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NASA TM-82400

IECM CALIBRATION AND DATA REDUCTION REQUIREMENTS

By Fred D. Wills and Charles W. Davis

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16. ABSTRACT

The Induced Environment Contamination Monitor (IECM) tape recorder format, as it relates to the output of meaningful data from the IECM instrument, is explained in this report. Eight-bit words (or bytes) generate numbers that represent voltage levels of electronic detection probes for each experiment. This information is amalgamated by the IECM Data Acquisition and Control System (DACS). In some cases bits represent certain status situations concerning an experiment, such as whether a valve is opened or closed. Voltages are transformed into meaningful physical phenomena through equations of calibration. Data formats and plots are generated as requested for each IECM experimenter.

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I. INTRODUCTION

The main purpose of this document is the presentation and explanation of the Induced Environment Contamination Monitor (IECM) tape recorder format as it relates to the IECM instrument output of meaningful data. This document will be constructed logically from the IECM tape recorder format of experiment data. The main sources of information for this document were NASA TM 78193[1] and a series of seven memoranda to R. Hall of the Computer Services Office (AH22), Marshall Space Flight Center (MSFC):

1) TQCM Data Reduction Requirements, July 19, 1979.

2) Data Reduction for IECM Instruments Cascade Impactor and Camera Photometer, July 23, 1979.

3) Data Reduction for IECM Instrument Optical Effects Module, July 24, 1979.

4) Data Reduction for IECM Instrument Air Sampler, Humidity Monitor, and Dew Point Hygrometer, July 25, 1979.

5) CQCM Data Reduction Requirements, August 17, 1979.

6) Mass Spectrometer Data Reduction Requirements, October 31, 1979.

7) Housekeeping Data from the IECM, February 8, 1980.

The IECM tape recorder format will be discussed extensively in the beginning of this document, followed by a discussion of the individual experiments integrated into the IECM framework.

1. An Induced Environment Contamination Monitor for the Space Shuttle (Edgar R. Miller and Rudolf Decher, eds.), NASA TM-78193, August 1978.

II. IECM TAPE RECORDER FORMAT

The IECM tape recorder format is displayed in Figure 1. The format consists of a block record before it repeats itself. A block record contains a 12-byte (or more) leader and 1 to 40 frames composed of 134 bytes each. Each frame will contain data from an individual experiment.

A byte is a data word consisting of eight bits. A bit is a number that has the value "0" or "1". An example of a byte in a data format is:

1 0 1 0 1 0 1 0 .

A byte is usually read from right to left. In reading a byte to obtain a useful number to represent data consider the following table:

8	7	6	5	4	3	2	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

If the extreme right bit is "0," then it represents the number zero. If the extreme right bit is "1," then it represents the number $2^0 = 1$. If the second bit is "0," then it represents the number zero. If the second bit is "1," then it represents $2^1 = 2$. Proceeding, one can see that if all the bits in an 8-bit word, or byte, are zero, this would represent the pure number zero. If all the bits in an 8-bit word are one, this would represent the pure number 255:

8	7	6	5	4	3	2	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

The number 255 was obtained by adding 1 + 2 + 4 + 8 + 16 + 32 + 64 + 128 = 255. Therefore, any pure number between 0 and 255 can be generated by the appropriate arrangement of bits in an 8-bit word. Examples are as follows:

4.0 IECM TAPE RECORDER FORMAT

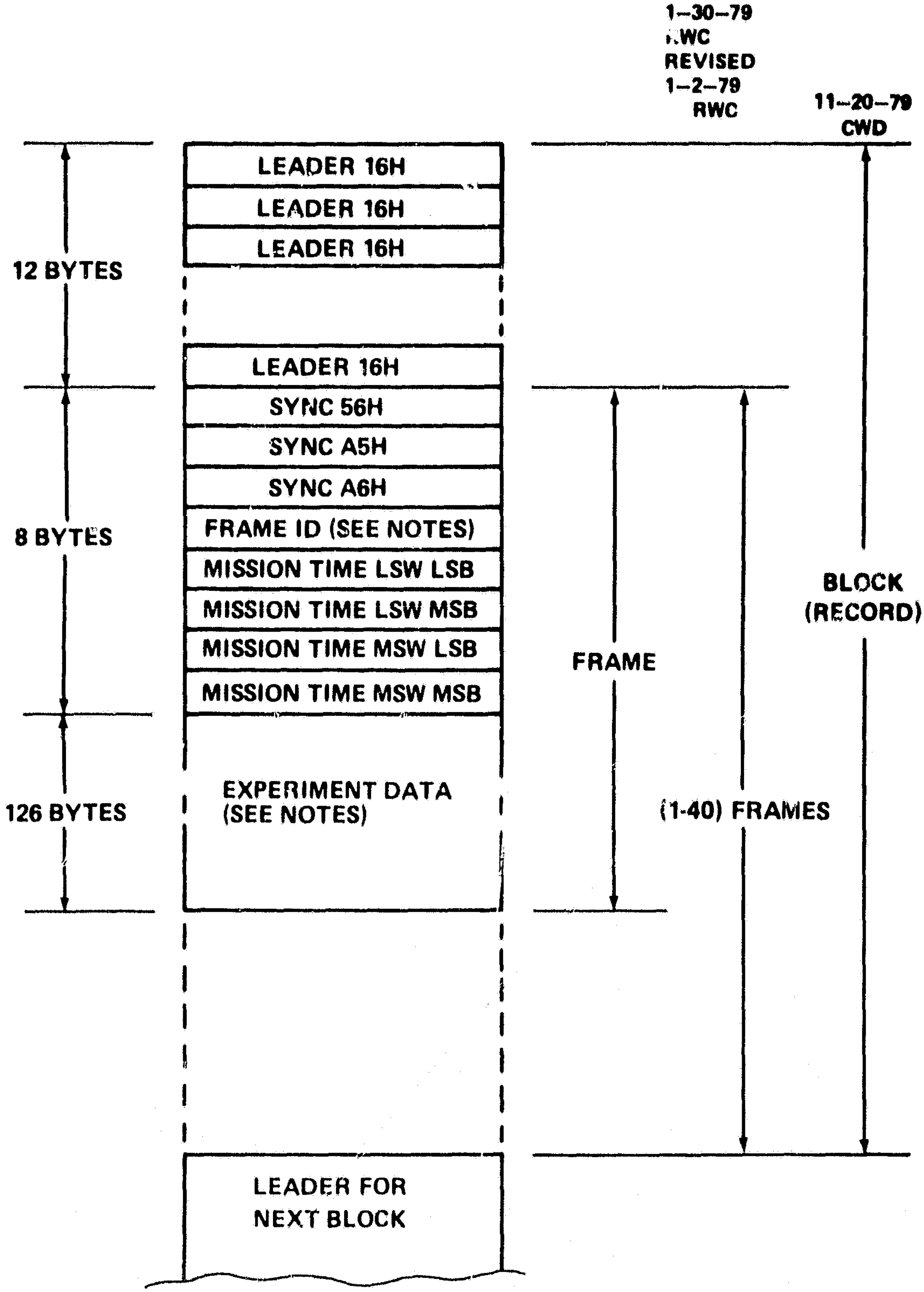


Figure 1. IECM tap recorder format.

0 0 1 1 0 0 1 0 = 50

1 0 1 0 1 1 0 0 = 172 .

Quite often the information contained in an 8-bit word can be represented in hex notation, which is a simpler way to dump information or store it. Hex notation has the automatic feature of being able to condense large volumes of information. Imagine an 8-bit word broken down to two 4-bit words. Consider the following representation of all possible bit combinations in a 4-bit word:

0 0 0 0 = 0

0 0 0 1 = 1

0 0 1 0 = 2

0 0 1 1 = 3

0 1 0 0 = 4

0 1 0 1 = 5

0 1 1 0 = 6

0 1 1 1 = 7

1 0 0 0 = 8

1 0 0 1 = 9

1 0 1 0 = A

1 0 1 1 = B

1 1 0 0 = C

1 1 0 1 = D

1 1 1 0 = E

1 1 1 1 = F

Now suppose it is desired to represent the 8-bit word

0 1 0 0 ⋮ 0 1 1 0

in hex notation. Divide the 8-bit word into two 4-bit words with an imaginary line, illustrated by the dashes. The hex notation for the left side is "4" and the hex notation for the right side is "6". Therefore, the entire 8-bit word can be represented in hex notation as "46".

Consider the hex notation "4C". What would the 8-bit word be? From the table form

4C = 0 1 0 0 1 1 0 0 .

The number formed from this would be 76. With this explanation, the 12-byte leader for the block data of the tape recorder format in Figure II-1 can be explained. Each of the first 12 bytes would have a hex configuration of 16; i.e.,

16H = 0 0 0 1 0 1 1 0 .

The computer's identification of 12 bytes of data in a row, as in the preceding from the tape recorder format, defines the beginning of a block of data consisting of 1 to 40 frames.

The question arises: How does one know when a frame of data has begun? There are three sync bytes (words) that follow the format order 1, 2, 3; they are, respectively, 56H, A5H, and A6H:

56H = 0 1 0 1 0 1 1 0 ,

A5H = 1 0 1 0 0 1 0 1 ,

A6H = 1 0 1 0 0 1 1 0 .

The next logical question concerns identification of the frame containing the data for a particular experiment. This is accomplished in the fourth byte (word) of a frame.

The identifications are:

0 0 0 0 0 0 0 1 = 01H Temperature-controlled Quartz Crystal Microbalance (TQCM) Data

0 0 0 0 0 0 1 0 = 02H Cryogenic Quartz Crystal Microbalance (CQCM) Data

0 0 0 0 0 0 1 1 = 03H Optical Effects Module (OEM) Data

0 0 0 0 0 1 0 0 = 04H Air Sampler Data, Humidity Monitor, and Dew Point Hygrometer

0 0 0 0 0 1 0 1 = 05H Camera Current Data

0 0 0 0 0 1 1 0 = 06H Camera Voltage and Thermistor Data

0 0 0 0 0 1 1 1 = 07H Cascade Impactor Data

0 0 0 0 1 0 0 0 = 08H Mass Spectrometer Data

0 0 0 0 1 0 0 1 = 09H Temperature Sensor Data (Housekeeping)

The next four bytes in a frame comprise the IECM mission time. The IECM mission time recorded on the tape recorder format, before the data sets are recorded within the frame, is the time resolved to 1 min of the last data set in that frame. Consider the following extract of the IECM mission time from a frame of data:

1	MISSION TIME LSW LSB
2	MISSION TIME LSW MSB
3	MISSION TIME MSW LSB
4	MISSION TIME MSW MSB

If all bits are "0," the time is zero. Mission time is calculated by reading the bit numbers from right to left, starting with byte 1. For instance, if byte 1 contained all "1s" and bytes 2, 3, and 4 contained all "0s," the IECM mission time would read 255 min. If there were all "1s" in bytes 1 and 2 and all "0s" in bytes 3 and 4, the IECM mission time would read 65,535 min.

Following the mission time, there are 126 bytes available for experiment data to be recorded in that particular frame. Each IECM experiment has, as a general observation, a different number of bytes per data set. One data set is as long as 25 bytes (TQCM), and another data set is as short as 2 bytes (Mass Spectrometer). Programmed into each experiment internally is a data rate. In many cases it will be necessary to know the data rate per IECM experiment. It could be (as in one mode of operation of the mass spectrometer) as small as 0.2 sec. The IECM clock is accurate in resolution to only 1 min. Therefore, it may be necessary to interpolate between time readings of 1 min by taking account of the data rate in cases where more accurate time resolution is needed. In some cases it may not be possible to get more than a few seconds time resolution in interpolation.

The remainder of this document addresses the individual experiment data that fill the remaining 126 bytes of the 134 bytes that compose a frame.

The discussion so far has covered the first eight bytes of a frame. Three bytes identify the formation of a frame, one byte identifies the particular experiment whose data fills the frame, and four bytes identify the time of entry of the last data set in a frame resolved to the nearest minute.

III. TQCM DATA REDUCTION REQUIREMENTS (O1H)

As a basis for beginning discussion of the data reduction requirements for the TQCM, refer to Figure 2.

Consider the status byte; reading from right to left:

R: "1", TED #5 ON; "0" means not on.

S: "1", TQCM START COUNT is on; "0" means not on.

T: "1", TEMP SELECT 1 (+80°C) is on; "0" means not on.

U: "1", TEMP SELECT 2 (+30°C) is on; "0" means not on.

