Thermal Emission Spectrometer

TES-TSDR Standard Data Product Software Interface Specification

N. Gorelick
Arizona State University

Approved:

Philip R. Christensen TES Principal Investigator	Date
Greg L. Mehall TES Instrument Manager	Date

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CONTENTS

1. Introduction

1.1. Purpose and Scope of Document

This document describes the format and content of the Thermal Emission Spectrometer (TES) Time Sequential Data Records (TSDR) standard data products.

1.2. Applicable Documents

TES Software Specification Document 642-441, Vol. 5
TES Operation User's Guide, 642-444 Vol. 5
PDS Data Dictionary, July 15, 1996, JPL D-7116, Rev D
PDS Data Preparation Workbook, Feb. 1995, Version 3.1, JPL D-7669, Part 1
Planetary Data System Standards Reference, July 1995, Version 3.2, JPL D-7669, Part 2

2. Data Product Characteristics and Environment

2.1. Instrument Overview

The TES instrument uses a Michelson interferometer to make infrared spectrometric measurements, and uses two sets of broad-band bolometric detectors to cover the thermal and visible bands. Each of the three bands has a co-aligned array of 6 detectors arranged in a 3x2 configuration and each detector has a field of view of 8.3 mrad square.

In normal operation the TES completes a scan of the Michelson mirror every 2 seconds and each of the spectrometer detectors measures the spectral radiance of the target at 143 wavelengths with 10-wavenumber spacing. The visual and thermal bolometers integrate during the entire scan and produce one measurement per detector. This 2-second scan is called a "single length"scan.

The TES has a second operating mode in which the Michelson mirror is scanned twice as far over a 4-second period. This mode is referred to as a "double length" scan and produces 286 spectral points with 5-wavenumber spacing for each of the spectrometer detectors. During double scans the two bolometric channels integrate twice as long, but still produce only a single value per detector.

The instrument also contains software to optionally perform spectral, spatial, and temporal averaging of the spectrometer data. None of these post-processing steps are applied to the bolometric data.

The TES has a rotating pointing mirror that allows the instrument to take measurements ranging from the nadir position up to and past the planet's limb in both the fore and aft directions. Additionally, the pointing mirror can be positioned to take measurements of space and of the internal reference surfaces and lamps contained within the body of the TES instrument.

2.2. Data Product Overview

The TES Standard Data Product contains the raw and calibrated thermal IR radiance spectra, the visual and thermal bolometric radiance measurements, and several atmospheric and surface properties derived from this data. Also included are the parameters that describe each observation, some downlinked diagnostic information, and the derived pointing and positional information calculated from the project's SPICE kernels.

The TES data are divided into the following 10 tables:

- OBS - Observation Parameters
- RAD - Raw and Calibrated Radiance Data
- BOL - Bolometer Data
- GEO - Derived Positional & Geometric Values
- POS - Raw Positional & Geometric Data
- TLM - Auxiliary Observation Parameters
- IFG - Raw Interferogram Data
- CMP - Raw Complex Data
- ATM - Derived Properties - Atmospheric Observations
- LMB - Derived Properties - Atmospheric Limb Observations

Each table is stored in a separate file with a PDS TABLE structure (i.e., using fixed-length binary records with extensions to handle the variable length spectra). Every record is stored with the spacecraft time, and related records can be retrieved from each table using time as a common key. In some tables up to 6 records can be stored for a given time, one for each detector. In these cases these records also include a field named "detector", that with the time field uniquely identifies the record.

Each scan of the instrument always produces the following data records:

- 1 record in the OBS table,
- 6 records in the BOL table.

Because the instrument is capable of spatially and temporally averaging the spectral data, the number of records in the RAD table can vary from 0 to 6 for each scan.

There are 7 spatial averaging combinations that combine together the data from different detectors. This has the net effect of reducing the number of active detectors, and consequently fewer spectra are downlinked. One RAD record is produced for each spectrum downlinked. The spatial masks are described in the DETMASK.TXT document.

If temporal averaging is applied to the spectrometer data, then the averaged data are associated with the first scan. The other scans in the average contain no spectrometer data, but still have OBS and BOL records associated with them. All other tables, with the exception of the OBS and BOL tables, also treat temporally averaged data as belonging to the first scan. Each scan (or set of scans if temporal averaging is applied) may generate the following records as well:

- 1 record in the IFG table,
- 1 record in the CMP table,
- 1 record in the TLM table.

The data contained in these tables are downlinked from the instrument only upon request.

If a scan targets the planet (as opposed to targeting space or an internal reference surface) then the following records are also generated:

6 records in the GEO table
0 to 6 records in the ATM table

The ATM records are only generated for those scans that actually observe the planet's surface.

2.3. Standards Used in Generating Data Products

2.3.1. Time Standards The time value stored with each TES-TSDR data record is the value of the spacecraft clock at the start of the observation, truncated to an integer value. This number is equal to the number of seconds since 12:00 a.m. 1/1/1980 GMT.

2.3.2. Coordinate Systems All of the derived geometry fields that relate to longitude and latitude on the surface of Mars are computed using an areocentric coordinate system with west longitudes. Specifically, geometric parameters are computed using the ellipsoid and prime meridian constants available in the IAU-1994 report and the NAIF pck00005 kernel:

BODY499 POLE RA = (317.681, -0.108, 0.0)
BODY499 POLE DEC = (52.886, -0.061, 0.0)
BODY499 PM = (176.901, +350.8919830, 0.0)
BODY499 RADII = (3397.0, 3397.0, 3375.0)

2.3.3. Orbit Numbers The attached PDS labels for TES data files include the fields START_ORBIT_NUMBER and STOP_ORBIT_NUMBER. These fields refer to the beginning and ending orbits during which the data were acquired, using the TES Team orbit numbering system, also known as the Orbit Counter Keeper (ock). During the Orbit Insertion Phase TES ock numbers and MGS Project orbit numbers were identical, except that the Project counted orbits from one periapsis to the next, while TES considered an orbit to begin at the spacecraft maneuver preceding periapsis, usually a difference of no more than twenty minutes. However, the MGS Project reset its orbit count to 1 at the beginning of the Mapping Phase. TES ock numbers were not reset, in order to preserve the unique orbit identifier. For TES data products acquired during mapping, the MGS Project mapping orbit number can be determined by subtracting 1683 from the TES ock number. During mapping, both TES and the MGS Project consider the beginning of an orbit to occur at the descending equator crossing.

2.3.4. Data Storage Conventions All the TES-TSDR records are stored in binary form. Numerical fields are stored using the most significant byte first (MSB), and real numbers are stored using standard IEEE floating-point format. Character and string fields are space padded but not null terminated.

3 Detailed Data Product Specifications

Each table is stored with a PDS TABLE structure using fixed-length binary records sorted time-sequentially. Each table file is prefixed with an ASCII header that describes the contents and format of the table, and a pointer that indicates where the binary table data start. The description identifies each column in the table, detailing its name, starting position (in bytes), size (in bytes), data type, description, and scaling factors if applicable. In some cases the column being described is a fixed-length array of related, homogeneous values (such as temperatures or voltages). For that case, the column description also includes the number of items in the array and the size of each item. A typical column description follows:

```
OBJECT              = COLUMN
    NAME            = PNT_ANGLE
    DATA_TYPE       = MSB_INTEGER
    START_BYTE      = 12
    BYTES           = 2
    SCALING_FACTOR  = .046875
    DESCRIPTION     = "Scan mirror pointing angle,  degrees from nadir."
END_OBJECT          = COLUMN
```

The RAD, ATM, CMP, and IFG tables store some variable-length data. These variable length records are stored in a file separate from the fixed-length records and are addressed from the fixed-length records with a "pointer" column. Pointer columns contain the position of the variable length data, in bytes, from the start of the file in which it is listed. A position value of -1 in a pointer column indicates that there are no variable length data for that record. Additional keywords in a column's description are used to identify it as a pointer to a variable length column, and describe the data in the variable length records. These keywords are:

```
VAR_DATA_TYPE
VAR_ITEM_BYTES
VAR_RECORD_TYPE
```

The VAR_DATA_TYPE and VAR_ITEM_BYTES keywords are similar to the PDS keywords DATA_TYPE and ITEM_BYTES, but refer to the structure of the variable-length data. The VAR_RECORD_TYPE keyword identifies the overall format of the variable-length record. This keyword has two possible values:

```
VAR_RECORD_TYPE = VAX_VARIABLE_LENGTH
VAR_RECORD_TYPE = Q15
```

The value VAX_VARIABLE_LENGTH indicates that the variable-length record has the size of the record in bytes, as a 2-byte integer, both before and after the record. This corresponds to the VAX/VMS variable-length record format.

Figure 1 illustrates the use of variable-length records, and how they relate to the fixed-length records. In this example, the table contains 2 columns, one of which is a pointer to the variable-length records. The table shows 6 rows, but only 5 of the rows actually point to variable-length records. The fourth record contains -1 in the pointer column, indicating that there are no variable-length data for that row.

```
OBJECT              = COLUMN
    NAME            = KEY
    DATA_TYPE       = ASCII_INTEGER
    BYTES           = 1
END_OBJECT          = COLUMN
```

```
OBJECT                   = COLUMN
    NAME                 = VDATA
    DATA_TYPE            = ASCII_INTEGER
    BYTES                = 2
    VAR_ITEM_BYTES       = 1
    VAR_RECORD_TYPE      = CHARACTER
    VAR_DATA_TYPE        = VAX_VARIABLE_LENGTH
END_OBJECT               = COLUMN
```

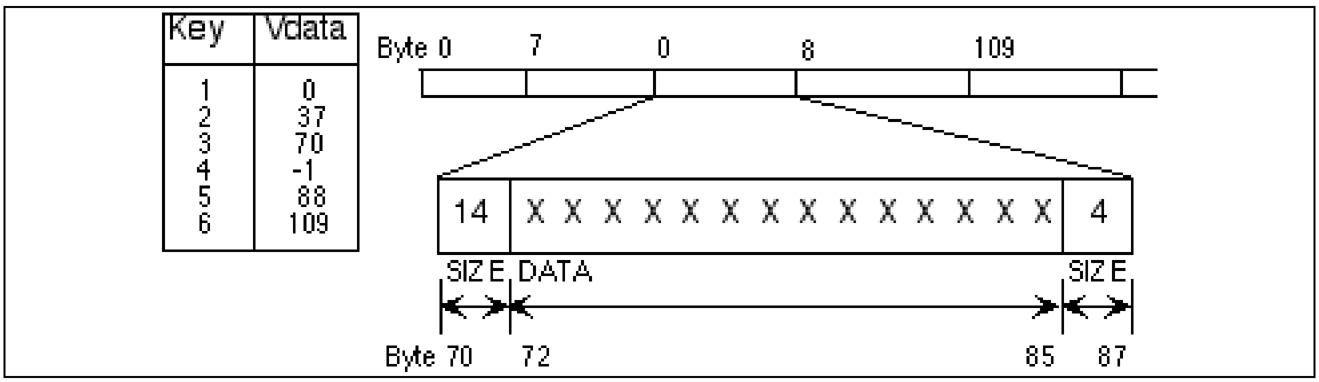

Figure 1. An example of a variable length record.

