Phoenix (PHX)

Software Interface Specification

Interface Title: **Microscopy, Electrochemistry and Conductivity Analyzer (MECA) –Non-imaging Reduced Data Record (RDR)**

Mission: PHX Date: 19-DEC-2008

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Phoenix Project

Software Interface Specification (SIS)

MECA Non-imaging Reduced Data Record (RDR)

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California Institute of Technology

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19-DEC_08	WCL Changes To RDR Format

TBD ITEMS

Section	Description
All	As indicated by PINK TEXT

CONTENTS

TABLES

1. PURPOSE AND SCOPE OF DOCUMENT

The purpose of this document is to provide users of MECA Reduced Data Records (RDR) with a detailed description of the products and how they are generated, including data sources and destinations.

The document is intended to provide enough information to enable users to read and understand the data products. Intended users of this document are the scientists who will analyze the mission and supporting data, both those associated with the Phoenix Project and members of the general planetary science community.

2. APPLICABLE DOCUMENTS

1. Planetary Data System Standards Reference, JPL D-7669 part 2, version 3.7, March 20, 2006.
2. Phoenix Project Archive Generation, Validation and Transfer Plan, JPL D-29392, Rev. 1.0, December 20, 2004.
3. Planetary Data System Archive Preparation Guide, version 1.1, August 29, 2006.
4. Mars Exploration Program Data Management Plan, Arvidson et al., Rev. 3.0, March 20, 2002.
5. Data Management and Computation, Volume 1: Issues and Recommendations, Committee on Data Management and Computation, Space Science Board, Assembly of Mathematical and Physical Sciences, National Research Council, National Academy Press, Washington D.C., 1982
6. Issues and Recommendations Associated with Distributed Computation and Data Management Systems for Space Sciences, Space Science Board, Assembly of Mathematical and Physical Sciences, National Research Council, National Academy Press, Washington D.C., 1986
7. MECA Non-Imaging Experiment Data Record (EDR) Software Interface Specification, JPL-33232, January 25, 2007.
8. MECA Non-Imaging EDR and RDR Archive Volume Software Interface Specification, Version 1.0, February 18, 2008.

3. RELATIONSHIPS WITH OTHER INTERFACES

This SIS document, and the products that it describes, could be affected by changes to the MECA or Phoenix flight software, the MECA EDR SIS [Applicable Document #7], or PDS standards. Such changes may require updates to this document as applicable. Major changes would require re-approval of all listed individuals and teams per the signature page.

4. DATA PRODUCT CHARACTERISTICS AND ENVIRONMENT

The Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) is a suite of soil analysis instruments that combines a wet chemistry laboratory (WCL), an optical microscope (OM), an atomic-force microscope (AFM), and a thermal and electrical-conductivity probe (TECP), with common supporting structure, electronics, and software.

Data in this product has been transformed from the digital numbers (DNs) in the lower level packets to physical units. Data from the OM, which are described in the Phoenix Camera EDR/RDR SIS, are archived on the Imaging node of the Planetary Data System. However, status information pertaining to those images and various tabular data that determine how they are acquired are part of this Non-Imaging product.

4.1 Instrument Overview

The MECA instrument suite is a component of the Mars ’07 Phoenix investigation, which will also return data from a Thermal and Evolved Gas Analyzer (TEGA), three cameras, and a meteorology suite (MET). Phoenix is motivated by the goals of (1) studying the history of water in all its phases, and (2) searching for habitable zones. Samples of surface and subsurface soil and ice will be delivered to MECA and TEGA from a trench excavated by a Robot Arm (RA), while MECA’s Thermal and Electrical Conductivity Probe (TECP) will be deployed in soil and air by the Robot Arm. The Robot Arm Camera (RAC) will document the morphology of the trench walls, while the Surface Stereo Imager (SSI) and the Mars Descent Imager (MARDI) establish a geological context. Throughout the mission, MET will monitor polar weather and local water transport.

4.1.1 Atomic Force Microscope (AFM)

The Atomic Force Microscope (AFM) is part of the MECA Microscopy Station, which comprises a Sample Wheel and Translation Stage (SWTS), an optical microscope (OM), and the AFM. As shown in Figure 4-1, the MECA AFM is located between the OM and the SWTS inside the darkened MECA enclosure on the spacecraft deck. It scans a small region (from 1-65 μm square) on any of 69 substrates, each 3-mm in diameter, positioned along the rim of the SWTS. The chief scientific objectives of the AFM are to analyze small dust and soil particles in terms of their size, size distribution, shape, and texture. The AFM is particularly well suited to analyze particles carried by the wind, which are believed to be in the size range 1-3 μm.

Prior to AFM scanning, OM images are acquired to document the substrates and provide context for the AFM scans. OM data is described in the Phoenix camera SIS, along with the RAC and SSI, and is outside the scope of this document. The reader is also referred to that document for more detailed description of the SWTS and its substrates.

The AFM is contributed by a Swiss-led consortium spearheaded by the University of Neuchatel. Run by a dedicated microcontroller, the AFM uses one of an array of eight micromachined cantilevers with sharp tips to obtain topographs (sometimes called “scans” or “images”) of up to a 65×65-μm area of the sample. Within this constraint the scan can be of any size, but the AFM can only address a narrow horizontal stripe of each substrate. Since the sample wheel can be rotated (but not elevated) prior to initiation of scanning, the AFM can access a thin band approximately 1/3 of the way up from the bottom of the corresponding OM image. Note that the x and y axes of the MECA AFM image are rotated by +45 degrees relative to the OM images (Figure 4-2).

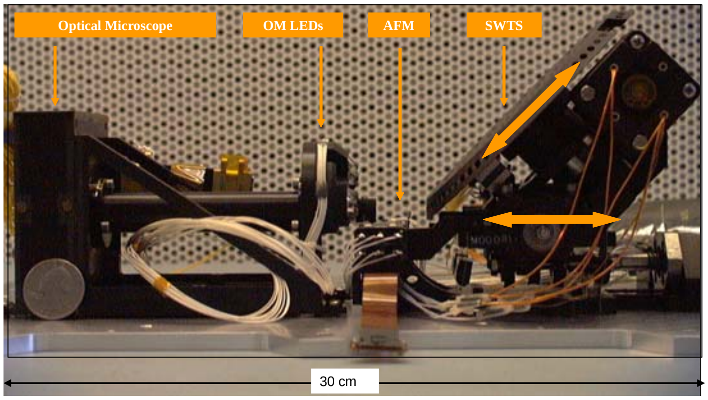


Figure 4 1. Left: The SWTS translates in and out to collect samples, remove excess material, focus, and approach the AFM. It rotates to select any of 69 substrates. Right: The sampling chute, viewed from the top with 6 substrates exposed

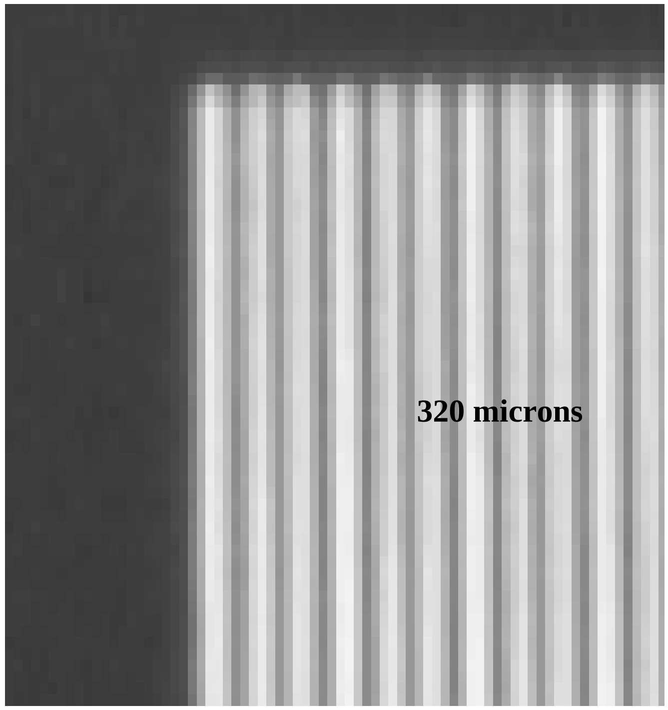
The 69 substrates on the SWTS are divided into ten sets of six (a weak and a strong magnet, two "microbuckets", a textured substrate, and a sticky silicone pad) and nine utility or calibration targets. Using the SWTS, these can be coated with a thin layer of dust or soil, and then rotated to the vertical scanning position where they can be imaged by the optical microscope. Of the six substrates in each set, two are specifically designed for AFM use in that they resist the tendency for particles to become dislodged and to adhere to the AFM tip. Such particle adhesion can degrade the scans in question and the quality of the tip in general. One of these substrates is a uniform piece of silicone that remains pliant under martian conditions. The second is a custom micro-machined silicon substrate with pits and posts that hold particles of an appropriate scale for AFM scanning. Two of the remaining four substrates are magnets that may, under certain circumstances, be appropriate for AFM scanning. The final two substrates are deep "buckets" that would not normally be accessible to the AFM.

There are three types of AFM calibration targets. The tip standard target is used to check the profile of the AFM tip and for 'reverse imaging'. The target is made up of an array of very sharp silicon tips (radius < 10nm), with a period of 3±0.05 microns, a diagonal period of 2.12 microns and a height of 0.3-0.5 microns. The tip opening angle is about 50 degrees. For more information on the target, see: http://www.ntmdt-tips.com/catalog/gratings/afm_cal/products/TGT1.html

The linear calibration target is used to check and correct the orthogonality of the AFM scan plane. It is an etched silicon target with a checkerboard pattern of square pillars with sharp undercut edges. The period is 3±0.05 microns and height is 0.3-0.6 microns. The curvature radius is less than 10 nm. For more information on the target, see: http://www.ntmdt-tips.com/catalog/gratings/afm_cal/products/TGX1.html

The tip finder target is used to accurately locate the AFM tip relative to the OM frame. The central part of the target is a 2x2 mm piece of quartz glass with an aluminium pattern on top. The quartz glass is painted with a white epoxy on the back before bonding to a cylindrical 3 mm aluminium disk that is inserted into the SWTS.

Figure 4-2 shows an optical micrograph of the aluminum pattern.



There are 9 areas each of which are 320 microns wide by 256 microns tall. The “outer” 8 areas consist of vertical lines with a specific pitch. The pitch ranges from 6 microns to 20 microns between the white lines. All lines have a width of 4 microns.

The central region (Area 5) has a detailed pattern which includes a coding scheme to identify the position of the features (both laterally and vertically) within that region. Figure 4-3 shows a schematic of how the 8-bit binary coding is implemented for the vertical direction.

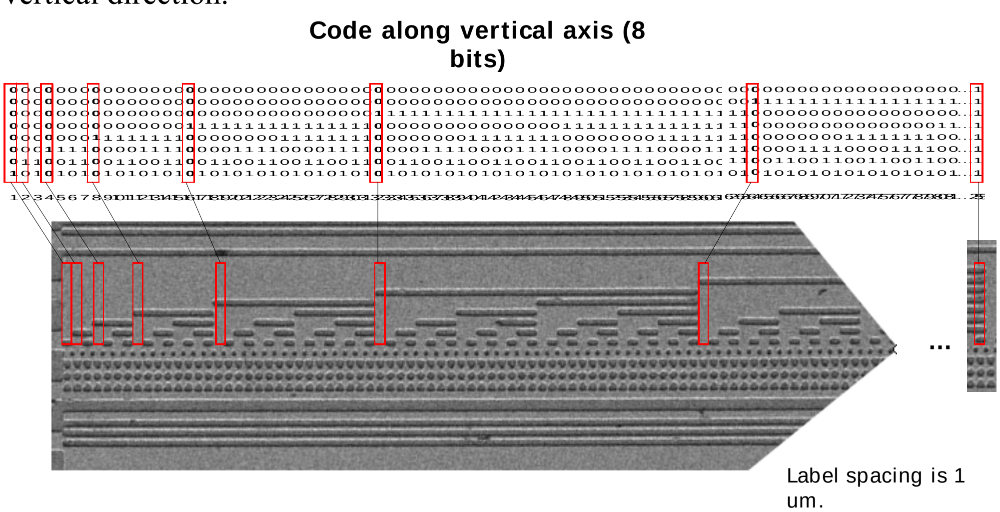


Figure 4-1: SEM image of part of the detailed region showing how the coding is implemented in the vertical direction. Note, the image is rotated 90 degrees.

The top right hand corner of the detailed pattern is shown in Figure 4-4. The features are vertical lines and dots with 16 repeating patterns in the horizontal direction, each with a period of 20 microns. The periods are numbered 0-15 from left to right with a least significant bits 4-bit binary code.

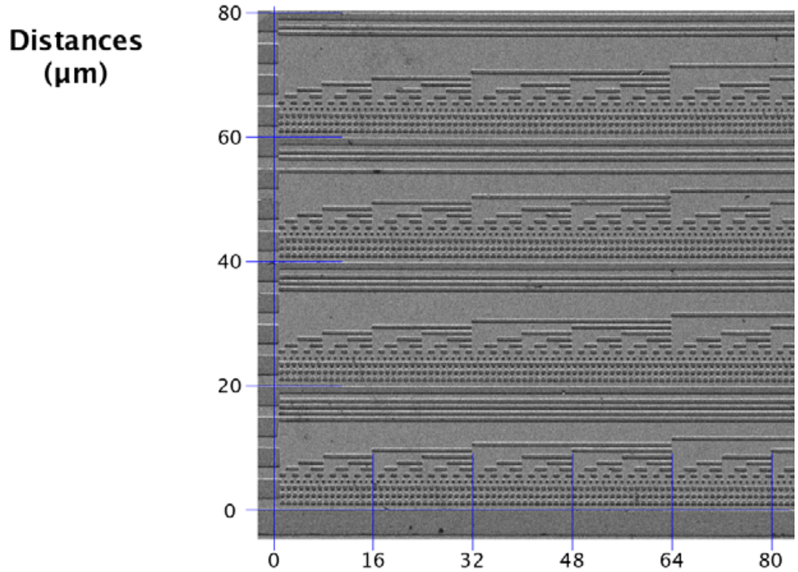


Figure4-4: SEM image of part of the detailed region showing the dimensions (microns) of the features.

The nanobucket substrates provide the possibility of in-situ scanner calibration and scan region location as they include patterns of micro-fabricated etched features. Figure 4-5 shows an optical image of one of the nanobucket substrates.

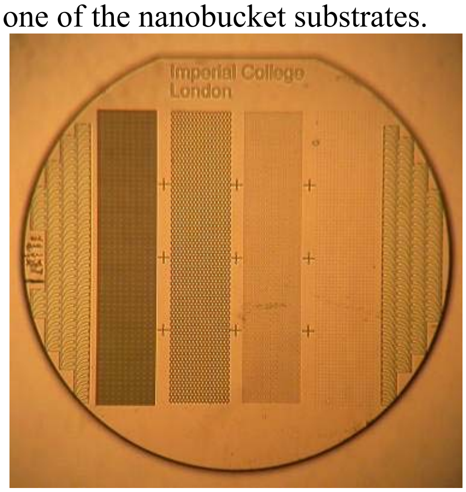


Figure 4-5: Optical micrograph of a 3 mm diameter nanobucket substrate showing the etched patterns.

Five different features are included in these substrates:

a) tear-shape beakers, ~ 5μm deep, on both sides of the substrate
b) 5μm diameter round beakers with a pitch of 7μm and a depth of ~ 5μm,
c) 20μm diameter round beakers with a pitch of 24μm and a depth of ~ 5μm,
d) round posts of 3μm diameter and about 5μm height, having a pitch of 8μm,
e) round posts of 3μm diameter and about 5μm height, having a pitch of 23μm.

To operate the microscopy station, soil samples are deposited by the RA (or dust from the air) onto a segment of the SWTS ring that has been extended such that exactly one set of 6 substrates protrudes from a horizontal slot in the MECA enclosure. Excess material is removed by passing the substrates under a blade positioned 0.2 mm above the surface, after which the samples are rotated from their horizontal load positions into their vertical imaging positions for imaging by the OM and AFM. The SWTS is also used for focusing and AFM coarse positioning.

Attempting to scan excessively steep or ragged surfaces with the AFM will result in scans that are largely out of range, and could conceivably damage the tip. Further, bandwidth and time constraints severely limit the number of scans that can be acquired and returned to Earth. These considerations dictate a two-day imaging strategy for each set of microscopy samples. On the first day a sample is delivered, then characterized by the optical microscope. AFM calibration scans are also acquired. These images are evaluated on the ground and targets for AFM scanning are selected. On the second day the targeted areas are imaged again with the optical microscope, and then scanned with the AFM.

MECA's AFM comprises three major components, a microfabricated probe-chip, an electro-magnetic scanner-actuator and single board control electronics. The probe-chip features 8 cantilevers, numbered 0-7. The chip is mounted with two orthogonal tilt angles of 10 degrees relative to the sample to ensure that only one tip contacts the sample at a time. In case of contamination or malfunction of this front-most tip, the defective cantilever and its support beam can be cleaved off by a special tool on the sample wheel, after which the next one in the array becomes active. The force constant of the levers varies between 9 and 13 N/m.