V: "1", TEMP SELECT 3 (0°C) is on; "0" means not on.

W: "1", TEMP SELECT 4 (-30°C) is on; "0" means not on.

X: "1", TEMP SELECT 5 (-60°C) is on; "0" means not on.

Y: "1", THERMO-ELECTRIC DEVICES OFF; "0" means otherwise.

In the TQCM data format there are three measurements from each of the five sensor heads to be recorded and analyzed.

1) Frequency: Frequency from each of the five sensor heads is represented by two 8-bit words. Bit configuration will generate a number range from 0 to 65,535. The representation of bit number to frequency is 1 bit number equals 1 Hz (cycle/second).

2) Sensor Temperature: Temperature sensors are represented by one 8-bit word. Bit configuration will generate a number range from 0 to 255. Each bit number corresponds to a change of 0.02 V (20 mV). Hence, there is a voltage range of 5.1 V. The temperature range of each sensor is from -83°C to 107°C (190°C difference). Therefore, each volt represents 37.255°C, and each bit (or 20 mV) equals 0.745°C. This assumes a linear relationship between voltage and temperature. The right will be reserved to change this to a polynomial if the linear relationship is not sufficient.

3) Heat Sink Temperature: The information given for the temperature sensor is applicable for measurement of heat sink temperature.

The frequency verification ready 8-bit word is not used in data reduction for the TQCM. The 32-bit IECM clock word resolution is one bit number equals 1 min.

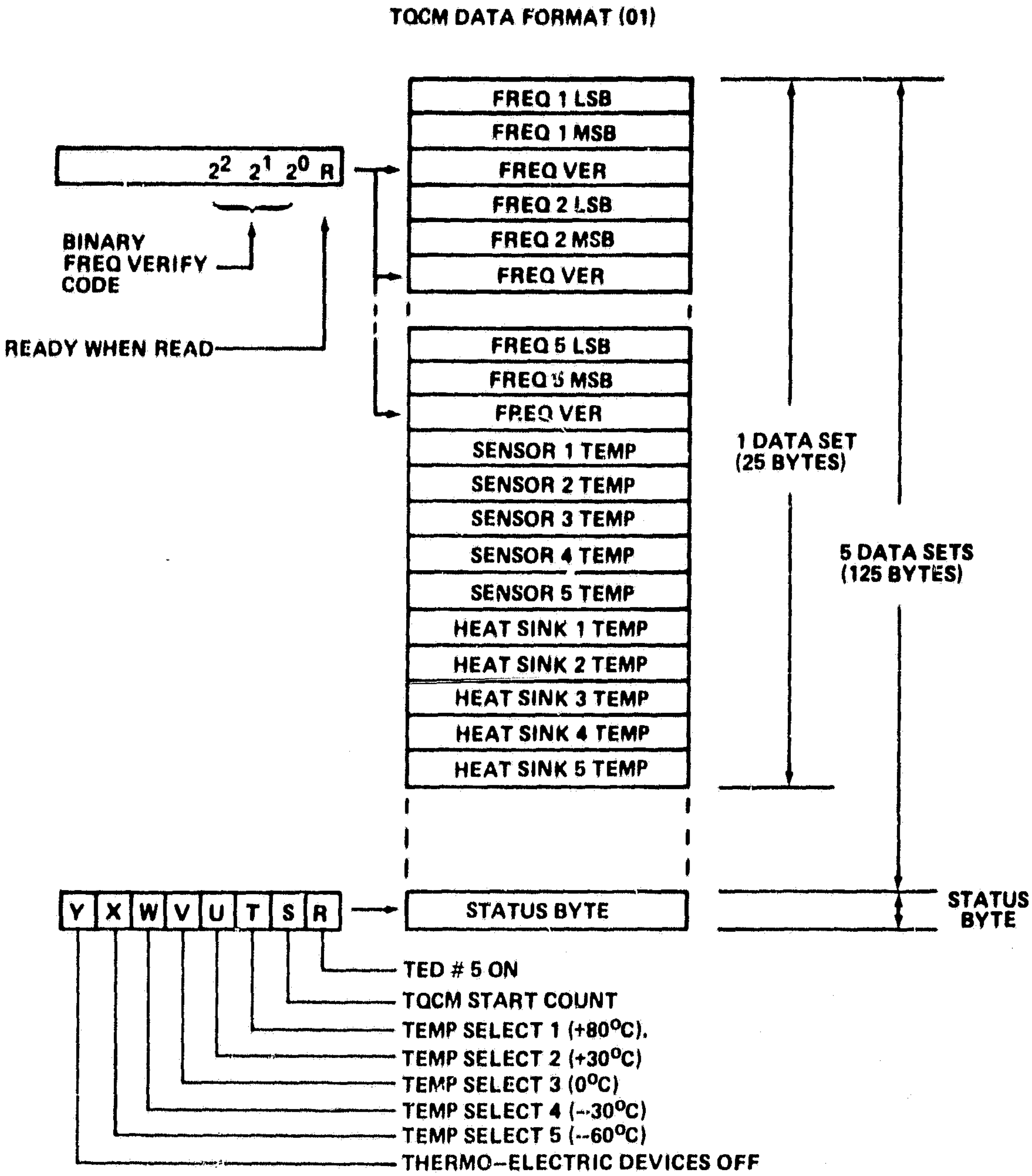


Figure 2. TQCM data format (01).

Requirement 1: Designate the frequency of any particular sensor as F. Then the mass per unit area is computed by the relationship

$$M/A = (1.56 \times 10^{-9})\ F\ \text{grams/cm}^2 \quad . \tag{3.1}$$

The first step will be a continuous plot for each sensor of mass/area, sensor temperature, and heat sink temperature versus time. Break the y-axis into two parts and have mass/area on the upper part ranging from 1×10^{-9} grams/cm^2 to 1×10^{-3} grams/cm^2 over a six-cycle semi-log scale. This range may vary after actual flight data levels are determined. On the lower part of the y-axis let temperature range from -83°C to 107°C on a linear scale. The x-axis will be a linear scale of IECM clock time. Also indicate actual calendar day and hour in universal time on the x-axis. On the lower part plot both the sensor temperature and the heat sink temperature on the scale. The plots will constitute three phases for each sensor combination. There will be an ascent, on-orbit, and descent phase. The ascent phase will last approximately 1-hr. The descent phase will last approximately 1.5 hr. Time will be referenced to the IECM clock, which will be turned on at launch. Separate plots are to be made for each sensor combination during each phase and labeled +x, -x, +y, -y, +z. Provisions should be made so that for each flight, the serial numbers of the TQCM controllers, sensors, heat sinks and electronics can be indicated and each axis measurement will be so identified. In the ascent and descent phases, each sensor combination will be recorded every 5 sec. For the on-orbit phase, data will be recorded each minute.

The on-orbit phase for each sensor combination of the time scale per plot is to run 570 min. For subsequent flights this time may change. The number of plots per sensor combination per mission will vary from approximately 5 to 20. During on-orbit operations 570 min is the time taken to complete one TQCM command-temperature sequence cycle. During such a cycle there will be a series of commands to change the temperature. An indication of the command associated with each temperature change is requested at its approximate time on the temperature graph. There will be an addition to the housekeeping data that will identify the time at which a temperature change command is made. Additional information on the location and nature of this command signal will be given later.

Requirement 2: Consider any particular sensor combination (frequency and temperature). Each sensor combination will go through a TQCM command-temperature sequence cycle covering four collection temperatures of +30°C, 0°C, -30°C, -60°C, and the 80°C cleanup periods. For each sensor combination tabulate the following for each mission:

80°C TIME (Mid-point of 30 min clean-up)	80°C INITIAL MASS/AREA grams/cm^2	X°C FINAL MASS/AREA grams/cm^2	X°C TIME (Mid-point of mass collection temperature cycle)	X°C MASS/AREA CHANGE grams/cm^2

X will take on the four temperature values mentioned previously MASS/AREA CHANGE equals FINAL MASS/AREA minus INITIAL MASS/AREA (occurs over a 90-min time span).

Requirement 3: Construct a semi-log plot (for each sensor) of the MASS/AREA CHANGE in the previous table versus time. Use a six-cycle scale along the y-axis running from 1×10^{-9} grams/cm^2 to 1×10^{-3} grams/cm^2. Time will be in hours along the x-axis. Let the time range be on-orbit time for each mission. There should be four curves on this graph corresponding to each of the four collection temperatures.

Requirement 4: Construct a semi-log plot of the INITIAL MASS/AREA from the tables versus time at mid-point of each 30-min cleanup. Use a three-cycle semi-log scale along the y-axis running from 1×10^{-9} grams/cm^2 to 1×10^{-6} grams/cm^2. The time will be mission on-orbit time along the x-axis in hours. This will be one continuous curve for all 80°C, 30-min cleanup periods for each sensor. Collection temperatures need not be labeled.

Requirement 5: Construct a tabular listing of TIME, t, in minutes, TEMPERATURE, T, in °C, and MASS/AREA, m, in grams/cm^2 with annotation of commands during the heating subcycle from -60°C to +80°C. This table will include all data points per subcycle or 4 × (30 min) = 120 data points. There will be four command sequences from -60°C to +80°C. These command sequences will be (1) to -30°C, (2) to 0°C, (3) to +30°C, (4) to +80°C, occurring 30 min apart.

Requirement 6: We are now ready to calculate the average desorption activation energies using the data constructed in tabular form in Requirement 5. Consider the equation

$$\Delta E = RT \ln (\tau/t) \ln (S_o/S_r) \quad . \tag{3.2}$$

R and τ are constants and their numerical values will be furnished later. The symbol τ will always be 30 min (1800 sec). For illustration purposes consider the first heat application command sequence to go from -60°C to -30°C. Then S_o will be the mass at the beginning of the sequence and S_r will be the mass at the end of the sequence. To calculate the value of T, sum up all the temperatures from the beginning to the end of the sequence. There should be 30 of them. Then calculate T for the sequence by:

$$T = 273°K + \frac{\text{sum of temperatures}}{30} \quad .$$

Hence we have all the numbers available to calculate the average desorption energies in the four temperature ranges. Calculate them for each sensor combination and tabulate them according to the following table, identifying each as +x, -x, +y, -y, +z.

AVERAGE DESORPTION ACTIVATION ENERGIES

TIME[a]	-60°C to -30°C	TIME	-30°C to 0°C	TIME	0°C to 30°C	TIME	30°C to 80°C

a. TIME refers to cycle mid-point.

Requirement 7: The following housekeeping data are requested:

1) A plot of the temperatures of thermocouples near each TQCM head and TQCM controller as a function of time. These temperature sensors will be selected from 14 sensors in the housekeeping data. The length of the graph can be confined to mission time.

2) A plot of total pressure from the mass spectrometer as a function of time for mission duration, a plot of the partial pressure of AMU 18 as a function of time for mission duration.

3) A time-line or printout of as many Orbiter activities as possible, such as door openings and closings, engine firings, water dumps, etc.

Scales on graphs should be capable of being changed so that different time scales may be selected if it becomes desirable. It will be desirable to have the capability of selecting and graphing any data over a selected time span for expanded and detailed study. All commands given to the TQCM should be noted on the graph.

IV. CQCM DATA REDUCTION REQUIREMENTS (02H)

Refer to Figure 3 as a basis for beginning discussion of the data reduction requirements for the CQCM.