The Q15 format is very similar to the VAX_VARIABLE_LENGTH format; however it is only used to store floating point values in a compact representation. This format is an array of floating point mantissas stored as 2-byte signed integers. These mantissas share a scaling exponent that is stored as the first item in the record as another 2-byte signed integer. All the elements in the array must be scaled by the exponent, by multiplying them by 2 to the power (exp-15). Just like the VAX_VARIABLE_LENGTH records, the Q15 records are also stored with the size of the record in bytes, as a 2-byte integer, both before and after the record. A diagram of a complete Q15 variable length record is shown in figure 2

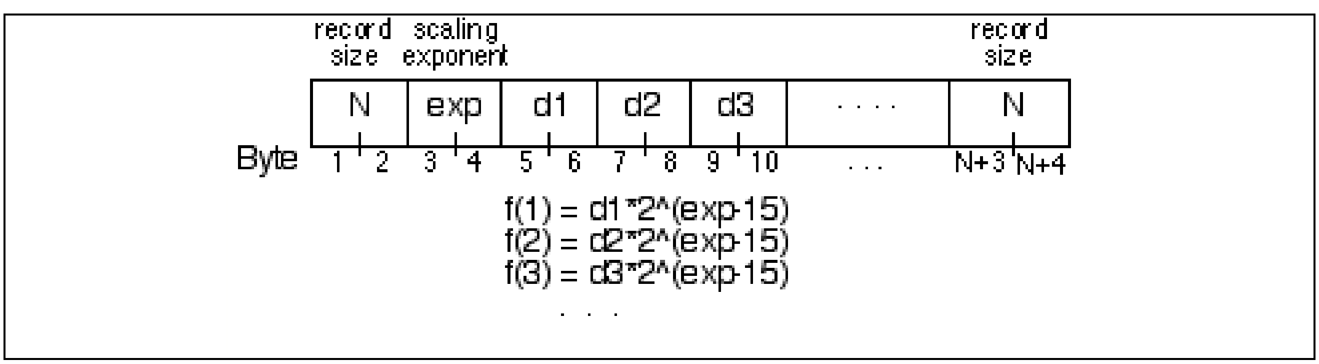

Figure 2. A Q15 record

The fixed-length records are stored in files with a .DAT extension. The variable length records that are referenced by an individual .DAT file can be found in a file with the same name, but with a .VAR extension.

3.1. Label and Header Descriptions

Each .DAT file is prefixed with an ASCII header in PDS 3.0 format. The format of this header consists of sets of keyword=value pairs, followed by the keyword END. A sample header is given below:

```
  PDS_VERSION_ID                   = PDS3
  FILE_NAME                        = "OBS04101.DAT"
  RECORD_TYPE                      = FIXED_LENGTH
  RECORD_BYTES                     = 39
  FILE_RECORDS                     = 1245
  LABEL_RECORDS                    = 35
  ^TABLE                           = 36
  SPACECRAFT_ID                    = MGS
  INSTRUMENT_ID                    = TES
  MISSION_PHASE_NAME               = "MAPPING"
  TARGET_NAME                      = MARS
  PRODUCT_ID                       = "TES04101"
  PRODUCER_ID                      = MGS_TES_TEAM
  DATA_SET_ID                      = "MGS-M-TES-3-TSDR-V1.0"
  PRODUCT_RELEASE_DATE             = 1998-08-18
  PRODUCT_CREATION_TIME            = 1998-08-18T17:30:00
  START_TIME                       = 1997-10-26T08:33:44.293
  STOP_TIME                        = 1997-10-29T06:43:30.274
  SPACECRAFT_CLOCK_START_COUNT     = 562322042
  SPACECRAFT_CLOCK_STOP_COUNT      = 562574628
  START_ORBIT_NUMBER               = 28
  STOP_ORBIT_NUMBER                = 29

  OBJECT                           = TABLE
    NAME                           = OBS
    INTERCHANGE_FORMAT             = BINARY
    PRIMARY_KEY                    = ( "SPACECRAFT_CLOCK_START_COUNT",
                                       "DETECTOR_NUMBER" )
    START_PRIMARY_KEY              = ( 562322042, 1 )
    STOP_PRIMARY_KEY               = ( 562574628, 6 )
    ROWS                           = 1210
    STRUCTURE                      = "OBS.FMT"
  END_OBJECT                       = TABLE
END
```

The above header consists of three primary parts: a description of the whole file, a pointer to the binary table data, and a set of nested PDS objects that identify the contents and layout of the table.

The first few lines of the header describe the overall structure of the file and in this case indicate that the file consists of 1,245 fixed-length records, 39 bytes in length. These lines include the entire ASCII header which is padded with white space to occupy an integral number of records of this length.

The keyword TABLE is a pointer to the start of the binary data. The number given with this keyword is the record number of the start of the table data. In this case the record number is 36, which starts at byte 1404 counting from byte zero (35 records * 39 bytes/record).

The remainder of the header identifies the origin of the data and describes the table contained in the file. The data are identified by the time they were acquired, as shown in the SPACECRAFT_CLOCK_START_TIME and SPACECRAFT_CLOCK_STOP_TIME keywords which contain the time on the first and last record in the file, respectively. These times are also given as UTC time strings in the START_TIME and STOP_TIME fields

The columns within the table are specified as a collection of PDS COLUMN objects. A sample column definition follows:

```
OBJECT                  = COLUMN
    NAME                = POINTING_MIRROR_ANGLE
    ALIAS_NAME          = PNT_ANGLE
    DATA_TYPE           = MSB_INTEGER
    START_BYTE          = 10
    BYTES               = 2
    SCALING_FACTOR      = .046875
    DESCRIPTION         = "Scan mirror pointing angle,  degrees from nadir."
END_OBJECT              = COLUMN
```

The column definitions give the name, type, and size of every field in the table. In the case of this field, "pnt_angle", a scaling factor is also given to convert from the stored value to useful units. A scaling offset may also be included, but if not included, should be assumed to be zero. Scaling factors and offsets should be applied as follows:

scaled_value = (stored_value * scaling_factor) + scaling_offset

Descriptions are provided for every column as well. These descriptions are surrounded by quotes and may span several lines. In the case of a fixed-length array, the BYTES term indicates the size of the array, and the two fields ITEMS and ITEM_SIZE are included to describe the number and size of a single element in the array.

This following column description indicates the column "interferogram_maximum" and is a homogeneous array of 6, 2-byte integers.

```
OBJECT                    = COLUMN
    NAME                  = INTERFEROGRAM_MAXIMUM
    DATA_TYPE             = MSB_INTEGER
    START_BYTE            = 29
    BYTES                 = 12
    ITEMS                 = 6
    ITEM_BYTES            = 2
    SCALING_FACTOR        = 0000152587890625
    DESCRIPTION           = " Array of 6 interferogram maximum values ."
END_OBJECT                = COLUMN
```

4. Applicable Software

4.1. Utility Programs

The TES project has produced a software tool that not only reads the PDS table and the variable-length records, but is also capable of joining the related records among multiple tables. This piece of software is called 'vanilla' and is included on every volume. In addition the software is available via anonymous ftp from ftp://east.la.asu.edu/pub/software/vanilla/vanilla.tar.Z.

The vanilla program was developed for use on UNIX machines with integers in MSB_INTEGER format, and for PCs.

4.2. Applicable PDS Software Tools

The TES team uses no PDS software to view, manipulate or process the data. However, the tables are stored using the PDS TABLE standard structure and any tool that understands that structure should be able to read all of the data except the variable-length spectra.

A. Appendices

A.1 ATM Table

NAME = ATM
COLUMNS = 13
ROW_BYTES = 130
INTERCHANGE_FORMAT = BINARY
PRIMARY_KEY = ("SPACECRAFT_CLOCK_START_COUNT")
DESCRIPTION = "

The ATM table contains temperature profiles, aerosol opacities, and related elements derived from the TES calibrated data. Derived values are based on the average spectra of all six detectors measured while TES is operating in the nadir observation mode. Only data with the following quality flags are included for atmospheric evaluation:
RAD.QUALITY:MAJOR_PHASE_INVERSION = 0;
RAD.QUALITY:SPECTROMETER_NOISE = 0-1;
RAD.QUALITY:DETECTOR_MASK_PROBLEM = 0.
Observations that target a body other than Mars (e.g., Phobos and Deimos), or do not include Mars in the field of view, do not have correlating data in this table.

The ATM:QUALITY product contains information on the quality of the calculated quantities (see DOCUMENT/QUALITY.TXT for more information). Users should also be aware of the following data quality issues:

Significant problems in temperature retrieval are known to occur over topographic highs, e.g., the Tharsis volcanoes. Over regions of high surface temperature, retrieved atmospheric temperatures in the lowest scale height may be inaccurate. However, large RMS radiance residuals (TEMPERATURE_PROFILE_RESIDUAL) usually occur in these cases.

TES collects data in either of two spectral resolution modes: “double scan” and “single scan” (see DATA/WAVNUMDS.TAB and DATA/WAVNUMSS.TAB for specific wavenumbers). We have observed that the RMS radiance residual values (TEMPERATURE_PROFILE_RESIDUAL) associated with the double scan mode temperature profiles are higher that hose associated with the single scan mode data. However, there appears to be no bias or other distortion present in the two sets of profiles that is outside of the expected temperature uncertianty of ~2K.

Negative dust, water ice, and CO2 opacity values (NADIR_OPACITY[1:2]) are known to exist even for data with a QUALITY:ATM_OPACITY_RATING equal to zero. The estimated uncertainty for any one retrieval of aerosol optical depth is about +/- 0.05. Therefore, we have chosen to include all retrieved NADIR_OPACITY[1:2] values greater than -0.05. A retrieved optical depth in the range 0 to -0.05 is consistent with an actual optical depth of zero. Additionally, we require that the retrieved CO2 optical depth (NADIR_OPACITY[3]) be in the range -0.01 to 0.05 for QUALITY:ATM_OPACITY_RATING to be zero. A retrieved CO2 optical depth greater than 0.05 is unphysical and an optical depth in the range 0 to -0.01 is consistent with zero. No constraints or quality checks are make for the basalt surface component (NADIR_OPACITY[4]).

The opacity algorithm fails when the thermal contrast between the atmosphere and the ground is too small. Experience indicates that results may be unreliable if the surface temperature drops below about 220K. We suggest that opacity users limit their searches to include only those values for which the CO2_CONTINUUM_TEMP is greater than 220K, and the quality bits QUALITY:TEMPERATURE_PROFILE_RATING and QUALITY:ATMOSPHERIC_OPACITY_RATING are both equal to zero.