Each of the 8 MECA cantilevers features an integrated piezo-electric stress sensor, which is used to measure its pure deflection (static mode) or its vibration amplitude, frequency and phase (dynamic mode). In static mode the deflection signal is proportional to the force, while in dynamic mode the shift of the resonance frequency is a measure of the force gradient. Dynamic mode minimizes the interactions between tip and surface and is less likely to result in particles being moved around or dislodged during the scan. In either mode, these signals are used to regulate the distance between the tip and the sample in the z-direction by means of a proportional-integral feedback loop.

The z-axis servo signal (referred to has height) represents the sample topography as the tip is rastered across the surface in the x (fast) and y (slow) directions. (Though the resulting topograph is sometimes referred to as an image, it bears little resemblance to an optical image until it is transformed and processed.) Imperfect feedback or an out-of-range condition can result in residual bending of the cantilever in static mode, or a phase shift of the oscillation in dynamic mode. This error signal may optionally be recorded in a second data channel. Since each line in the raster scan begins at the same point on the x-axis, both primary and error signals may be recorded either on the forward or the backward legs of the scan (or, typically, both). Thus a single raster scan can produce up to four arrays of data: Forward (height), forward (error), backward (height), and backward (error), each of which can be displayed in image format.

Several of the status values returned in MECA telemetry refer to the configuration and status of the AFM digital feedback loop. The piezoresistors on the cantilevers are addressed by a multiplexer, which links them to a temperature-compensated Wheatsone bridge. For static mode imaging the value of the bridge is directly compared to a setpoint. For dynamic mode imaging a frequency modulation technique is applied that maintains the resonant frequency of the cantilever at a setpoint while stabilizing the amplitude. The measured parameters are the phase-shift between the excitation of the cantilever and the measured signal from the Wheatstone bridge, maintained by a phase locked loop. The array geometry is designed to spread the resonant frequencies of the levers between 30 and 40 kHz in order to avoid cross-talk during dynamic operation (these shift slightly with temperature).

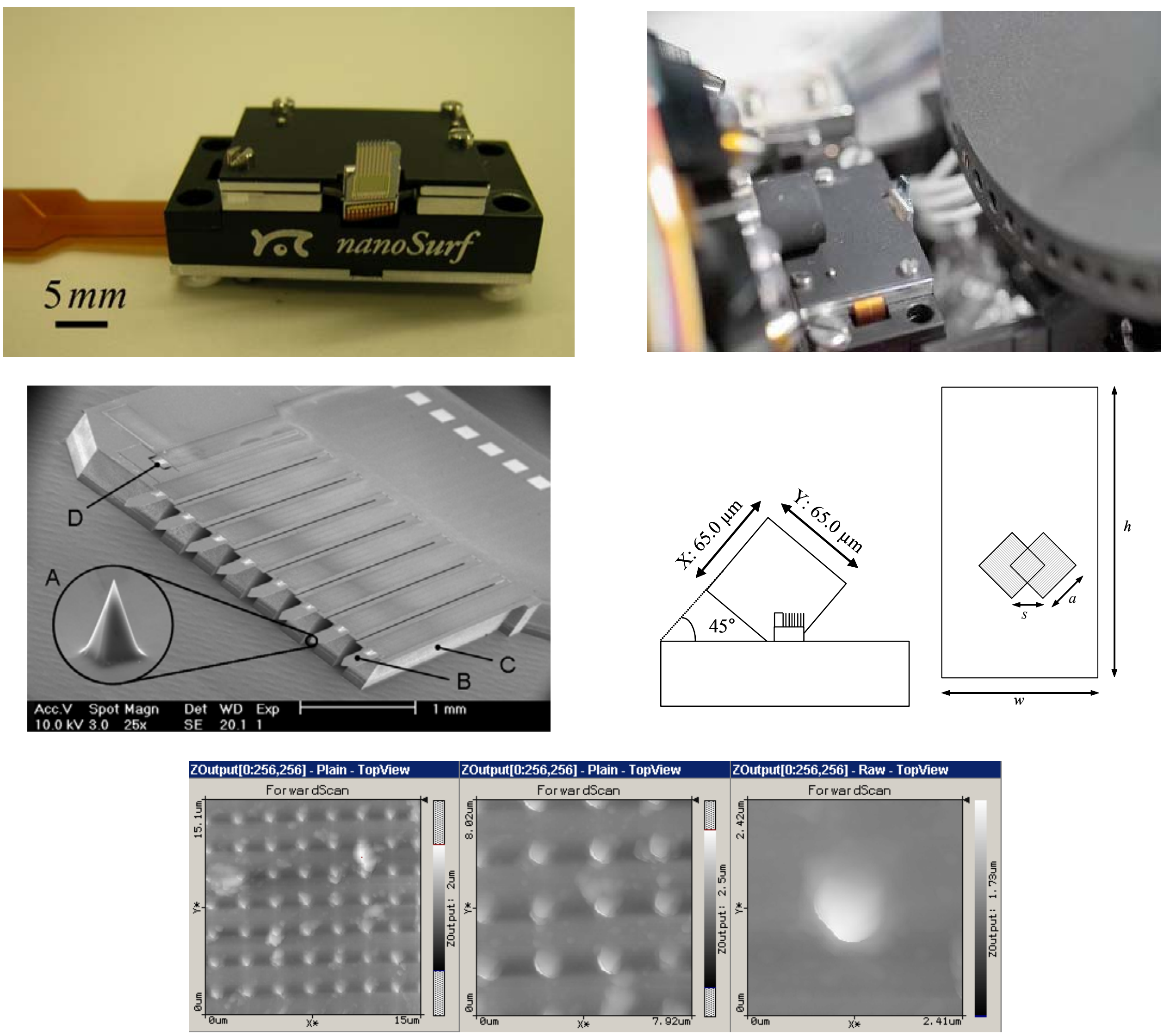


Figure 4-6. Upper Left: The AFM scanner viewed from the perspective of the sample. Upper right: The scanner

positioned under the nose of the OM and in front of the SWTS. Middle left: The AFM chip. (A) is a close-up of one of the silicone tips, (B) points is one of 8 cantilevers mounted on a cleavable support-beam (C). D) is a reference piezoresistor used for temperature compensation. Middle right: Geometry of the AFM scan field relative to the OM coordinate system. Cartoon on right exaggerates size of AFM scan (OM image is 2 mm high by 1 mm wide) . Bottom: topographs of pincussion array with increasing magnification.

It must be emphasized that an AFM scan is acquired by rastering a physical tool across a surface. As a result, line-to-line noise and artifacts may be significantly different than point-to-point artifacts along the scan direction. Moreover, outside the range of authority of the cantilever (approximately 65 x 65 micrometers laterally and 13 micrometers in height) the topograph does not go “out of focus” but simply saturates, while anywhere within its range of authority it is equally “in focus.” The topograph itself reflects the interaction between a tip of finite size and a non-uniform surface, and therefore convolves physical characteristics of both the probe and the target. Thus, while an AFM topograph may look like an image product, the processing required bears little in common with the processing of an actual optical image. The AFM data processing algorithms will be discussed in Section 4.3.1.1.

A full description of the MECA AFM instrument can be found in Hecht et al 2008. To jump to the next AFM section of the document see paragraph 4.3.1.1.

4.1.2 Thermal and Electrical Conductivity Probe (TECP)

An end-effector on the Phoenix Robotic Arm (figure 4-7), the TECP is a probe of soil physical properties including temperature, thermal conductivity and diffusivity, electrical conductivity and permittivity, as well as atmospheric temperature, humidity, and wind speed. These measurements are made with four conical needles, three of which contain electrical heaters and thermometers, and a hygrometer sensor mounted separately in the body of the TECP.

Three of the four parallel needles contain a thermocouple and a heater. The two needle pairs are used as electrodes for regolith electrical properties measurements (see figure 4-8). The same needles also serve as heating elements and thermometers for regolith thermal properties and wind speed measurements. The needles can be inserted into the soil for thermal and electrical measurements or positioned above the surface for atmospheric temperature, and wind speed measurements. Regolith thermal properties (including temperature, thermal conductivity, thermal diffusivity, volumetric heat capacity, and thermal inertia) as well as wind speed are derived from the heating and cooling behavior of the needles before and after a known amount of heat is added. Regolith electrical properties, including electrical conductivity and dielectric permittivity, are measured with capacitance and resistance sensors coupled to the regolith through the sensing needles. Atmospheric water vapor concentration is measured with a calibrated capacitance hygrometer mounted near a temperature sensor on the TECP printed circuit board, but exposed to the atmosphere through a particulate filter.

The humidity sensor determines the capacitance of the thin film hygrometer, which is a calibrated function of the relative humidity at the film surface. By measuring the film temperature with the adjacent temperature sensor, the result can be converted to absolute humidity. Under the assumption that gradients in vapor pressure are small, external relative humidity can be determined by comparison of the TECP result with the MET temperature sensors.

The scientific objectives of the TECP are:

- To provide ground-truth for orbital surface thermal measurements and input parameters for thermal models by directly measuring the thermal properties of Martian regolith.
- To measure the concentration and nature of water in martian regolith in solid, “non-frozen,” liquid, and vapor states.
- To determine changes in the reservoirs of water when soil is freshly exposed.
- To characterize the movement of water in and out of the soil by measuring atmospheric humidity, temperature, and wind speed above the surface.

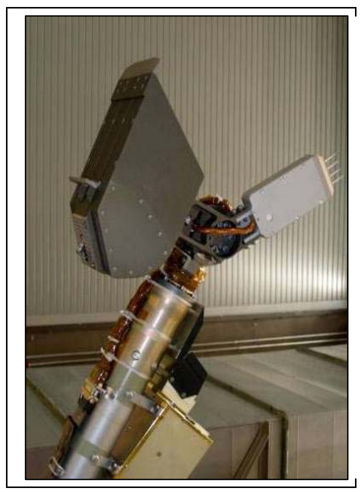


Figure 4-7: TECP (right) mounted on the robotic arm. The small white circle on the lower left is the humidity sensor. The four needles at right perform the other sensor measurements.

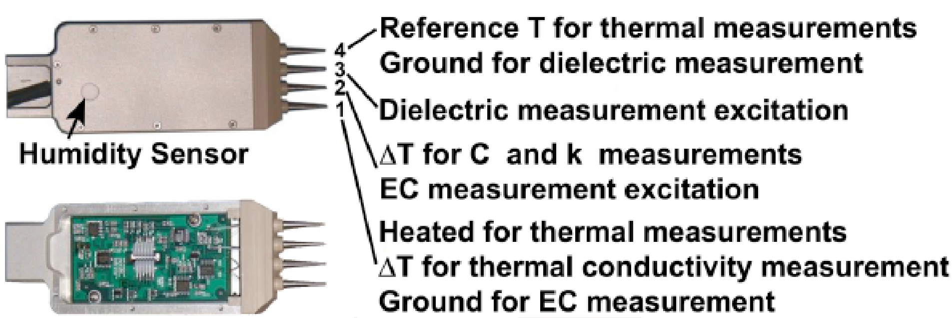


Figure 4-8 Photograph of the TECP instrument (top) and with the external cover removed to allow access to the electronics board (bottom). For each needle, the numerical designation and functionality is identified at right.

TECP thermal and electrical properties measurement quality depends on proper needle placement by the RA. Non-linear insertion, partial insertion, and lateral movement all affect data quality negatively. Thermal properties measurements can also be negatively impacted by non steady state thermal conditions, and the TECP should therefore be allowed to equilibrate to its thermal environment before making thermal properties measurements.

Measurement electronics are contained in the body of the TECP, and include a 12 bit A/D converter, two phase detectors, three resistance bridges, and a digital shift register. The A/D converter and shift register communicate through a serial interface to an FPGA on the primary MECA control and measurement electronics (CME) board.

A full description of the TECP portion of the MECA instrument can be found in Zent et al., 2008. To skip to the next TECP specific section of this document see paragraph 4.3.1.2.

4.1.3 Wet Chemistry Laboratory (WCL)

MECA's wet chemistry laboratory (WCL) comprises four single-use modules, each consisting of a beaker assembly and an actuator assembly (figure 4.9). The modules mix soil samples with a leaching solution in a pressure vessel for electrochemical analysis. The scientific objective of the WCL is to determine the total pH, redox properties, and concentration of the principal aqueously solvated components of the acquired soil samples.

Chemical data is returned by 26 distinct sensors, some redundant, lining the walls of each beaker. These measure: Temperature; pH (3); conductivity; oxidation-reduction potential; the anions chloride (2), bromide, and iodide; cations sodium, potassium, calcium, magnesium; and barium, used in a sulfate titration. Also included are electrodes for cyclic voltammetry, anodic stripping voltammetry, and chronopotentiometry (3). Lithium electrodes (2) are used as a reference relative to the known concentration of lithium salts in the solution. Sensors for nitrate, ammonium, dissolved oxygen and carbon dioxide, which for various reasons do not provide a quantitative measure of soil composition, are used only for context. A heater is imbedded in the base of the beaker to maintain water temperature during operation.

Each WCL actuator assembly (AA) includes a tank containing 26 ml of a calibration and leaching solution, a sample loading drawer with a capacity of ~1.0 cm^3, temperature and pressure sensors, heaters, a stirring mechanism, and a device to dispense up to five small crucibles into the solution. The AA is responsible for soil, water, and solid reagent addition as well as stirring and two-zone internal heating (tank and drawer). Telemetry returned by the AA includes internal cell pressure, water storage tank and sampling drawer temperatures, and certain limit switch positions.

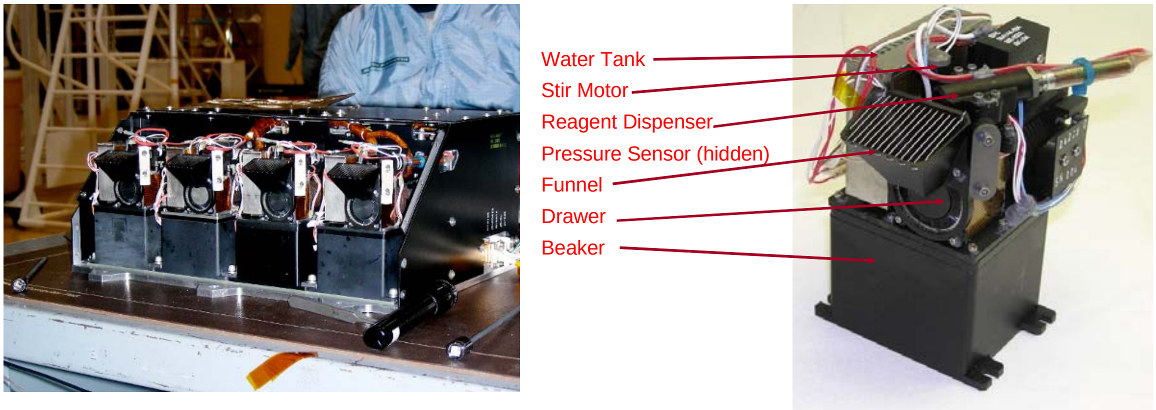


Figure 4-9: MECA Wet chemistry cells installed in flight enclosure (left) and detail (right)

Each WCL experiment lasts two days (Sol A and Sol B), not necessarily sequential. After an initial post-landing checkout, preparation for a chemical experiment starts with melting the frozen leaching/calibration solution in the storage tank and delivering it to the beaker by actuating a puncture mechanism. Sensors are calibrated in that solution, and then calibrated again after addition of a crucible containing small quantities of specific salts. The combined ion concentration from the initial solution and from the crucible, less than 10-4 molar for most ions, establishes the detection floor. The final step is to open the sampling drawer and receive a sample from the robotic arm. The total sample volume is estimated with an accuracy of 0.25 cc (maximum 1 cc) from images acquired by the robot arm camera. For the remainder of the day, the concentration of major anions and cations are monitored as well as key indicators such as pH, redox potential, conductivity, and cyclic voltammetry, stirring when appropriate and maintaining a constant temperature of 5C. At the end of the day the solution is allowed to freeze in the beaker.

A second day (Sol B) of measurement begins with thawing of the solution in the beaker, determining the sensor baseline, and adding an acid-containing crucible to lower the pH. Monitoring continues as on the first day. The final activity is the sequential addition of three crucibles of barium chloride. A sulfate titration is performed by monitoring the barium and chloride levels as the crucible contents slowly dissolve.

Most sensors will have three separate calibration steps prior to their use on Mars. Each individual electrochemical sensor was first calibrated prior to integration into the beaker by laboratory measurement in several standard solutions using commercial electronics. The second calibration was performed with the same solutions after beaker integration, using flight-like analog electronics and a laboratory digital controller. The exceptions were the bromide and iodide sensors, which could not be tested after integration without contaminating the chloride sensor. The final two-point calibration will occur on Mars. In general, the ion selective electrodes exhibit classic logarithmic Nernstian behavior over the specified measurement range. Error analysis indicated that the best results for calculating unknown sample concentrations are obtained by using the average slope obtained from all the preflight calibrations anchored at the TS21 point.

