30 ①	139	78	74
57	30 ①	142	78	74
58		149	78	73
56		156	77	72
57	5C	152	75	71
57	5C			

Remarks and supplemental coded data:

10 1500
70
RADAT 11197
17 1031 D.B. 75.8 W.B. 72.1
PRESS 1015.2
PRESS 1015.2 DB 79.3 WB 74.0
100 1108
SS 1015.6 D.B. 86.4 WB 73.7 ⊗
HCT 49 (MET) TCU SE-SW-NW
SS 1015.2 DB 85.0 WB 74.7
TCU-S-W-N RADAT 10143
TCU-S-W 807 12014
SS 1014.6 DB 84.3 WB 75.2
TCU SW-NW
TCU SW-W
TCU SW-W 617 1201
CB SW-W
CB SW 500 1372
CB-SSW
314 1070

Station pressure (inches): 29.960

Total sky cover / Obs: 7 NF; 2 NF; 0 NF; 0 NF; 2 W; DS; 10 DS; DS; 10 DS; FO; 10; 10; 9; 6; 3 KT; 3 KT; 4 KT; 5; 3; 4; 6 NF; 3 NF; 8 NF; 7 NF; 4 NF

Remarks, notes, and miscellaneous phenomena:

* TEST 7670 XMIT VIA GREEN TRUNK TO LWO
⊗ "SFC SUPPORTING FLT RCS" (1.2 DRRS)

Summary of the day	Precip	Snow fall	Snow depth
	0	0	0

Peak wind	Speed (knots)	Direction	Time (LST)
	16	11	1536

ORIGINAL PAGE IS
OF POOR QUALITY

APPENDIX C

RAWINSONDE DATA
(1974)

RAWINSONDE RUN AN/GMQ-4
CAPE KENNEDY AFS, FLORIDA
0515Z 29 MAY 1974
ASCENT NBR 0320

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT	AB HUM G/M3	DENSITY G/M3	T/R N	VS KTS	SHEAR /SEC	SHEAR DEG
16	110	5	24.2	20.3	1019.00	79	17.41	1183.54	366	672	0	0
1000	112	13	23.0	17.2	984.78	79	16.28	1148.47	352	670	.013	113
2000	120	10	20.5	19.0	950.98	91	16.24	1118.31	346	668	.005	261
3000	127	6	18.2	17.4	918.06	95	14.77	1088.73	331	665	.008	290
4000	357	1	16.6	15.4	886.08	93	13.10	1057.42	315	663	.011	313
5000	308	10	15.2	13.8	855.01	92	11.89	1025.97	301	661	.016	303
6000	302	17	14.5	9.5	824.90	73	9.03	993.57	276	661	.012	296
7000	299	20	13.7	5.2	795.75	57	6.73	962.36	256	660	.005	278
8000	293	19	11.3	2.7	767.47	55	5.84	936.60	243	657	.003	197
9000	278	16	9.6	-3.2	739.94	44	4.02	909.16	227	655	.010	159
10000	274	14	8.5	-14.8	713.27	18	1.51	881.29	208	654	.003	123
11000	274	12	6.9	-22.2	687.41	11	.82	854.62	196	652	.003	96
12000	271	10	6.6	-19.0	662.40	14	1.06	824.34	190	652	.004	106
13000	262	9	3.9	-25.5	638.16	10	.60	802.25	182	648	.003	143
14000	260	9	1.2	-26.1	614.58	11	.57	780.09	177	645	.001	215
15000	265	9	-0.4	-28.5	591.71	10	.46	755.45	171	643	.002	338
16000	279	9	-2.5	-31.9	569.56	8	.34	732.83	165	641	.004	3
17000	290	10	-4.1	-34.6	548.08	7	.26	709.64	160	639	.003	10
18000	295	8	-5.9	99.9	527.28	999	99.99	687.28	154	637	.003	85
19000	304	7	-7.9	99.9	507.14	999	99.99	666.14	149	634	.003	78
20000	308	7	-11.0	-40.0	487.57	7	.15	647.89	145	631	.001	359

MANDATORY LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT
558	111	10	23.6	19.6	1000	78
2026	120	10	20.4	19.0	950	91
3555	121	3	17.3	16.3	900	94
5155	306	11	15.0	13.3	850	90
6840	299	19	13.9	5.7	800	58
8616	282	17	9.7	2.3	750	60
10489	274	13	7.6	-17.9	700	15
12483	266	9	5.3	-24.8	650	11
14604	261	9	.3	-27.1	600	11
16872	290	9	-4.0	-34.4	550	7
19316	307	7	-9.1	99.9	500	999