Further discussion of the values in this table is available in DOCUMENT/PROCESS; questions about the content of the data should be directed to Michael Smith at Michael.D.Smith@gsfc.nasa.gov or John Pearl at John.Pearl@gsfc.nasa.gov."

```
OBJECT                      = COLUMN
    NAME                    = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 1
    BYTES                   = 4
    ALIAS_NAME              = sclk_time
    DESCRIPTION             = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = SURFACE_PRESSURE
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 5
    BYTES                   = 2
    SCALING_FACTOR          = 0.001
    NOT_APPLICABLE_CONSTANT = 444.4
    ALIAS_NAME              = srf_pressure
    DESCRIPTION             = "Surface pressure is calculated from the altitudes given by the MGS -Mars
                              Orbiter Laser Altimeter (MOLA) 1/4 degree x 1/4 degree topographic map,
                              the hydrostatic law assuming a 10 km scale height, and an adjustment for the
                              seasonal CO2 sublimation cycle.  Proper normalization is obtained by fitting
                              the pressures observed by the Viking and Pathfinder landers.
                              For more information, see DOCUMENT/PROCESS."
    UNIT                    = "mbar x1000"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = NADIR_TEMPERATURE_PROFILE
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 7
    BYTES                   = 76
    ITEMS                   = 38
    ITEM_BYTES              = 2
    SCALING_FACTOR          = 0.01
    NOT_APPLICABLE_CONSTANT = 444.4
    ALIAS_NAME              = nadir_pt
    DESCRIPTION             = "Array of temperatures from nadir observations corresponding to the 38
                              atmopsheric pressure levels, given in millibars, shown below.  Thefill value
                              (NOT_APPLICABLE_CONSTANT) is inserted when (1) the temperature
                              retrieval fails, or (2) the pressure either exceeds the local surface pressure, or
                              is less than 0.1 mbar.
                                 1:  16.5815200
                                 2:  12.9137000
                                 3:  10.0572000
                                 4:  7.8325550
                                 5:  6.1000000
                                 6:  4.7506850
                                 7:  3.6998370
                                 8:  2.8814360
                                 9:  2.2440650
                                 10:  1.7476790
```

```
                                     11:  1.3610940
                                     12:  1.0600210
                                     13:  0.8255452
                                     14:  0.6429352
                                     15:  0.5007185
                                     16:  0.3899599
                                     17:  0.3037011
                                     18:  0.2365227
                                     19:  0.1842040
                                     20:  0.1434582
                                     21:  0.1117254
                                     22:  0.0870000
                                     23:  0.0678000
                                     24:  0.0528000
                                     25:  0.0411000
                                     26:  0.0320000
                                     27:  0.0249000
                                     28:  0.0194000
                                     29:  0.0151000
                                     30:  0.0118000
                                     31:  0.0091700
                                     32:  0.0071400
                                     33:  0.0055600
                                     34:  0.0043300
                                     35:  0.0033700
                                     36:  0.0026300
                                     37:  0.0020500
                                     38:  0.0015900"
   UNIT                            = "degK x100"
END_OBJECT                         = COLUMN

OBJECT                             = COLUMN
   NAME                            = CO2_CONTINUUM_TEMP
   DATA_TYPE                       = MSB_UNSIGNED_INTEGER
   START_BYTE                      = 83
   BYTES                           = 2
   SCALING_FACTOR                  = 0.01
   ALIAS_NAME                      = co2_cont_temp
   DESCRIPTION                     = "Mean of brightness temperature just outside the wings of the 667 cm-1
                                   CO2 absorption band.  For10 cm-1 and 5 cm-1 data, all wavenumbers
                                   between 508 to 531 cm-1 and 805 to 827 cm-1 are used with a total of 6 and
                                   10 wavenumbers used in the calculation, respectively."
   UNIT                            = "degK x100"
END_OBJECT                         = COLUMN

OBJECT                             = COLUMN
   NAME                            = SPECTRAL_SURFACE_TEMPERATURE
   DATA_TYPE                       = MSB_UNSIGNED_INTEGER
   START_BYTE                      = 85
   BYTES                           = 2
   SCALING_FACTOR                  = 0.01
   ALIAS_NAME                      = srf_temp_est
   DESCRIPTION                     = "Mean of derived temperatures for each detector of the observed target."
   UNIT                            = "degK x100"
END_OBJECT                         = COLUMN
```

```
OBJECT                        = COLUMN
    NAME                      = TEMPERATURE_PROFILE_RESIDUAL
    DATA_TYPE                 = IEEE_REAL
    START_BYTE                = 87
    BYTE                      = 4
    NOT_APPLICABLE_CONSTANT   = 444.4
    ALIAS_NAME                = rms_pt
    DESCRIPTION               = "RMS difference between radiances measured within the 667 cm-1 CO2
                                band, and the radiances calculated within that band using the derived
                                pressure- temperature profile."
    UNIT                      = "watts cm-2 steradian-1 wavenumber-1"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    NAME                      = NADIR_OPACITY
    DATA_TYPE                 = MSB_INTEGER
    START_BYTE                = 91
    BYTES                     = 18
    ITEMS                     = 9
    ITEM_BYTES                = 2
    SCALING_FACTOR            = 0.001
    NOT_APPLICABLE_CONSTANT   = 22.22
    ALIAS_NAME                = best_fit_opacities
    DESCRIPTION               = "Array of scaling factors that when multiplied by standard spectral shapes
                                gives a best fit for aerosol opacities, CO2 hot and isotope bands, and a
                                reference surface spectral emissivity.  The standard spectral shapes are
                                archived in DATA/STDSHAPES.TAB.
                                Spectral shapes represented in array elements:
                                   1: dust
                                   2: water ice
                                   3: CO2 hot and isotope bands
                                   4: surface
                                   5-9: not used"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    NAME                      = NADIR_OPACITY_ RESIDUAL
    DATA_TYPE                 = IEEE_REAL
    START_BYTE                = 109
    BYTE                      = 4
    NOT_APPLICABLE_CONSTANT   = 444.4
    ALIAS_NAME                = rms_opacities
    DESCRIPTION               = "RMS opacity residual between opacities retrieved point by point across
                                the spectrum and the opacities computed using the best-fit opacity scaling
                                factors."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    NAME                      = CO2_DOWNWELLING_FLUX
    DATA_TYPE                 = IEEE_REAL
    START_BYTE                = 113
    BYTE                      = 4
    NOT_APPLICABLE_CONSTANT   = 444.4
    ALIAS_NAME                = co2_dw_flux
    DESCRIPTION               = "Down-welling flux from 667 cm-1 CO2 band."
    UNIT                      = "watts cm-2"
```

```
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = TOTAL_DOWNWELLING_FLUX
  DATA_TYPE                   = IEEE_REAL
  START_BYTE                  = 117
  BYTE                        = 4
  NOT_APPLICABLE_CONSTANT     = 444.4
  ALIAS_NAME                  = total_dw_flux
  DESCRIPTION                 = "Down-welling flux from CO2 and atmospheric aerosols."
  UNIT                        = "watts cm-2"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = QUALITY
  DATA_TYPE                   = MSB_BIT_STRING
  START_BYTE                  = 121
  BYTES                       = 2
  ALIAS_NAME                  = quality
  DESCRIPTION                 = "16-bit atmosphere quality word.  Bit column description and code
                              definitions follow; see also quality.txt for more information"

  OBJECT                        = BIT_COLUMN
    NAME                        = TEMPERATURE_PROFILE_RATING
    BIT_DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BIT                   = 1
    BITS                        = 2
    ALIAS_NAME                  = atm_pt_rating
    DESCRIPTION                 = "Identifies quality of nadir pressure-temperature profile values:
                                   0 = nadir values are good
                                   1 = nadir values are questionable
                                   2 = nadir values are bad
                                   3 = nadir values are not available (N/A)"
  END_OBJECT                    = BIT_COLUMN

  OBJECT                        = BIT_COLUMN
    NAME                        = ATMOSPHERIC_OPACITY_RATING
    BIT_DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BIT                   = 3
    BITS                        = 2
    ALIAS_NAME                  = atm_opacity_rating
    DESCRIPTION                 = "Identifies quality of opacity values:
                                   0 = nadir values are good
                                   1 = nadir values are questionable
                                   2 = nadir values are bad
                                   3 = nadir values are not available (N/A)"
  END_OBJECT                    = BIT_COLUMN

END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = SURFACE_RADIANCE
  DATA_TYPE                   = MSB_INTEGER
  START_BYTE                  = 123
  BYTES                       = 4
  VAR_DATA_TYPE               = MSB_INTEGER
```

```
    VAR_ITEM_BYTES          = 2
    VAR_RECORD_TYPE         = Q15
    ALIAS_NAME              = srf_radiance
    DESCRIPTION             = "Derived surface radiance;  this field is not used in this release."
    UNIT                    = "watts cm-2 steradian-1 wavenumber-1"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = ATMOSPHERIC_CALIBRATION_ID
    DATA_TYPE               = CHARACTER
    START_BYTE              = 127
    BYTES                   = 4
    ALIAS_NAME              = version_id
    DESCRIPTION             = "Version ID of nadir temperature and aerosol retrieval algorithm."
END_OBJECT                  = COLUMN
```