Pre-amplifier circuitry for the electrochemical sensors is embedded in the beaker walls. Analog to digital conversion (12-bit) is performed on a heavily-multiplexed "Analog

Board" which interfaces to an FPGA on the primary MECA control and measurement electronics (CME) board. The FPGA also generates waveforms for the voltammetric and potentiometric sensors, performs temperature control, and operates actuators. Also returned in telemetry is a reading from an external temperature sensor located on the base of the microscopy sample stage.

A complete description of the WCL portion of the MECA instrument can be found in Kounaves et al., 2008. To skip to the next WCL specific section of this document see paragraph 4.3.1.3.

4.1.4 Software and Electronics

MECA flight software (FSW) runs on the primary spacecraft computer and communicates to MECA hardware at 9600 baud via a serial Payload and Attitude Control Interface (PACI) interface. On the other side of that interface is an FPGA, located on the Command and Measurement Electronics (CME) board inside the MECA enclosure. The FPGA controls all hardware functions in the MECA suite with the exception of the Atomic Force Microscope (AFM), which has an embedded processor, and discreet switches, controlled directly by the spacecraft computer, for powering MECA and for switching between AFM processor and FPGA. Data return described here is generated by the FPGA.

The common MECA electronics return telemetry packets indicative of the overall instrument configuration, including parameter tables, the status of the command and measurement electronics, and the products of a low-level command parser that can be used to address any of the four instruments.

4.2 Data Product Overview

MECA non-imaging RDR data are broken into 12 different data types according to instrument sub-system.

The AFM sub-system has 3 ASCII data types associated with it, two data files and one text description file. The AFM Scan Data Records (SDR) are AFM scan data that has been converted from DN to physical units. AFM Scan derivative records (SDD) are line-by-line first order spatial derivatives of the SDRs, processed using the Savitzky-Golay filter method. AFM data are grouped by measurement day.

Table 4-1AFM RDR Data Types

AFM Data Types	Format	Description
SDR	TAB	Calibrated scan data with x-y scan ranges that has been assembled from the EDRs and converted from DN to engineering units (microns)
SDD	TAB	A line-by-line derivative of the calibrated scan data. The derivatives are a simple way to simulate what the eye would see if the topographs represented macroscopic surfaces illuminated from overhead
AFM REPORT	TXT	Text file that describes the measurement day's events.

The TECP sub-system yields four data types. The data are the electrical conductivity, relative humidity, relative permittivity, and the thermal conductivity measurements converted from DN to physical units. TECP data are in a time-series, with a single data file for each data type per observation, where an observation is a related set of measurements spanning no more than a day (sol). Date types and description are listed in Table 4-2 TECP Data Types.

Table 4-2 TECP Data Types

TECP Data Types	Format	Description
EC	TAB	Time-series electrical conductivity data.
HUM	TAB	Time-series relative humidity data.
PRM	TAB	Time-series relative permittivity (dielectric constant) data.
TC	TAB	Time_series temperature data from three needles, before, during, and after a heat pulse. These data can be processed to yield thermal conductivity and heat capacity or (if the instrument is above the surface) wind speed.

The WCL sub-system has five data types, one for each sensor type or measurement method. The data are generally EDR data that has been converted to physical units and grouped in a time-series corresponding to a single observation, which typically refers to a segment of a two-day chemistry experiment (during calibration, for example, or after acid addition). Data types and descriptions are listed in Table 4-3.

Table 4-3 WCL Data Types

WCL Data Types	Format	Description
ISEs	TAB	Time_series of individual sensor data including chloride, bromide, iodide, sodium, potassium, calcium, magnesium; barium, etc..
COND	TAB	Time-series of conductivity data
CV	TAB	Cyclic voltammetry data
CP	TAB	Chronopotentiometry data
PT	TAB	Time-series of pressure and temperature data

4.3 Data Processing Overview

Reduced Data Records (RDR), the Level 1 products, are generated from the MECA non-imaging EDR data, ancillary data gleaned from command logs and channelized telemetry, and calibration, characterization, and cataloguing (CCC) data generated by a variety of laboratory instruments. The intent of the RDR data product is to be an easily accessible, scientifically useful dataset that will facilitate interpretation of the MECA data. Each MECA non-imaging RDR consists of time-series data of a single type, grouped together by virtue of being acquired on the same sol with the same assigned token, which delineates a discrete observation. Tokens are embedded in the file labels and are assigned at the time of sequence generation specifically for the purpose of dividing data products into logical segments and helping to associate them with the original command sequence. The token can be used to cross-correlate data products that are related.

4.3.1 Data Processing Level

MECA non-imaging RDRs are equivalent to NASA Level 1A and 1B (CODMAC Level 3 and 4) data products as defined in Appendix-A. Higher level special products may be available at mission end for each of the MECA sub-systems.

4.1.2 Data Product Generation

The following sections describe how and by whom the MECA non-imaging RDRs are created.

4.3.1.1 AFM

AFM RDR data products will be generated by the MECA Science Team using software at the Science Operations Center (SOC), the Jet Propulsion Laboratory (JPL) or their home institutions. The RDRs produced will be “processed” data (NASA Level 1). The input will be one or more MECA non-imaging EDR or RDR data products and the output will be formatted according to this SIS and consists of a data file with a .TAB file extension, a PDS label file that has the same name as the data file with a .LBL file extension and a text (.TXT) file that contains information about how the data was collected. Additional meta-data may be added by the software to the PDS label or the data product header table.

The two scan data AFM RDR data products are formatted to have a detached ASCII PDS label (see http://pds.jpl.nasa.gov/documents/qs/labels.html for more information about PDS labels). The SDR and SDD data products consist of five attached data tables. The first table is the header table that describes the AFM scan parameters (Table 4-4) and other important information pertaining to that scan, followed by the calibrated scan data in four sequential ASCII TABLE objects. See paragraph 4.3.3, 4.3.4, 4.3.5, and 4.3.6 for conventions used in this data product.

Table 4-4 AFM Header Table Column Names and Descriptions.

Field name	Description	Eng Units
cmdTimewhole	Spacecraft command receipt time (whole seconds)	Secs
cmdTimeremainder	Spacecraft command receipt time (remainder)	Secs/ 2^{32}
readTimewhole	Time at which last scanline was received from the instrument (whole seconds)	Secs
readTimeremainder	Time at which last scanline was received from the instrument (remainder)	Secs/ 2^{32}
dataLength	Record length (minus headers)	Bytes
Cols	Image width	Points
Lines	Image height	Lines
Direction	Scan direction mask. 1 = forward, 2 = backward	N/A
	Channel represented. 1 = error, 2 = height.	N/A
channelGain	Determines the height scale (for height data) and the error scale (for error data). Ranges from 0 to 8, with 0=full range (13.8 microns (height) or 20V (error)), and reducing by factors of 2 each time. i.e. Gain of 2 = 3.45 microns or 5V.	N/A

Field name	Description	Eng Units
refOMimage	Filename of the relevant OM image taken at the AFM scan position prior to start of the scan. This provides the context for interpreting the AFM scan data.	N/A
refOMimage2	Filename of the relevant OM image taken at the AFM scan position after the scan. This provides the context for interpreting the AFM scan data.	N/A
opsToken	Ops token	N/A
SwtsTemperature	Temperature of the SWTS just prior to the scan	Kelvin
X-scanrange	Scan range in the x-direction of the AFM scan plane (fast axis)	Micrometers
Y-scanrange	Scan range in the y-direction of the AFM scan plane (slow axis)	Micrometers
Scaling_factor	The scaling factor that was used to calibrate the height data (i.e. converts DNs to micrometers) to produce this RDR (for SDR only)	N/A
Smoothing_factor	Number of points used in the Savitzky-Golay filter function. (for SDD only)	N/A
AFM_OM_ref_x	The approximate location of the center of the AFM scan field relative to the context OM image. X-coordinate in pixels.	Pixel
AFM_OM_ref_y	The approximate location of the center of the AFM scan field relative to the context OM image. Y-coordinate in pixels.	Pixel
X-slope	The x-slope of the substrate relative to the x-y scanner.	N/A
Y_slope	The y-slope of the substrate relative to the x-y scanner.	N/A
ScanSpeed	Scan speed of the AFM in micrometers/second	micrometers/second

The scan data follows the header as four sequential ASCII table objects, forward scan error, forward scan height data, backward scan error and backward scan height data. Within each table, three columns (X,Y,Z) are repeated 512 times to specify the X and Y position and the Z value (height in microns or error in volts) of each point in a 512 x 512 matrix. Typically, scans will be square with 256 x 256 rows and columns but can be as little as 8 x 8 or up to 512 x 512. The data will always be presented in the 512 x 512 configuration, padded out with zeros where necessary. All four sets of data, representing one AFM scan, and the header information will be stored in the same RDR file with a unique filename in the format described in 0. All scans run on the same day will be grouped together in folders labeled by sol number.

The AFM scan plane is a square that is rotated clockwise by 45 degrees and flipped vertically relative to an OM image (see **Error! Reference source not found.** The axis that defines a scan line (the one along which scan samples are taken) is called the *fast-axis* (i.e. it increments/decrements more rapidly). The other axis determines scan line rows and is only incremented/decremented at the end of each scan line. Thus it is referred to as the *slow-axis*. The default fast-axis for the AFM is the x-axis, the default slow axis is the y-axis. Note that the scan point (0,0) is in the middle of the scan plane, i.e. for a 256 x 256 scan, the scan field goes from -128 to +127 in x and -128 and +127 in y. The starting point of a scan is not the origin of the scan field however, but the most negative x and y positions, i.e for a 256 x 256 scan, the scan starts at the point (x=-128,y=-128) and proceeds to more positive values in both directions.

The scan data is ordered such that the first line of data in the file represents the first line of data acquired by the AFM. The AFM acquires the scan data in an 'upward' (or positive 'y') direction in the AFM scan coordinate system (Figure 4-10). Thus, to plot the AFM scan the right way up in the OM frame of reference, the origin (0,0) for the x and y coordinates in the AFM RDR data should be in the top left corner, with positive 'y' downwards and positive 'x' to the right. An additional 45 degree clockwise rotation is also required to allow the AFM image to be overlaid on an OM image.

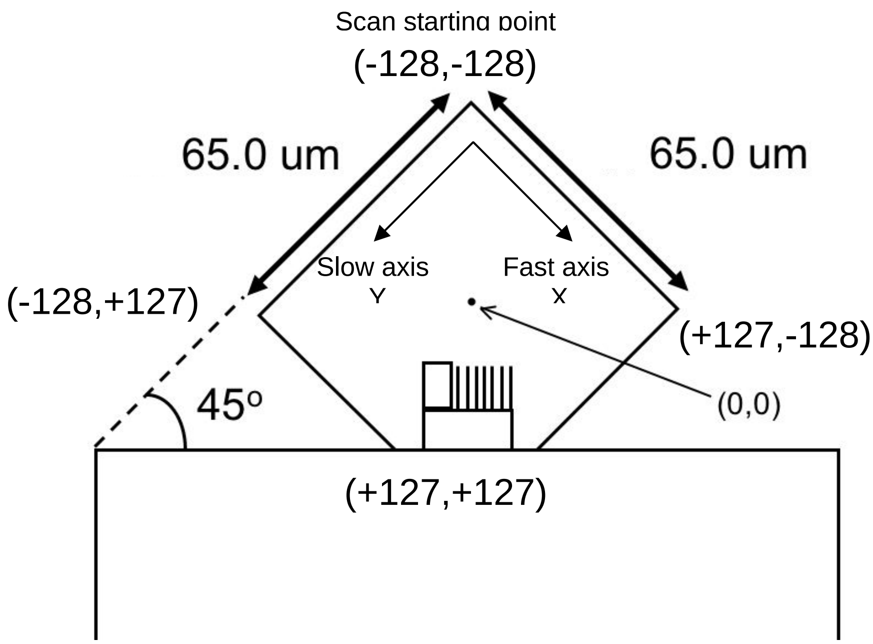


Figure 4-10 **Schematic of AFM scan plane looking towards the substrate from the OM. The starting point of a scan is at the topmost corner with the x-axis positive towards the southeast and the y-axis positive towards the southwest. In this example, a 256 x 256 pixel scan is acquired.**

The AFM_SDR data type is calibrated scan data with x-y scan ranges. Due to distortians in the scan plane, the header includes separate values for the X and Y scan ranges. As such, the images may not be square. The height and scan range data will be calibrated based on data from calibration scans of the AFM pincushion substrate that will be performed just prior to the AFM scans on Mars. It should be noted that the calibrated scans start at 0,0 in contrast to the un-calibrated scans that start in the center of the image. The scaling factor used for the conversion from DNs to micrometers (height) is included in the header of the RDR. Data are presented in units of micrometers and represented by real numbers to three decimal places. The error channel data in this data type are given in units of Volts with no in-situ calibration applied and represented by real numbers to six decimal places.

The AFM_SDD data type is a line by line derivative of the calibrated scan data. By converting slope (Z) to grayscale, derivatives are a simple way to simulate what the eye would see if the topographs represented macroscopic surfaces illuminated from overhead. In MECA team renderings, 0-slope corresponds to the middle of the grayscale, thus simulating diffuse side lighting. The derivative will be performed using the Savitsky-Golav[1] method, following the raster-scanning direction because the discontinuities that

[1] A. Savitzky and Marcel J.E. Golay (1964). *Smoothing and Differentiation of Data by Simplified Least Squares Procedures*. Analytical Chemistry, 36: 1627-1639. doi :10.1021/ac60214a047. Note that the original publication contained several errors that were later corrected by Jean Steinier, Yves Termonia, Jules Deltour (1972). *Smoothing and differentiation of data by simplified least square procedure*. Analytical Chemistry, 44(11): 1906-1909. doi :10.1021/ac60319a045

are often present between lines would produce unacceptable noise in a true 2-dimensional derivative.

Savitzky-Golay is a simple running filter that smoothes data while optionally performing various orders of derivatives, depending on the selection of filter parameters. It is a numerical algorithm for performing a local polynomial regression of degree k on at least k+1 equally-spaced points. For the AFM derivatives, selection of the number of points will be done manually depending on the noisiness of the data. The number of points used is recorded in the derivative header table in the smoothing_factor field. The derivative values are unitless.

The final AFM data type is the AFM Report file. This is an ASCII text file with an attached PDS label that contains a narrative of events during an operational day. There will be one file per sol that is manually generated by an AFM team member. This file may contain items such as rationale for picking a particular target, difficulties in making a particular measurement, or other general information that is not easily captured elsewhere.

The header includes values representing the X and Y coordinates of the estimated center position of the AFM scan location in the context OM image. For the cases where context images were taken before and after the scan, the scan location coordinates are only given for the 'before' image. The origin of the coordinate system in the OM frame of reference is taken to be the top left of the OM image as shown in FigX.

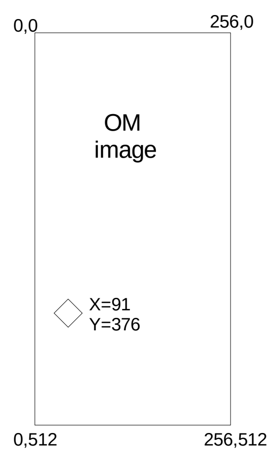


Figure 4- Schematic of the OM reference frame showing the coordinate system used to define the pixel location of the AFM scan region (shown as a diamond).

4.3.1.2 TECP

TECP RDR data products will be generated by the MECA Science Team using software at the SOC, JPL or their home institutions. The RDRs produced will be "processed" data (NASA Level 1). The input will be one or more MECA non-imaging EDR or RDR data products and the output will be formatted according to this SIS. Additional meta-data may be added by the software to the PDS label or the data product header table.

There are four types of TECP data, electrical conductivity (designated EC), humidity (designated HUM), relative permittivity or dielectric constant (designated PRM) and temperature (TC). The EC data is formatted as six ASCII tables, a general comments table, an EC comments table, a conversions table, two tables with conversion constants, and a data table that contains a time-series of measurements. The HUM, PRM and TC data are all formatted as a general comments table, a data type specific comments table, a conversions table and a data table that contains a time-series of measurements. The conversions table contains the DN to physical unit equations for the particular data type. Table 4-5 lists all the DN to physical unit conversions used to convert TECP EDR data into TECP RDR data. In some equations the abbreviation ADC is used for Analog to Digital Converter and is equivalent to DN.