SIGNIFICANT LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	T/R N
16	110	5	24.2	20.3	1019.00	366
3167	128	5	17.9	17.1	912.68	329
4787	310	8	15.4	14.5	861.56	305
6361	301	19	14.4	7.2	814.28	265
7288	298	20	13.4	4.3	787.54	251
8508	284	18	9.7	3.3	753.39	243
9471	279	15	9.5	-12.5	727.28	211
12062	271	10	6.6	-18.7	660.89	190
13669	259	9	1.7	-25.5	622.32	179
17914	295	8	-5.8	-37.5	529.05	155
18903	304	7	-7.6	99.9	509.08	149
19776	310	7	-10.4	-39.5	491.92	146

TEST NBR 06005 0 MINUS 13 H
RAWINSONDE RUN AN/GMD-4
CAPE KENNEDY AFS, FLORIDA
30 DAY 30 MAY 1974
ASCENT NBR 0324

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT	AIR DEN G/M3	DENSITY G/M3	I/R N	VS KTS	SHEAR /SEC	SHEAR DG
16	190	8	25,2	21,6	1045,90	80	18,70	1174,78	372	673	0	0
1000	184	15	22,6	19,7	981,34	84	16,91	1145,81	356	670	,011	176
2000	185	13	21,9	11,4	947,85	52	9,93	1113,67	307	669	,002	347
3000	199	11	19,4	12,5	915,08	65	10,74	1083,19	306	666	,007	326
4000	229	9	17,4	14,6	883,25	84	12,39	1051,41	309	664	,009	323
5000	266	9	15,1	14,4	852,34	95	12,32	1022,80	303	661	,010	335
6000	287	10	13,4	12,3	822,29	93	10,65	993,25	288	659	,006	348
7000	297	11	11,1	10,2	793,08	95	9,03	966,34	274	657	,003	9
8000	302	12	9,1	8,1	764,68	94	8,30	938,87	261	654	,003	344
9000	304	12	8,2	3,5	737,14	73	6,18	908,99	241	653	,001	2
10000	304	11	7,7	-6,2	710,49	40	3,25	879,36	216	653	,003	126
11000	304	8	6,4	-12,9	684,70	23	1,75	852,15	201	651	,004	126
12000	310	7	3,6	-14,8	659,67	24	1,52 -	829,45	194	648	,002	91
13000	329	9	1,3	-17,0	635,33	23	1,27	804,33	187	646	,005	17
14000	342	9	-0,4	-18,4	611,71	24	1,14	780,57	181	643	,004	43
15000	354	9	-2,0	-20,1	588,83	23	,99	755,98	175	641	,003	85
16000	8	9	-4,1	-22,4	566,66	23	,82	733,35	169	639	,003	87
17000	4	9	-6,4	-23,7	545,15	24	,73	711,55	163	636	,001	245
18000	351	10	-8,9	-26,5	524,27	22	,57 -	690,94	158	633	,004	288
19000	346	12	-11,7	-26,4	503,97	28	,58	671,27	153	630	,004	323
20000	341	14	-14,3	-28,9	484,28	28	,47 -	651,40	148	627	,004	314

MANDATORY LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT
962	186	11	24,2	20,8	1000	83
1733	185	14	21,9	11,4	950	51
3465	211	10	18,5	13,5	900	73
5069	268	9	14,9	14,2	850	96
6749	295	11	11,7	10,7	800	94
8514	304	12	8,6	6,7	750	88
10383	304	10	7,6	-11,2	700	26
12369	318	7	2,9	-15,8	650	24
14477	347	9	-1,2	-19,3	600	24
16734	5	9	-5,9	-23,4	550	24
19154	345	12	-10,3	-26,7	500	29

SIGNIFICANT LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	I/R N
16	190	8	25,2	21,6	1015,60	372
978	184	15	22,7	20,0	982,45	357
1916	185	14	22,0	11,4	950,64	307
5919	279	10	14,2	13,6	842,68	298
7662	301	11	9,4	8,9	774,18	266
8919	304	12	8,6	6,6	750,27	253
10465	304	9	7,6	-12,0	698,41	208
15193	350	9	-2,3	-20,4	584,50	174