A.2 BOL Table

```
NAME                    = BOL
COLUMNS                 = 12
ROW_BYTES               = 30
DESCRIPTION             = "
    The BOL table contains the raw and calibrated visual and thermal bolometer measurements, and
    several properties derived from these measurements.

    Six BOL records are generated for each instrument scan, one for each detector.  When spectrometer
    data are temporally averaged, there can be up to 4 scans of bolometer data."

OBJECT                  = COLUMN
    NAME                 = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BYTE          = 1
    BYTES               = 4
    ALIAS_NAME           = sclk_time
    DESCRIPTION         = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = DETECTOR_NUMBER
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BYTE          = 5
    BYTES               = 1
    ALIAS_NAME          = detector
    DESCRIPTION         = "The number of the detector that made the observation. Detectors are numbered
                          from 1 to 6"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = TEMPORAL_INTEGRATION_SCAN_NUMBER
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BYTE          = 6
    BYTES               = 1
    ALIAS_NAME          = tic_count
```

```
    DESCRIPTION           = "The number of the scan from the set of temporally averaged scans"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = RAW_VISUAL_BOLOMETER
    DATA_TYPE             = MSB_INTEGER
    START_BYTE            = 7
    BYTES                 = 2
    SCALING_FACTOR        = .000152587890625
    ALIAS_NAME             = vbol
    DESCRIPTION           = "Raw visual bolometer data, per detector.
                          Scaling factor is 5.0/2^15."
    UNIT                  = "VOLTS"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = RAW_THERMAL_BOLOMETER
    DATA_TYPE             = MSB_INTEGER
    START_BYTE            = 9
    BYTES                 = 2
    SCALING_FACTOR        = .000152587890625
    ALIAS_NAME            = tbol
    DESCRIPTION           = "Raw thermal bolometer data, per detector,
                           Scaling factor is 5.0/2^15."
    UNIT                  = "VOLTS"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = CALIBRATED_VISUAL_BOLOMETER
    DATA_TYPE             = IEEE_REAL
    START_BYTE            = 11
    BYTES                 = 4
    ALIAS_NAME            = cal_vbol
    DESCRIPTION           = "Calibrated visual bolometric radiance."
    UNIT                  = "watt cm-2 steradian-1 micron-1"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = LAMBERT_ALBEDO
    DATA_TYPE             = IEEE_REAL
    START_BYTE            = 15
    BYTES                 = 4
    ALIAS_NAME            = lambert_alb
     DESCRIPTION          = "Lambertian albedo, derived from visual bolometer"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = BOLOMETRIC_THERMAL_INERTIA
    DATA_TYPE             = IEEE_REAL
    START_BYTE            = 19
    BYTES                 = 4
    ALIAS_NAME            = ti_bol
    DESCRIPTION           = "Thermal inertia, derived from thermal bolometer"
    UNIT                  = "J m-2 s-1/2 K-1"
END_OBJECT                = COLUMN
```

```
OBJECT                        = COLUMN
    NAME                       = BOLOMETRIC_BRIGHTNESS_TEMP
    DATA_TYPE                 = MSB_UNSIGNED_INTEGER
    START_BYTE                = 23
    BYTES                     = 2
    SCALING_FACTOR            = 0.01
    ALIAS_NAME                = brightness_temp_bol
    DESCRIPTION               = "Temperature observed by the thermal bolometer, assuming the target is radiating
                                as a black body"
    UNIT                      = "K"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    NAME                      = VISUAL_BOL_CALIBRATION_ID
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 25
    BYTES                     = 2
    ALIAS_NAME                = vbol_version_id
    DESCRIPTION               = "Calibration algorithm version ID for visual bolometer data"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    NAME                      = THERMAL_BOL_CALIBRATION_ID
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 27
    BYTES                     = 2
    ALIAS_NAME                = tbol_version_id
    DESCRIPTION               = "Calibration algorithm version ID for thermal bolometer data"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    NAME                      = QUALITY
    DATA_TYPE                 = MSB_BIT_STRING
    START_BYTE                = 29
    BYTES                     = 2
    ALIAS_NAME                = quality
    DESCRIPTION               = "16-bit thermal inertia quality word.  Bit column description and code definitions
                                follow; see also index/quality.txt for more information"

    OBJECT                        = BIT_COLUMN
        NAME                      = BOLOMETRIC_INERTIA_RATING
        BIT_DATA_TYPE             = MSB_UNSIGNED_INTEGER
        START_BIT                 = 1
        BITS                      = 3
        ALIAS_NAME                = ti_bol_rating
        DESCRIPTION               = "Values of 0 to 3 rate the uncertainty of the  modeled bolometer thermal
                                    inertia based on design-specified instrument noise levels;  additional sources of
                                    uncertainty are present, see document/process.asc or process.pdf.
                                    Values of 5 to 7 rate the reasons why valid bolometer thermal inertia could not
                                    be modeled.
                                      0 = best quality
                                      1 = good quality
                                      2 = medium quality
                                      3 = low quality
                                      4 = not assigned
                                      5 = lowest quality - observed temperature outside of model-predicted range
```

6 = lowest quality - no model temperature variation as a function of thermal inertia
7 = lowest quality - thermal inertia value not computed due to lack of necessary data"

```
    END_OBJECT              = BIT_COLUMN

    OBJECT                    = BIT_COLUMN
        NAME                  = BOLOMETER_LAMP_ANOMALY
        BIT_DATA_TYPE         = MSB_UNSIGNED_INTEGER
        START_BIT             = 4
        BITS                  = 1
        ALIAS_NAME            = bol_ref_lamp
        DESCRIPTION           = "Visual bolometer calibration requires regular sampling of one of the two
                              internal reference lamps;  when the reference lamp looks are unavailable for a
                              significant period of time, the calibration may be adversly affected and the
                              calibrated data products should be used with caution.  This bit is specifically
                              designed to track the bolometer reference lamp gap spanning ocks 12064 to
                              12688.
                                0 = reference lamp looks routinely sampled
                                1 = reference lamp looks missing”
    END_OBJECT              = BIT_COLUMN

END_OBJECT                  = COLUMN
```

A.3 CMP Table

```
NAME                        = CMP
COLUMNS                     = 3
ROW_BYTES                   = 9
DESCRIPTION                 = "
    The CMP table contains the real and complex data from the FFT.  The complex data is only
    downlinked when requested and can only be requested for a single detector per observation.

    The CMP array contains 286 points (143 real, 143 complex) for a short scan (OBS Table,
    SCAN_LENGTH = 1), and 572 points (286 real, 286 complex) for a long scan (OBS Table,
    SCAN_LENGTH = 2)."

OBJECT                      = COLUMN
    NAME                    = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 1
    BYTES                   = 4
    ALIAS_NAME              = sclk_time
    DESCRIPTION             = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = DETECTOR_NUMBER
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 5
    BYTES                   = 1
    ALIAS_NAME              = detector
```

```
    DESCRIPTION          = "The number of the detector that made the observation. Detectors are numbered
                           from 1 to 6"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = FFT_COMPLEX_DATA
    DATA_TYPE            = MSB_UNSIGNED_INTEGER
    START_BYTE           = 6
    BYTES                = 4
    VAR_DATA_TYPE        = MSB_INTEGER
    VAR_ITEM_BYTES       = 2
    VAR_RECORD_TYPE      = Q15
    ALIAS_NAME           = complex
    DESCRIPTION          = "The real and imaginary parts of the FFT. This column is the pointer to the data."
    UNIT                 = "Transformed Volts"
END_OBJECT               = COLUMN
```

A.4 GEO Table

```
NAME                     = GEO
COLUMN                   = 20
ROW_BYTES                = 43
DESCRIPTION              = "
    The GEO table contains information about the sun/spacecraft/target geometry in a format that is
    easily searched.  These values are computed for every scan other than those used to calibrate the
    instrument.  If a viewing vector does not intersect the target body (i.e., an atmospheric observation),
    then most of the geometry is calculated relative to the point on the viewing vector closest to the body
    (i.e., the tangent point).  If the closest point lies behind the spacecraft, fill values are used."

OBJECT                   = COLUMN
    NAME                 = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE            = MSB_UNSIGNED_INTEGER
    START_BYTE           = 1
    BYTES                = 4
    ALIAS_NAME           = sclk_time
    DESCRIPTION          = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DETECTOR_NUMBER
    DATA_TYPE            = MSB_UNSIGNED_INTEGER
    START_BYTE           = 5
    BYTES                = 1
    ALIAS_NAME           = detector
    DESCRIPTION          = "The number of the detector that made the observation. Detectors are numbered
                           from 1 to 6"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = LONGITUDE
    DATA_TYPE            = MSB_UNSIGNED_INTEGER
    START_BYTE           = 6
    BYTES                = 2
```

```
    SCALING_FACTOR        = 0.01
    DESCRIPTION           = "Areocentric west longitude of target point"
    UNIT                  = "DEGREE"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = LATITUDE
    DATA_TYPE             = MSB_INTEGER
    START_BYTE            = 8
    BYTES                 = 2
    SCALING_FACTOR        = 0.01
    DESCRIPTION           = "Areocentric latitude of target point"
    UNIT                  = "DEGREE"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = PHASE_ANGLE
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 10
    BYTES                 = 2
    SCALING_FACTOR        = 0.01
    ALIAS_NAME            = phase
    DESCRIPTION           = "Angle between the spacecraft, the target point and the sun"
    UNIT                  = "DEGREE"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = EMISSION_ANGLE
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 12
    BYTES                 = 2
    SCALING_FACTOR        = 0.01
    ALIAS_NAME            = emission
    DESCRIPTION           = "Angle between the spacecraft, the target point and the surface normal vector at
                            the target"
    UNIT                  = "DEGREE"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = INCIDENCE_ANGLE
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 14
    BYTES                 = 2
    SCALING_FACTOR        = 0.01
    ALIAS_NAME            = incidence
    DESCRIPTION           = "Angle between the sun, the target point and the surface normal vector at the
                            target"
    UNIT                  = "DEGREE"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = PLANETARY_PHASE_ANGLE
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 16
    BYTES                 = 2
```

```
    SCALING_FACTOR          = 0.01
    ALIAS_NAME              = planetary_phase
    DESCRIPTION             = "Angle between the spacecraft, the center of the target body and the sun"
    UNIT                    = "DEGREE"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = SOLAR_LONGITUDE
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 18
    BYTES                   = 2
    SCALING_FACTOR          = 0.01
    DESCRIPTION             = "Planetocentric longitude of the sun"
    UNIT                    = "DEGREE"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = SUB_SPACECRAFT_LONGITUDE
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 20
    BYTES                   = 2
    SCALING_FACTOR          = 0.01
    ALIAS_NAME              = sub_sc_lon
    DESCRIPTION             = "Areocentric west longitude of sub-spacecraft point"
    UNIT                    = "DEGREE"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                     = SUB_SPACECRAFT_LATITUDE
    DATA_TYPE               = MSB_INTEGER
    START_BYTE              = 22
    BYTES                   = 2
    SCALING_FACTOR          = 0.01
    ALIAS_NAME              = sub_sc_lat
    DESCRIPTION             = "Areocentric latitude of sub-spacecraft point"
    UNIT                    = "DEGREE"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = SUB_SOLAR_LONGITUDE
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 24
    BYTES                   = 2
    SCALING_FACTOR          = 0.01
    ALIAS_NAME              = sub_solar_lon
    DESCRIPTION             = "Areocentric west longitude of the sub-solar point"
    UNIT                    = "DEGREE"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = SUB_SOLAR_LATITUDE
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 26
    BYTES                   = 2
    SCALING_FACTOR          = 0.01
```

```
     ALIAS_NAME              = sub_solar_lat
     DESCRIPTION             = "Areocentric latitude of the sub-solar point"
     UNIT                    = "DEGREE"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
     NAME                    = TARGET_DISTANCE
     DATA_TYPE               = MSB_UNSIGNED_INTEGER
     START_BYTE              = 28
     BYTES                   = 2
     DESCRIPTION             = "Distance from the spacecraft to the target point"
     UNIT                    = "KM"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
     NAME                    = TARGET_ALTITUDE
     DATA_TYPE               = MSB_UNSIGNED_INTEGER
     START_BYTE              = 30
     BYTES                   = 2
     SCALING_FACTOR          = 0.01
     ALIAS_NAME              = height
     DESCRIPTION             = "Distance from the surface to the target point.
                               This value is non-zero only for atmospheric targets"
     UNIT                    = "KM"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
     NAME                    = SPACECRAFT_ALTITUDE
     DATA_TYPE               = MSB_UNSIGNED_INTEGER
     START_BYTE              = 32
     BYTES                   = 2
     ALIAS_NAME              = altitude
     DESCRIPTION             = "Distance from the spacecraft to the sub-spacecraft point on the surface"
     UNIT                    = "KM"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
     NAME                    = LOCAL_TIME
     DATA_TYPE               = MSB_UNSIGNED_INTEGER
     START_BYTE              = 34
     BYTES                   = 2
     SCALING_FACTOR          = 0.001
     DESCRIPTION             = "Local time at target, in decimal Martian hours.
                             The Martian day is divided into 24 equal hours."
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
     NAME                    = SOLAR_DISTANCE
     DATA_TYPE               = MSB_UNSIGNED_INTEGER
     START_BYTE              = 36
     BYTES                   = 2
     SCALING_FACTOR          = 10000
     DESCRIPTION             = "Distance from the center of the sun to the center of the target body"
     UNIT                    = "KM"
END_OBJECT                   = COLUMN
```

```
OBJECT              = COLUMN
  NAME               = PLANETARY_ANGULAR_RADIUS
  DATA_TYPE         = MSB_UNSIGNED_INTEGER
  START_BYTE        = 38
  BYTES             = 2
  SCALING_FACTOR    = 0.01
  ALIAS_NAME        = angular_semidiameter
  DESCRIPTION       = "Smallest angular radius of Mars as viewed from the spacecraft."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
  NAME              = GEOMETRY_CALIBRATION_ID
  DATA_TYPE         = CHARACTER
  START_BYTE        = 40
  BYTES             = 4
  ALIAS_NAME         = version_id
  DESCRIPTION       = "Version ID of geometry algorithm used"
END_OBJECT          = COLUMN
```