Table 4-5 TECP DN to Physical Unit Conversions

Parameter Name	Conversion Equation
TEMP_BOARD	TEMP_BOARD (K) = 0.0831*ADC - 4.76, where ADC =DN
TEMP_NEEDLE_n (TC)	Seebeck (mV/K) =1e-3*(1.05e-6*TEMP_BOARD^3 - 1.04e-3*TEMP_BOARD^2 +4.32e-1*TEMP_BOARD - 1.62)
	deltaV_TC (mV) = (2500/1956.9) * (ADC/2048) , for ADC < 2048
	deltaV_TC (mV) = (2500/1956.9) * [(ADC-2048)/2048 - 1] , for ADC >= 2048
	deltaT_TC = deltaV_TC / Seebeck
	TEMP_NEEDLE_n (K) = TEMP_BOARD (K) + deltaT_TC
	do while temp_change > 0.001
	Seebeck = Seebeck(TEMP_NEEDLE_n) , recalculate Seebeck using needle temperature
	deltaT_TC = deltaV_TC / Seebeck
	temp_change = abs(TEMP_NEEDLE_n - (TEMP_BOARD + deltaT_TC))
	TEMP_NEEDLE_n = TEMP_BOARD + deltaT_TC
	enddo
NEEDLE_HEATED	ops_tok_bit_N = bit #N of "OPS TOKEN"
	if ops_tok_bit_15 = 1 then NEEDLE_HEATED = 1
	elseif ops_tok_bit_14 = 1 then NEEDLE_HEATED = 2
	elseif ops_tok_bit_11 = 1 then NEEDLE_HEATED = 4
	else NEEDLE_HEATED = 9 (indicates none are heated)
RELATIVE PERMITTIVITY (PRM)	1.172e-9*ADC^3 - 8.528e-6*ADC^2 +2.289e-2*ADC - 10.58 (Jan. 2007 cal)
RELATIVE HUMIDITY (HUM)	TbC = TEMP_BOARD - 273.15
	qa = -59.9217
	qb = 673.6071 + 8.843*TbC
	qc = (2820.1706 - ADC) - 1.251*TbC - 0.017443*TbC^2
	RELATVE_HUMIDITY = (-qb + sqrt(qb^2 - 4*qa*qc)) / (2*qa)

VAPOR_PRESSURE	VAPOR_PRESSURE = RELATIVE_HUMIDITY * 10^(-2663.5/TEMP_BOARD + 12.537) , [Marti and Mauersberger 1993]
HEATER_CURRENT	HEATER_CURRENT (mA) = 0.61 * ADC
ELECTRICAL CONDUCTIVITY (EC)	ELECTRICAL_CONDUCTIVITY = 10^6 / (Rm * pc)
	pc (cm) = apc * [ln(Rm)]^2 + bpc * ln(Rm) + cpc, where

	apc	bpc	cpc
high gain	-1.97E-02	5.40E-01	6.01E-02
med. gain	-3.99E-03	8.90E-03	3.39
low gain	0	0	3.79

Rm (ohms) = exp[a*ADC_EC^4 + b*ADC_EC^3 + c*ADC_EC^2 + d*ADC_EC + e]
To calculate Rm for a given needle temperature, calculate Rm for the temperatures above and below, then linearly interpolate the values.

	Valid DN range*
high gain	DN < 3421
med. gain	229 < DN < 3636
low gain	211 < DN

High Gain Coefficients, DN<3421

Temp (K)	a	b	c	d	e
160	-8.341E-14	8.237E-10	-2.751E-06	4.743E-03	3.136E+00
200	-7.892E-14	7.927E-10	-2.691E-06	4.718E-03	3.128E+00
240	-7.809E-14	7.858E-10	-2.673E-06	4.699E-03	3.136E+00
280	-7.742E-14	7.807E-10	-2.661E-06	4.690E-03	3.139E+00
323	-7.769E-14	7.820E-10	-2.662E-06	4.689E-03	3.141E+00

Medium Gain Coefficients, 229<DN<3636

Temp (K)	a	b	c	d	e
160	-3.248E-14	4.654E-10	-1.922E-06	4.037E-03	7.918E+00
200	-3.171E-14	4.536E-10	-1.885E-06	4.004E-03	7.910E+00
240	-3.263E-14	4.605E-10	-1.903E-06	4.019E-03	7.905E+00
280	-3.128E-14	4.498E-10	-1.877E-06	4.000E-03	7.901E+00
323	-3.100E-14	4.478E-10	-1.873E-06	3.998E-03	7.901E+00

Low Gain Coefficients, 211<DN<2751

Temp (K)	a	b	c	d	e
160	3.433E-13	-1.813E-09	2.535E-06	9.912E-04	1.185E+01
200	3.451E-13	-1.826E-09	2.565E-06	9.698E-04	1.185E+01
240	2.342E-13	-1.116E-09	1.133E-06	1.971E-03	1.166E+01
280	1.111E-13	-1.938E-10	-9.454E-07	3.561E-03	1.135E+01
323	2.909E-13	-1.240E-09	9.917E-07	2.302E-03	1.157E+01

Low Gain Coefficients, 2750<DN<3401

Temp (K)	a	b	c	d	e
200	0	1.3236E-08	-1.1648E-04	3.4362E-01	-3.2341E+02
240	0	1.2165E-08	-1.0593E-04	3.0932E-01	-2.8657E+02
280	0	1.9291E-08	-1.7078E-04	5.0553E-01	-4.8393E+02

*EC is not defined for DNs outside these ranges in the specified gain.

TECP orientation information is given in all four TECP data types. The orientation information is obtained from the Robotic Arm (RA) and was acquired at the time of the most recent RA move. The orientation information is given in both the payload frame and in the local level frame for ease of use. The definitions of the PHOENIX coordinate systems are documented in Table 4-6

Table 4-6 Phoenix Coordinate Systems

Coordinate System	*Origin*	*Orientation*	
Local Level	Same as payload frame, and it moves with the Lander	+X +Z +Y	North down along gravity vector East
Payload Frame	At the shoulder of the Robotic Arm. Attached and moves with the Lander	+X +Z +Y	along Lander –X (point out into the work space) down along Lander (vertical axis) along Lander -Y
Site Frame	Same as payload frame when first defined and never moves relative to Mars. Possible to define multiple site frames in case the Lander moves/slips.	Same as local level	

4.3.1.3 WCL

WCL RDR data products will be generated by the MECA Science Team using software at the SOC, JPL or their home institutions. The RDRs produced will be "processed" data (NASA Level 1). The input will be one or more MECA non-imaging EDR or RDR data products and the output will be formatted according to this SIS. Additional meta-data may be added by the software to the PDS label or the data product header table.

4.3.1.3.1 ISE

The MECA WCL Ion-Selective Electrode (ISE) RDR is formatted as a header table followed by an events table followed by the ISE data header table and finally the ISE data table. The header table contains information about the instrument and how the data was collected. A complete list of fields contained in the header table can be found in Table 4-7 ISE Header Fields. The events table gives the time at which important events in the experiment were carried out. The ISE data table contains a time-series of mV data for fifteen of the ion-selective electrodes mounted in the WCL beaker walls. These sensors include 9 ISEs for directly measuring inorganic ionic species (Na^+, K^+, Ca^{2+}, Mg^{2+}, NO_3^-, NH_4^+, Br^-, I^-, Cl^-), a single Ba^{2+} ISE for the indirect measurement of sulfate, 2 polymer pH sensors, one iridium oxide pH sensor, and two Li^+ sensors to serve as reference electrodes. See Table 4-8 ISE Data Table Fields for a list of the data fields and their converted physical unit.

The header table is used to record information that is useful for tracking the origin of the ISE data as well as providing ancillary data useful for data interpretation. It is especially important to note the WCL_CELL_NUMBER as each of the four cells may have slightly different measurement characteristics. Also of note is the PARENT_EDR_N field(s). This field(s) contains the names of the EDR data products that were used in the generation of the RDR. Lastly, the CALIBRATION_EQUATION field contains the equation (see eq. 4-1) used to convert the EDR DN value to mV recorded in the RDR. It is possible that this equation could change over the course of the mission.

Table 4-7 ISE Header Fields

Field	Description
PRODUCT_ID	Represents a permanent, unique identifier assigned to a data product by its producer.
PRODUCT_TYPE	MECA_WCL_ISES
PARENT_EDR_N (N number of fields)	The EDR filename(s) from which the RDR was generated.
PLANET_DAY_NUMBER	Mission Sol number on which the data was acquired
WCL_CELL_NUMBER	The number of the WCL (0-3)
RECORD_TYPE	Indicates the record format of a file - “FIXED LENGTH” for all WCL ISE RDRs.
RECORD_BYTES	Indicates the number of bytes in a physical file record, including record terminators and separators.
DATA_RECORDS	Number of data points for each sensor (1 record should correspond to 1 reading of all the ISEs)
SCLK_START_COUNT	Spacecraft clock count of the first record in the data set
SCLK_STOP_COUNT	Spacecraft clock count of the last record in the data set
LTST_START_TIME	Local true solar time of the first record in the data set
LTST_STOP_TIME	Local true solar time of the last record in the data set
CALIBRATION_EQUATION	DN to Physical unit conversion equation

The events table, a three-column table with events, time and notes fields, keeps track of the significant events during the course of an experiment. For the ISE experiment the critical events are solution dispense, drawer open, drawer_close, and reagent release. The critical events are described in the following paragraphs.

Solution Dispense: The melted solution in the WCL tank is transferred from the water tank to the WCL beaker via an actuator that punctures the bottom the water tank. Nominally there is no entry in the notes field for the solution dispense event.

Drawer Open and Drawer Close: The WCL sample drawer is commanded to open and then commanded to close in three cases - for a “burp”, sample delivery, or sample verification, as specified in the notes field:

> ***“Burp”***: The WCL sample drawer is “burped” (opened and closed) to equilibrate the pressure inside the beaker.
>
> ***Sample Delivery***: The WCL sample drawer is opened while the Robotic Arm delivers a sample to the open drawer and documents the delivery with the Robotic Arm Camera (RAC). The drawer is then closed, and the sample falls into the beaker solution.
>
> ***Sample Verification:*** After sample delivery, the WCL sample drawer is open a second time for the RAC to document whether the sample was delivered successfully.

Reagent Release: One of the five WCL crucibles (calibrant, acid, 3 x $BaCl_2$) is commanded to be released into the beaker solution. Prior to the release of each crucible the drawer is "burped" at least once. The type of crucible released is specified in the notes field:

> ***Calibrant Crucible***: The calibrant crucible contains a pre-determined amount of specific salts that serve as a calibration reagent for the ISE sensors.
>
> ***Acid Crucible***: The acid crucible nominally contains 0.004g of 2-Nitrobenzoic Acid.
>
> ***$BaCl_2$ Crucible***: The $BaCl_2$ crucible contains 0.11g-0.12g. of barium chloride.

Note that the CMD_TIME of the reagent release events indicates the time at which the command to begin heating the actuator that delivers the crucible was issued to MECA. The time at which the crucible actually drops into the solution is a function of the thermal conditions and the voltage applied to the actuator, and it can be best estimated by referring to the studies documented in the MECA Wet Chemistry Laboratory Calibration Report (located in the archive calibrations folder). Overall, the time at which the crucible physically drops is expected to be no more than 5 minutes after the actuator begins heating.

The ISE data header table contains one row of information. The information is the label of each of the columns in the ISE data table. This table will be useful to those reading the RDR data product in either a text editor or spreadsheet program.

The ISE data header table contains one row of information. The information is the label of each of the columns in the ISE data table. This table will be useful to those reading the RDR data product in either a text editor or spreadsheet program.

The ISE data table, the fields of which are described in Table 4-8 ISE Data Table Fields, contains the mV value for each ISE sensor reading in the RDR. The readings are a result of a potential across the sensor's membrane/solution interface, the value of which is dependent on the activity of the selected ionic species in the beaker solution. Note that oxidation-reduction potential (ORP) is not specifically listed as a sensor because it serves as the ground for all other sensors, and $V_{ORP} = -V_{Li}$. This grounding scheme also has an implication in determining the absolute potential of the ISEs. In order to determine the absolute potential of the ISEs, the potential of one of the lithium reference electrodes must be subtracted from the potential values of the rest of the ISEs.

Table 4-8 ISE Data Table Fields

Field	Description	Units
Time	series of SCLK read times	s
Li_a	series of lithium electrode (2 of 2) potentials	mV
Li_b	series of lithium electrode (1 of 2) potentials	mV
pH_a	series of polymer pH electrode (2 of 2) potentials	mV
pH_b	series of polymer pH electrode (1 of 2) potentials	mV
pH_irid	series of iridium pH electrode potentials	mV
Na	series of sodium electrode potentials	mV
K	series of potassium electrode potentials	mV

NH4	series of ammonium electrode potentials	mV
Ca	series of calcium electrode potentials	mV
Ba	series of barium electrode potentials	mV
Mg	series of magnesium electrode potentials	mV
Cl	series of chloride electrode potentials	mV
ClO4	series of perchlorate electrode potentials	mV
Br	series of bromine electrode potentials	mV
I	series of iodide electrode potentials	mV

Note: ORP will not be a separate sensor on this list since it is the negative of the Li ISEs.
CO2, Cl_ref, DO_ref, and V_mon have been omitted from the RDRs

The conversion from data numbers (DN) in the corresponding ISE EDR to mV in the ISE RDR comes from the characteristics of the analog-to-digital converter circuit common to most the ISEs. Nominal values for the half-cell are:

$$V(mV) = -0.80579 \cdot DN + 2057.8 \qquad \text{(eq. 4-1)}$$

The equation given above is explained fully in the Calibration Report, which is the definitive reference for calibration equations.

The conversion from raw mV to molar concentration of ions in the beaker solution is a detailed process that begins with determining referenced ISE potentials by subtracting the potential measured on either of the lithium reference sensors from the raw ISE potentials. Following the subtraction, the conversion to ionic concentrations requires beaker-specific calibration constants, conductivity data, and experimentally-determined selectivity data. The conversion to concentrations will be documented in the MECA WCL special data products that will be generated by the Phoenix science team during surface operations.

4.3.1.3.2 Conductivity

The MECA WCL electrical conductivity RDR omits the conversion from conductance to conductivity via the cell constant. Appropriate cell constant values can be determined from the Calibration Report.

The conductivity RDR is formatted as a header table followed by an events table followed by the conductivity data header table and finally the conductivity data table. The header table contains information about the instrument and how the data was collected. A complete list of fields contained in the header table can be found in **Error! Not a valid bookmark self-reference.**. The events table gives the time at which important events in the experiment were carried out. The conductivity data header table gives the column names for the conductivity data table and the conductivity data table contains a time-series of two ranges of electrical conductivity microsiemen (μS) data.

The header table (**Error! Not a valid bookmark self-reference.**) is used to record information that is useful for tracking the origin of the conductivity data as well as providing ancillary data useful for data interpretation. Mission and instrument parameters are recorded. It is especially important to note the WCL_CELL_NUMBER as each of the four cells may have slightly different measurement characteristics. Also of note is the PARENT_EDR_N field(s). This field(s) contains the names of the EDR data products that were used in the generation of the RDR. For the electrical conductivity data, five fields have been added to the header table. These fields contain the information necessary to use the DN to physical units equations presented below. Please note that the values for the equation constants given in the RDR data records are the definitive source for the values. It is possible that these values could change over the course of the mission.

Table 4-9 Conductivity Header Fields

Field	Description
PRODUCT_ID	Represents a permanent, unique identifier assigned to a data product by its producer.
PRODUCT_TYPE	MECA_WCL_CND
PARENT_EDR_N (N number of fields)	The EDR filename(s) from which the RDR was generated
PLANET_DAY_NUMBER	Mission Sol number on which the data was acquired
WCL_CELL_NUMBER	The number of the WCL (0-3)
RECORD_TYPE	Indicates the record format of a file - "FIXED LENGTH" for all WCL COND RDRs.
RECORD_BYTES	Indicates the number of bytes in a physical file record, including record terminators and separators.
DATA_RECORDS	Number of conductance data points in the time series
SCLK_START_COUNT	Spacecraft clock count of the first record in the data set
SCLK_STOP_COUNT	Spacecraft clock count of the last record in the data set.
LTST_START_TIME	Local true solar time of the first record in the data set
LTST_STOP_TIME	Local true solar time of the last record in the data set
COND_RECORDS	Number of conductivity data points in time-series
COND_LOW_CALIBRATION_EQ	DN to conductance (μS) low equation
COND_HIGH_CALIBRATION_EQ	DN to conductance (μS) high equation

The events table, a three-column table with events, time and notes fields, keeps track of the significant events during the course of an experiment. The critical events are the same as those for the ISE data.

The data header table contains one row of data, the column labels for the conductivity data table. This table will be useful to those reading the RDR data product in either a text editor or spreadsheet program.

The MECA electrical conductance data table holds the conductance measurements in a time-series of two ranges of microsiemen (μS). The conductance of a solution is a measure of its ability to carry a current and is thus directly proportional to the total concentration of dissolved ionic species in the water. In raw EDR form, MECA WCL conductivity data consists of a time-series of data numbers (DN) that specify the current in each of two ranges and a voltage which is read twice (once for each range). Conversion to physical units begins with conversion of data numbers (DN) to resistance, with the nominal gain given by.

$$R_{low}(\Omega) = 5715.3 \cdot (V/I_{low}) \quad \text{(eq. 4-2)}$$

$$R_{high}(\Omega) = 5810.4 \cdot (V/I_{high}) \quad \text{(eq. 4-3)}$$

where $V = 2517.95\text{-}DN$ and $I = 2570\text{-}DN$.