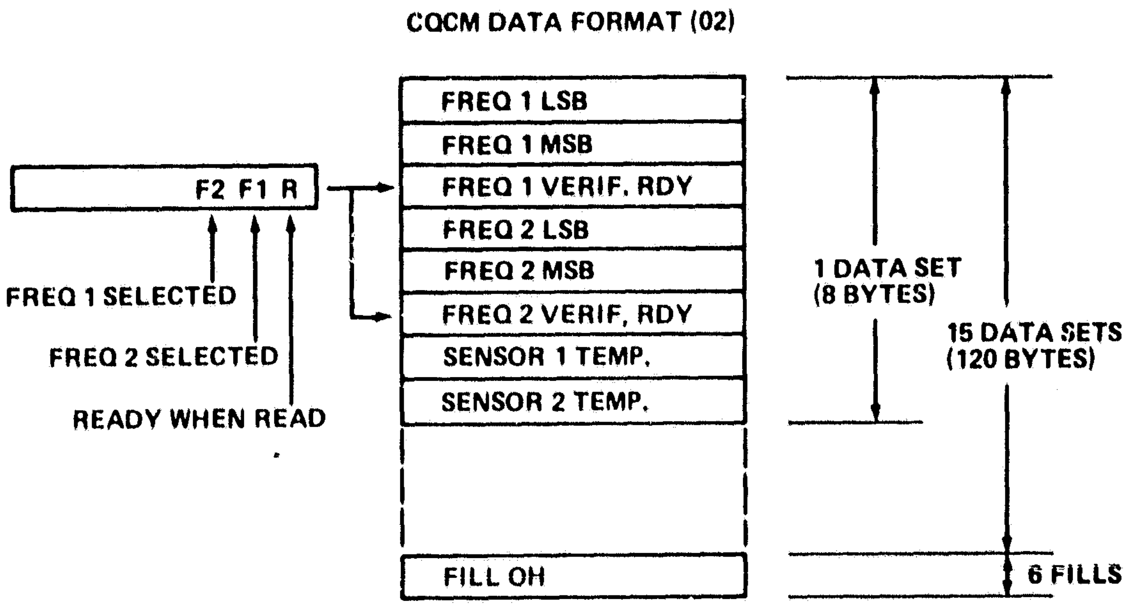


Figure 3. CQCM data format (02).

The CQCM data set consists of eight bytes. Fifteen data sets (120 bytes) will fill a frame, with six bytes left over to be filled with zeros. There are two frequency measurements that take up four bytes (two bytes/frequency measurement) in a data set. There are two frequency verification and ready bytes that are not used in data reduction; they are to be ignored. Finally, two sensor temperature bytes complete a data set.

The CQCM operates in the three modes of ascent, on-orbit, and descent. The data rate on ascent and descent is one data set every 5 sec. The data rate on-orbit is one data set per minute.

The frequency calibration is the same as it is for the TQCM as discussed in previously mentioned memorandum No. 1 (July 19, 1979). The conversion of frequency to MASS/AREA is the same as for the TQCM as stated on page 2 of the memorandum.

The sensor temperature calibration is as follows: As usual, each bit in a temperature sensor represents 0.02 V (20 mV). Two hundred fifty-five (255) maximum bits in a word of one byte represent 5.1 V. The temperature range for each sensor runs from −103°C to +37°C, a difference of 140°. Therefore, to calculate the temperature for a particular sensor reading, multiply the bit number by 0.549 and add (−103) to this number.

In the ascent and descent modes construct the following table for all data points:

ASCENT (DESCENT)

MISSION TIME	MASS/AREA ONE	SENS. TEMP. ONE	MASS/AREA TWO	SENS. TEMP. TWO
H M S	gm/cm^2	°C	gm/cm^2	°C

H, M, and S under mission time stand for hours, minutes and seconds. As stated in memorandum No. 1, the ascent phase will last approximately 1 hr. The descent phase will last approximately 1.5 hr.

Consider equation (2) from the memorandum:

$$\Delta E = RT \ln (\tau/t) \left[\left| \ln (S_o/S_r) \right| \right] \quad . \tag{4.1}$$

This is the equation for calculating the average desorption activation energies. It is possible (and probable) that adsorption will occur in the operation of the CQCM. Over a particular time, t, when adsorption occurs, the ratio $S_o/S_r < 1$; i.e., $S_r > S_o$. At every data point in the on-orbit operation it is requested that the average desorption/adsorption activation energy be calculated for each sensor. R and τ are constants, and their numerical values will be furnished later. The time, represented by the symbol t, will be the time between data points, 1 min (60 sec). The value of the temperature, T, will be 273°K + (the average of temperature at the data point under consideration and the temperature at the data point 1 min previous). If T_o is the temperature from the previous data point and T_r is the temperature at the data point under consideration, then;

$$T = 273 + (T_o + T_r)/2 \quad . \tag{4.2}$$

S_o will represent the mass 1 min prior to the point under consideration, and S_r will represent the mass at the point under consideration. S_o and S_r are proportional by the same constant to the frequency measurement. Hence, their ratio S_o/S_r is calculated by taking the ratio of the frequencies at each data point.

Before a calculation is executed with equation (4.1), a test is to be made on $\ln(S_o/S_r)$ to determine if it is less than zero. If it is less than zero, then adsorption has occurred and the resulting calculation for ΔE should be labeled "A(number)". Of course, if $S_o/S_r = 1$, then $\Delta E = 0$. For all situations where $S_o/S_r > 1$, desorption has occurred and the resulting calculation for ΔE should be labeled "D(number)".

The on-orbit data are to be tabulated to include everything in the preceding table for ascent (descent) with the addition of the activation energies. The top of the table is to be labeled ON-ORBIT instead of ASCENT or DESCENT. Observe the preceding table and move from left to right. Insert the following columns: after the third column and after the fifth column, respectively,

ACTIVATION ENERGY (1) ergs
D (number)
A (number)

ACTIVATION ENERGY (2) ergs
A (number)
D (number)

Examples hεve been placed in the columns to show the designation of adsorption or desorption. In order to have data to calculate the first set of activation energies, use the final values of the data in the ascent mode.

For each of the three modes of operation plot a set of two graphs for each of the two sensors. A set of two graphs will consist of mass/area and sensor temperature versus time on the same page. Break the vertical axis into two parts and have mass/area on the upper part ranging from 1×10^{-9} grams/cm^2 to 1×10^{-3} grams/cm^2 over a six-cycle semi-log scale. This range may vary after actual flight data levels are determined. On the lower part of the vertical axis let temperature range from -103°C to +37°C on a linear scale. The horizontal axis will be a linear scale of IECM clock time. Also indicate actual calendar day and hour in universal time at the beginning of the IECM clock time scale on all individual graphs. There will be three graphs of a set of two graphs for each of the two sensors. Each of three graphs will range in time for whatever the ascent, on-orbit, and descent time is for a particular mission. Provisions should be made so that each flight, the serial numbers of the CQCM controllers, sensors, and electronics can be indicated.

The following housekeeping data are requested:

1) A plot of the temperatures of thermocouples near each CQCM head and CQCM controller as a function of time. These temperature sensors will be selected from 14 sensors in the housekeeping data. The length of the graph can be confined to mission time.

2) A plot of total pressure from the mass spectrometer as a function of time for mission duration, and a plot of the partial pressure of AMU 18 as a function of time for mission duration.

3) A time-line or printout of as many Orbiter activities as possible, such as door openings and closings, engine firings, water dumps, etc.

Scales on graphs should be made to be changeable so that different time scales may be selected if it becomes desirable. It will be desirable to have the capability of selecting and graphing any data over a selected time span for expanded and detailed study. All commands given to the CQCM should be noted on the graph.

V. OEM DATA REDUCTION REQUIREMENTS (03H)

Refer to Figure 4 as a guideline and starting point for discussion of the data reduction requirements for the OEM.

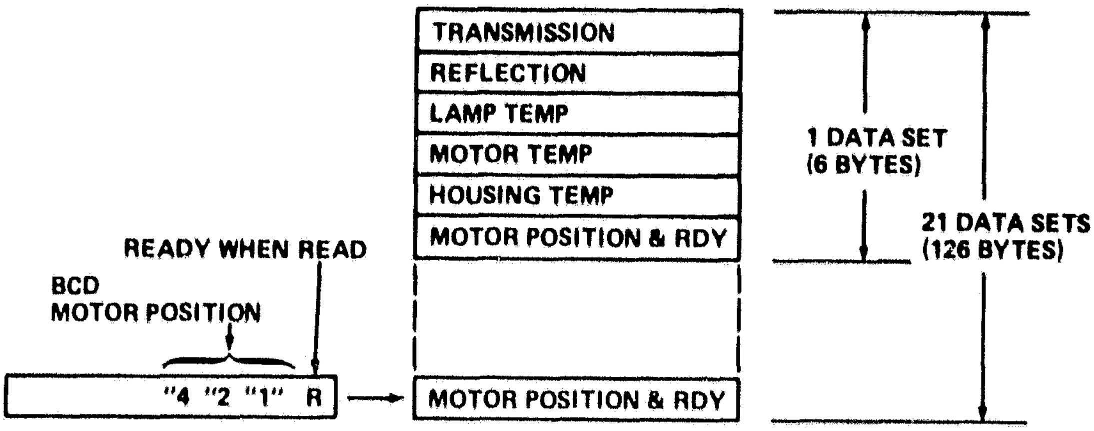


Figure 4. OEM data format (03).

A data set for the OEM consists of six bytes. Therefore, there are 21 data sets in an OEM frame. The first two bytes of an OEM data set represent light transmission and reflection, respectively. Also, the voltage range is 0 to 7 V represented over a 255-bit number range. Therefore, 1 bit number = 27.45 mV. The third, fourth, and fifth bytes represent lamp temperature, motor temperature, and housing temperature, respectively. Each of these bytes ranges from 0 to 255 bit numbers corresponding to the standard 0 to 5.1 V (20 mV = 1 bit number). To convert to temperatures, use 0 bits as 0°C and 255 bits as 102°C. Fifty mV represents a 1°C change. Therefore, to obtain the lamp, motor, or housing temperature multiply the bit number in the appropriate byte by 0.4 to convert it to degrees centigrade.

The following sequence represents the station being observed in a data set:

Sequence	Bit Configuration			Station
1	0	0	0	0
2	0	0	1	1
3	0	1	0	2
4	0	1	1	3
5	1	0	0	4
6	1	0	1	5
7	0	0	0	0

The bit configuration is taken from the fifth, sixth and seventh bits of the sixth byte in a data set. The power-on command will have a fixed time cycle in which it will go through the preceding sequence in 80 sec (+11 sec per station). Then the OEM will rest for 500 sec and repeat the sequence. A sequence takes up seven data sets. There are 21 data sets to a frame; hence, three sequences will fill a frame. Therefore, it will take 1240 sec (20.66 min) to fill a frame. Note that the first and last sequence are at the same station. Hence, there are six distinct stations.

For the transmission channel sum the first and seventh station readings for each measurement cycle and divide by two. Store this as VT0 if $0.5 \leq VT0 \leq 0.99$; otherwise, obtain VT0 from next or subsequent valid sequence. Each of the other five stations will have VT1, VT2, VT3, VT4, and VT5. Divide each by VT0 to form IT1, IT2, IT3, IT4, and IT5. For the first valid data cycle store the ratio values as T01, T02, T03, T04, and T05. Each subsequent data measurement cycle will have transmission ratios Tm1, Tm2, Tm3, Tm4, and Tm5. Then form the ratios 100(T01 - Tm1)/T01 = TR1, 100(T02 - Tm2)/T02 - TR2, 100(T03 - Tm3)/T03 = TR3, 100(T04 - Tm4)/T04 = TR4, and 100(T05 - Tm5)/T05 = TR5. We will repeat this for the reflection channel: Sum the first and seventh station readings for each measurement cycle and divide by two. Store this as VR0. Each of the other five stations will have voltages VR1, VR2, VR3, VR4, and VR5. For each VR1, VR2, etc., subtract VR0 and store as absolute magnitude (positive) VR11, VR22, etc. Divide each by VT0 to form IR1, IR2, IR3, IR4, and IR5. For the very first valid data cycle store the ratio values as R01, R02, R03, R04, and R05. Each subsequent data measurement cycle will have reflection ratios Rm1, Rm2, Rm3, Rm4, and Rm5. Then from the ratios 100(R01 - Rm1)/R01 = RR1, 100(R02 - Rm2)/R02 - RR2, 100(R03 - Rm3)/R03 - RR3, 100(R04 - Rm4)/R04 = RR4, and 100(R05 - Rm5)/R05 = RR5.

Two special cases to consider are the 0-channel transmission and reflection ratios. After the first data set, designate the average of the two 0-channel voltages as VT0m and VR0m for transmission and reflection, respecitvely. Then form TR0 = 100 (VT0 - VT0m)/VT0 and RR0 = 100 (VR0 = VR0m)/VR0.

For the 0 channel form the following table:

CHANNEL 0

MT	UT	VT0	TR0	VR0	RR0

Here MT stands for mission time and UT stands for universal time. The time need not be more accurate than 1 min.

For channels 1 through 5 form the following table (channel 1 used as example):

CHANNEL 1

MT	UT	VT1	IT1	TR1	VR1	IR1	RR1

Plots of all values generated in the preceding tables are requested as a function of time. The time will run from 0 (mission begins) to end of mission. Voltages will run from 0 to 7V. Intensities will run from 0 to 1 (dimensionless). Percentile ratios will run from 0 to 100.