A.5 IFG Table

```
NAME                = IFG
COLUMNS             = 3
ROW_BYTES           = 9
DESCRIPTION         = "
  The IFG table contains the raw interferogram data.  The interferogram data is only downlinked when
  requested and can only be requested for a single detector per observation.

  The IFG array contains 1600 points for a short scan (OBS Table, SCAN_LENGTH = 1), and 3200
  points for a long scan (OBS Table, SCAN_LENGTH = 2)."

OBJECT              = COLUMN
  NAME              = SPACECRAFT_CLOCK_START_COUNT
  DATA_TYPE         = MSB_UNSIGNED_INTEGER
  START_BYTE        = 1
  BYTES             = 4
  ALIAS_NAME        = sclk_time
  DESCRIPTION       = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT          = COLUMN


OBJECT              = COLUMN
  NAME              = DETECTOR_NUMBER
  DATA_TYPE         = MSB_UNSIGNED_INTEGER
  START_BYTE        = 5
  BYTES             = 1
  ALIAS_NAME        = detector
  DESCRIPTION       = "The number of the detector that made the observation. Detectors are numbered
                      from 1 to 6"
END_OBJECT          = COLUMN
```

```
OBJECT                  = COLUMN
    NAME                = INTERFEROGRAM_DATA
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BYTE          = 6
    BYTES               = 4
    VAR_DATA_TYPE       = MSB_INTEGER
    VAR_ITEM_BYTES      = 2
    VAR_RECORD_TYPE     = Q15
    ALIAS_NAME          = ifgm
    DESCRIPTION         = "Raw interferogram data"
    UNIT                = "VOLTS"
END_OBJECT              = COLUMN
```

A.6 LMB Table

```
NAME                    = LMB
COLUMNS                 = 8
ROW_BYTES               = 1592
DESCRIPTION             = "
    The LMB table contains values derived from spectra that look at the limb of Mars.  It contains one
    record for each limb set - sequential observations that view the limb at different altitudes.  See the
    limb parameters quality word for information on the validity of calculated variables. The aerosol
    information may include data from surface observations taken at other times of the same geographic
    location.

    The uncertainty array provides error information for surface radiance spectrum values taken near the
    same time."

OBJECT                  = COLUMN
    NAME                = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BYTE          = 1
    BYTES               = 4
    ALIAS_NAME          = sclk_time
    DESCRIPTION         = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = AEROSOL_OPACITY_PROFILE_LIMB
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BYTE          = 5
    BYTES               = 76
    ITEMS               = 38
    ITEM_BYTES          = 2
    SCALING_FACTOR      = 0.001
    ALIAS_NAME          = opacity_profile
    DESCRIPTION         = "Aerosol integrated normal optical depth from infinity to each of 38 pressures at
                          TBD microns."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = AEROSOL_OPACITY_SPECTRUM_LIMB
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
```

```
        START_BYTE           = 81
        BYTES                = 572
        ITEMS                = 286
        ITEM_BYTES           = 2
        SCALING_FACTOR       = 0.001
        ALIAS_NAME           = opacity_spectrum
        DESCRIPTION          = "Aerosol column optical depth spectrum to surface"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
        NAME                 = AEROSOL_SNG_SCAT_ALB_SPECTRUM
        DATA_TYPE            = MSB_UNSIGNED_INTEGER
        START_BYTE           = 653
        BYTES                = 572
        ITEMS                = 286
        ITEM_BYTES           = 2
        SCALING_FACTOR       = 0.001
        ALIAS_NAME           = ss_albedo
        DESCRIPTION          = "Aerosol single scattering albedo spectrum at  pressure level indicated in
                             aerosol_sng_scat_pres_level_ind column."
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
        NAME                 = AEROSOL_SNG_SCAT_PRES_LEVEL_IND
        DATA_TYPE            = MSB_UNSIGNED_INTEGER
        START_BYTE           = 1225
        BYTES                = 1
        ALIAS_NAME           = ss_pressure
        DESCRIPTION          = "Pressure Level index (1-38) of the pressure level to which the single scattering
                             albedo  spectrum pertains.
                             Pressure level is chosen where the tangent optical depth is approximately unity."
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
        NAME                 = LIMB_TEMPERATURE_PROFILE
        DATA_TYPE            = MSB_UNSIGNED_INTEGER
        START_BYTE           = 1226
        BYTES                = 76
        ITEMS                = 38
        ITEM_BYTES           = 2
        SCALING_FACTOR       = 0.01
        ALIAS_NAME           = limb_pt
        DESCRIPTION          = "Atmospheric temperature profile at 38 pressures derived from limb set
                             observation"
        UNIT                 = "K"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
        NAME                 = SURFACE_RAD_SPECTRUM_UNCERTAINTY
        DATA_TYPE            = MSB_UNSIGNED_INTEGER
        START_BYTE           = 1302
        BYTES                = 286
        ITEMS                = 286
        ITEM_BYTES           = 1
        ALIAS_NAME           = srs_uncertainty
        DESCRIPTION          = "Percent uncertainty in surface radiance spectrum."
```

```
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                   = LIMB_PARAMETERS_QUALITY
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 1588
    BYTES                 = 4
    ALIAS_NAME            = lmb_quality
    DESCRIPTION           = "32-bit data quality word. Bits TBD"
END_OBJECT                = COLUMN
```