TEST NBR 08005 07670 OMINUS
RAWINSONDE RUN AT/GMD-4
CAPE KENNEDY AFS, FLORIDA
05002 30 MAY 1974
ASCENT NBR 0325

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT	AB HUM G/M3	DENSITY G/M3	U/R M	VS FS	SHEAR /SEC	SHEAR DEG
16	190	5	24,9	21,1	1014,90	79	18,15	1175,44	369	673	0	0
1000	194	14	24,1	19,6	962,50	77	16,87	1139,67	353	672	,016	196
2000	193	13	22,2	16,6	947,38	71	15,89	1129,24	330	669	,002	22
3000	209	11	21,6	13,2	914,75	63	11,17	1078,23	307	668	,007	326
4000	233	11	17,4	14,1	883,02	81	11,99	1051,53	307	664	,008	301
5000	263	9	15,2	14,4	852,13	95	12,35	1021,94	303	662	,010	1
6000	301	8	13,4	12,9	822,11	97	11,24	992,72	290	659	,010	25
7000	316	8	11,7	10,9	792,94	95	9,95	963,90	276	657	,004	33
8000	320	8	9,4	8,8	764,61	96	8,69	937,37	263	655	,001	96
9000	318	9	7,4	6,7	737,05	95	7,69	910,57	250	653	,003	308
10000	319	11	6,8	2,9	710,36	76	5,83	880,44	233	652	,003	321
11000	317	9	6,2	-24,7	684,52	11	,77	853,14	195	651	,003	145
12000	311	7	4,8	-27,5	659,52	6	,51	826,38	187	649	,004	159
13000	311	6	2,5	99,9	635,24	999	99,99	842,65	181	647	,002	131
14000	329	6	,6	99,9	611,69	999	99,99	778,52	173	645	,003	94
15000	344	7	-1,2	99,9	588,85	999	99,99	754,44	168	642	,003	32
16000	354	7	-3,5	99,9	566,71	999	99,99	732,17	163	640	,002	80
17000	351	7	-5,8	99,9	545,23	999	99,99	710,52	158	637	,001	232
18000	348	7	-8,6	99,9	524,37	999	99,99	690,58	154	634	,001	256
19000	344	7	-11,4	99,9	504,10	999	99,99	670,95	150	630	,001	263
20000	335	9	-13,6	99,9	484,33	999	99,99	650,59	145	627	,004	311

MANDATORY LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT
443	194	12	24,7	20,6	1000	78
1918	193	13	22,2	17,0	950	72
3456	221	11	19,4	14,5	900	74
5062	266	9	15,1	14,4	850	95
6744	316	8	12,1	11,4	800	96
8511	319	8	8,1	7,4	750	95
10377	316	11	4,1	1,5	700	72
12364	309	7	3,6	-20,3	650	16
14477	336	6	-0,5	99,9	600	999
16738	353	7	-5,3	99,9	550	999
19161	342	7	-11,9	99,9	500	999

SIGNIFICANT LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	U/R M
16	190	5	24,9	21,1	1014,90	369
1246	194	14	22,4	18,1	962,50	341
2678	195	11	21,5	12,3	934,93	388
3545	223	11	19,1	14,8	897,34	331
4020	234	11	17,3	14,1	884,40	388
4206	247	10	16,5	15,8	867,28	312
5405	280	8	14,6	14,2	839,87	290
8307	319	8	8,8	8,2	756,06	256
8689	319	9	7,5	6,8	745,53	293
9809	316	11	6,8	5,6	720,70	248
10584	318	11	5,7	1,0	695,17	229
11020	317	9	6,2	-25,9	684,02	193
11581	319	8	5,8	99,9	669,89	186
11973	311	7	4,9	-28,0	660,19	187
12811	309	6	2,8	-24,2	639,78	184
13256	313	6	2,0	99,9	629,13	177
15015	344	7	-1,3	99,9	588,52	168
17909	348	7	-8,4	99,9	526,25	154
18414	348	7	-9,6	-27,0	515,91	155
18628	348	7	-11,0	99,9	507,56	150
19266	341	7	-12,1	-38,1	490,81	149
19685	337	8	-13,9	-38,0	480,57	148