Finally, plot the lamp temperature, motor temperature, and housing temperature as a function of mission time. The temperature scale for each will run from 0 to 102°C.

VI. AIR SAMPLERS HUMIDITY MONITOR, AND DEW POINT HYGROMETER DATA REDUCTION REQUIREMENTS (04H)

As a basis for beginning discussion of the data reduction requirements for the Air Sampler, Humidity Monitor, and Dew Point Hygrometer, refer to Figure 5.

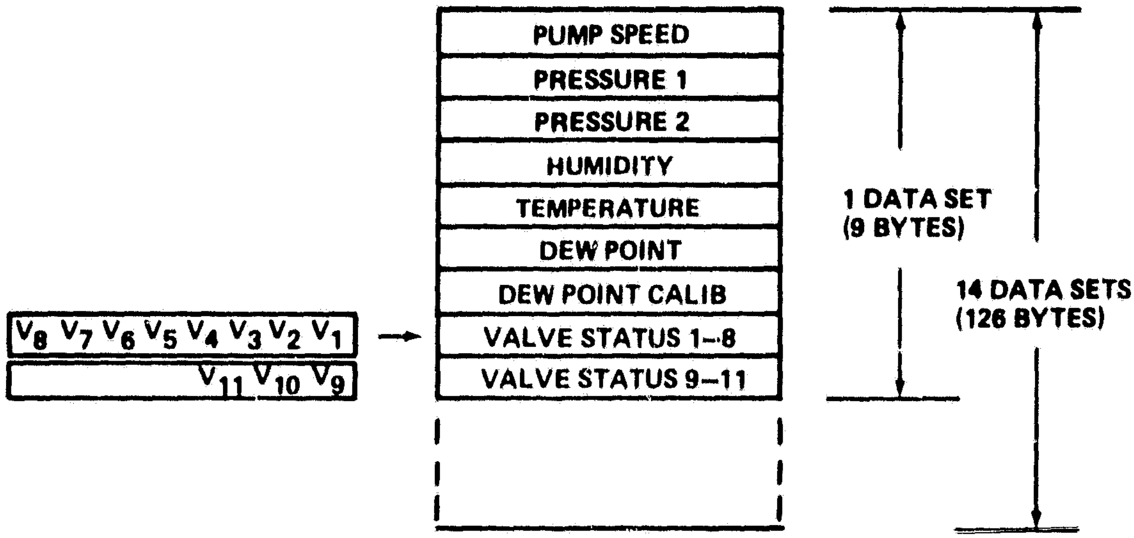


Figure 5. Air sampler data format (04).

A data set containing all of the required data information for the Air Sampler, Humidity Monitor, and Dew Point Hygrometer consists of nine bytes. Since 126 bytes constitute a data frame, there can be 14 data sets to a frame.

It appears that the data rate will be six data sets per minute, or one every 10 sec. The Air Sampler and the Humidity Monitor require this rate. The Dew Point Hygrometer requires data at a rate of once a minute. However, because the information for all three instruments goes into the same data set, the information from the Dew Point Hygrometer will also be expressed at six per minute.

The first byte in the data set is PUMP SPEED. Convert the bit reading to volts by multiplying the bit number by 0.02. The second and third bytes are PRESSURE 1 and PRESSURE 2. Convert each bit number to volts, again by multiplying by 0.02. Call the conversions V1 and V2. Then calculate the pressures; $P1 = 16.0 - (V1/5.0 \times 16.0)$, and $P2 = 16.0 - (V2/5.0)(16.0)$.

The fourth byte is the HUMIDITY (relative) measurement for the Humidity Monitor. Zero to 5 V represents relative humidity from 0% to 100%. Each bit number represents 0.02 V. Hence, each bit number represents 0.4% relative humidity. Multiply the bit number by 0.4 to obtain the required relative humidity data for the Humidity Monitor. The fifth byte is the TEMPERATURE measurement for the Humidity Monitor. Zero to 5 V represents temperature from 0°C to 100°C. Each bit number represents 0.02 V. Hence, each bit number represents 0.4°C. Multiply the bit number by 0.4 to obtain the required temperature data for the Humidity Monitor.

The sixth byte is the DEW POINT measurement for the Dew Point Hygrometer. The dew point is represented by a temperature reading. Zero to 5 V represents a temperature range from -6.7°C (20°F) to 26.7°C (80°F). Each bit number represents 0.02 V. Hence each bit number represents 0.1336°C (0.24°F). Multiply the bit number by (0.1336) and subtract 6.7 to obtain the required dew point in °C. Multiply the bit number by 0.24 and add 20 to obtain the required dew point in °F. The DEW POINT CALIB byte is the seventh byte. Convert the bit number to volts by multiplying by 0.02. This is the required calibration information in volts.

Bytes 8 and 9 are an indication of the open and closed status for 11 valves in the Air Sampler system. Their locations are indicated in the format. For valves 1 through 3 and 6 through 11 a zero bit means the valve is closed and a 1 bit means the valve is open. For valves 4 and 5 a 0 bit means the valve is open, and a 1 bit means the valve is closed.

Output a data set for the Air Sampler in the following format:

TIME =				
PUMP SPEED (VOLTS)	PRESS 1 (PSI)	PRESS 2 (PSI)	PRESS 2 - PRESS 1 (PSI)	VALV1 Open/ Closed
VALV2 Open/ Closed VALV7 Open/ Closed	VALV3 Open/ Closed VALV8 Open/ Closed	VALV4 Open/ Closed VALV9 Open/ Closed	VALV5 Open/ Closed VALV10 Open/ Closed	VALV6 Open/ Closed VALV11 Open/ Closed

Time will be mission time in minutes interpolated to every 10 sec since the data rate is six per minute. Express the time as two numbers, such as 10M and 10S, which would read 10 min and 10 sec, meaning 10 min and 10 sec after the mission has begun.

Output a data set for the Humidity Monitor and Dew Point Hygrometer in the following format:

Time Min/Sec	Temperature (°C) (°F)	Humidity (%)	Dew Point (°C) (°F)	DP Calib (V)

Again, TIME is mission time interpolated to the nearest 10 sec. Express the temperature in Centigrade and Fahrenheit. Use the formula °F = (9/5) (°C) + 32 where necessary. Finally, plot humidity and temperature versus time on one plot and dew point and temperature versus time on another plot. In fact, make four graphs because these instruments operate only on ascent and descent. On two of the graphs the time range will be mission time during ascent. On the other two the time range will be mission time during descent. Temperature will range from 0°C to 100°C. Relative humidity will range from 0% to 100%. Dew point will range from -10°C to +30°C.

VII. CAMERA PHOTOMETER DATA REDUCTION REQUIREMENTS (05H and 06H)

As a basis for beginning discussion of the data reduction requirements for the Camera Photometer, refer to Figure 6.

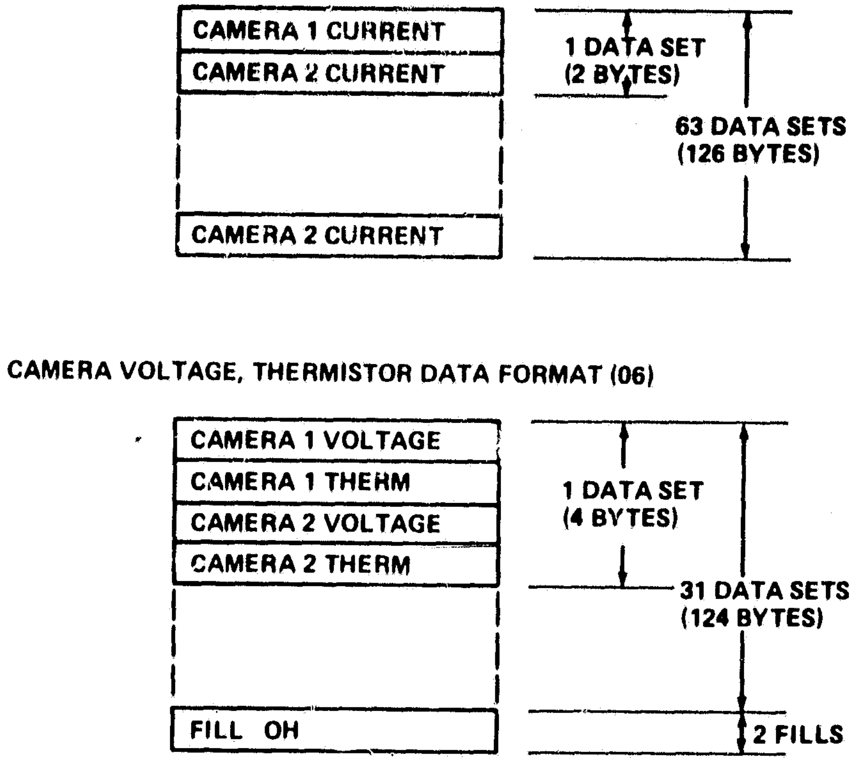


Figure 6. Camera current data format (05).

In the Camera-Photometer experiment the nomenclature for the camera current data format is changed to Integrated Photometer Output 1 and Integrated Photometer Output 2. The data rate is one data set every 2 s. Construct a table as follows:

Resolve mission elapsed time and universal time as accurately as possible to days, hours, minutes, and seconds. The bit numbers for IPO-1 and IPO-2 are converted to volts by multiplying each bit number by 0.02 (20 mV).

(TIME)

TABLE A

MET (D-H-M-S)	UT (D-H-M-S)	IPO-1	IPO-2

It is desired to convert the Integrated Photometer Output voltages into photometric units. The Integrated Photometer Output voltages are designated IPO-1 and IPO-2 for Camera Photometers 1 and 2. Photometric units for each camera will be normalized to solar brightness, and a plot of background brightness versus time is requested for each camera.

The conversion to photometric units and background brightness will involve the following computational steps:

1) Consider the first data point for IPO-1. Perform a computation for IPO-1 to test if it is greater than zero. If IPO-1 is greater than zero, initialize an exposure time $t1 = 0$ coincidently for IPO-1. After t1 is set equal to zero at the first encounter of IPO-1 $\neq 0$, t1 is updated by $t1 + 2.0$ for each successive nonzero value of IPO-1. This update continues until the next IPO-1 = 0 is encountered. Then t1 is updated by 2.0 sec for the final time of the sequence coincidently with the first IPO-1 = 0 after a sequence of non zero IPO-1's. In normal operations the maximum possible exposure time, t1, is 150 sec. Hence, the exposure time t1 will always be such that $t1 \leq 150$ sec.

2) A universal time (UT) will be associated with the midpoint of the exposure time t1. Using the information from IECM clock time, UT when the IECM clock is started, and the data rate, determine as accurately as possible the UT associated with the midpoint of the exposure time, t1. Call it UT1.

3) Associate with the previously computed exposure time, t1, the last IPO-1 voltage greater than zero in the previously described sequence. Call it V1.

4) Calculate the background brightness in terms of solar brightness using the following formula:

$$B1 = (1.11456E - 12) * (V1/t1) \quad .$$

5) Finally, form a data set from all of the preceding values with the background brightness in terms of solar brightness and the universal time, UT1: (B1, UT1).

Repeat the preceding steps independently for IPO-2 to form a data set (B2, UT2). Continue this process sequentially through all of the data for a mission and form the following table:

TABLE B

UT1 (D-H-M-S)	B1 BBR	UT2 (D-H-M-S)	B2 BBR

Make two plots for the data in Table B. One plot will be the mission time in terms of universal time along the horizontal axis and background brightness along the vertical axis for IPO-1 data. The other plot will be a similar plot for IPO-2 data.

Consider the camera voltage, thermistor data format. One data set consists of Camera 1 voltage, Camera 1 temperature and Camera 2 voltage, Camera 2 temperature. The data rate is one data set every 10 min. Construct the following table:

TABLE C

MET D-H-M	UT D-H-M	HV-1 (V)	TM-1 °C °F	HV-2 (V)	TM-2 °C °F

Resolve the mission elapsed time and universal time to days, hours, and minutes. The bit numbers for high voltage 1 (HV-1), temperature monitor 1 (TM-1), HV-2, and TM-2 are converted to volts by multiplying each bit number by 0.02 (20 mV). It is not necessary to note on/off. The Camera Photometer is on during on-orbit operations and off during ascent and descent.