A.7 OBS Table

```
NAME                       = OBS
COLUMNS                   = 20
ROW_BYTES                 = 42
DESCRIPTION               = "
    The OBS table stores the state of the instrument at the start of each observation.  One OBS record is
    generated for each observation."

OBJECT                    = COLUMN
    NAME                  = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 1
    BYTES                 = 4
    ALIAS_NAME            = sclk_time
    DESCRIPTION           = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = DETECTOR_NUMBER
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 5
    BYTES                 = 1
    ALIAS_NAME            = detector
    DESCRIPTION           = "The number of the detector that made the observation. Detectors are numbered
                            from 1 to 6"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = ORBIT_COUNTER_KEEPER
    DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BYTE            = 7
    BYTES                 = 2
    ALIAS_NAME            = ock
    DESCRIPTION           = "Sequential count of the number of orbital Revolutions since orbit insertion. This
                            number is identical to the project supplied orbit up until the first time it is reset to
                            zero."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
    NAME                  = INSTRUMENT_TIME_COUNT
```

```
    DATA_TYPE          = MSB_UNSIGNED_INTEGER
    START_BYTE         = 9
    BYTES              = 4
    ALIAS_NAME         = ick
    DESCRIPTION        = "The number of two-second intervals that have elapsed since the start of the orbit.
                       The two-second interval is the smallest time unit defined by the instrument and
                       equals the time to complete a single length scan."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = TEMPORAL_AVERAGE_COUNT
    DATA_TYPE          = MSB_UNSIGNED_INTEGER
    START_BYTE         = 13
    BYTES              = 1
    ALIAS_NAME         = tic
    DESCRIPTION        = "The number of two-second scans averaged into this observation.
                       Valid values are 1, 2 and 4"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = MIRROR_POINTING_ANGLE
    DATA_TYPE          = MSB_INTEGER
    START_BYTE         = 14
    BYTES              = 2
    SCALING_FACTOR     = .046875
    ALIAS_NAME         = pnt_angle
    DESCRIPTION        = "Scan mirror pointing angle, degrees from nadir about the spacecraft's +Y axis."
    UNIT               = "DEGREE"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = IMC_COUNT
    DATA_TYPE          = MSB_UNSIGNED_INTEGER
    START_BYTE         = 16
    BYTES              = 1
    ALIAS_NAME         = pnt_imc
    DESCRIPTION        = "The number of image motion compensation steps used."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = OBSERVATION_TYPE
    DATA_TYPE          = CHARACTER
    START_BYTE         = 17
    BYTES              = 1
    ALIAS_NAME         = pnt_view
    DESCRIPTION        = "The observation classification.  Coarsely identifies the type of observation as
                       one of the following:
                         B=Internal black body reference surface,
                         1=Visual Bolometer calibration lamp 1,
                         2=Visual Bolometer calibration lamp 2,
                         D=Planet, Day side,
                         N=Reference observation NOT used in calibration,
                         L=Planet, limb,
                         S=Space"
END_OBJECT             = COLUMN
```

```
OBJECT                  = COLUMN
    NAME                = SCAN_LENGTH
    DATA_TYPE           = CHARACTER
    START_BYTE          = 18
    BYTES               = 1
    ALIAS_NAME          = scan_len
    DESCRIPTION         = "Length of scan
                           1 = single length scans (~10 wavenumber spacing),
                           2 = double length scans (~5 wavenumber spacing)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = DATA_PACKET_TYPE
    DATA_TYPE           = CHARACTER
    START_BYTE          = 19
    BYTES               = 1
    ALIAS_NAME          = pckt_type
    DESCRIPTION         = "Downlink packet format
                           S = short packets (no auxiliary info)
                           L = long packets (auxiliary info included)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = SCHEDULE_TYPE
    DATA_TYPE           = CHARACTER
    START_BYTE          = 20
    BYTES               = 1
    ALIAS_NAME          = schedule_type
    DESCRIPTION         = "Schedule type being executed:
                           T = Real time plan,
                           C = Record plan,
                           O = Overlay"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = SPECTROMETER_GAIN
    DATA_TYPE           = CHARACTER
    START_BYTE          = 21
    BYTES               = 1
    ALIAS_NAME          = spc_gain
    DESCRIPTION         = "Spectrometer amplifier gain channel number,
                           Channel 1 = ~1
                           Channel 2 = ~2
                           Channel 3 = ~4
                           Channel 4 = ~8"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = VISUAL_BOLOMETER_GAIN
    DATA_TYPE           = CHARACTER
    START_BYTE          = 22
    BYTES               = 1
    ALIAS_NAME          = vbol_gain
    DESCRIPTION         = "Visual bolometer amplifier gain setting,
                           L = Low setting,
                           H = High setting"
```

```
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
   NAME                      = THERMAL_BOLOMETER_GAIN
   DATA_TYPE                 = CHARACTER
   START_BYTE                = 23
   BYTES                     = 1
   ALIAS_NAME                = tbol_gain
   DESCRIPTION               = "Thermal bolometer amplifier gain setting,
                                L = Low setting,
                                H = High setting"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
   NAME                      = PREPROCESSOR_DETECTOR_NUMBER
   DATA_TYPE                 = MSB_UNSIGNED_INTEGER
   START_BYTE                = 24
   BYTES                     = 1
   ALIAS_NAME                = comp_pp
   DESCRIPTION               = "Precompressor reference detector number. The spectrum from each detector
                             within a single ICK is subtracted from the spectrum of this detector  prior to data
                             compression to reduce signal entropy"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
   NAME                      = DETECTOR_MASK
   DATA_TYPE                 = MSB_UNSIGNED_INTEGER
   START_BYTE                = 25
   BYTES                     = 1
   ALIAS_NAME                = det_mask
   DESCRIPTION               = "Spatial detector mask number, one of eight possible combinations in which the
                             spectra from the six TES detectors can be co-added prior to transmission to Earth.
                             Varies from no combination (all detectors separate) to all detectors co-added into a
                             single spectrum.
                             See TES Software User's Guide for details"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
   NAME                      = OBSERVATION_CLASSIFICATION
   DATA_TYPE                 = MSB_BIT_STRING
   START_BYTE                = 26
   BYTES                     = 4
   ALIAS_NAME                = class
   DESCRIPTION               = "32-bit observation classification word.  Bit column descriptions and code
                             definitions follow;  see class.txt for more information"

   OBJECT                    = BIT_COLUMN
      NAME                      = MISSION_PHASE
      BIT_DATA_TYPE             = MSB_UNSIGNED_INTEGER
      START_BIT                 = 1
      BITS                      = 3
      ALIAS_NAME                = phase
      DESCRIPTION               = "Identifies MGS Mission Phase:
                                   0 = Error
                                   1 = Aerobraking Phase 1 (AB-1)
                                   2 = Science Phasing Orbit 1 (SPO-1)
```

```
                                3 = Science Phasing Orbit 2 (SPO-2)
                                 4 = Aerobraking Phase 2 (AB-2)
                                5 = Mapping Phase
                                >5 = Error"
END_OBJECT                = BIT_COLUMN

OBJECT                    = BIT_COLUMN
    NAME                      = INTENDED_TARGET
    BIT_DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BIT                 = 4
    BITS                      = 4
    ALIAS_NAME                = type
    DESCRIPTION               = "Description of observation type, including various physical targets and
                              various tes ts conducted
                                0 = No Target
                                1 = Surface Observation
                                2 = Atmospheric Observation
                                3 = Phobos Observation
                                4 = Deimos Observation
                                5 = Reference Observation
                                6 = Space and Global Mars Observations
                                7 = Test Data
                                8 = Less Than Ick 15
                                9 = PROM Data "
END_OBJECT                = BIT_COLUMN

OBJECT                    = BIT_COLUMN
    NAME                      = TES_SEQUENCE
    BIT_DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BIT                 = 8
    BITS                      = 4
    ALIAS_NAME                = sequence
    DESCRIPTION               = "Description of observation sequence performed, must be used in
                              conjunction with  OBSERVATION_TYPE; see class.txt for bit codes and
                              definitions"
END_OBJECT                = BIT_COLUMN

OBJECT                    = BIT_COLUMN
    NAME                      = NEON_LAMP_STATUS
    BIT_DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BIT                 = 12
    BITS                      = 2
    ALIAS_NAME                = lamp_status
    DESCRIPTION               = "Describes the status of the neon lamp, and by correlation, defines when
                              spectra are collected
                                0 = Neon lamp on, spectra collected
                                1 = Neon lamp off, spectra not collected"
END_OBJECT                = BIT_COLUMN

OBJECT                    = BIT_COLUMN
    NAME                      = TIMING_ACCURACY
    BIT_DATA_TYPE             = MSB_UNSIGNED_INTEGER
    START_BIT                 = 14
    BITS                      = 1
    ALIAS_NAME                = timing
```

```
        DESCRIPTION              = "Describes the accuracy of observation timing, based on availability of
                                 equator crossing  broadcasts
                                   0 = most accurate timing, MGS-PDS equator crossing broadcast received
                                   1 = timing drifts present, MGS-PDS equator crossing broadcast not
                                   received"
    END_OBJECT               = BIT_COLUMN

    OBJECT                   = BIT_COLUMN
        NAME                     = SPARE
        BIT_DATA_TYPE            = MSB_UNSIGNED_INTEGER
        START_BIT                = 15
        BITS                     = 2
        ALIAS_NAME               = spare
        DESCRIPTION              = "Reserved for future use "
    END_OBJECT               = BIT_COLUMN

    OBJECT                   = BIT_COLUMN
        NAME                     = CLASSIFICATION_VALUE
        BIT_DATA_TYPE            = MSB_INTEGER
        START_BIT                = 17
        BITS                     = 16
        ALIAS_NAME               = class_value
        DESCRIPTION              = "One of the following signed numerical details:
                                   latitude coordinates
                                   timing before or after periapsis (seconds)
                                   ANS roll number relative to periapsis
                                 Must be used in conjunction with TES_SEQUENCE and
                                 OBSERVATION_TYPE"
    END_OBJECT               = BIT_COLUMN

END_OBJECT                   = COLUMN


OBJECT                       = COLUMN
    NAME                     = QUALITY
    DATA_TYPE                = MSB_BIT_STRING
    START_BYTE               = 30
    BYTES                    = 4
    ALIAS_NAME               = quality
    DESCRIPTION              = "32-bit observation quality word.  Bit column description and code definitions
                             follow; see also quality.txt for more information"

    OBJECT                   = BIT_COLUMN
        NAME                     = HGA_MOTION
        BIT_DATA_TYPE            = MSB_UNSIGNED_INTEGER
        START_BIT                = 1
        BITS                     = 2
        ALIAS_NAME               = hga_motion
        DESCRIPTION              = "Identifies motion and rate of High Gain Antenna;
                                   0 = HGA motion unknown
                                   1 = HGA not moving
                                   2 = HGA moving at 0.05 deg/sec (autotrack)
                                   3 = HGA moving at 0.51 deg/sec (rewind)"
    END_OBJECT               = BIT_COLUMN

    OBJECT                   = BIT_COLUMN
```

```
    NAME                    = SOLAR_PANEL_MOTION
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 3
    BITS                    = 3
    ALIAS_NAME              = pnl_motion
    DESCRIPTION             = "Identifies motion and rate of both Solar Panels;
                                0 = panel motion unknown
                                1 = panels not moving
                                2 = panels moving at 0.051 deg/sec (autotrack)
                                3 = panels moving at 0.120 deg/sec (prior to ock 3859)
                                4 = panels moving at 0.240 deg/sec (starting at ock 3859)
                                5 = panels moving at 0.400 deg/sec (aerobraking only)
                                6 = panels moving & changing between rates
                                7 = not assigned"
END_OBJECT                  = BIT_COLUMN

OBJECT                      = BIT_COLUMN
    NAME                    = ALGOR_PATCH
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 6
    BITS                    = 1
    ALIAS_NAME              = algor_patch
    DESCRIPTION             = "Status of algor flight software patch;
                                0 = Algor flight software patch not onboard TES
                                1 = Algor flight software patch onboard TES"
END_OBJECT                  = BIT_COLUMN

OBJECT                      = BIT_COLUMN
    NAME                    = IMC_PATCH
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 7
    BITS                    = 1
    ALIAS_NAME              = imc_patch
    DESCRIPTION             = "Status of IMC flight software patch;
                                0 = imc moving in forward direction (IMC patch not onboard)
                                1 = imc moving in reverse direction (IMC patch onboard)"
END_OBJECT                  = BIT_COLUMN

OBJECT                      = BIT_COLUMN
    NAME                    = MOMENTUM_DESATURATION
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 8
    BITS                    = 1
    ALIAS_NAME              = moment
    DESCRIPTION             = "Occurence of autonomous angular momentum desaturation;
                                0 = angular momentum desaturation not occurring on spacecraft
                                1 = angular momentum desaturation occurring on spacecraft"
END_OBJECT                  = BIT_COLUMN

OBJECT                      = BIT_COLUMN
    NAME                    = EQUALIZATION_TABLE
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 9
    BITS                    = 1
    ALIAS_NAME              = equal_tab
    DESCRIPTION             = "Status of equalization tables;
```

```
                                   0 = equalization tables not onboard TES
                                   1 = equalization tables onboard TES"
    END_OBJECT                 = BIT_COLUMN

END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = PRIMARY_DIAGNOSTIC_TEMPERATURES
    DATA_TYPE                  = MSB_UNSIGNED_INTEGER
    START_BYTE                 = 34
    BYTES                      = 8
    ITEMS                      = 4
    ITEM_BYTES                 = 2
    SCALING_FACTOR             = 0.01
    ALIAS_NAME                 = temps
    DESCRIPTION                = "Primary diagnostic temperatures:
                                 temps[1] = T1 = Visual Bolometer Detector Package
                                 temps[2] = T2 = Thermal Bolometer Detector Package
                                 temps[3] = T3 = Spectrometer Detector Package
                                 temps[4] = T4 = Thermal Bolometer Black Body Reference"
    UNIT                       = "K"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = FFT_START_INDEX
    DATA_TYPE                  = MSB_UNSIGNED_INTEGER
    START_BYTE                 = 42
    BYTES                      = 1
    ALIAS_NAME                 = ffti
    DESCRIPTION                = "This parameter specifies the starting wavenumber of the spectra.  The
                               wavenumber of the first data channel is 10.58 times the index number.  This value
                               also defines how the spectral mask is to the channels."
END_OBJECT                     = COLUMN
```