TEST NBR 07670 08005 0-5HR
RAWINSONDE RUN AN/GMD-4
CAPE KENNEDY AFS, FLORIDA
08004 30 MAY 1974
ASCENT NBR 0326

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT	AB HUM G/M3	DENSITY G/M3	I/R N	VS KTS	SHEAR /SEC	SHEAR DEG
16	210	4	22.1	20.7	1013.90	92	17.91	1185.13	370	669	0	0
1000	199	14	23.6	20.1	979.48	81	17.20	1139.69	356	671	.017	195
2000	200	15	22.4	16.6	946.01	70	13.83	1106.89	329	670	.002	214
3000	211	11	20.0	14.8	913.43	72	12.44	1077.81	315	667	.008	355
4000	234	5	17.6	15.3	881.74	86	12.97	1048.59	312	664	.011	14
5000	250	4	16.1	13.4	850.91	84	11.51	1017.75	296	663	.003	7
6000	237	5	14.3	10.2	821.08	78	9.41	988.78	278	661	.008	190
7000	241	4	12.2	8.7	791.95	79	8.55	961.65	267	658	.002	42
8000	293	4	10.0	7.7	763.66	86	8.07	934.75	258	656	.006	321
9000	302	5	8.9	.2	736.21	55	4.77	906.59	232	654	.002	338
10000	303	4	6.5	-2.6	709.58	52	3.94	881.63	221	651	.002	117
11000	289	6	6.0	-11.7	683.75	27	1.94	852.06	202	651	.004	258
12000	282	8	4.4	-14.8	658.76	23	1.51	825.97	194	649	.003	261
13000	291	6	3.9	99.9	634.57	999	99.99	798.06	178	648	.004	79
14000	323	5	1.6	99.9	611.18	999	99.99	775.02	173	646	.005	61
15000	327	5	-0.8	99.9	588.38	999	99.99	752.51	168	643	.001	5
16000	328	6	-3.0	99.9	566.29	999	99.99	730.18	163	640	.002	331
17000	335	8	-6.0	-38.2	544.86	6	.18	710.32	159	637	.004	397
18000	342	10	-8.8	-38.7	524.08	6	.17	689.26	155	634	.004	20
19000	349	12	-10.1	-39.2	503.85	9	.19	667.24	150	632	.004	354
20000	333	15	-13.2	-26.6	484.26	31	.56	648.95	148	628	.007	202

MANDATORY LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT
101	204	11	24.1	21.9	1000	88
1877	199	15	22.7	16.4	950	68
3415	217	8	19.2	15.3	900	78
5022	250	4	16.1	13.3	850	83
6709	234	4	12.8	8.8	800	76
8479	301	5	9.2	3.1	750	69
10347	299	5	6.3	-5.6	700	43
12333	283	7	4.2	-21.3	650	15
14455	328	5	.6	99.9	600	999
16720	333	8	-5.1	-38.3	550	9
19148	346	13	-10.9	-34.4	500	14

SIGNIFICANT LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	I/R N
16	210	4	22.1	20.7	1013.90	370
420	204	12	24.2	22.0	999.37	372
1311	198	15	23.8	19.1	988.95	347
1760	198	15	23.1	16.3	983.98	328
4282	244	4	16.7	14.7	872.94	308
7200	249	3	11.8	8.7	786.22	286
7628	278	3	10.1	7.7	774.09	261
8080	296	4	10.0	7.7	761.43	258
8943	302	5	9.0	.2	737.76	282
9429	303	5	8.1	.2	724.78	289
9834	306	4	6.6	-1.4	713.91	284
10999	290	6	6.0	-12.3	686.30	202
12099	281	8	4.3	-15.0	658.32	198
12957	289	7	4.1	-26.1	645.17	184
13013	291	6	3.9	99.9	634.27	178
13941	303	5	2.6	99.9	626.50	176
16180	328	7	-3.2	99.9	592.38	168
18610	331	6	-4.6	-38.4	558.15	161
19033	336	8	-6.1	-38.8	544.17	159
18879	350	12	-9.9	-42.1	580.42	166
19701	336	14	-12.1	-28.8	468.30	149