The temperature in degrees Centigrade and degrees Fahrenheit for Camera 1 and Camera 2 is calculated by the following formulas:

$$^{\circ}C = 101.087 * VTM - 215.277 \quad ,$$

$$^{\circ}F = 180.388 * VTM - 352.723 \quad .$$

VTM refers to the voltage for either TM-1 or TM-2. These values are to be placed in Table C as indicated.

From Orbiter housekeeping data construct the following table:

TABLE D

MET	UT	ALPHA	DELTA	THETA

As in Table A, resolve the time to days, hours, minutes, and seconds, if possible. ALPHA is the right ascension of the pointing direction of the z-axis in degrees (as accurately as possible); DELTA is the declination of the pointing direction of the z-axis in degrees (as accurately as possible); THETA is the solar depression angle as observed from the spacecraft in degrees (as accurately as possible). Further clarification of these terms will be furnished later.

Finally, construct a table of events (such as water dumps, attitude change, engine burn, etc.):

TABLE E

MET	UT	EVENT

Resolve the time as accurately as possible.

VIII. CASCADE IMPACTOR DATA REDUCTION REQUIREMENTS (07H)

As a basis for beginning discussion of the data reduction requirements for the Cascade Impactor, refer to Figure 7.

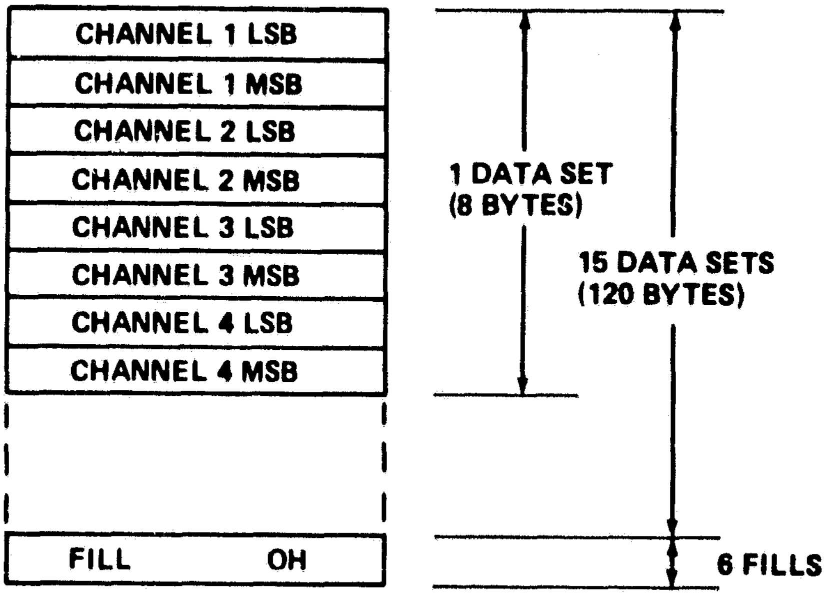


Figure 7. Cascade impactor data format.

Consider any frame of data for any IECM experiment. The IECM mission time, recorded on the tape recorder format before the data sets are recorded within the frame, is the time resolved to 1 min of the last data set in that frame. Therefore, in calculating the time associated with data sets preceding the last data set, it would be necessary to work backward from the recorded frame time, using the data rate associated with this particular experiment.

The Cascade Impactor data set consists of eight bytes. These eight bytes represent four beat frequencies. A beat frequency is represented by two bytes. The conversion used for the TQCM and CQCM is the same for the cascade impactor frequencies; i.e., one bit number = 1 Hz (cycle/sec).

From the tape recorded format make the identification that beat frequency 1 comes over channel 1, beat frequency 2 over channel 2, etc. Extract the CQCM baseplate temperature and construct a table in the following format:

FREQUENCY (Hz)

TIME	TEMP	1	2	3	4

Convert the time to days, hours, minutes, and seconds if possible. Three different tables should be constructed for the three modes of ascent, on-orbit, and descent. Conversion factors will be furnished in a memorandum on the CQCM on the conversion from bit numbers to degrees Centigrade. The data rate is six data sets per minute on ascent and descent and one data set per minute on-orbit.

Plots of each of the beat frequencies and CQCM baseplate temperature are requested as a function of time. The frequencies can be placed on one graph and the temperature on another graph. Make three different graphs for each of the three modes of operation. Construct the scales such that time (along x-axis) is ascent, on-orbit, and descent time. Frequencies will be best represented on a linear scale from 0 to 4000. The temperature range will be whatever the CQCM temperature range is. In addition, plots of the altitude in kilometers and the payload compartment pressure in pounds per square inch versus mission time are requested from the Orbiter housekeeping data.

IX. MASS SPECTROMETER DATA REDUCTION REQUIREMENTS (08H)

Refer to Figure 8 as a basis for beginning discussion of the data reduction requirements for the Mass Spectrometer.

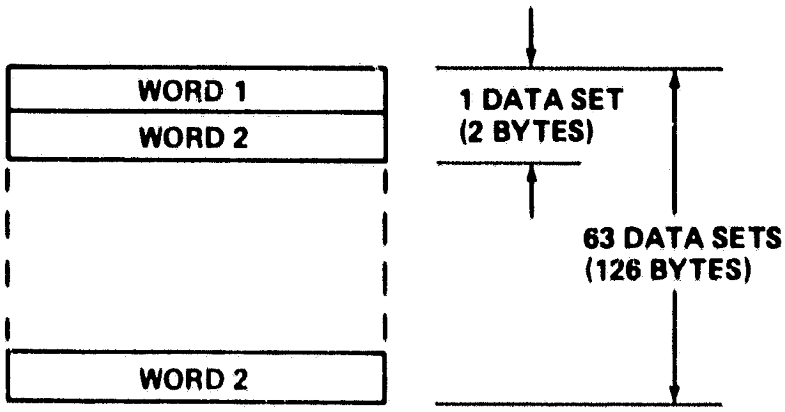


Figure 8. Mass spectrometer data format.

The mass spectrometer data set consists of two 8-bit words (or two bytes). In a frame of information 126 bytes are available for data. Therefore, 63 data sets of mass spectrometer data will fill a frame. Each bit in a data set for the mass spectrometer is very meaningful. Therefore, a sequential explanation of each bit in a data set will follow, starting with the most significant bit of word one or byte one.

Bit 1 is a synchronization bit. It is to be interrogated for each data set to determine if its value is zero or 1. Normally it will be zero and be directly related to an atomic mass unit. When the sync bit is 1, the mass spectrometer data system has recycled.

Bits 2 and 3 of word 1 from each data set will be combined sequentially until an 8-bit word is formed. Hence, four sequential data sets will form an 8-bit word. This is interpreted as an analog measurement. As an example, a noninterrupted sequence of 320 data sets would map into 80 analog measurements. The most significant bit is first on the left, and the least significant bit is last on the right.

Bits 4, 5, 6 and 7 of word 1 from each data set will determine the exponent of an expression to be discussed for a term referred to as the mass count. Bit four is the most significant bit of the exponent, and bit 7 is the least significant bit of the exponent. As an example, if bits 4, 5, and 6 are zero and bit 7 is 1, then the exponent is 1. If bit 4 is 1 and bits 5, 6 and 7 are zero, then the exponent is 8.

Bit 8 of word 1 and all of word 2 of a data set form a 9-bit expression for a term that will be referred to as the fraction. Bit 8 of word 1 is the most significant bit of the fraction, and bit 8 of word 2 is the least significant bit of the fraction.

Call the bit value of the fraction FRAC. Call the bit value of the exponent EXP. Let the mass count be abbreviated MC. Then

MC = (FRAC + 512) * 2 ** (EXP-1) . (9.1)

The maximum value of the FRAC is 511. The maximum value of the EXP is 15. Hence, the largest value for the mass count is

MC = (1023) * 2 ** 14 = 16,760,823 . (9.2)

One exception to equation (9.1) is the case for which EXP = 0. Then

MC = FRAC . (9.3)

The normal mode of operation will be for the IECM data acquisition system (DACS) to interrogate the Mass Spectrometer every 2 sec. Therefore, the normal data rate for a 2-word data set is 2 sec, i.e., one data set every 2 sec. There is also a fast-sweep mode of operation of 0.2 sec for the IECM data acquisition. The DACS will interrogate the Mass Spectrometer every 0.2 sec. Therefore, in the fast mode of operation the data rate for a 2-word data set is 0.2 sec, or one data set every 0.2 sec.

Let us now classify a data acquisition operation that will be referred to as a data sweep. The purpose of the Mass Spectrometer is to measure the molecular environment around Spacelab. To do this it will sequentially sweep through a range of atomic mass units from 1 to 150. Furthermore, an additional sweep identical to the first sweep will follow and will concentrate uniquely on atomic mass unit 18, i.e., H_2O (water). There will normally be 160 data sets per sweep. Again, the first sweep will be sequentially through the atomic mass units from 1 to 150. To complete 160 data sets, AMU 28 branches into 28-8, 28-6, 28-4, 28-2, 0, 28+2, 28+4, 28+6; in addition, there will be CALIBRATE, TOTAL and ZERO. The second sweep will concentrate only on water.

There is an abbreviated sweep mode that will be used for time resolution during a gas calibration sequence. This abbreviated sweep will contain approximately 60 data sets.

The Mass Spectrometer will operate on on-orbit only. At first turn-on of the instrument the data are unsynchronized. Therefore, check bit 1 (most significant bit, MSB) of word 1 until a "1" is found. Then the "sync pulse" will have occurred and a data sweep will have begun, with synchronized data to follow.

If the instrumentation of the Mass Spectrometer works as expected, in the normal mode of operation, 319 data sets should follow the data set with the sync bit before another complete data cycle would start. The start of a data cycle is expressed by a "1" in the MSB of word 1 of a data set. A data cycle sweeps through AMU from 1 to 150 and water.

Recall that four sequential sets of data create an analog word. The headings for these analog words are:

Sync Bit	Analog Word No.	AMU	Analog Heading
1		Zero	
0,0,0,0	1	001,002,003,004	(4) Power Monitor
0,0,0,0	2	005,006,007,008	(8) Analog Mass
0,0,0,0	3	009,010,011,012	(12) Power Monitor
0,0,0,0	4	013,014,015,016	(16) Power Monitor
0,0,0,0	5	017,108,019,020	(20) RFAGC
0,0,0,0	6	021,022,023,024	(24) Filament Current
0,0,0,0	7	025,026,027,8-8	(28) Filament Voltage
0,0,0,0	8	8-6,8-4,8-2,028	(28) Multana
0,0,0,0	9	8+2,8+4,8+6,029	(29) Multana
0,0,0,0	10	030,031,032,033	(33) Multana
0,0,0,0	11	034,035,036,037	(37) Anode Current
0,0,0,0	12	038,039,040,041	(41) High Voltage
0,0,0,0	13	042,043,044,045	(45) Electrometer
0,0,0,0	14	046,047,048,049	(49) Gas Temp
0,0,0,0	15	050,051,052,053	(53) ACC Monitor
0,0,0,0	16	054,055,056,057	(57) Power Monitor
0,0,0,0	17	058,059,060,061	(61) Gage Temp
0,0,0,0	18	062,063,064,065	(65) An Temp
0,0,0,0	19	066,067,068,069	(69) Oscillator Temp
0,0,0,0	20	070,071,072,073	(73) 15 Volt Supply
0,0,0,0	21	074,075,076,077	(77) Mux Temp
0,0,0,0	22	078,079,080,081	(81) Analog Mass
0,0,0,0	23	082,083,084,085	(85) RFAGC
0,0,0,0	24	086,087,088,089	(89) Filament Current
0,0,0,0	25	090,091,092,093	(93) Filament Voltage
0,0,0,0	26	094,095,096,097	(97) Anode Current
0,0,0,0	27	098,099,100,101	(101) High Voltage
0,0,0,0	28	102,102,104,105	(105) Electrometer

Sync Bit	Analog Word No.	AMU	Analog Heading
0,0,0,0	29	106,107,108,109	(109) 5 Volt Supply
0,0,0,0	30	110,111,112,113	(113) Acc Monitor
0,0,0,0	31	114,115,116,117	(117) Gas Temp
0,0,0,0	32	118,119,120,121	(121) Gage Temp
0,0,0,0	33	122,123,124,125	(125) An Temp
0,0,0,0	34	126,127,128,129	(129) Oscillator Temp
0,0,0,0	35	130,131,132,133	(133) Multana
0,0,0,0	36	134,135,136,137	(137) 15 Volt Supply
0,0,0,0	37	138,139,140,141	(141) Mux Temp
0,0,0,0	38	142,143,144,145	(145) RFAGC
0,0,0,0	39	146,147,148,149	(149) Ana Mass
0,0,0,0	40	150, calibrate, total, zero	(0) Power Monitor
0,0,0,0 etc.	41 etc.	018,018,018,018 etc.	Start repetition of all analog headings but add WS for "water sweep". Example:
			(4) Power Monitor (WS)
0,0,0,0	78	018,018,018,018	(145) RFAGC (WS)
0,0,0,0	79	018,018,018,018	(149) Ana Mass (WS)
0,0,0,1	80	018, calibrate, total, zero	(0) Power Monitor (WS)

A data cycle will have been completed and a new data cycle will have started.