A.8 POS Table

```
NAME                           = POS
COLUMNS                        = 7
ROW_BYTES                      = 70
DESCRIPTION                    = "
    The POS table stores the positions of the spacecraft and sun relative to the planet, the spacecraft's
    orientation quaternion, and the Mars body quaternion, all relative to the J2000 system.

    These data are initially derived from the project's SPICE kernels, but may be corrected from various
    other sources.  This table may also include interpolated values where SPICE data were unavailable."

OBJECT                         = COLUMN
    NAME                       = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE                  = MSB_UNSIGNED_INTEGER
    START_BYTE                 = 1
    BYTES                      = 4
    ALIAS_NAME                 = sclk_time
```

```
    DESCRIPTION          = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT               = COLUMN


OBJECT                   = COLUMN
    NAME                 = EPHEMERIS_TIME
    DATA_TYPE            = IEEE_REAL
    START_BYTE           = 5
    BYTES                = 8
    ALIAS_NAME           = et
    DESCRIPTION          = "Ephemeris time, seconds since 1/1/2000"
    UNIT                 = "Seconds"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = SPACECRAFT_POSITION
    DATA_TYPE            = IEEE_REAL
    START_BYTE           = 13
    BYTES                = 12
    ITEMS                = 3
    ITEM_BYTES           = 4
    ALIAS_NAME           = pos
    DESCRIPTION          = "Spacecraft position vector relative to Mars in the J2000 reference frame"
    UNIT                 = "KM"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = SUN_POSITION
    DATA_TYPE            = IEEE_REAL
    START_BYTE           = 25
    BYTES                = 12
    ITEMS                = 3
    ITEM_BYTES           = 4
    ALIAS_NAME           = sun
    DESCRIPTION          = "Sun position vector relative to Mars in the J2000 reference frame"
    UNIT                 = "KM"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = SPACECRAFT_QUATERNION
    DATA_TYPE            = IEEE_REAL
    START_BYTE           = 37
    BYTES                = 16
    ITEMS                = 4
    ITEM_BYTES           = 4
    ALIAS_NAME           = quat
    DESCRIPTION          = "Spacecraft pointing quaternion in the J2000 reference frame"
END_OBJECT               = COLUMN


OBJECT                   = COLUMN
    NAME                 = MARS_QUATERNION
    DATA_TYPE            = IEEE_REAL
    START_BYTE           = 53
    BYTES                = 16
    ITEMS                = 4
```

```
    ITEM_BYTES              = 4
    ALIAS_NAME              = qbody
    DESCRIPTION             = "Mars body quaternion in the J2000 reference frame"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = POSITION_SOURCE_ID
    DATA_TYPE               = CHARACTER
    START_BYTE              = 69
    BYTES                   = 2
    ITEMS                   = 2
    ITEM_BYTES              = 1
    ALIAS_NAME              = id
    DESCRIPTION             = "2-character source ID.
                               First character is source of positions.
                               Second character is source of pointing.
                               See ancillary table for details."
END_OBJECT                  = COLUMN
```

A.9 RAD Table

```
NAME                        = RAD
COLUMNS                     = 11
ROW_BYTES                   = 32
DESCRIPTION                 = "
    The RAD table contains the raw and calibrated observed radiances. For each observation there can
    be up to 6 RAD records, one for each active spectrometer detector. If the Temporal Integration
    Count (OBS Table, TEMPORAL_AVERAGE_COUNT) is greater than 1, then the data represent the
    average of the measurements from that many scans.

    The instrument can apply a programmable spectral mask to the raw data causing neighboring
    channels to be averaged; however, this feature is used only when downlink bandwidth is limited.
    When spectrally masked data are received, the averaged-out channels are replaced with the averaged
    value to expand the spectra back to its original size. The spectral-mask that was used to perform the
    averaging is kept in this table.

    The raw spectra are compressed for downlink. The original bit-packed compression header,
    containing the size of the compressed data and the compression mode used, is kept in this table in
    order to be used to evaluate the performance of the compressor."

OBJECT                      = COLUMN
    NAME                    = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 1
    BYTES                   = 4
    ALIAS_NAME              = sclk_time
    DESCRIPTION             = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = DETECTOR_NUMBER
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 5
```

```
     BYTES                    = 1
     ALIAS_NAME               = detector
     DESCRIPTION              = "The number of the detector that made the observation. Detectors are numbered
                              from 1 to 6"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
     NAME                     = SPECTRAL_MASK
     DATA_TYPE                = MSB_UNSIGNED_INTEGER
     START_BYTE               = 6
     BYTES                    = 1
     ALIAS_NAME               = spectral_mask
     DESCRIPTION              = "ID number of spectral mask applied.
                              See ancillary Masks table"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
     NAME                      = COMPRESSION_MODE
     DATA_TYPE                = MSB_UNSIGNED_INTEGER
     START_BYTE               = 7
     BYTES                    = 2
     ALIAS_NAME               = cmode
     DESCRIPTION              = "16-bit compression header of original data containing the size and compression
                              mode of the original compressed data.  See TES Users Guide."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
     NAME                     = RAW_RADIANCE
     DATA_TYPE                = MSB_UNSIGNED_INTEGER
     START_BYTE               = 9
     BYTES                    = 4
     VAR_DATA_TYPE            = MSB_INTEGER
     VAR_ITEM_BYTES           = 2
     VAR_RECORD_TYPE          = Q15
     ALIAS_NAME               = raw_rad
     DESCRIPTION              = "Raw spectral radiance"
     UNIT                     = "transformed volts"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
     NAME                     = CALIBRATED_RADIANCE
     DATA_TYPE                = MSB_UNSIGNED_INTEGER
     START_BYTE               = 13
     BYTES                    = 4
     VAR_DATA_TYPE            = MSB_INTEGER
     VAR_ITEM_BYTES           = 2
     VAR_RECORD_TYPE          = Q15
     ALIAS_NAME               = cal_rad
     DESCRIPTION              = "Calibrated spectral radiance"
     UNIT                     = "watts cm-2 steradian-1 wavenumber-1"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
     NAME                      = DETECTOR_TEMPERATURE
     DATA_TYPE                = MSB_UNSIGNED_INTEGER
     START_BYTE               = 17
```

```
    BYTES                    = 2
    ALIAS_NAME               = tdet
    DESCRIPTION              = "Derived temperature of the detector, used to remove instrument radiance in
                             calibration algorithm"
    UNIT                     = "K"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    NAME                     = TARGET_TEMPERATURE
    DATA_TYPE                = MSB_UNSIGNED_INTEGER
    START_BYTE               = 19
    BYTES                    = 2
    ALIAS_NAME               = target_temp
    DESCRIPTION              = "Derived temperature of the observed target"
    UNIT                     = "K"
    SCALING_FACTOR           = 0.01
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    NAME                     = SPECTRAL_THERMAL_INERTIA
    DATA_TYPE                = IEEE_REAL
    START_BYTE               = 21
    BYTES                    = 4
    ALIAS_NAME               = ti_spc
    DESCRIPTION              = "Thermal inertia, derived from spectrometer data"
    UNIT                     = "J m-2 s-1/2 K-1"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    NAME                     = RADIANCE_CALIBRATION_ID
    DATA_TYPE                = CHARACTER
    START_BYTE               = 25
    BYTES                    = 4
    ALIAS_NAME               = version_id
    DESCRIPTION              = "Calibration algorithm version id for spectral data."
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    NAME                     = QUALITY
    DATA_TYPE                = MSB_UNSIGNED_INTEGER
    START_BYTE               = 29
    BYTES                    = 4
    ALIAS_NAME               = quality
    DESCRIPTION              = "32-bit observation quality word.  Bit column  description and code definitions
                             follow; see also quality.txt for more information"

    OBJECT                   = BIT_COLUMN
        NAME                     = MAJOR_PHASE_INVERSION
        BIT_DATA_TYPE            = MSB_UNSIGNED_INTEGER
        START_BIT                = 1
        BITS                     = 1
        ALIAS_NAME               = phase_inversion
        DESCRIPTION              = "Identifies data that contains major phase inversions;
                                   0 = data does not contain major phase inversions
                                   1 = data does contain major phase inversions"
    END_OBJECT               = BIT_COLUMN
```

```
OBJECT                  = BIT_COLUMN
    NAME                    = ALGOR_RISK
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 2
    BITS                    = 1
    ALIAS_NAME              = algor_risk
    DESCRIPTION             = "Identifies whether data is at low or high risk for algor phase inversions;
                                0 = data at low risk of algor phase inversion
                                1 = data at high risk of algor phase inversion"
END_OBJECT              = BIT_COLUMN

OBJECT                  = BIT_COLUMN
    NAME                    = CALIBRATION_QUALITY
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 3
    BITS                    = 3
    ALIAS_NAME              = calib_quality
    DESCRIPTION             = "These bits are reserved for future use; value of these bits currently set to 0"
END_OBJECT              = BIT_COLUMN

OBJECT                  = BIT_COLUMN
    NAME                    = SPECTROMETER_NOISE
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 6
    BITS                    = 2
    ALIAS_NAME              = spect_noise
    DESCRIPTION             = "Identifies noise level in data based on space observations made at least once
                            every 12 orbits;
                                0 = instrument noise not calculated
                                1 = instrument noise at nominal levels
                                2 = instrument noise at anomalously high levels
                                3 = not assigned"
END_OBJECT              = BIT_COLUMN

OBJECT                  = BIT_COLUMN
    NAME                    = SPECTRAL_INERTIA_RATING
    BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
    START_BIT               = 8
    BITS                    = 3
    ALIAS_NAME              = ti_spc_rating
    DESCRIPTION             = "Values of 0 to 3 rate the uncertainty of the  modeled spectral thermal inertia
                            based on design-specified instrument noise levels;  additional sources of
                            uncertainty are present, see document/process.asc or process.pdf.
                            Values of 5 to 7 rate the reasons why valid spectral thermal inertia could not be
                            modeled.
                                0 = best quality
                                1 = good quality
                                2 = medium quality
                                3 = low quality
                                4 = not assigned
                                5 = lowest quality - observed temperature outside of model-predicted range
                                6 = lowest quality - no model temperature variation as a function of thermal
                                inertia
                                7 = lowest quality - thermal inertia value not computed due to lack of
                                necessary data"
```

```
    END_OBJECT              = BIT_COLUMN

    OBJECT                  = BIT_COLUMN
        NAME                    = DETECTOR_MASK_PROBLEM
        BIT_DATA_TYPE           = MSB_UNSIGNED_INTEGER
        START_BIT               = 11
        BITS                    = 1
        ALIAS_NAME              = det_mask_problem
        DESCRIPTION             = "Identifies spectra affected by onboard detector (spatial) mask processing;
                                use spectra with extreme caution.
                                  0 = spectrum not affected
                                  1 = spectrum affected by the detector mask 1 problem"
    END_OBJECT              = BIT_COLUMN

END_OBJECT                  = COLUMN
```