TEST NBR 08005 07670 OMINLS
RAWINSONDE RUN AN/GMD-4
CAPE KENNEDY AFS, FLORIDA
1052Z 30 MAY 1974
ASCENT NBR 0327

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT	AB HUM G/M3	DENSITY G/M3	I/R N	VS KTS	SHEAR /SEC	SHEAR DEG
16	230	4	20,7	19,9	1014,68	95	17,11	1192,70	368	668	0	0
1000	262	8	22,2	20,0	980,41	87	17,14	1149,99	357	670	,009	286
2000	257	8	21,2	17,2	946,77	78	14,48	1111,86	334	668	,001	159
3000	261	7	19,1	14,5	914,06	75	12,27	1082,14	315	666	,002	95
4000	280	7	16,9	12,0	882,40	73	10,51	1053,20	298	663	,004	354
5000	288	8	14,3	9,3	851,41	72	8,87	1026,20	283	661	,003	327
6000	278	7	11,9	7,9	821,05	77	8,12	998,40	272	658	,002	166
7000	250	6	10,2	5,8	791,72	74	7,06	969,14	260	656	,006	146
8000	244	5	7,7	6,3	763,25	91	7,42	942,17	256	653	,002	100
9000	279	5	6,7	,4	735,62	64	4,89	912,73	234	652	,005	344
10000	291	7	5,3	-5,8	708,83	45	3,08	885,09	217	650	,004	323
11000	298	8	4,5	-20,6	682,88	15	,96	856,30	197	649	,003	327
12000	315	7	3,8	-20,1	657,78	16	,99	826,80	190	648	,004	83
13000	322	6	1,8	-27,2	633,51	9	,51	802,34	182	646	,003	109
14000	301	7	-0,1	-24,5	609,97	14	,67	777,92	178	644	,005	292
15000	295	9	-2,1	-26,6	587,14	13	,55	754,37	172	641	,003	269
16000	309	8	-4,5	-28,1	565,01	14	,49	732,36	166	639	,002	43
17000	324	10	-7,1	-29,4	543,52	15	,43	711,49	161	635	,005	23
18000	332	13	-9,3	-27,8	522,66	21	,51	689,88	157	633	,006	354
19000	341	15	-11,1	-35,6	502,42	11	,24	667,79	150	631	,005	18
20000	353	18	-13,1	-37,2	482,86	11	,21	646,84	145	628	,008	38

MANDATORY LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT
431	268	7	23,6	21,7	1000	92
1900	258	8	21,4	17,5	950	79
3433	268	6	17,9	13,4	900	75
5031	288	8	14,3	9,2	850	72
6703	260	6	10,6	6,5	800	76
8460	261	5	7,5	3,3	750	75
10317	294	7	4,4	-5,5	700	48
12293	318	7	1,2	-24,2	650	11
14403	297	8	-1,0	-23,8	600	16
16659	318	9	-0,2	-29,0	550	14
19077	343	16	-11,2	-35,7	500	11

SIGNIFICANT LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	I/R N
16	230	4	20,7	19,9	1014,68	365
406	268	7	23,1	21,7	1000,86	372
4368	288	7	16,2	11,4	870,72	293
4943	289	8	14,5	9,8	856,03	285
5383	286	8	13,9	8,3	839,57	276
5886	280	8	12,2	7,9	824,46	273
7304	241	5	9,7	6,0	782,97	258
7787	238	5	8,3	8,0	769,24	262
9072	281	5	6,6	0	733,66	243
9503	288	6	6,3	-7,1	722,03	218
10476	295	8	4,1	-5,4	696,30	215
11017	299	8	4,5	-21,1	682,44	196
11537	306	8	3,8	-13,5	669,29	198
12924	320	7	2,6	-26,7	644,47	185
13722	301	8	-3,5	-27,4	571,11	166
16431	308	8	-5,3	-28,7	560,00	169
18013	333	13	-9,4	-27,7	522,40	157
18392	335	14	-11,3	-27,8	514,84	156
19383	346	16	-11,6	-35,9	494,84	148