The SYNC BIT needs to be checked for each data set. If a "1" shows up before 319 data sets have been interrogated, one of two possible happenings is indicated:

1) The "1" has occurred around the sixtieth data set, and an abbreviated data sweep has occurred.

2) A "glitch" somewhere in the Mass Spectrometer system caused the system to recycle back to zero atomic mass unit.

It is quite possible that an abbreviated data sweep or a "glitch" may terminate or occur in the middle of formation of an analog measurement. When that happens, consider as good data only the analog words that have been completely formed in the particular data sweep under consideration.

One should note that there is a bit in the housekeeping data labeled HI-RATE REQ. When that bit is "1", the Mass Spectrometer is in a fast data sweep mode of operation.

All Mass Spectrometer data on the DACS tape are to be output in the following format:

Sync Bit	Data Set No.	AMU	Mass Count	Analog Heading	Analog Count	Time Hr		Min
1	1	Zero	XXX			XX		XX
0	2	1	XXX			XX		XX
0	3	2	XXX			XX		XX
0	4	3	etc.				Etc.	
0	5	4		———	XXX			
0	6	5						
0	7	6						
0	8	7						
0	9	8		———	XXX			
.	.	.	.	.	.			.
.		.		.	.			
0	20	19	XXX			XX		XX
0	21	20		———	XXX			
0	22	21						
0	23	22	Etc.				Etc.	
0	24	23						
0	25	24		———	XXX			
0	26	25						
0	27	26						
0	28	27						
0	29	28-8		———	XXX			
0	30	28-6						
0	31	28-4						
0	32	28-2						
0	33	28		———	XXX			
0	34	28+2	XXX			XX		XX
0	35	28+4	XXX			XX		XX
0	36	28+6	XXX			XX		XX
0	37	29	Etc.	———	XXX		Etc.	
0	38	30						
0	39	31						
0	40	32						
0	41	33		———	XXX			
0	42	34						
0	43	35						
.	.	.	.	.	.	.		.
.	.	.	.	.	.			.
0	154	146	XXX			XX		XX
0	155	147	XXX			XX		XX
0	156	148	XXX			XX		XX
0	157	149	Etc.	———	XXX		Etc.	
0	158	150						
0	159	CAL						
0	160	TOT						

Sync Bit	Data Set No.	AMU	Mass Count	Analog Heading	Analog Count	Time Hr	Min
0	161	Zero		---	XXX		
0	162	18					
0	163	18					
0	164	18					
0	165	18		---	XXX		
-	---	--	---	---	---	--	--
-	---	--	---	---	---	--	--
0	314	18	XXX			XX	XX
0	315	18	XXX			XX	XX
0	316	18	XXX			XX	XX
0	317	18	Etc.	---	XXX	Etc.	
0	318	18					
0	319	CAL					
0	320	TOT					
1	1	Zero	Start Over	---	XXX	Start Over	
0	2	1					
0	3	2					
0	4	3					
0	5	4		---	XXX		
-	---	---	---	---	---	--	--

The table for Mass Spectrometer data illustrates a complete data cycle. As pointed out earlier, there normally will be 320 data sets in a data cycle, but either a short cycle of approximately 60 data sets or a recycle "glitch" could cut this short. The ANALOG COUNT in the Table is the bit count, which will range from 0 to 255. It is a pure decimal number from eight binary bits. The TIME is the IECM clock time accurate to hours and minutes that needs to be printed only with the last data set of a frame. This format will be continuous and cover all Mass Spectrometer data on the DACS tape recorder. Obviously the fast data rate can be observed from the TIME.

The following concerns graphs:

1) It is requested that each AMU be plotted versus time for mission duration. By AMU it is meant the MASS COUNT for each AMU. Place the MASS COUNT along the left vertical axis of the plot. Place an equivalent pressure scale along the right vertical axis. This will be given later from the calibration results of preflight testing. Note that there will be 164 graphs of full mission duration. Referring to the table for Mass Spectrometer data as a guide, that is ZERO, AMU's 1 to 150 plus 7 extra for splitting AMU 28, CALIBRATE, TOTAL, another ZERO, one graph for 157 extra data points on AMU 18, another CALIBRATE and another TOTAL. The MASS COUNT scale will be a log scale from 10^0 to

10^7 in range. There will be MASS COUNTS of zero that obviously cannot be exactly located on a log scale. It is suggested that the log scale run from 10^{-2} to 10^7 on the graph. Then call any zero MASS COUNTS 10^{-1} on a log scale and plot them as such.

2) It is also requested that a set of 15 higher resolution graphs be plotted. These 15 graphs of MASS COUNTS for AMU's are to be determined (TBD) and may be changed between missions. This requirement is difficult to state; two examples are: Suppose the mission is for 2 days. We wish the time resolution on each graph to be 24 hours. Hence, for a 2-day mission this will be 2 × 15 = 30 additional graphs. Suppose the mission is for 6 days. Then there will be 6 × 15 = 90 additional graphs of higher time resolution.

3) A set of graphs is requested to display the analog data. This will display analog counts versus time for mission duration. Four analog channels can be plotted per graph. Since there are 80 analog channels, there will be 20 graphs. The scale on the vertical axis will run from 0 to 255. Label each curve by its analog channel.

4. A plot of Orbiter data for the angle of the vehicle Z-axis with respect to the vehicle velocity vector versus mission time is requested. Also a plot of two Orbiter surface temperatures versus mission time is requested. These requirements can be placed on the same graph, with each curve properly labeled. The Z-axis angle to velocity vector scale can be placed on the left vertical axis, and the temperature scale can be placed on the right vertical axis. The angle range will run from 0 to 180 degrees. The temperature range will be furnished later. The data will come from Orbiter data tapes.

These tabulations and graphs will be the first quick-look data. Additional charts will be requested. Certain correlations of MASS COUNTS, TIME, and Orbiter attitude will provide calibration points which can be put into fairly simple equations. These equations are now being developed by the Mass Spectrometer supplier. Once the coefficients of the equations are defined by the preceding calibration, all of the mass counts can be transformed by the equations into reduced data such as Molecular Columnar Density. The additional data reduction requirements are expected to be determined in the near future.

X. HOUSEKEEPING DATA REDUCTION REQUIREMENTS (09H)

As a basis for beginning discussion of the data reduction requirements for housekeeping refer to Figure 9.

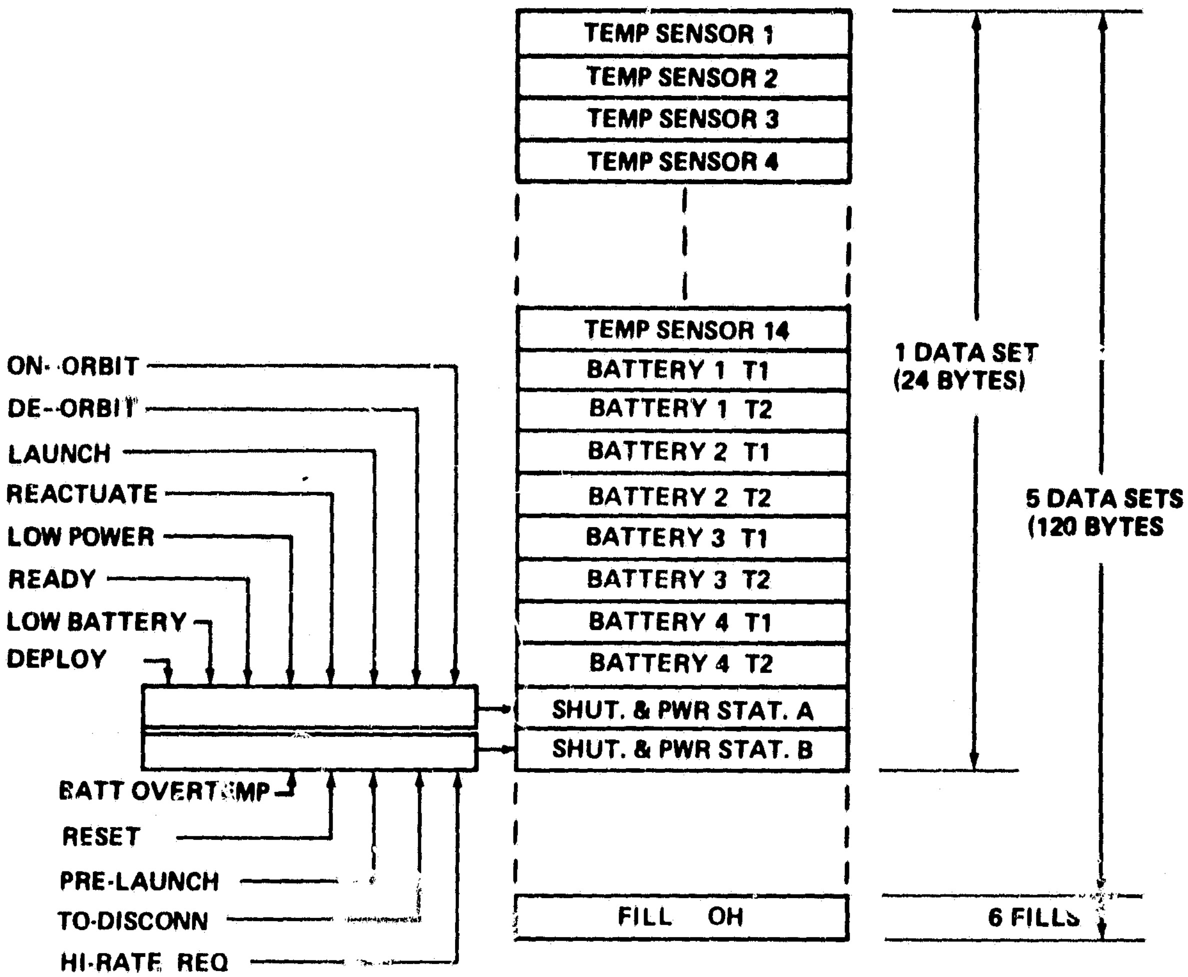


Figure 9. Temperature sensors data format.

A housekeeping data set consists of 14 temperature sensor bytes, 8 battery temperature bytes, and 2 Shuttle and power status bytes. The second Shuttle and power status byte uses only 5 bits of information in the direction from least significant bit to most significant bit. Hence, there are 24 bytes to a data set and, 5 data sets to a frame plus 6 fills to make up 126 bytes.

The temperature sensors and battery temperatures are represented by the usual bit to voltage conversion for the DACS system of the IECM experiments: each bit number corresponds to a change of 0.02 V or 20 mV.

Consider any voltage generated from any one of the 14 temperature sensors, which are also referred to as the base-plate temperature sensors, represented by a capital V. Now define

$$A = 1252.8(V)-4691.8 \quad , \tag{10.1}$$

$$B = V-20 \quad . \tag{10.2}$$

Then in degrees Fahrenheit

$$\text{BASE PLATE TEMPERATURE} = A/B+32 \tag{10.3}$$

Now consider any of the voltages generated from any one of the eight battery temperature bytes, also to be represented by a capital V.

Now define

$$C = 2000(20-V)/(22000V) \quad , \tag{10.4}$$

$$D = 1/298-(\ln C)/3442 \quad . \tag{10.5}$$

Then in degrees Fahrenheit

$$\text{BATTERY TEMPERATURE} = (9/5)(1/D-273.18)+32 \quad . \tag{10.6}$$

The data rate for the housekeeping data is one data set per minute. Since there are five data sets per frame, it will take approximately 5 min to fill a frame.

At the option of the programmer, the expressions (10.3) and (10.6) for the BASE PLATE TEMPERATURE and the BATTERY TEMPERATURE, respectively, may be used to generate tables to tabulate temperatures as a function of voltage over a range of 0 to 5.1 V in increments of 0.02 V. This table could then be used in a scheme to convert voltage to temperature.