Conductance is the reciprocal of the resistance. Conductance is converted to conductivity by multiplying by the cell constant, which varies from beaker to beaker. Cell constants are 1.45 +0.15 or – 0.05 (depending on the conductance value) and are fully described in the WCL Calibration Report. The cell constant will be updated after *in situ* calibration and will be reported in this document, in the header table and in the WCL Calibration Report. Conductance is calculated as:

$$COND_{low} = 1000000\cdot(2570-I_{DN\_LOW})/[5715.3\cdot(2517-V_{DN\_LOW})] \qquad \text{(eq. 4-4)}$$

$$COND_{high} = 1000000\cdot(2570-I_{DN\_HIGH})/[5810.4\cdot(2517-V_{DN\_HIGH})] \qquad \text{(eq. 4-5)}$$

Where I_{DN_LOW}, V_{DN_LOW}, I_{DN_HIGH}, and V_{DN_HIGH} are the DN fields from the corresponding EDR, and K is the cell conductivity constant.

The electrical conductivity (EC) of a solution is a measure of its ability to carry a current and is thus directly proportional to the total concentration of dissolved ionic species (e.g., Na^+, K^+, Ca^{2+}, Cl^-, $SO_4^{=}$) in the water. The unit for EC is the siemen (S) and is measured in microsiemens per centimeter (µS/cm). Electrical conductivity is mainly affected by temperature and the nature of the ionic species. The conductance measurements reported in the RDRs will not be adjusted for temperature, but as a general rule for the salts most likely to be found on Mars, the temperature is expected to produce a 2% increase per 1°C.

4.3.1.3.3 CV

The MECA WCL Cyclic Voltammetry (CV) RDR type encompasses three types of measurements: Conventional cyclic voltammetry using either a macro-electrode or an array of micro-electrodes; Anodic Stripping Voltammetry using the micro-electrode; and a Dissolved Oxygen measurement acquired with an ion selective electrode with CV-style detection. Each CV RDR contains the scan results from only one of the three electrodes. The RDR is formatted as a header table, a conversions table, an events table, a scan header table and the CV data table. The header table (**Error! Not a valid bookmark self-reference.**) contains information about the collection parameters. The conversions table (The CV conversions table (**Error! Not a valid bookmark self-reference.**) lists the nominal parameters used to convert EDR DN values to the RDR physical unit values. The definitive reference for this conversion will be the WCL calibration report, available elsewhere in this archive. Conversions are given for the specified electrode at all gain settings. The physical units are either mV or nA.

Table 4-11) contains the necessary information to convert DNs to physical units, i.e. mV and nA. The events table gives the time at which important events in the experiment were carried out. The scan header table contains information about how the scan data was collected. A complete list of fields contained in the scan header table can be found in Table 4-12. The CV scan table contains a time series of electrode potential (mV) and current (nA) data for measurements made with one of the three CV electrodes. The following paragraphs describe the tables in more detail.

The CV header table is used to record information that is useful for tracking the origin of the CV data as well as providing ancillary data useful for data interpretation. Mission and instrument parameters are recorded. It is especially important to note the WCL_CELL_NUMBER as each of the four cells may have slightly different measurement characteristics. Also of note is the PARENT_EDR_N field(s). This field(s) contains the names of the EDR data products that were used in the generation of the RDR.

Table 4-10. CV Header Table Fields

Field	Description
PRODUCT_ID	Represents a permanent, unique identifier assigned to a data product by its producer.
PRODUCT_TYPE	MECA_WCL_CV
PARENT_EDR_N (N number of fields)	The EDR filename(s) from which the RDR was generated
PLANET_DAY_NUMBER	Mission Sol number on which the data was acquired
WCL_CELL_NUMBER	The number of the WCL (0-3)
RECORD_TYPE	Indicates the record format of a file - “STREAM” for all WCL CV RDRs.
NUMBER_OF_SCANS	Number of CV scans in the RDR
DATA_RECORDS	Number of data records in the RDR
SCLK_START_COUNT	Spacecraft clock count of the first scan in the data set
SCLK_STOP_COUNT	Spacecraft clock count of the last scan in the data set
LTST_START_TIME	Local true solar time of the first scan in the data set
LTST_STOP_TIME	Local true solar time of the last scan in the data set
CALIBRATION_EQUATION	Slope*DN+Intercept

The CV conversions table (**Error! Not a valid bookmark self-reference.**) lists the nominal parameters used to convert EDR DN values to the RDR physical unit values. The definitive reference for this conversion will be the WCL calibration report, available elsewhere in this archive. Conversions are given for the specified electrode at all gain settings. The physical units are either mV or nA.

Table 4-11 CV Conversion from DN to physical units*

Electrode	Gain	Slope	Intercept	Units
AS	All	1.61502704	-3310.806949	mV
AS	0	0	0	nA
AS	1	-0.743298058	1891.516463	nA
AS	2	-0.073396702	186.5834669	nA
AS	3	-8.547046907	21756.68294	nA
AS	4	0	0	nA
AS	5	-2.569185621	6541.043701	nA
AS	6	-0.245511254	624.6780403	nA
AS	7	-46.10616184	117372.5422	nA
Electrode	Gain	Slope	Intercept	Units
CV	All	1.615045803	-3310.785824	mV
CV	0	0	0	nA
CV	1	-0.734344416	1870.508949	nA

CV	2	-0.072530343	184.8247537	nA
CV	3	-8.431700883	21465.75175	nA
CV	4	0	0	nA
CV	5	-2.538570781	6466.249181	nA
CV	6	-0.242707023	618.3029691	nA
CV	7	-45.57029194	115993.7519	nA
Electrode	Gain	Slope	Intercept	Units
DO	All	-1.617035954	3306.909638	mV
DO	0	0	0	nA
DO	1	-0.743204615	1892.7551	nA
DO	2	-0.073381274	187.2334646	nA
DO	3	-8.537496781	21724.46212	nA
DO	4	0	0	nA
DO	5	-2.568176462	6539.055079	nA
DO	6	-0.245551114	625.8110921	nA
DO	7	1	0	nA

* Calibration values for review purposes only.
These are not the flight electronics calibration constants. For flight electronics values refer to the WCL Calibration Report.

The events table, a three-column table with events, time and notes fields, keeps track of the significant events during the course of an experiment. See the ISE events table section for a full description of possible events.

The CV scan header table records (Table 4-12) important instrument parameter information for each of the measurement sets. Note that the mVmin, mVmax and the CV_scan_rate fields can be used to generate the CV waveform.

Table 4-12 CV Scan Header Fields

Header Field Name	Description
Electrode	CV, ASV, DO
Gain	The instrument gain setting which can equal 1,2,3,4,5,6,or 7.
mVMin	The minimum scan value
mVMax	The maximum scan value
CV_Scan_Rate	The scan rate in mV/sec
Read_time	This is the time that the data was returned to the spacecraft computer across the serial interface from the MECA subsystem. Units are seconds of Spacecraft Clock (SCLK)
Number_of_Samples	Number of samples in the scan, maximum value is 2015.

The CV data table contains a time-series of electrode potential (mV) and current (nA) data for measurements made with one of the three electrodes described above. The macro-electrode (CV) is a 250 μm diameter gold disk electrode, the dissolved oxygen electrode (DO) is covered with a oxygen permeable polymer membrane, and the micro-electrode array (AS) is a 3.1mm x 3.4 mm array of 564 interconnected 12 μm gold disk microelectrodes with 66μm center-to-center spacing.

In a WCL CV experiment, a three-electrode configuration is employed, with one of the three CV electrodes as the working electrode, the WCL platinum ORP electrode as the counter electrode, and one of the chloride ISEs as the reference electrode. Current flow is measured as the potential of the working and reference electrodes is swept between two preset voltages, with a reversal in scan direction occurring at a preset switching potential. This triangular waveform is used with a constant forward and reverse scan rate.

A detailed review of the cyclic voltammetry is beyond the scope of this document and the reader is referred to the many texts that describe the theory and experimental practice of CV [e.g. Bard and Faulkner, 2000].

In a CV measurement, the level of current that flows between the working and counter electrodes depends on a number of factors including the concentrations of soluble redox active species. The WCL voltammetry circuit has six different gain settings to allow measurement over a broad range of current levels. Since the measurement circuit does not have autoscaling capability, each CV scan will be repeated at up to 6 gain settings. The calibration constants for conversion from data numbers (DN) in the corresponding CV EDR to physical units (mV and nA) in the CV RDR are included in the Calibration Report.

The use of a WCL chloride ISE as the reference represents deviation from standard laboratory practice where a reference electrode with a constant and known potential is used. In the WCL, the potential of the reference electrode in each of four WCL cells will be a function of both electrode performance characteristics and the quantity of soluble chloride in the soil samples. Calculation of the electrode potential for each of the chloride reference ISEs will depend on their pre-flight ISE calibrations and results of the ISE measurements made on Mars. Since the chloride concentration of the Mars soil samples is unknown, the potential window over which the CV electrode is scanned relative to a standard reference will not be known until after data from the WCL Sol A operations are returned to Earth. The conversion WCL CV electrode potentials to standard reference electrode potentials will be documented in the MECA WCL special data products that will be generated by the Phoenix science team during surface operations.

4.3.1.3.4 CP

The MECA WCL Chronopotentiometry (CP) RDR is formatted as a header table, a conversions table, an events table and a scan header table followed by the CP data table. The header table (**Error! Not a valid bookmark self-reference.**) contains information about the collection parameters. The conversions table (Table 4-14) contains the necessary information to convert DNs to physical units, i.e. mV and nA. The events table contains information about experiment. The scan header table contains information about how the scan data was collected. A complete list of fields contained in the scan header table can be found in Table 4-15. The CP RDR data table contains a time series of electrode potential (mV) and current (nA) data for measurements made with one of the three CP electrodes mounted in the WCL beaker walls. The following paragraphs describe the tables in more detail.

The CP header table (**Error! Not a valid bookmark self-reference.**) is used to record information that is useful for tracking the origin of the CP data as well as providing ancillary data useful for data interpretation. Mission and instrument parameters are recorded. It is especially important to note the WCL_CELL_NUMBER as each of the four cells may have slightly different measurement characteristics. Also of note is the PARENT_EDR_N field(s). This field(s) contains the names of the EDR data products that were used in the generation of the RDR. For the CP data, two fields have been added to the header table. These fields contain the number of scans in the RDR and the DN to physical units conversion equation.

Table 4-13 CP Header Table Fields

Field	Description
PRODUCT_ID	Represents a permanent, unique identifier assigned to a data product by its producer.
PRODUCT_TYPE	MECA_WCL_CP
PARENT_EDR_N (N_number if fields)	The EDR filename(s) from which the RDR was generated
PLANET_DAY_NUMBER	Mission Sol number on which the data was acquired
WCL_CELL_NUMBER	The number of the WCL (0-3)
RECORD_TYPE	Indicates the record format of a file - "STREAM" for all WCL CP RDRs.
NUMBER_OF_SCANS	Number of CP scans in the RDR
DATA_RECORDS	Number of data records in the RDR
SCLK_START_COUNT	Spacecraft clock count of the first scan in the data set
SCLK_STOP_COUNT	Spacecraft clock count of the last scan in the data set
LTST_START_TIME	Local true solar time of the first scan in the data set
LTST_STOP_TIME	Local true solar time of the last scan in the data set
CALIBRATION_EQUATION	Slope*DN+Intercept

The CP conversions table (Table 4-14) lists the conversions from EDR DN values to the RDR physical unit values. The spacecraft command interface limits the maximum duration of a CP scan to ~11 seconds (Kounaves et al in press). Due to this limitation, multiple CP scans at different current levels (gain settings) will be needed to measure concentration ranges of ~1.5×10^{-4} to ~1.0×10^{-1}M. The definitive reference for this conversion will be the WCL calibration report, available elsewhere in this archive. The calibration constants for conversion from DN in the corresponding CP EDR to physical units (mV and nA) in the CP RDR are given in Table 4-14.

Table 4-14 CP Conversions from DN to Physical Units

Electrode	Gain	Slope	Intercept	Units
CPS1	All	-0.698679581	1776.839338	mV
CPS1	0	0	0	nA
CPS1	1	-6.464510364	13248.68019	nA
CPS1	2	-62.83727615	128788.9638	nA
CPS1	3	-0.648630271	1327.474623	nA
CPS1	4	-122.2181456	250461.9047	nA
CPS1	5	-3.230626295	6621.080738	nA
CPS1	6	-31.84885661	65279.67294	nA
CPS1	7	-0.323704123	661.8029613	nA
Electrode	Gain	Slope	Intercept	Units
CPS2	All	-0.69952097	1780.321361	mV

CPS2	0	0	0	nA
CPS2	1	-6.43201714	13181.25264	nA
CPS2	2	-62.52739464	128148.3205	nA
CPS2	3	-0.645213119	1319.609226	nA
CPS2	4	-121.6137426	249225.2126	nA
CPS2	5	-3.214153931	6585.943085	nA
CPS2	6	-31.68889345	64947.61571	nA
CPS2	7	-0.322065314	657.6167091	nA
Electrode	Gain	Slope	Intercept	Units
CPP	All	-0.706492911	1797.87488	mV
CPP	0	0	0	nA
CPP	1	-6.432016332	13183.96797	nA
CPP	2	-62.5277989	128152.6211	nA
CPP	3	-0.645554157	1323.621639	nA
CPP	4	-121.6217697	249241.7423	nA
CPP	5	-3.214754627	6588.893945	nA
CPP	6	-31.69153813	64955.62965	nA
CPP	7	1	0	nA

* Calibration values for review purposes only.
These are not the flight electronics calibration constants. For flight electronics values refer to the WCL Calibration Report.

The events table, a three-column table with events, time and notes fields, keeps track of the significant events during the course of an experiment. The critical events are the same as those for the ISE data.

The CP scan header table (Table 4-15) records important instrument parameter information for each of the measurement sets. Note that the nAmin, nAmax and the CV_scan_time fields can be used to generate the CV waveform.

Table 4-15 CP Scan Header Fields

Header Field Name	Description
Electrode	CPS1, CPS2, CPP
Gain	The instrument gain setting which can equal 1,2,3,4,5,6,or 7.
nAMin	The minimum scan value
nAMax	The maximum scan value
CP_Scan_time	Time of scan in seconds.
Read_time	This is the time that the data was returned to the spacecraft computer across the serial interface from the MECA subsystem. Units are seconds of Spacecraft Clock (SCLK)
Number_of_Samples	Number of samples in the scan, maximum value is 2015.

The MECA WCL Chronopotentiometry (CP) data table contains a time series of electrode potential (mV) and current (nA) data for measurements made with one of the three CP electrodes mounted in the WCL beaker walls. The CP electrodes include: two 1 mm diameter Ag electrodes (CPS1 and CPS2) and one 1 mm diameter Pt (CPP) electrode. In a WCL CP measurement, which is sometime referred to a coulombic titration, the electrochemical cell potential is measured as the current is stepped (or ramped) from zero to a set current. A three-electrode configuration is employed, with either one of the Ag electrodes or the Pt electrode as the working electrode, the platinum ORP electrode as the counter electrode, and one of the chloride ISEs serving as the reference electrode. In nominal Mars surface operations, anodic (oxidizing) polarity is used for measurements made with the Ag electrodes and cathodic (reducing) polarity is use with the Pt electrode.

In general, the concentration of a single analyte in the bulk solution C^* can be calculated using the Sand equation, which for the CP current step technique can be expressed as:

$$C^* = (2i\tau^{1/2})/(nFAD^{1/2}\pi^{1/2}) \qquad \text{(eq. 4-6)}$$

where i is the applied current, τ the transition time, F Faraday's constant, A the electrode area, D the diffusion coefficient. Correction estimates for double-layer effects and other source of error will be made using the method described by Bard [*Bard A. J.,* 1963]. In this approach:

$$i\tau / C_o^* = a + b/C_o^*\tau^{1/2} \qquad \text{(eq.4-7)}$$

where a equals $nFADo^{1/2}\pi^{1/2}/2$ and b represents a correction factor. By measuring τ in the calibration solution, prior to soil addition, at multiple known current values, both a and b can be determined from plots of $\tau^{1/2}$ vs. $i\tau$.

A detailed review of CP is beyond the scope of this document and the reader is referred to the many texts that describe the theory and experimental practice of CP [Bard and Faulkner, 2000].

The potential at which a reaction proceeds at the working electrode in a CP measurement depends, in part, upon the redox potential of the process. Additionally, as is the case with CV, the potential of the reference electrode in each of four WCL cells will be a function of both electrode performance characteristics and the quantity of soluble chloride in the soil samples. Calculation of the electrode potential for each of the chloride reference ISEs will depend on their preflight ISE calibrations and results of the ISE measurements made on Mars. The conversion of measured WCL CP electrode potentials to standard reference electrode potentials and the correlation of measured potentials to specific analytes (e.g. chloride, bromide), as well as derived concentrations, will be documented in the MECA WCL special data products that will be generated by the Phoenix science team during surface operations.

4.3.1.3.5 PT

The MECA WCL pressure and temperature (PT) RDR is formatted as a header table, a DN to physical unit conversions table, an events table, a data header table and finally the PT data table. The header table contains information about the instrument and how the data was collected. A complete list of fields contained in the header table can be found in Table 4-16. The conversions table (Table 4-17) provides the EDR DN to RDR physical unit equation parameters. The events table gives the time at which important events in the experiment were carried out. The data header table contains the column labels for the PT data table. The PT data table contains time-series data of pressure measurements of the internal pressure sensor, temperature data from each of four sensors mounted on the beaker wall, the water tank, the sample drawer, and the optical microscope stage, and heater states for the beaker, tank, and drawer heaters.