TEST NBR 08005 07670 T-0
RAWINSONDE RUN AW/GMD-4
CAPE KENNEDY AFS, FLORIDA
1300Z 30 MAY 1974
ASCENT NBR 0328

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT	AB HUM G/M3	DENSITY G/M3	I/R N	VS KTS	SHEAR /SEC	SHEAR DEG
10	296	7	26.2	22.5	1015.40	80	19.69	1149.70	176	678	0	0
1000	300	8	22.8	19.0	981.11	79	16.11	1145.24	351	670	.003	343
2000	290	8	22.4	17.4	947.92	7[illegible]	14.62	1107.87	334	670	.002	182
3000	292	7	21.5	14.4	914.94	68	12.15	1077.83	313	665	.001	94
4000	299	9	18.2	11.4	883.22	64	10.05	1049.88	294	665	.004	321
5000	297	11	15.1	8.7	852.29	65	8.47	1024.80	280	661	.003	286
6000	292	11	12.9	7.4	822.16	69	7.82	996.42	270	659	.002	222
7000	283	10	11.2	5.5	792.88	68	6.90	967.30	258	657	.004	161
8000	270	9	9.1	2.2	764.45	62	5.51	940.24	244	654	.004	159
9000	271	8	8.3	-6.6	736.86	35	2.90	911.20	221	653	.001	74
10000	282	7	7.2	-11.0	710.15	26	2.04	881.36	209	652	.003	35
11000	298	7	5.5	-7.7	684.30	38	2.70	853.79	207	650	.003	34
12000	315	6	4.4	-18.6	659.27	16	1.19	826.75	192	649	.004	67
13000	329	7	2.5	-24.2	635.00	12	.68	801.80	183	647	.003	26
14000	328	9	1.4	-26.7	611.90	10	.54	775.74	176	645	.005	325
15000	328	11	-0.7	-26.7	588.75	12	.55	752.43	171	643	.002	334
16000	342	12	-2.2	-27.3	566.66	13	.52	731.05	166	640	.005	43
17000	352	14	-5.7	-24.9	545.21	21	.67	709.77	162	637	.005	39
18000	356	15	-8.1	-23.8	524.37	28	.77	690.68	159	634	.002	33
19000	2	16	-10.6	-30.5	504.17	19	.43	668.61	152	631	.004	46
20000	12	18	-12.4	-35.3	484.50	13	.25	647.37	146	629	.006	64

MANDATORY LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT
951	309	8	22.8	19.5	1000	82
1922	291	8	22.6	17.6	950	74
3062	298	8	19.5	12.7	900	65
5066	296	11	15.0	8.7	850	66
6742	286	10	11.6	5.8	800	66
8504	269	9	8.6	-3.0	750	44
10369	288	7	6.7	-10.5	700	29
12354	322	6	3.6	-22.8	650	12
14471	327	10	.5	-25.8	600	12
16737	351	13	-5.9	-26.8	550	16
19165	4	17	-10.7	-33.7	500	14

SIGNIFICANT LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	I/R N
16	290	7	26.2	22.5	1015.40	176
449	309	8	22.8	19.5	1000.14	359
1760	292	8	22.8	18.1	955.46	346
4055	299	9	18.1	11.4	881.49	294
4980	298	10	16.7	9.9	868.29	286
7903	273	9	9.6	3.6	775.63	250
9089	278	8	7.5	-10.1	738.35	212
10280	286	7	6.9	-11.8	702.84	208
10797	294	7	5.8	-5.5	687.49	211
12191	319	6	4.1	-23.6	654.37	188
14139	327	10	1.2	-25.9	608.28	170
18248	357	15	-8.2	-22.9	517.60	197
18795	1	16	-10.4	-27.3	500.25	194
19393	5	17	-10.9	-36.5	490.41	148

TEST NBR 08005 TPLUS 2HR
RAWINSONDE RUN AN/GMD-4
CAPE KENNEDY AFS, FLORIDA
15004 30 MAY 1974
ASCENT NBR 0329

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT	AB HUM G/M3	DENSITY G/M3	I/R N	VS KTS	SHEAR /SEC	SHEAR DEG
16	340	9	29.4	21.1	1015.20	61	17.99	1158.04	362	678	0	0
1000	321	7	25.3	16.7	981.91	59	13.78	1137.35	334	673	.006	159
2000	312	7	22.4	17.3	948.02	73	14.48	1108.79	333	670	.006	259
3000	308	8	20.0	13.0	915.35	64	11.08	1081.09	307	667	.001	249
4000	304	9	17.9	11.2	883.57	65	9.92	1051.45	294	665	.002	282
5000	301	10	15.2	9.6	852.60	69	9.00	1024.80	283	661	.002	288
6000	298	11	13.1	8.2	822.48	72	8.26	995.85	272	659	.001	248
7000	295	11	11.0	5.9	793.22	71	7.11	968.24	260	657	.001	199
8000	296	10	9.6	4.1	764.80	69	6.28	938.66	248	655	.002	96
9000	304	8	8.3	-1.9	737.24	51	4.26	910.10	229	654	.003	83
10000	312	8	7.5	-8.6	710.56	31	2.46	880.43	211	653	.002	58
11000	325	7	5.6	-9.5	684.72	33	2.32	854.40	205	650	.003	58
12000	342	6	3.6	-19.3	659.64	17	1.09	829.71	192	646	.004	89
13000	349	6	1.5	-17.5	635.29	23	1.22	805.24	187	646	.001	73
14000	350	7	.5	-28.6	611.70	9	.46	778.61	176	644	.001	254
15000	339	8	-1.8	-28.2	588.83	11	.48	755.64	171	642	.003	279
16000	342	8	-3.5	-28.0	566.68	13	.49	731.83	166	640	.001	26
17000	1	9	-6.5	-24.1	545.19	26	.74	711.94	163	636	.005	72
18000	16	10	-9.1	-25.8	524.29	25	.65	691.38	158	633	.005	69
19000	22	11	-10.9	-31.0	504.03	17	.38	669.36	152	631	.003	68
20000	27	12	-12.3	-28.1	484.44	27	.53	646.59	148	629	.002	73