It has been suggested that the BASE PLATE TEMPERATURE and the BATTERY TEMPERATURE will be better expressed in degrees Centigrade rather than degrees Fahrenheit. Therefore, after the calculations are made from (10.3) and (10.6), or if a table scheme is used, convert to Centigrade for all tabulations and graphs.

Tabulate all 14 base plate temperatures as a function of IECM clock time.

There are four batteries and two battery temperature readings for each battery. Average the two temperatures from each battery and tabulate all battery temperatures and the average for each battery as a function of IECM time.

Plot the 14 base plate temperatures as a function of IECM clock time. Put three graphs per page, stacked. Make the time axis for 24 hours only. This will mean four pages of three graphs and one page of two graphs. Each plot should be labeled as to the sensor it represents and the mode of operation, e.g., Pre-Launch, Ascent, On-Orbit, De-Orbit. Information will be furnished as to each sensor's location on the IECM.

Plot the battery temperatures as a function of IECM clock time. Since there are four batteries and three temperatures per battery, put three graphs per page, stacked, which will represent the temperatures, T1, T2, and TA (average of T1 and T2) for each battery on one page. Naturally, there will be four pages of graphs, one page for each battery. Label each page for the battery it represents. Make the time axis for 24 hours only.

The maximum and minimum temperatures to be ranged along the vertical axes can be determined from expressions (10.3) and (10.6) by substituting the maximum and minimum values of V, namely 5.1 and 0 V, respectively.

Tabulate the individual bit value for the SHUT. and PWR STAT. A and SHUT. and PWR STAT. B words as a function of IECM clock time. This tabulation should form 14 vertical columns—1 column for IECM clock time and 13 columns for bits. Label the 13 columns as follows:

SHUT. and PWR STAT. A
(Reading from MSB to LSB)

1. DEPLOY: Change to DE/PLOY
2. LOW BATTERY: Shorten to LOW/BAT
3. READY: Shorten to RDY
4. LOW POWER: Shorten to LOW/PWR
5. REACTUATE: Shorten to RE/ACTU
6. LAUNCH: Shorten to LUH
7. DE-ORBIT: Shorten to DE/ORBT
8. ON-ORBIT: Shorten to ON/ORBT

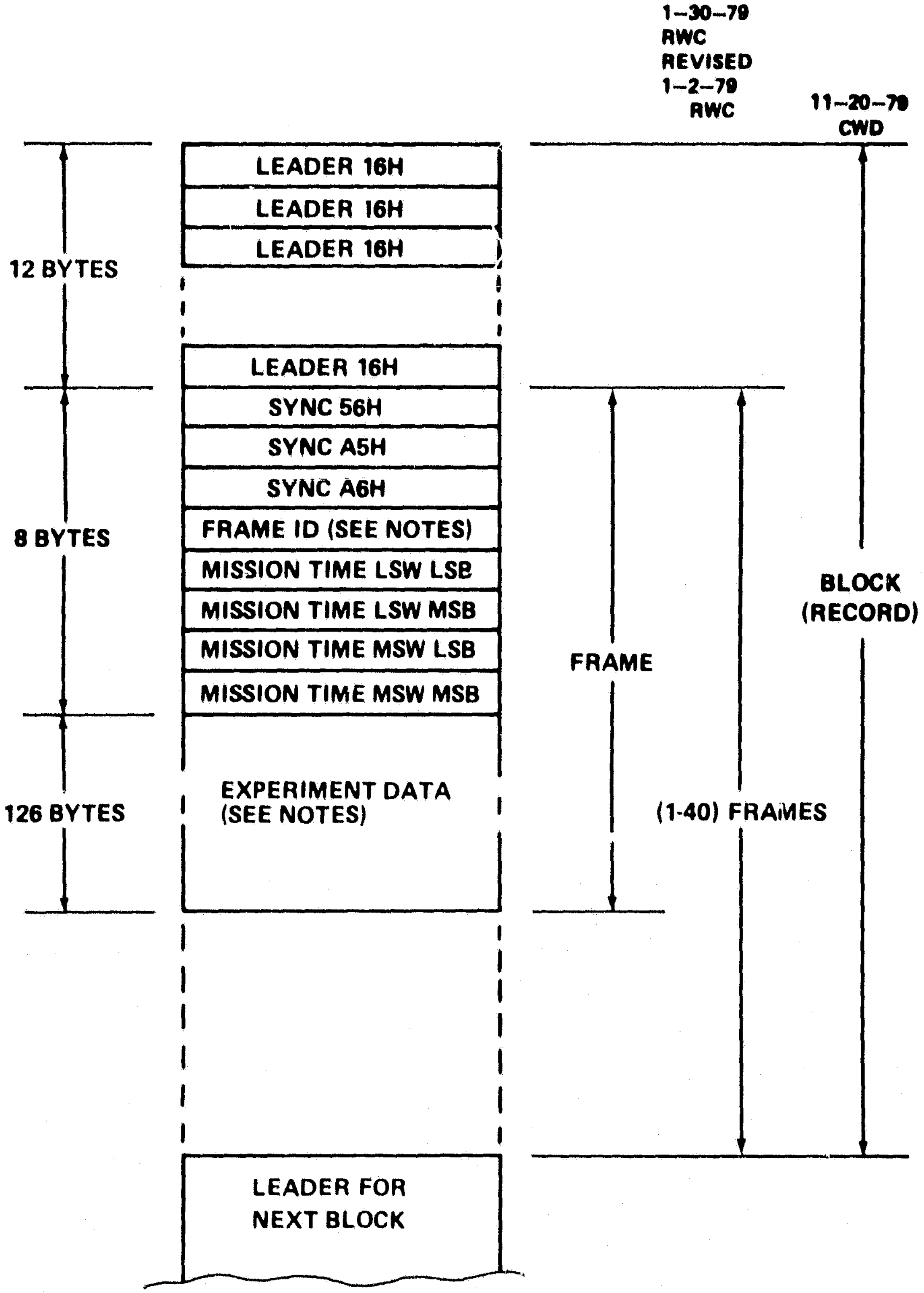
SHUT. and PWR STAT. B
(Reading from MSB to LSB)

4. BATTERY OVTEMP MEMORY: Shorten to BAT/OTMEM
5. RESET: Shorten to RE/SET
6. PRE-LAUNCH: Shorten to PRE/LUH
7. TO-DISCONNECT: Shorten to TO/DSCN
8. HI-RATE REQ: Shorten to HI/REQ

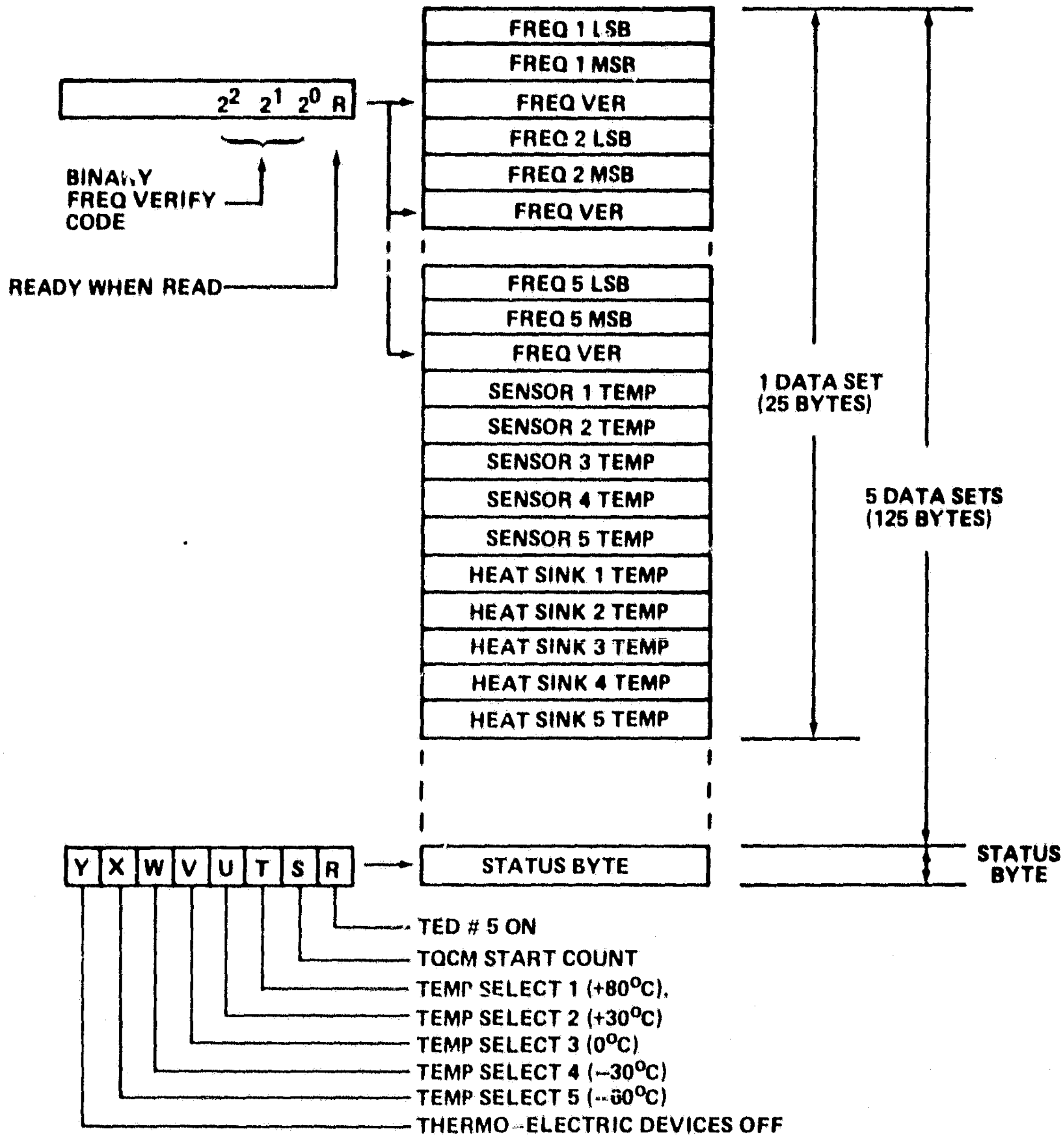
Because the data rate is once per minute, the information on the individual bit data will be recorded once per minute. However, it is expected that as a usual rule there will be little, if any, change in status from minute to minute of operation. Hence, tabulate the status information only when there is a change in any one of the 13 status bits, together with the IECM clock time, when the change occurs.

The Appendix consists of a complete continuous listing of the IECM tape recorder format.