The header table (Table 4-16) is used to record information that is useful for tracking the origin of the PT data as well as providing ancillary data useful for data interpretation. Mission and instrument parameters are recorded. It is especially important to note the WCL_CELL_NUMBER as each of the four cells may have slightly different measurement characteristics. Also of note is the PARENT_EDR_N field(s). The CALIBRATION_EQUATION field contains the DN to physical unit equation for the PT measurements. This field(s) contains the names of the EDR data products that were used in the generation of the RDR.

Table 4-16 PT Header Table Fields

Field	Description
PRODUCT_ID	Represents a permanent, unique identifier assigned to a data product by its producer.
PRODUCT_TYPE	MECA_WCL_PT
PARENT_EDR_N (N number of fields)	The EDR filename(s) from which the RDR was generated
PLANET_DAY_NUMBER	Mission Sol number on which the data was acquired
WCL_CELL_NUMBER	The number of the WCL (0-3)
RECORD_TYPE	Indicates the record format of a file - "FIXED LENGTH" for all WCL PT RDRs.
RECORD_BYTES	Indicates the number of bytes in a physical file record, including record terminators and separators.
DATA_RECORDS	Number of data points for each sensor. One record should correspond to one reading of the pressure sensor and one reading of each of the temperature sensors.
SCLK_START_COUNT	Spacecraft clock count of the first record in the data set
SCLK_STOP_COUNT	Spacecraft clock count of the last record in the data set
LTST_START_TIME	Local true solar time of the first record in the data set
LTST_STOP_TIME	Local true solar time of the last record in the data set
CALIBRATION_EQUATION	DN to Physical unit conversion equation

The conversions table contains the DN to physical unit conversions for the PT data. Except for the stage sensor, the conversion to physical units is specific to the selected chemistry cell. The conversion follows the appropriate formula below:

$$P(\text{mbar}) = a \cdot DN + b \qquad \text{(eq.4-8)}$$

$$T(°C) = a \cdot DN + b \qquad \text{(eq.4-9)}$$

Nominal values of a and b are specified in Table 4-17. .The definitive reference for the conversion equations is the WCL calibration report found elsewhere in this archive. The definitive reference for the conversions factors are the values found in the RDRs.

Table 4-17 PT DN to Physical Unit Conversion Factors

	a	B
T stage	0.0664	-154.15
Cell 0		
P	0.338903	-124.002
T beaker	0.06290586	-143.267
T tank	0.0643204	-145.966
T drawer	0.06947986	-158.314
Cell 1		
P	0.340479	-135.385
T beaker	0.06495649	-145.755
T tank	0.09388902	-208.137
T drawer	0.07991369	-182.836
Cell 2		
P	0.344203	-150.138
T beaker	0.06726234	-151.284
T tank	0.06370578	-136.16
T drawer	0.06797629	-151.228
Cell 3		
P	0.246445	-126.864
T beaker	0.05697277	-132.773
T tank	0.06379372	-135.449
T drawer	0.07836308	-179.763

The events table, a three-column table with events, time and notes fields, keeps track of the significant events during the course of an experiment. The critical events are the same as those for the ISE data.

The PT data header table contains the labels for the data columns in the PT data table. This table will be useful to those reading the RDR data product in either a text editor or spreadsheet program.

The MECA WCL PT data table contains time-series data of pressure measurements of the internal pressure sensor as well as temperature data from each of three sensors mounted on the water tank, the sample drawer, and in the beaker wall (**Error! Not a valid bookmark self-reference.**). The pressure and temperature readings apply to the active WCL cell (known from the command history), and the units of the RDR data are mbar for pressure and Celsius for temperature. The tank sensor is used to monitor and verify thawing of the stored leaching solution, while the drawer sensor monitors the operation of sample introduction and reagent addition actuators. The beaker sensor is critical for analysis of chemical data. Regardless of which cell is active, each telemetry record includes a reading of the microscopy sample stage temperature. Thus many of the WCL PT RDRs may be for the purpose of supporting microscopy experiments.

Table 4-18 PT Data Fields and Descriptions

Field	Description	Units
Time	series of SCLK CMD_read times	S
Pressure	series of pressure measurements for the selected WCL cell	Mbar
T_beaker	series of beaker temperature measurements for the selected WCL cell	C
T_tank	series of tank temperature measurements for the selected WCL cell	C

T_drawer	series of drawer temperature measurements for the selected WCL cell	C
T_stage	series of microscopy stage temperature measurements	C
beaker_htr_state	series of beaker heater states (0=off, 1=on)	
tank_htr_state	series of beaker tank states (0=off, 1=on)	
darwer_htr_state	series of beaker drawer states (0=off, 1=on)	

4.3.2 Data Flow

After generation, each RDR is saved locally and delivered to the Science Operation Center (SOC) at the University of Arizona. Upon arrival at the SOC, these files/products will be published into the product catalog (ROMe) via another automated process. It will subsequently be organized in time order and delivered to the PDS in the form of an Archive Volume by the MECA team.

After the validation period has passed, all applicable products such as EDRs, RDRs, etc. will be put into a PDS archive volume and submitted to the PDS geosciences node by the MECA team.

4.3.3 Labeling and Identification standards

The RDR labeling format described in this document will follow the Phoenix product file naming conventions as described in Appendix-D. All filenames will be PDS compliant and will follow the Phoenix file naming convention described in Appendix D. Additional identification information will be contained in the PDS label as described in Appendix-C.

4.3.4 PDS Standards

MECA non-imaging RDR products will comply with the Planetary Data System's standards as specified in the PDS Standards Reference (see Applicable Document #1). All label keywords are PDS compliant and registered in the PDS dictionary.

4.3.5 Time Standards

The following time standards and conventions are used throughout this document, as well as the Phoenix project for planning activities and identification of events.

SCET — Spacecraft event time. This is the time when an event occurred on-board the spacecraft, in UTC. It is usually derived from SCLK.

SCLK — Spacecraft Clock. This is an on-board 64-bit counter, in units of nano-seconds and increments once every 100 milliseconds. Time zero corresponds to midnight on 1-Jan-1980.

ERT — Earth Received Time. This is the time (UTC) when the first bit of the packet containing the current data was received at the Deep Space (DSN) station.

Local Solar Time — Local Solar Time (LST). This is the local solar time defined by the local solar days (sols) from the landing

	date using a 24 "hour" clock within the current local solar day (HR:MN:SC). Since the Mars day is 24h 37m 22s long, each unit of LST is slightly longer than the corresponding Earth unit. LST is computed using positions of the Sun and the landing site from SPICE kernels specified in the CHRONOS setup file. If a landing date is unknown to the program (e.g. for calibration data acquired on Earth) then no sol number will be provided on output LST examples: SOL 12 12:00:01 SOL 132 01:22:32.498 SOL 2 9
True Local Solar Time	This is related to LST which is also know as the mean solar time, is the time of day based on the position of the sun, rather than measure of time based on midnight to midnight "day". True local solar time is used in all MIPL generated products.
SOL	Solar Day Number, also known as PLANET DAY NUMBER in PDS label. This is the number of complete solar days on Mars since landing. The landing day therefore is SOL zero.

4.3.6 Data Storage Conventions

MECA non-imaging RDR products will be stored as ASCII files with detached PDS labels, with the exception of the AFM REPORT product that has an attached label. The PDS labels conform to PDS standards using an ASCII format, with each keyword definition terminated by ASCII carriage-return and line-feed characters. The RDR products are defined as PDS table objects (Applicable Document 1). All MECA non-imaging RDRs will contain fixed length records with the exception of the MECA_WCL_CV and MECA_WCL_CP data types. The WCL_CV and MECA_WCL_CP data types are stream records. In all data types the number of rows will vary.

4.4 Data Validation and Peer Review

The MECA non-imaging RDR product design, as described in this SIS, is subject to PDS peer review. The peer review will be completed well in advance of actual production, to allow time for changes in the design as needed. This SIS document will be updated to show any such changes.

Validation of MECA non-imaging RDR products during production will be performed according to specifications in the Phoenix Archive Plan and the MECA Team – Geosciences Node ICD (Applicable Documents 2 and 10). The MECA Team will validate the science content of the data products, and the Geosciences Node will validate the products for compliance with PDS standards and for conformance with the design specified in this SIS.

5. DETAILED DATA PRODUCT SPECIFICATIONS

5.1 Data Product Structure and Organization

5.1.1 AFM

There are three AFM data types, the AFM_SDR, the AFM_SDD and the AFM REPORT. The AFM_SDR is the converted scan data record and the AFM_SDD is the scan data derivative. The first two data types are structured as five table units (files) that contain a 22-column 4-row header table, a 1536-column forward scan error table, a 1536-column forward scan height data table, a 1536-column backward scan error table, and a 1536-column backward scan height table. The AFM REPORT is a text file that describes the activities of a measurement day. See 0 for label examples and table structures.

The AFM_SDR and AFM_SDD are organized as ASCII data files containing data from a single scan of the AFM, with a detached ASCII text PDS label file for each data file. The AFM REPORT is an ASCII text file with an attached ASCII PDS label. Data will be grouped by instrument (AFM) and then by sol.

5.1.1 TECP

There are four types of TECP data, TECP_EC, TECP_HUM, TECP_PRM and TECP_TC. The TECP_EC data is a time-series of electrical conductivity measurements. The TECP_HUM data is a time-series of relative humidity measurements. The TECP_PRM data is a time-series of relative permittivity data, and the TECP_TC data is a time-series of temperature measurements. The TECP data are organized as ASCII data files. The TECP_EC data files are structured as a 1-column general comments table, a 1-column EC comments table, and 2-column conversions table that holds the DN to physical unit conversion equations. The conversions table is followed by a 4-column table that holds the gain specific probe constant conversion coefficients. Next is a 7-column table that contains the gain specific resistance conversion coefficients and last the 13-column data table. The TECP_HUM, TECP_PRM, and TECP_TC data files are all structured in the same way. The file begins with a 1-column general comments table, a – column data type specific comments table, and a 2-column conversions table that holds the DN to physical unit conversions used to make the RDRs. The conversions table is followed by the data table. The EC and HUM data are 13-column data tables. The PRM data table is a 12-column data table and the TC data table is a 16-column table. See 0 for label examples and table structures.

Each of the four TECP data types are organized as ASCII data files containing data from a single Martian sol, with a detached ASCII text PDS label file for each data file. Data will be grouped by instrument (TECP) then by sol.

5.1.2 WCL

There are five types of WCL data, WCL_ISE, WCL_CND, WCL_CV, WCL_CP, and WCL_PT. The WCL_ISE data are a time-series of ion selective electrode data. The WCL_COND data are a time-series of electrical conductivity measurements. The WCL_CV data are a time-series of electrode potential and current cyclic voltammetry measurements. The WCL_CP data are a time-series of electrode potential and current chronopotentiometry measurements. The WCL_PT data are a time-series of pressure and temperature measurements. The ISE and CND data are formatted similarly, as are the CV and CP data. PT data is like the ISE and CND, except that is contains an additional table. The ISE and CND data are formatted with a 2-column header table, a 3-column events table, a data header table and a data table. The CV and CP data are formatted with a 2-column header table, a 6-column conversions table, a 3-column events table followed by a 2-column scan header table and a 2-column data table. The PT data is formatted as a 2-column header table, a 5-column conversions table, a 3-column events table, a 6-column data header table and a 6-column data table. See 0 for label examples and table structures for each of the WCL data types.

Each of the five WCL data types are organized as ASCII data files containing data from a single Martian sol, with a detached ASCII text PDS label file for each data file. Files for all the WCL data types are grouped by instrument (WCL) and then by sol.

5.2 Label and Header

Each MECA non-imaging RDR data product has a detached PDS labels stored as ASCII text in a file with the extension .lbl and the same name as the RDR data product. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains the keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file.

PDS labels are written in Object Description Language (ODL) [3]. PDS label statements have the form of “keyword = value”. Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object. Examples of the MECA non-imaging PDS labels are provided in 0, and definitions of the keywords used in the labels are given in 0.

Most of the MECA non-imaging data products also contain header information. The header information is used to record the instrument setting for a particular analysis set. AFM headers are located in the AFM_HEADER table portion of the data records. The first row in the table records the collection parameters for the first data table, the second row corresponds to the second data table etc. The TECP data type does not contain any header information. The WCL header information is captured in the WCL_HEADER table object in the WCL data types. The header information describes the collection parameters used during an analysis set. Examples of the header table labels can be found in 0.

6. APPLICABLE SOFTWARE

MECA non-imaging RDRs are all provided as ASCII data. Software specifically designed for use with the MECA non-imaging RDRs will not be provided.

APPENDIX A - PRODUCT LEVELS

Definitions of Data Processing Levels

This table shows definitions of processing levels as defined by NASA and by CODMAC, the Committee on Data Management and Computation (Applicable Documents 8 and 9)

Table A.1 Data Processing Levels

NASA	CODMAC	Description
Packet data	Raw - Level 1	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Level-0	Edited - Level 2	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed.
Level 1A	Calibrated - Level 3	Level 0 data that have been located in space and may have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied).
Level 1B	Resampled - Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength).
Level 1C	Derived - Level 5	Level 1A or 1B data that have been resampled and mapped onto uniform space-time grids. The data are calibrated (i.e., radiometrically corrected) and may have additional corrections applied (e.g., terrain correction).
Level 2	Derived - Level 5	Geophysical parameters, generally derived from Level 1 data, and located in space and time commensurate with instrument location, pointing, and sampling.
Level 3	Derived - Level 5	Geophysical parameters mapped onto uniform space-time grids.
	Ancillary – Level 6	Data needed to generate calibrated or resampled data sets.

APPENDIX B - PDS LABEL KEYWORDS

Keyword Name	Definition	Type	Units	Valid Values	Location & Source
DATA_SET_ID	A unique alphanumeric identifier for a data set or a data product. The DATA_SET_ID value for a given data set or product is constructed according to flight project naming conventions. In most cases the DATA_SET_ID is an abbreviation of the DATA_SET_NAME. Note: In the PDS, the values for both DATA_SET_ID and DATA_SET_NAME are constructed according to standards outlined in the Standards Reference.	string(40)		See example labels for actual values used in each product type For RDR: PHX-M-MECA-4-NIRDR-V1.0	Constant for each MECA instrument. Table look up and CCSDS header
DESCRIPTION (not by MIPL)	General text descriptor to describe CCC data. Free format comment field, enclosed in double quotes	string			**UNK for MIPL pipeline. Filled in for MECA generated calibration/characterization data**
EARTH_RECEIVED_START_TIME	Provides the beginning time at which telemetry was received during a time period of interest. This should be represented in UTC system format.	Datetime		YYYY-MM-DDThh:mm:ss[.fff]Z	SFDU Calculated CHDO_82:ert

Keyword Name	Definition	Type	Units	Valid Values	Location & Source
EARTH_RECEIVED_STOP_TIME	Provides the ending time for receiving telemetry during a time period of interest. This should be represented in UTC system format.	Datetim e		YYYY-MM-DDThh:mm:ss[.fff]Z	SFDU Calculated CHDO_82:ert
FILE_RECORDS	Indicates the number of physical file records.	Integer		Number of records in this EDR	Computed/updated by generating, or updating software
INSTRUMENT_ID	Instrument Identification string	String		"MECA_AFM" "MECA_TECP" MECA_WCL"	Constant
INSTRUMENT_NAME	Name of the instrument, free format, enclosed in double quotes. See example labels for various names used for MECA non-imaging products	String		""MECA ATOMIC FORCE MICROSCOPE", "MECA THERMAL AND ELECTRICAL CONDUCTIVITY PROBE", "MECA WET CHEMISTRY LABORATORY",	Table took up and constants.
INSTRUMENT_HOST_ID	Short name of the host the instrument is based on.	String		"PHX"	Constant
INSTRUMENT_HOST_NAME	The full name of the host on which this instrument is based	String		"PHOENIX"	Constant
LABEL_REVISION_NOTE	Version of Label definitions	String			Determined by generating software
MISSION_NAME	Identifies a major planetary mission or project. A given planetary mission may be associated with one or more spacecraft.	string		"PHOENIX"	Constant

Keyword Name	Definition	Type	Units	Valid Values	Location & Source
MISSION_PHASE_NAME	Provides the commonly-used identifier of a mission phase.	string(30)		"CRUISE", "EXTENDED MISSION", "PRIMARY MISSION", "ATLO", "ORT1", "ORT2", "CCC", "TBD", "TEST", etc.	Tabel look from, based on parameter input.
OPS_TOKEN	32-bit operations token, represented as an 8-digit hex value	Integer		0 – 16#FFFFFFFF	Telemetry, instrument header
OPS_TOKEN_ACTIVTY	16-bit Activity Code from the the OPS token. Represented as a 4 digit Hex value	Integer		0 – 15#FFFF	Telemetry, 16 msb of the ops token
OPS_TOKEN_PAYLOAD	4-bit payload value of the Ops. token, represented as a single Hex digit	Integer		0 – 16#F	Telemetry ops token
OPS_TOKEN_SEQUENCE	12-bit command sequence number of the ops. token, represented at a decimal value	Integer		0 – 16#FFF	Telemetry, least 12-bits of the ops token
PDS_VERSION_ID	Represents the version number of the PDS standards document that is valid when a data product label is created.	string(6)		"PDS3"	Constant
PLANET_DAY_NUMBER	Indicates the number of sidereal days (rotation of 360 degrees) elapsed since a reference day (e.g., the day on which a landing vehicle set down). Days are measured in rotations of the planet in question from the reference day (which is day zero). Landing day is 0	integer			Computed from SCLK present in telemetry