MANDATORY LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	RH PCT
455	333	8	27.6	19.0	1000	60
1937	313	7	22.6	17.3	950	72
3474	306	8	19.0	12.0	900	64
5077	300	10	14.9	9.5	850	78
6754	295	11	11.5	6.5	800	71
8517	300	9	8.7	1.7	750	61
10386	316	8	6.9	-8.4	700	33
12367	340	6	2.8	-19.7	650	18
14478	343	7	-1.0	-28.6	600	10
16737	356	9	-5.6	-25.9	550	20
19158	23	11	-11.3	-31.6	500	17

SIGNIFICANT LEVELS

ALTITUDE FEET	DIR DEG	SPEED KTS	TEMP DEG C	DEW PT DEG C	PRESS MBS	I/R N
16	340	9	29.4	21.1	1015.20	362
2016	312	7	22.7	17.3	947.50	333
3109	307	8	19.8	12.5	911.98	304
7098	294	11	10.8	5.7	790.40	258
8786	302	8	8.3	.5	748.06	238
9620	308	8	8.7	-8.9	720.60	213
11505	331	7	4.7	-10.4	674.47	208
12096	344	6	3.4	-20.7	657.27	198
13014	349	6	1.4	-17.5	634.94	187
13940	351	7	.6	-28.6	613.11	177
16484	349	8	-4.5	-28.3	556.22	164
17378	9	9	-8.0	-20.9	537.24	163
19420	25	12	-11.7	-32.3	495.73	149

APPENDIX D

PIBAL DATA
(1974)

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
100Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	170	6
1000	162	22
2000	163	21
3000	161	22
4000	153	20
5000	153	14
6000	210	8
7000	277	10
8000	293	16
9000	295	22
10000	299	25
11000	298	25
12000	293	26
13000	291	26
14000	289	25
15000	289	24
16000	289	18
17000	302	14

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
200Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	180	10
1000	178	20
2000	181	27
3000	174	28
4000	169	25
5000	181	18
6000	211	16
7000	229	13
8000	282	13
9000	300	16
10000	299	17
11000	295	25
12000	292	24
13000	294	26
14000	293	28
15000	297	25
16000	302	17
17000	314	14

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
400Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	200	4
1000	197	14
2000	197	21
3000	195	22
4000	189	17
5000	197	11
6000	221	14
7000	251	14
8000	267	13
9000	275	12
10000	291	15
11000	310	9
12000	295	11
13000	293	13
14000	308	12
15000	307	10
16000	311	10
17000	341	9

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
600Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	200	5
1000	209	16
2000	204	21
3000	199	23
4000	198	17
5000	222	13
6000	268	11
7000	297	9
8000	300	8
9000	312	7
10000	323	6
11000	305	6
12000	336	9
13000	335	12
14000	347	10
15000	331	10
16000	304	8
17000	300	8

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
700Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	200	4
1000	200	15
2000	198	23
3000	197	22
4000	202	22
5000	246	9
6000	268	8
7000	263	6
8000	267	5
9000	255	5
10000	230	4
11000	215	3
12000	302	5
13000	307	7
14000	312	7
15000	341	7
16000	300	12
17000	282	12

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
900Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	210	4
1000	226	16
2000	235	20
3000	232	19
4000	222	16
5000	227	13
6000	225	9
7000	239	5
8000	256	12
9000	260	10
10000	247	9
11000	246	12
12000	268	6
13000	194	3
14000	263	6
15000	267	5
16000	260	5
17000	280	14