4.0 IECM TAPE RECORDER FORMAT



TQCM DATA FORMAT (01)

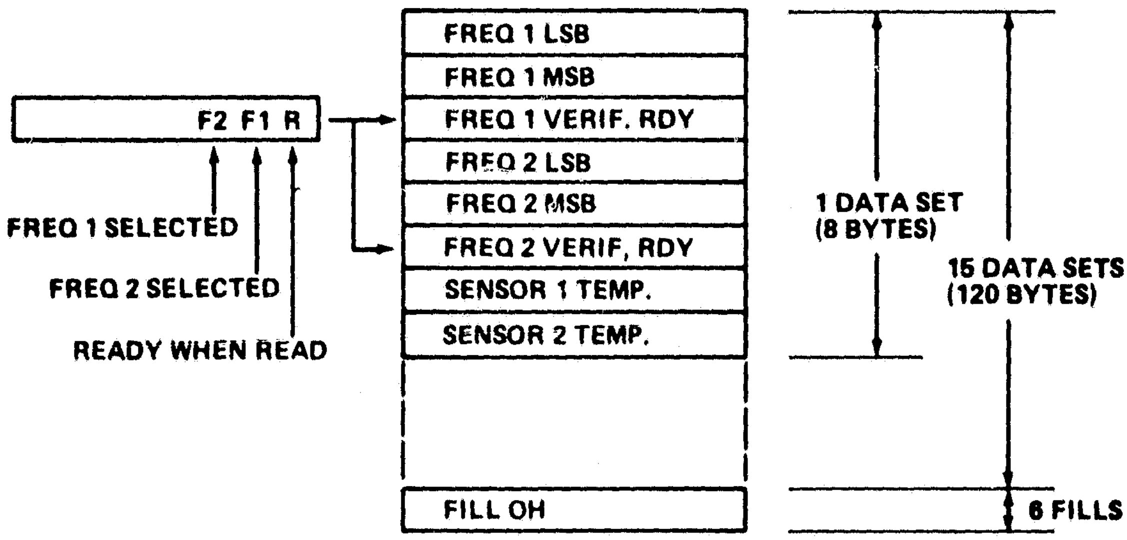


NOTES:

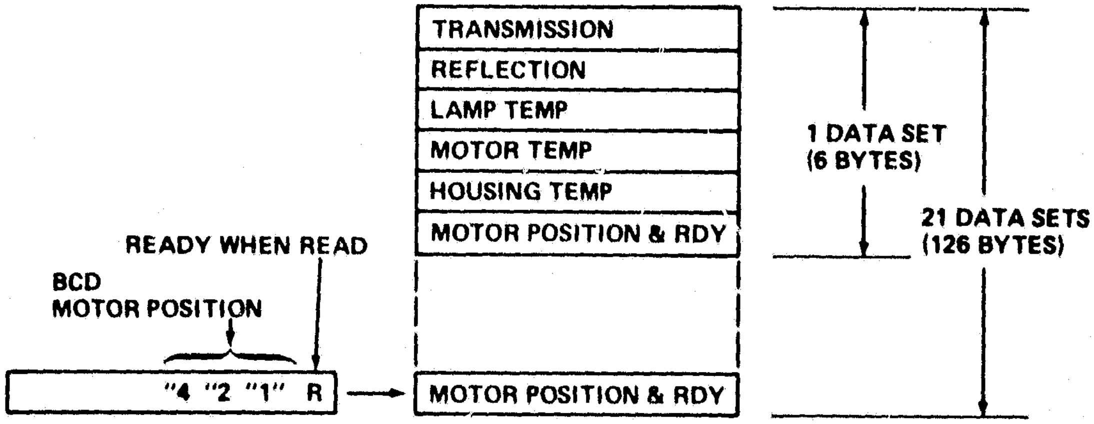
FRAME ID

01H	TQCM DATA
02H	CQCM DATA
03H	OEM DATA
04H	AIR SAMPLER DATA
05H	CAMERA CURRENT DATA
06H	CAMERA VOLTAGE AND THERMISTOR DATA
07H	CASCADE IMPACTOR DATA
08H	MASS SPEC DATA
09H	TEMPERATURE SENSOR DATA

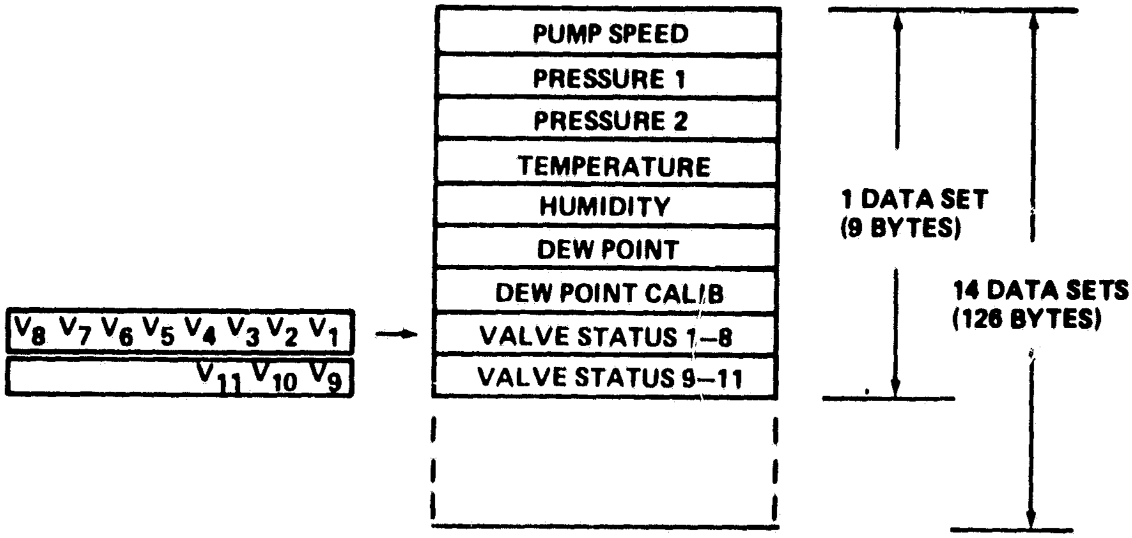
CQCM DATA FORMAT (02)



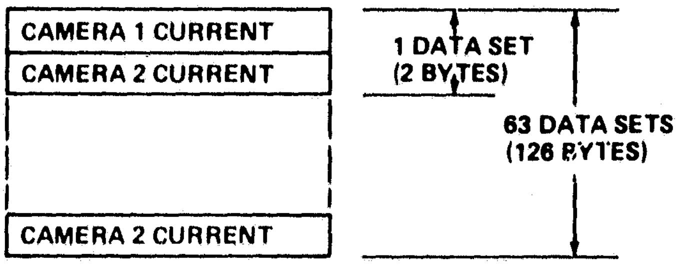
OEM DATA FORMAT (03)



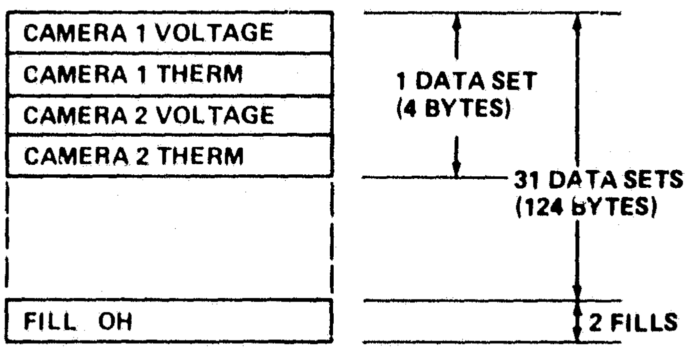
AIR SAMPLER DATA FORMAT (04)



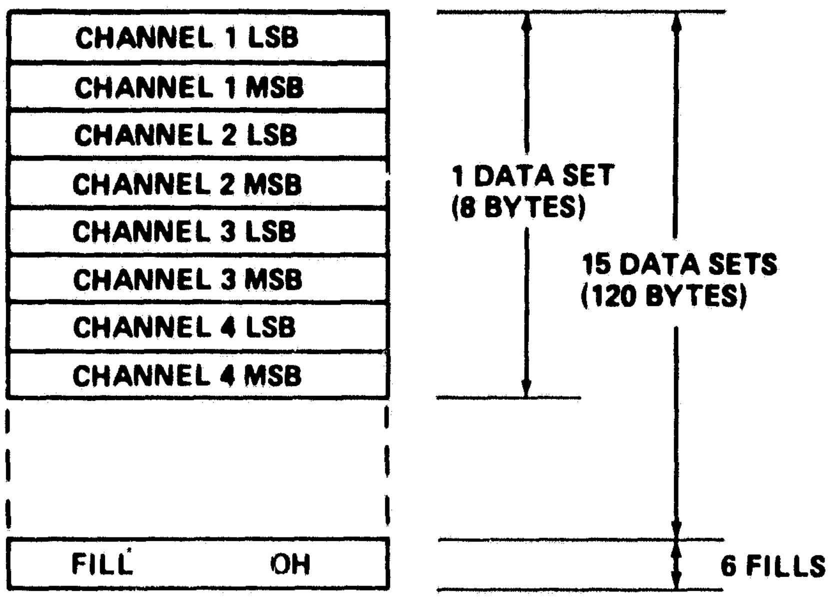
CAMERA CURRENT DATA FORMAT (05)



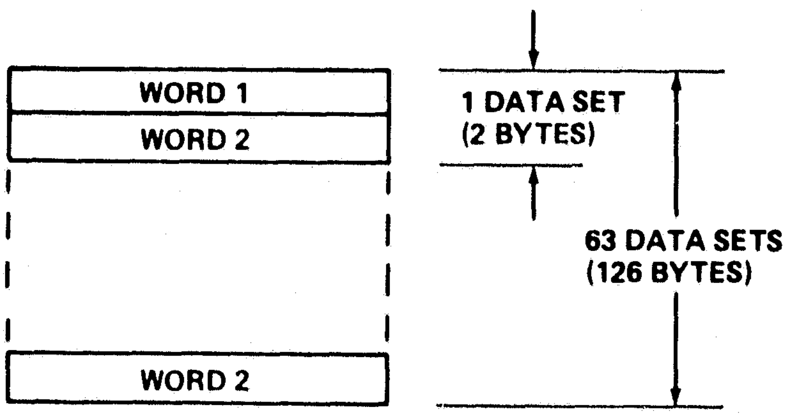
CAMERA VOLTAGE, THERMISTOR DATA FORMAT (06)



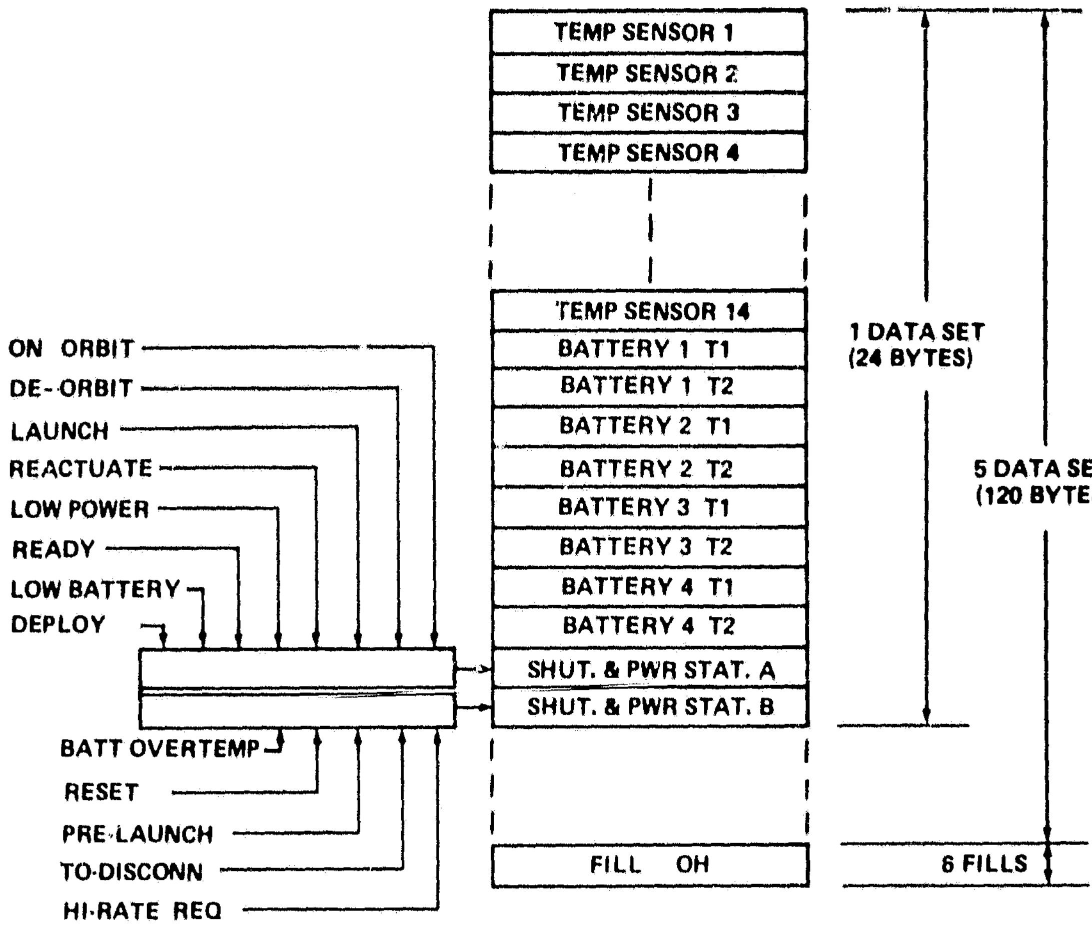
CASCADE IMPACTOR DATA FORMAT



MASS SPEC DATA FORMAT



TEMPERATURE SENSORS DATA FORMAT



APPROVAL

IECM CALIBRATION AND DATA REDUCTION REQUIREMENTS

By Fred D. Wills and Charles W. Davis

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

RUDOLF DECHER
Chief, Space Physics Division

CHARLES A. LUNDQUIST
Director, Space Sciences Laboratory

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