Keyword Name	Definition	Type	Units	Valid Values	Location & Source
PRODUCER_FULL_NAME	Individual who acquired/generated the data			e.g. "Alice Stanboli"	
PRODUCER_INSTITUTION_NAME	Identifies a university, research center, NASA center or other institution associated with the *production* of a data set. This would generally be an institution associated with the element PRODUCER_FULL_NAME.	string(60)		Generally, "MULTIMISSION INSTRUMENT PROCESSING LAB, JET PROPULSION LAB"	Static Value
PRODUCT_CREATION_TIME	Defines the UTC system format time when a product was created.	string		YYYY-MM-DDThh:mm:ss[.fff]Z	**SFDU header**
PRODUCT_ID	Represents a permanent, unique identifier assigned to a data product by its producer. See also: source_product_id. Note: In the PDS, the value assigned to product_id must be unique within its data set. Additional note: The product_id can describe the lowest-level data object that has a PDS label.	string(40)		File name, less the extension.	Calculated static value
PRODUCT_TYPE	The PRODUCT_TYPE data element identifies the type or category of a data product within a data set. See example labels for actual values used within MECA non-imaging data set	string(30)		"MECA_AFM_SDR" "MECA_AFM_SDD" "MECA_AFM_REPORT" "MECA_TECP_EC" "MECA_TECP_HUM" "MECA_TECP_PRM" "MECA_TECP_TC" "MECA_WCL_ISE" "MECA_WCL_COND" "MECA_WCL_CP" "MECA_WCL_CV" "MECA_WCL_PT"	Table lookup

Keyword Name	Definition	Type	Units	Valid Values	Location & Source
PRODUCT_VERSION_ID	Identifies the version of an individual product within a data set. PRODUCT_VERSION_ID is intended for use within AMMOS to identify separate iterations of a given product, which will also have a unique FILE_NAME. Note: This might not be the same as the data set version that is an element of the DATA_SET_ID value.	String(12)		"V<vernum> D-22850"	User Parameter
RECORD_BYTES	Indicates the number of bytes in a physical file record, including record terminators and separators.	integer		0 to n	Telemetry and instrument header
RECORD_TYPE	Indicates the record format of a file. (Does not apply to label lines except that collectively the label length must be a multiple of the record length).	string(20)		"FIXED_LENGTH"	Constant

Keyword Name	Definition	Type	Units	Valid Values	Location & Source
RELEASE_ID	Unique identifier associated with the release to the public of all or part of a data set. The first release of a data set should have a RELEASE_ID of "0001." When a data set is released incrementally, such as every three months during a mission, the RELEASE_ID is updated each time part of the data set is released.	string			User Parameter
SPACECRAFT_CLOCK_START_COUNT	Starting SCLK, smallest, value of all the records contained in the EDR.	string(30)		Format is dddddddddd.ddd, measured in units of seconds stored internally as a floating point number.	Telemetry and instrument engineering header Note: It is possible for the sclk to be earlier than the DVT time reported in the data product meta data file and the sclk reported in the data product file name.
SPACECRAFT_CLOCK_STOP_COUNT	Ending SCLK, largest value of all the records contained in the EDR.	string(30)		Format is dddddddddd.ddd, measured in units of Seconds and is stored internally as a floating point number.	Calculated
START_TIME	SPACECRAFT_CLOCK_START_COUNT converted and represented in UTC	string		Formation rule: YYYY-MM-DDThh:mm:ss[.fff]	Calculated

Keyword Name	Definition	Type	Units	Valid Values	Location & Source
STOP_TIME	SPACECRAFT_CLOCK_STOP_COUNT converted and represented in UTC	string		Formation rule: YYYY-MM-DDThh:mm:ss[.fff]	Calculated
TARGET_NAME	Identifies a target. The target may be a planet, satellite, ring, region, feature, asteroid or comet. See TARGET_TYPE. This is based on mission phase.	string(30)		"MARS", "CALIBRATION"	Static

APPENDIX C - RDR FILE NAMING CONVENTION

Standards

The file naming convention defined for the MECA non-imaging RDRs complies with the conventions for Phoenix EDRs and RDRs, which in turn complies with the PDS Level II 27.3 file naming standards.

Each product name is uniquely identifiable throughout the mission.

File Naming Rules

A template for general filename is shown below. Character positions 9 through 25 are reserved for instrument specific information.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Instrument	Source/Epic	Sol			Product Type			*MECA non-imaging Specific*																	Producer	Version	.	Extension		

Detailed definitions of product filenames are defined in the tables below. The tables document the naming conventions for each of the MECA sub-systems. Both the generic and MECA-specific fields are described.

Table C-19 MECA AFM Naming Conventions

Position	Name	Description/value
1	Instrument	**O** MECA-OM **P** MECA-TECP **F** MECA-AFM **W** MECA-WCL X MECA-Misc
2	Source/Epic	Spacecraft **S** Surface, flight model **T** Test-bed **C** Cruise, flight model
3-5	SOL	Solar days since first full day on Mars. Landing day is Sol zero. If Source/Epic is T, day of year should is used (ERT or SCET). For cruise phase, it is always set to " C ".

Position	Name	Description/value
6-8	Product Type	3-char identifiers to differentiate products as either EDR (Level 0) or RDR (Level 1+) products. If the identifier begins with an "E", then the product is a type of EDR. Otherwise, it is a type of RDR, defined as needed. **SDR** Calibrated scan data with x-y scan ranges **SDD** Derivative data
9	Reserved	Set to the underscore " " character
10-11	Revision	RDR revision number, 0-255, represented at a 2-digit Hex value.
12	Scan Number	0-9,A-Z (36 total)representing the number of the scan on a particular sol.
13	Reserved	Set to the underscore " " character
14-17	Record Length	Length of records represented as a 4-digit Hex value.
18-25	Ops Token	Token value represented as an 8-digit Hex value
26	Producer	Producer's id. **A** For MECA-AFM Team generated RDRs
27	Version	Version number, 0-9,A-Z (36 total)
28	Period	Always set to "." (ASCII period)
29-31	File Extension	PDS file extension **TAB** PDS Table object file

Table C-20 MECA TECP File Naming Conventions

Position	Name	Description/value
1	Instrument	**O** MECA-OM **P** MECA-TECP **F** MECA-AFM **W** MECA-WCE X MECA-Misc
2	Source/Epic	Spacecraft **S** Surface, flight model **T** Test-bed **C** Cruise, flight model
3-5	SOL	Solar days since first full day on Mars. Landing day is Sol zero. If Source/Epic is T, day of year should is used (ERT or SCET). For cruise phase, it is always set to " C ".
6-8	Product Type	3-char identifiers to differentiate products as either EDR (Level 0) or RDR (Level 1+) products. If the identifier begins with an "E", then the product is a type of EDR. Otherwise, it is a type of RDR, defined as needed. **EC_** Electrical Conductivity **HUM** Relative Humidity **PRM** Relative permittivity **TC_** Thermal Conductivity .

Position	Name	Description/value
9	Reserved	Always set to " "
10-11	Revision	RDR revision number, 0-255, represented at a 2-digit Hex value.
12-17	Reserved	Always set to " "
18-25	Ops Token	Token value represented as an 8-digit Hex value
26	Producer	Producer's id. **T** For MECA-TECP Team generated RDRs
27	Version	Version number, 0-9,A-Z (36 total)
28	Period	Always set to "." (ASCII period)
29-31	File Extension	PDS file extension **TAB** PDS Table object file

Table C-21 MECA WCL File Naming Conventions

Position	Name	Description/value
1	Instrument	**O** MECA-OM **P** MECA-TECP **F** MECA-AFM **W** MECA-WCL X MECA-Misc
2	Source/Epic	Spacecraft **S** Surface, flight model **T** Test-bed **C** Cruise, flight model
3-5	SOL	Solar days since first full day on Mars. Landing day is Sol zero. If Source/Epic is T, day of year should is used (ERT or SCET). For cruise phase, it is always set to " C ".
6-7	Cell Number	The letter "**C**" followed bu the number of the WCL cell (0-3).
8-10	Product Type	3-char identifiers to differentiate products as either EDR (Level 0) or RDR (Level 1+) products. If the identifier begins with an "E", then the product is a type of EDR. Otherwise, it is a type of RDR, defined as needed. **ISE** Individual sensor data **CND** Conductivity data **CV_** cyclical voltammetry data **CP_** chronopotentiometry data **PT_** Pressure and temperature Data

11	Reserved/Electrode	Set to " " for all data types except CP and CV. For CP data this is the electrode field **1** CPS1 electrode **2** CPS2 electrode **3** CPP electrode For CV data this is the electrode field **1** CV electrode **2** ASV electrode **3** DO electrode
12	Reserved	Always set to " "
13-14	Revision	RDR revision number, 0-255, represented at a 2-digit Hex value.
15-17	Reserved	Always set to " "
18-25	Ops Token	Token value represented as an 8-digit Hex value
26	Producer	Producer's id. **W** For MECA-WCL Team generated RDRs
27	Version	Version number, 0-9,A-Z (36 total)
28	Period	Always set to "." (ASCII period)
29-31	File Extension	PDS file extension **TAB** PDS Table object file

APPENDIX D - EXAMPLE RDR PDS LABELS

AFM

AFM_SDR

```
PDS_VERSION_ID                      = "PDS3"
LABEL_REVISION_NOTE                 = "2008-02-02, Initial"

/* File characteristics */
RECORD_TYPE                         = FIXED_LENGTH
RECORD_BYTES                        = 23041
FILE_RECORDS                        = 2052

/* Pointers to object in file */
^AFM_HEADER_TABLE                   = ("FT000SDR_000_2E0100000000A0.TAB",1)
^AFM_F_ERROR_TABLE                  = ("FT000SDR_000_2E0100000000A0.TAB",5)
^AFM_F_HEIGHT_TABLE                 = ("FT000SDR_000_2E0100000000A0.TAB",517)
^AFM_B_ERROR_TABLE                  = ("FT000SDR_000_2E0100000000A0.TAB",1029)
^AFM_B_HEIGHT_TABLE                 = ("FT000SDR_000_2E0100000000A0.TAB",1541)

/* Identification */
DATA_SET_ID                         = "PHX-M-MECA-4-NIRDR-V1.0"
DESCRIPTION                         = "UNK"
PRODUCT_ID                          = "FT000SDR_000_2E0100000000A0_TAB"
PRODUCT_VERSION_ID                  = "V1.0"
PRODUCT_TYPE                        = "MECA_AFM_SDR"
RELEASE_ID                          = 0001
INSTRUMENT_HOST_NAME                = "PHOENIX"
INSTRUMENT_HOST_ID                  = PHX
INSTRUMENT_NAME                     = "MECA ATOMIC FORCE MICROSCOPE"
INSTRUMENT_ID                       = "MECA_AFM"
INSTRUMENT_MODE_ID                  = "SCAN"
MISSION_NAME                        = "PHOENIX"

OPS_TOKEN                           = "NULL"
OPS_TOKEN_ACTIVITY                  = "NULL"
OPS_TOKEN_PAYLOAD                   = "NULL"
OPS_TOKEN_SEQUENCE                  = "NULL"
TARGET_NAME                         = MARS


/* Time information */
MISSION_PHASE_NAME                  = "PRE-LAUNCH"
SPACECRAFT_CLOCK_START_COUNT        = "TEST STRING"
SPACECRAFT_CLOCK_STOP_COUNT         = "TEST STRING"
START_TIME                          = 2008-03-13T10:40:36
STOP_TIME                           = 2008-03-13T10:40:36
PLANET_DAY_NUMBER                   = 356
EARTH_RECEIVED_START_TIME           = 2008-03-13T10:40:36
EARTH_RECEIVED_STOP_TIME            = 2008-03-13T10:40:36
LOCAL_TRUE_SOLAR_TIME               = "00:00:00"
PRODUCT_CREATION_TIME               = 2008-03-13T10:40:36
```

```
/* Data object definition */

OBJECT                              = AFM_HEADER_TABLE
  INTERCHANGE_FORMAT                = ASCII
  COLUMNS                           = 21
  ROWS                              = 4
  ROW_BYTES                         = 190
  ROW_SUFFIX_BYTES                  = 22851
  ^STRUCTURE                        = "AFM_HEADER.FMT"
  DESCRIPTION                       = "This table contains the AFM scan
                                    parameter information. The table contains
                                    190 bytes of table data followed by 22851
                                    bytes of spare data, of which the last 2
                                    bytes contain the <CR><LF> pair. "

END_OBJECT                          = AFM_HEADER_TABLE

OBJECT                              = AFM_F_ERROR_TABLE
  INTERCHANGE_FORMAT                = ASCII
  COLUMNS                           = 1536
  ROWS                              = 512
  ROW_BYTES                         = 23041
  START_BYTE                        = 92165
  MISSING_CONSTANT                  = 0.00
  DESCRIPTION                       = "This table contains the AFM scan
                                      forward error information in Volts."

  OBJECT                            = CONTAINER
    BYTES                           = 45
    DESCRIPTION                     = "This table contains the AFM scan
                                      forward error information in Volts.
                                      Each row represents a scan line along
                                      the fast scan axis."
    NAME                            = "FORWARD ERROR"
    REPETITIONS                     = 512
    START_BYTE                      = 1

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 1
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "FORWARD ERROR X COORDINATE"
      START_BYTE                    = 1
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 2
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "FORWARD ERROR Y COORDINATE"
      START_BYTE                    = 16
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 3
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
```

```
      NAME                          = "FORWARD ERROR VALUE"
      START_BYTE                    = 31
    END_OBJECT                      = COLUMN
  END_OBJECT                        = CONTAINER
END_OBJECT                          = AFM_F_ERROR_TABLE

OBJECT                              = AFM_F_HEIGHT_TABLE
  INTERCHANGE_FORMAT                = ASCII
  COLUMNS                           = 1536
  ROWS                              = 512
  ROW_BYTES                         = 23041
  START_BYTE                        = 11889157
  MISSING_CONSTANT                  = 0.00
  DESCRIPTION                       = "This table contains the AFM scan
                                      forward Z-height information in microns
                                      Each row represents a scan line along
                                      the fast scan axis.
                                      The table contains 23041 bytes of table
                                      data of which the last 2 bytes contain
                                      the <CR><LF> pair. "

  OBJECT                            = CONTAINER
    BYTES                           = 45
    DESCRIPTION                     = "The container holds the X-Y-Z
                                       information for each AFM forward
                                       scan data point."
    NAME                            = "FORWARD HEIGHT"
    REPETITIONS                     = 512
    START_BYTE                      = 1

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 1
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "FORWARD HEIGHT X COORDINATE"
      START_BYTE                    = 1
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 2
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "FORWARD HEIGHT Y COORDINATE"
      START_BYTE                    = 16
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 3
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "FORWARD HEIGHT VALUE"
      START_BYTE                    = 31
    END_OBJECT                      = COLUMN
  END_OBJECT                        = CONTAINER
END_OBJECT                          = AFM_F_HEIGHT_TABLE

OBJECT                              = AFM_B_ERROR_TABLE
```

```
  INTERCHANGE_FORMAT                = ASCII
  COLUMNS                           = 1536
  ROWS                              = 512
  ROW_BYTES                         = 23041
  START_BYTE                        = 23686149
  MISSING_CONSTANT                  = 0.00
  DESCRIPTION                       = "This table contains the AFM scan
                                      backward error information in Volts.
                                      Each row represents a scan line along
                                      the fast scan axis."

  OBJECT                            = CONTAINER
    BYTES                           = 45
    DESCRIPTION                     = "The container holds the X-Y-Z
                                      information for each AFM scan
                                      error data point."
    NAME                            = "BACKWARD ERROR"
    REPETITIONS                     = 512
    START_BYTE                      = 1

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 1
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "BACKWARD ERROR X COORDINATE"
      START_BYTE                    = 1
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 2
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "BACKWARD ERROR Y COORDINATE"
      START_BYTE                    = 16
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 3
      BYTES                         = 14
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "BACKWARD ERROR VALUE"
      START_BYTE                    = 31
    END_OBJECT                      = COLUMN
  END_OBJECT                        = CONTAINER
END_OBJECT                          = AFM_B_ERROR_TABLE

OBJECT                              = AFM_B_HEIGHT_TABLE
  INTERCHANGE_FORMAT                = ASCII
  COLUMNS                           = 1536
  ROWS                              = 512
  ROW_BYTES                         = 23041
  START_BYTE                        = 35483141
  MISSING_CONSTANT                  = 0.00
  DESCRIPTION                       = "This table contains the AFM scan
                                      backward Z-height information in
                                      microns. Each row represents a scan
                                      line along the fast scan axis. The
```

```
                                         table contains 23041 bytes of table
                                         data of which the last 2 bytes contain
                                         the <CR><LF> pair. "

  OBJECT                               = CONTAINER
    BYTES                              = 45
    DESCRIPTION                        = "The container holds the X-Y-Z
                                         information for each AFM backward
                                         scan data point."
    NAME                               = "BACKWARD HEIGHT"
    REPETITIONS                        = 512
    START_BYTE                         = 1

    OBJECT                             = COLUMN
      COLUMN_NUMBER                    = 1
      BYTES                            = 14
      DATA_TYPE                        = ASCII_REAL
      NAME                             = "BACKWARD HEIGHT X COORDINATE"
      START_BYTE                       = 1
    END_OBJECT                         = COLUMN

    OBJECT                             = COLUMN
      COLUMN_NUMBER                    = 2
      BYTES                            = 14
      DATA_TYPE                        = ASCII_REAL
      NAME                             = "BACKWARD HEIGHT Y COORDINATE"
      START_BYTE                       = 16
    END_OBJECT                         = COLUMN

    OBJECT                             = COLUMN
      COLUMN_NUMBER                    = 3
      BYTES                            = 14
      DATA_TYPE                        = ASCII_REAL
      NAME                             = "BACKWARD HEIGHT VALUE"
      START_BYTE                       = 31
    END_OBJECT                         = COLUMN
  END_OBJECT                           = CONTAINER
END_OBJECT                             = AFM_B_HEIGHT_TABLE

END
```