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
1100Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	230	3
1000	255	12
2000	264	13
3000	252	13
4000	262	11
5000	263	11
6000	280	10
7000	294	11
8000	297	13
9000	289	14
10000	269	10
11000	235	9
12000	224	10
13000	219	11
14000	314	15
15000	286	9
16000	288	12
17000	311	93

TEST NBR08005
SINGLE THEODOLITE PIBAL
CAPE KENNEDY AFS
1200Z 30 MAY 1974

ALT FT.	WIND DIR DEG	WIND SPD KTS
16	230	4
1000	277	6
2000	277	7
3000	280	7
4000	299	6
5000	301	9
6000	292	8
7000	263	8
8000	242	8
9000	261	7
10000	275	8
11000	281	8

APPENDIX E

CALCULATION OF THERMODYNAMIC VARIABLES FROM RAWINSONDE DATA

The equations used for calculation of thermodynamic variables from measurements of altitude, temperature and relative humidity obtained from the GMD-4, AMQ-9 rawinsonde system are summarized herein; these equations, originally developed for the GMD-2 system (Ref. 1), must be used in conjunction with the list of symbols and units provided at the end of this appendix.

Atmospheric Density, ρ

$$\rho = 348.38 \frac{P}{T_v}$$

Pressure, P

$$P = P' 10^{-(h-h')/(221.266\ T_{vm})}$$

Geopotential Height, h

$$h = \frac{g_o}{9.8} \frac{r_e H}{r_e + H}$$

Virtual Temperature, T_v

$$T_v = T(1 + .376932\ e/P')$$

Mean Virtual Temperature, T_{vm}

$$T_{vm} = \frac{T_v' + T_v}{2}$$

Vapor Pressure, e

$$e = 6.11\ f_D\ 10^{7.5t/(t+237.3)}$$

Dew Point Temperature, t_d

$$t_d = \frac{237.3 \log e - 186.527}{8.236 - \log e}$$

Potential Temperature, θ

$$\theta = T \left(\frac{1000}{P}\right)^{.288}$$

Virtual Potential Temperature θ_v

$$\theta_v = T_v \left(\frac{1000}{P}\right)^{.288}$$

Absolute Humidity, ρ_w

$$\rho_w = 216.7\ e/p$$

Microwave Refractive Index, n

$$n = 1 + \left[\frac{1}{T}\left(77.6P - 11e + \frac{374808e}{T}\right)\right] 10^{-6}$$

For data tabulation, use:

$$N = (n-1)10^6$$

Speed of Sound, V_s

$$V_s = 643.855 \left(\frac{T}{273.16}\right)^{0.5}$$

LIST OF SYMBOLS AND UNITS

e	vapor pressure	millibars (mb)
f_D	relative humidity expressed as a decimal	
g_o	acceleration of gravity at geographical location of the rawinsonde station	meters/seconds^2 (m/sec^2)
h	geopotential height at the top of the layer bounded by h and h'	feet (ft)
h'	geopotential height at the bottom of the layer bounded by h and h'	(ft)
H	geometric altitude at the top of the layer bounded by H and H'	(ft)
H'	Geometric altitude at the bottom of the layer bounded by H and H'	(ft)
n	microwave refractive index	
N	unit of refractive index used for simplification of data tabulation	
P	pressure at geopotential height h	(mb)
p'	pressure at geopotential height h'	(mb)
r_e	radius of the earth	(ft)
t	temperature	degrees Celsius (^{O}C)
T	temperature	degrees Kelvin (^{O}K)
t_d	dew point temperature	(^{O}C)
T_v	virtual temperature at geopotential height h	(^{O}K)

T_v'	virtual temperature at geopotential height h'	(^oK)
T_{vm}	the mean virtual temperature of layer bounded by h and h'	(^oK)
V_s	speed of sound	knots
ρ	atmospheric density	grams/meter^3 (gm/m^3)
ρ_w	absolute humidity	(gm/m^3)
Θ	potential temperature	(^oK)
Θ_v	virtual potential temperature	(^oK)

REFERENCE

Daniel, O. H.: Digital Computer Reduction of AN GMD-2 Rawinsonde Data. Pan American World Airways, Guided Missile Range Division, Patrick Air Force Base, Florida, 10 May 1962.

APPROVAL

COMPENDIUM OF METEOROLOGICAL DATA FOR THE ATS-F LAUNCH IN MAY 1974

By J. Briscoe Stephens, S. I. Adelfang, and A. I. Goldford

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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