A.10 TLM Table

```
NAME                        = TLM
COLUMNS                     = 31
ROW_BYTES                   = 113
DESCRIPTION                 = "
    The TLM table stores the auxiliary observation parameters downlinked with the long packet format
    (see OBS Table, DATA_PACKET_TYPE).  Records in the TLM table occur at a frequency less than
    or equal to the frequency of OBS records; that is, one (or none) per observation."

OBJECT                      = COLUMN
    NAME                    = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 1
    BYTES                    = 4
    ALIAS_NAME              = sclk_time
    DESCRIPTION             = "The value of the spacecraft clock at the beginning of the observation"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    NAME                    = AUXILIARY_DIAGNOSTIC_TEMPS
    DATA_TYPE               = MSB_UNSIGNED_INTEGER
    START_BYTE              = 5
    BYTES                   = 24
    ITEMS                   = 12
    ITEM_BYTES              = 2
    SCALING_FACTOR          = 0.01
    ALIAS_NAME              = aux_temps
    DESCRIPTION             = "Array of 12 auxiliary temperatures,
                              Read from internal instrument thermistors.
                              1: T5 - Black Body 1
                              2: T6 - Black Body 2
                              3: T7 - Black Body 3
                              4: T8 - Bolometric Black Body Reference (spare)
                              5: T9 - Electronics
                              6: T10 - Power Supply
```

```
                                 7: T11 - Telescope Field Stop
                                 8: T12 - Interferometer Fixed Mirror
                                 9: T13 - Interferometer Beamsplitter
                                 10: T14 - Interferometer Motor
                                 11: T15 - Primary Mirror
                                 12: T16 - Secondary Mirror"
    UNIT                       = "K"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                        = INTERFEROGRAM_MAXIMUM
    DATA_TYPE                  = MSB_INTEGER
    START_BYTE                 = 29
    BYTES                      = 12
    ITEMS                      = 6
    ITEM_BYTES                  = 2
    SCALING_FACTOR              = 0.000152587890625
    ALIAS_NAME                 = ifgm_max
    DESCRIPTION                = "Array of 6 interferogram maximum values, one for each spectrometer detector.
                                 Scaling factor is 5.0/32768 V"
    UNIT                       = "VOLTS"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = INTERFEROGRAM_MINIMUM
    DATA_TYPE                  = MSB_INTEGER
    START_BYTE                 = 41
    BYTES                      = 12
    ITEMS                      = 6
    ITEM_BYTES                 = 2
    SCALING_FACTOR             = 0.000152587890625
    ALIAS_NAME                  = ifgm_min
    DESCRIPTION                = "Array of 6 interferogram minimum values, one for each spectrometer detector.
                               Scaling factor is 5.0/32768 V"
    UNIT                       = "VOLTS"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = ONBOARD_PROCESSING_EVENT_LOG
    DATA_TYPE                  = MSB_UNSIGNED_INTEGER
     START_BYTE                = 53
    BYTES                      = 12
    ITEMS                      = 6
    ITEM_BYTES                 = 2
    ALIAS_NAME                 = dsp_log
    DESCRIPTION                = "Array of digital signal processor event logs, 16-bit mask, one for each
                               spectrometer detector.  See TES User's Guide for details"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = DIAGNOSTIC_TELEMETRY_1
    DATA_TYPE                  = MSB_INTEGER
    START_BYTE                 = 65
    BYTE                       = 1
    SCALING_FACTOR             = 3.90625
    ALIAS_NAME                 = V1
```

```
    DESCRIPTION          = "Electronic power supply load current"
    UNIT                 = "mA"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_2
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 66
    BYTE                 = 1
    SCALING_FACTOR       = 1.95312
    ALIAS_NAME           = V2
    DESCRIPTION          = "Mechanic power supply load current"
    UNIT                 = "mA"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_3
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 67
    BYTE                 = 1
    SCALING_FACTOR       = 0.278906
    ALIAS_NAME           = V3
    DESCRIPTION          = Diagnostic voltage P26V2.  +26v: Pointing mirror motor."
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_4
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 68
    BYTE                 = 1
    SCALING_FACTOR       = 0.278906
    ALIAS_NAME           = V4
    DESCRIPTION          = "Diagnostic voltage P28V2.  +28v: Interferometer motor."
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_5
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 69
    BYTE                 = 1
    SCALING_FACTOR       = 4.45312
    OFFSET               = -17.00000
    ALIAS_NAME           = V5
    DESCRIPTION          = "Pointing mirror motor current"
    UNIT                 = "mA"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_6
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 70
    BYTE                 = 1
    SCALING_FACTOR       = 0.652344
    ALIAS_NAME           = V6
```

```
    DESCRIPTION          = "Interferometer motor current"
    UNIT                 = "mA"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_7
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 71
    BYTE                 = 1
    SCALING_FACTOR       = 0.119457
    ALIAS_NAME           = V7
    DESCRIPTION          = "Diagnostic voltage P10V1.  +10v: Servo Electronics"
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN


OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_8
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 72
    BYTE                 = 1
    SCALING_FACTOR       = -0.103067
    ALIAS_NAME           = V8
    DESCRIPTION          = "Diagnostic voltage N10V1.  -10v: Servo Electronics"
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_9
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 73
    BYTE                 = 1
    SCALING_FACTOR       = 0.15576
    ALIAS_NAME           = V9
    DESCRIPTION          = "Diagnostic voltage P16V1.  +16v: Analog MUX and A/D"
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_10
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 74
    BYTE                 = 1
    SCALING_FACTOR       = -0.15625
    ALIAS_NAME           = V10
    DESCRIPTION          = "Diagnostic voltage N16V1.  -16v: Analog MUX and A/D"
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_11
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 75
    BYTE                 = 1
    SCALING_FACTOR       = 0.0976055
    ALIAS_NAME           = V11
```

```
    DESCRIPTION          = "Diagnostic voltage P10V2.  +10v: Heaters"
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_12
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 76
    BYTE                 = 1
    SCALING_FACTOR       = -0.0985813
    ALIAS_NAME           = V12
    DESCRIPTION          = "Diagnostic voltage N10V2.  -10v: Heaters"
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_13
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 77
    BYTE                 = 1
    SCALING_FACTOR       = 0.976562
    ALIAS_NAME           = V13
    DESCRIPTION          = "Albedo Calibration Lamps current"
    UNIT                 = "mA"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_14
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 78
    BYTE                 = 1
    SCALING_FACTOR       = 0.0648437
    ALIAS_NAME           = V14
    DESCRIPTION          = "Neon lamps current"
    UNIT                 = "mA"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_15
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 79
    BYTE                 = 1
    SCALING_FACTOR       = 0.045727
    ALIAS_NAME           = V15
    DESCRIPTION          = "Diagnostic voltage P5V1.  +5v: Servo electronics and DSP"
    UNIT                 = "VOLTS"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    NAME                 = DIAGNOSTIC_TELEMETRY_16
    DATA_TYPE            = MSB_INTEGER
    START_BYTE           = 80
    BYTE                 = 1
    SCALING_FACTOR       = 0.0480992
    ALIAS_NAME           = V16
    DESCRIPTION          = "Diagnostic voltage P5V2.  Control processor and BIU."
```

```
     UNIT                           = "VOLTS"
END_OBJECT                          = COLUMN

OBJECT                              = COLUMN
     NAME                           = DIAGNOSTIC_TELEMETRY_17
     DATA_TYPE                      = MSB_INTEGER
     START_BYTE                     = 81
     BYTE                           = 1
     SCALING_FACTOR                 = 0.0478277
     ALIAS_NAME                     = V17
     DESCRIPTION                    = Diagnostic voltage P5V3.  +5v: Analog MUX, A/D, Timing sequencer"
     UNIT                           = "VOLTS"
END_OBJECT                          = COLUMN

OBJECT                              = COLUMN
     NAME                           = DIAGNOSTIC_TELEMETRY_18
     DATA_TYPE                      = MSB_INTEGER
     START_BYTE                     = 82
     BYTE                           = 1
     SCALING_FACTOR                 = 0.0488039
     ALIAS_NAME                     = V18
     DESCRIPTION                    = "Diagnostic voltage P5V4.
                                    +5v: Fringe and ZPD circuit"
     UNIT                           = "VOLTS"
END_OBJECT                          = COLUMN

OBJECT                              = COLUMN
     NAME                            = DIAGNOSTIC_TELEMETRY_19
     DATA_TYPE                      = MSB_INTEGER
     START_BYTE                      = 83
     BYTE                           = 1
     SCALING_FACTOR                 = 0.141966
     ALIAS_NAME                      = V19
     DESCRIPTION                    = "Diagnostic voltage P15V1.  +15v Amplifiers"
     UNIT                           = "VOLTS"
END_OBJECT                          = COLUMN

OBJECT                              = COLUMN
     NAME                            = DIAGNOSTIC_TELEMETRY_20
     DATA_TYPE                      = MSB_INTEGER
     START_BYTE                      = 84
     BYTE                           = 1
     SCALING_FACTOR                 = -0.149688
     ALIAS_NAME                      = V20
     DESCRIPTION                    = "Diagnostic voltage N15V1.  -15v Amplifiers"
     UNIT                           = "VOLTS"
END_OBJECT                          = COLUMN

OBJECT                              = COLUMN
     NAME                           = NEON_LAMP
     DATA_TYPE                      = MSB_UNSIGNED_INTEGER
     START_BYTE                     = 85
     BYTES                          = 1
     ALIAS_NAME                      = neon_lamp
     DESCRIPTION                    = "Control interferometer neon lamp in use, primary (1) or backup(2)"
END_OBJECT                          = COLUMN
```

```
OBJECT              = COLUMN
    NAME             = NEON_GAIN
    DATA_TYPE       = CHARACTER
    START_BYTE      = 86
    BYTES           = 1
    ALIAS_NAME      = neon_gain
    DESCRIPTION     = "Control interferometer neon lamp gain, (L)ow or (H)igh"
END_OBJECT          = COLUMN

OBJECT              = COLUMN
    NAME             = NEON_AMPLITUDE
    DATA_TYPE       = MSB_INTEGER
    START_BYTE      = 87
    BYTES           = 1
    ALIAS_NAME      = neon_amp
    DESCRIPTION     = "Control interfe rogram signal amplitude at zero path difference (zpd)"
END_OBJECT          = COLUMN

OBJECT              = COLUMN
    NAME            = NEON_ZPD
    DATA_TYPE       = MSB_UNSIGNED_INTEGER
    START_BYTE      = 88
    BYTES           = 2
    ALIAS_NAME      = neon_zpd
    DESCRIPTION     = "Control interferogram zero path difference (zpd) location measured in counts
                      from start of scan"
END_OBJECT          = COLUMN

OBJECT              = COLUMN
    NAME            = INTERFEROGRAM_ZPD
    DATA_TYPE       = MSB_UNSIGNED_INTEGER
    START_BYTE      = 90
    BYTES           = 12
    ITEMS           = 6
    ITEM_BYTES      = 2
    ALIAS_NAME      = ifgm_zpd
    DESCRIPTION     = "IR interferogram zero path difference (zpd) location measured from start of
                      scan"
END_OBJECT          = COLUMN

OBJECT              = COLUMN
    NAME            = INTERFEROGRAM_END
    DATA_TYPE       = MSB_UNSIGNED_INTEGER
    START_BYTE      = 102
    BYTES           = 12
    ITEMS           = 6
    ITEM_BYTES      = 2
    ALIAS_NAME      = ifgm_end
    DESCRIPTION     = "Number of extra counts at end of each IR interferogram"
END_OBJECT          = COLUMN
```