AFM_HEADER.FMT

```
OBJECT = COLUMN
   COLUMN_NUMBER = 1
   NAME = cmdTimewhole
   DATA_TYPE = ASCII_INTEGER
   BYTES = 9
   START_BYTE = 1
   UNIT = SECONDS
   DESCRIPTION = "This is the time that the command was issued from
   the spacecraft computer to the MECA subsystem across the serial
   interface. Units are seconds of Spacecraft Clock (SCLK)."
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
   COLUMN_NUMBER = 2
   NAME = cmdTimeremainder
   DATA_TYPE = ASCII_INTEGER
   BYTES = 10
   START_BYTE = 11
   UNIT = “SECONDS/2**32”
   DESCRIPTION = "The remainder, where 2^32 is a full second."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 3
   NAME = readTimewhole
   DATA_TYPE = ASCII_INTEGER
   BYTES = 9
   START_BYTE = 22
   UNIT = SECONDS
   DESCRIPTION = "This is the time that the data was returned to the
   spacecraft computer across the serial interface from the MECA
   subsystem (not used for some telemetry types). Units are seconds
   of Spacecraft Clock (SCLK)."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 4
   NAME = readTimeremainder
   DATA_TYPE = ASCII_INTEGER
   BYTES = 10
   START_BYTE = 32
   UNIT = SECONDS/2**32
   DESCRIPTION = "The remainder, where 2^32 is a full second."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 5
   NAME = dataLength
   DATA_TYPE = ASCII_INTEGER
   BYTES = 6
   START_BYTE = 43
   UNIT = BYTES
   DESCRIPTION = "The length of the following record (and all records in
   this product), not including this header."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 6
   NAME = cols
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 50
   UNIT = POINTS
   DESCRIPTION = "The width (number of points per line) of the AFM image."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 7
   NAME = lines
```

```
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 54
   UNIT = LINES
   DESCRIPTION = "The height (number of lines) of the AFM image."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 8
   NAME = direction
   DATA_TYPE = ASCII_INTEGER
   BYTES = 1
   START_BYTE = 58
   DESCRIPTION = "The scan direction, 1 = forward, 2 = backward."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 9
   NAME = channel
   DATA_TYPE = ASCII_INTEGER
   BYTES = 1
   START_BYTE = 60
   DESCRIPTION = "The RDR data channel, 1= error, 2= z-height."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 10
   NAME = channelGain
   DATA_TYPE = ASCII_INTEGER
   BYTES = 1
   START_BYTE = 62
   DESCRIPTION = "Ranges form 0 to 8, with 0=full (13.8 microns), and
   reducing by factors of 2 each time, e.g. gain of 2 = 3.45 microns."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 11
   NAME = refOMimage
   DATA_TYPE = CHARACTER
   BYTES = 33
   START_BYTE = 64
   DESCRIPTION = "File name of the Optical Microscope image taken
   before the scan for sample context."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 12
   NAME = refOMimage2
   DATA_TYPE = CHARACTER
   BYTES = 33
   START_BYTE = 98
   DESCRIPTION = "Filename of the OM image taken after the scan"
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 13
   NAME = opsToken
```

```
   DATA_TYPE = ASCII_INTEGER
   BYTES = 8
   START_BYTE = 132
   DESCRIPTION = "Ops Token for this scan."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 14
   NAME = SwtsTemperature
   DATA_TYPE = ASCII_INTEGER
   BYTES = 5
   START_BYTE = 141
   UNIT = KELVIN
   DESCRIPTION = "Temperature of the SWTS just prior to the scan."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 15
   NAME = scanrange
   DATA_TYPE = ASCII_REAL
   BYTES = 6
   START_BYTE = 147
   DESCRIPTION = "AFM scan range."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 16
   NAME = scaling_factor
   DATA_TYPE = ASCII_REAL
   BYTES = 10
   START_BYTE = 154
   DESCRIPTION = "The scaling factor used to calibrate the data
   (converts DNs to micrometers for height data and volts for error
   data)"
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 17
   NAME = AFM_OM_ref_X
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 165
   DESCRIPTION = "The approximate location of the center of the AFM
   scan field relative to the OM image. X-coordinate in pixels."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 18
   NAME = AFM_OM_ref_Y
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 169
   DESCRIPTION = "The approximate location of the center of the AFM
   scan field relative to the OM image. Y-coordinate in pixels."
END_OBJECT = COLUMN

OBJECT = COLUMN
```

```
   COLUMN_NUMBER = 19
   NAME = X_slope
   DATA_TYPE = ASCII_REAL
   BYTES = 6
   START_BYTE = 173
   DESCRIPTION = "Slope correction in the x-direction of the AFM
   scan plane."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 20
   NAME = Y_slope
   DATA_TYPE = ASCII_REAL
   BYTES = 6
   START_BYTE = 180
   DESCRIPTION = "Slope correction in the y-direction of the AFM
   scan plane."
END_OBJECT = COLUMN
OBJECT = COLUMN
   COLUMN_NUMBER = 21
   NAME = ScanSpeed
   DATA_TYPE = ASCII_REAL
   BYTES = 4
   START_BYTE = 187
   DESCRIPTION = "Scan speed of the AFM in micrometers/second"
END_OBJECT = COLUMN
```

AFM_SDD

```
PDS_VERSION_ID                      = "PDS3"
LABEL_REVISION_NOTE                 = "2008-02-02, Initial"

/* File characteristics */
RECORD_TYPE                         = FIXED_LENGTH
RECORD_BYTES                        = 19969
FILE_RECORDS                        = 2052

/* Pointers to object in file */
^AFM_D_HEADER_TABLE                 = ("FT000SDD_000_2E0100000000A0.TAB",1)
^AFM_F_ERROR_TABLE                  = ("FT000SDD_000_2E0100000000A0.TAB",5)
^AFM_F_HEIGHT_TABLE                 = ("FT000SDD_000_2E0100000000A0.TAB",517)
^AFM_B_ERROR_TABLE                  = ("FT000SDD_000_2E0100000000A0.TAB",1029)
^AFM_B_HEIGHT_TABLE                 = ("FT000SDD_000_2E0100000000A0.TAB",1541)

/* Identification */
DATA_SET_ID                         = "PHX-M-MECA-4-NIRDR-V1.0"
DESCRIPTION                         = "UNK"
PRODUCT_ID                          = "FT000SDD_000_2E0100000000A0_TAB"
PRODUCT_VERSION_ID                  = "V1.0"
PRODUCT_TYPE                        = "MECA_AFM_SDD"
RELEASE_ID                          = 0001
INSTRUMENT_HOST_NAME                = "PHOENIX"
INSTRUMENT_HOST_ID                  = PHX
INSTRUMENT_NAME                     = "MECA ATOMIC FORCE MICROSCOPE"
INSTRUMENT_ID                       = "MECA_AFM"
INSTRUMENT_MODE_ID                  = "SCAN"
MISSION_NAME                        = "PHOENIX"
```

```
OPS_TOKEN                          = "NULL"
OPS_TOKEN_ACTIVITY                 = "NULL"
OPS_TOKEN_PAYLOAD                  = "NULL"
OPS_TOKEN_SEQUENCE                 = "NULL"
TARGET_NAME                        = MARS


/* Time information */
MISSION_PHASE_NAME                 = "PRE-LAUNCH"
SPACECRAFT_CLOCK_START_COUNT       = "TEST STRING"
SPACECRAFT_CLOCK_STOP_COUNT        = "TEST STRING"
START_TIME                         = 2008-03-11T11:31:57
STOP_TIME                          = 2008-03-11T11:31:57
PLANET_DAY_NUMBER                  = 356
EARTH_RECEIVED_START_TIME          = 2008-03-11T11:31:57
EARTH_RECEIVED_STOP_TIME           = 2008-03-11T11:31:57
LOCAL_TRUE_SOLAR_TIME              = "00:00:00"
PRODUCT_CREATION_TIME              = 2008-03-11T11:31:57



/* Data object definition */

OBJECT                             = AFM_D_HEADER_TABLE
  INTERCHANGE_FORMAT               = ASCII
  COLUMNS                          = 22
  ROWS                             = 4
  ROW_BYTES                        = 193
  ROW_SUFFIX_BYTES                 = 19776
  ^STRUCTURE                       = "AFM_D_HEADER.FMT"
  DESCRIPTION                      = "This table contains the AFM scan
                                   parameter information. The table contains
                                   193 bytes of table data followed by 19776
                                   bytes of spare data, of which the last 2
                                   bytes contain the <CR><LF> pair. "

END_OBJECT                         = AFM_D_HEADER_TABLE

OBJECT                             = AFM_F_ERROR_TABLE
  INTERCHANGE_FORMAT               = ASCII
  COLUMNS                          = 1536
  ROWS                             = 512
  ROW_BYTES                        = 19969
  START_BYTE                       = 79877
  MISSING_CONSTANT                 = 0.00
  DESCRIPTION                      = "This table contains the AFM scan
                                      forward error derivative information.
                                      Each row represents a scan
                                      line along the fast scan axis"

  OBJECT                           = CONTAINER
    BYTES                          = 39
    DESCRIPTION                    = "The container holds the X-Y-Z
                                      information for each AFM scan error
                                      derivative data point. The table
                                      contains 19969 bytes of table data of
```

```
                                which the last 2 bytes contain the
                                <CR><LF> pair. "
    NAME                        = "FORWARD ERROR DERIVATIVE"
    REPETITIONS                 = 512
    START_BYTE                  = 1

    OBJECT                      = COLUMN
      COLUMN_NUMBER             = 1
      BYTES                     = 12
      DATA_TYPE                 = ASCII_REAL
      NAME                      = "FORWARD ERROR DERIVATIVE X COORDINATE"
      START_BYTE                = 1
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
      COLUMN_NUMBER             = 2
      BYTES                     = 12
      DATA_TYPE                 = ASCII_REAL
      NAME                      = "FORWARD ERROR DERIVATIVE Y COORDINATE"
      START_BYTE                = 14
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
      COLUMN_NUMBER             = 3
      BYTES                     = 12
      DATA_TYPE                 = ASCII_REAL
      NAME                      = "FORWARD ERROR DERIVATIVE VALUE"
      START_BYTE                = 27
    END_OBJECT                  = COLUMN
  END_OBJECT                    = CONTAINER
END_OBJECT                      = AFM_F_ERROR_TABLE

OBJECT                          = AFM_F_HEIGHT_TABLE
  INTERCHANGE_FORMAT            = ASCII
  COLUMNS                       = 1536
  ROWS                          = 512
  ROW_BYTES                     = 19969
  START_BYTE                    = 10304005
  MISSING_CONSTANT              = 0.00
  DESCRIPTION                   = "This table contains the AFM scan
                                forward Z-height derivative.
                                Each row represents a scan line along
                                the fast scan axis"

  OBJECT                        = CONTAINER
    BYTES                       = 39
    DESCRIPTION                 = "The container holds the X-Y-Z
                                information for each AFM forward
                                derivative scan data point."
    NAME                        = "FORWARD HEIGHT DERIVATIVE"
    REPETITIONS                 = 512
    START_BYTE                  = 1

    OBJECT                      = COLUMN
      COLUMN_NUMBER             = 1
      BYTES                     = 12
      DATA_TYPE                 = ASCII_REAL
```

```
      NAME                          = "FORWARD HEIGHT DERIVATIVE X COORDINATE"
      START_BYTE                    = 1
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 2
      BYTES                         = 12
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "FORWARD HEIGHT DERIVATIVE Y COORDINATE"
      START_BYTE                    = 14
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 3
      BYTES                         = 12
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "FORWARD HEIGHT DERIVATIVE VALUE"
      START_BYTE                    = 27
    END_OBJECT                      = COLUMN
  END_OBJECT                        = CONTAINER
END_OBJECT                          = AFM_F_HEIGHT_TABLE

OBJECT                              = AFM_B_ERROR_TABLE
  INTERCHANGE_FORMAT                = ASCII
  COLUMNS                           = 1536
  ROWS                              = 512
  ROW_BYTES                         = 19969
  START_BYTE                        = 20528133
  MISSING_CONSTANT                  = 0.00
  DESCRIPTION                       = "This table contains the AFM scan
                                       backward error derivative information
                                       Each row represents a scan line along
                                       the fast scan axis."

  OBJECT                            = CONTAINER
    BYTES                           = 39
    DESCRIPTION                     = "The container holds the X-Y-Z
                                      information for each AFM scan error
                                      derivative data point. The table
                                      contains 19969 bytes of table data
                                      of which the last 2 bytes contain
                                      the <CR><LF> pair."
    NAME                            = "BACKWARD ERROR DERIVATIVE"
    REPETITIONS                     = 512
    START_BYTE                      = 1

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 1
      BYTES                         = 12
      DATA_TYPE                     = ASCII_REAL
      NAME                          = "BACKWARD ERROR DERIVATIVE X COORDINATE"
      START_BYTE                    = 1
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
      COLUMN_NUMBER                 = 2
      BYTES                         = 12
```

```
      DATA_TYPE                    = ASCII_REAL
      NAME                         = "BACKWARD ERROR DERIVATIVE Y COORDINATE"
      START_BYTE                   = 14
    END_OBJECT                     = COLUMN

    OBJECT                         = COLUMN
      COLUMN_NUMBER                = 3
      BYTES                        = 12
      DATA_TYPE                    = ASCII_REAL
      NAME                         = "BACKWARD ERROR DERIVATIVE VALUE"
      START_BYTE                   = 27
    END_OBJECT                     = COLUMN
  END_OBJECT                       = CONTAINER
END_OBJECT                         = AFM_B_ERROR_TABLE

OBJECT                             = AFM_B_HEIGHT_TABLE
  INTERCHANGE_FORMAT               = ASCII
  COLUMNS                          = 1536
  ROWS                             = 512
  ROW_BYTES                        = 19969
  START_BYTE                       = 30752261
  MISSING_CONSTANT                 = 0.00
  DESCRIPTION                      = "This table contains the AFM scan
                                     backward Z-height derivative information.
                                     Each row represents a scan
                                     line along the fast scan axis"

  OBJECT                           = CONTAINER
    BYTES                          = 39
    DESCRIPTION                    = "The container holds the X-Y-Z
                                     information for each AFM backward
                                     scan Z-height derivative
                                     data point."
    NAME                           = "BACKWARD HEIGHT DERIVATIVE"
    REPETITIONS                    = 512
    START_BYTE                     = 1

    OBJECT                         = COLUMN
      COLUMN_NUMBER                = 1
      BYTES                        = 12
      DATA_TYPE                    = ASCII_REAL
      NAME                         = "BACKWARD HEIGHT DERIVATIVE X COORDINATE"
      START_BYTE                   = 1
    END_OBJECT                     = COLUMN

    OBJECT                         = COLUMN
      COLUMN_NUMBER                = 2
      BYTES                        = 12
      DATA_TYPE                    = ASCII_REAL
      NAME                         = "BACKWARD HEIGHT DERIVATIVE Y COORDINATE"
      START_BYTE                   = 14
    END_OBJECT                     = COLUMN

    OBJECT                         = COLUMN
      COLUMN_NUMBER                = 3
      BYTES                        = 12
      DATA_TYPE                    = ASCII_REAL
```

```
      NAME                          = "BACKWARD HEIGHT DERIVATIVE VALUE"
      START_BYTE                    = 27
    END_OBJECT                      = COLUMN
  END_OBJECT                        = CONTAINER
END_OBJECT                          = AFM_B_HEIGHT_TABLE

END
```

AFM_D_HEADER.FMT

```
OBJECT = COLUMN
   COLUMN_NUMBER = 1
   NAME = cmdTimewhole
   DATA_TYPE = ASCII_INTEGER
   BYTES = 9
   START_BYTE = 1
   UNIT = SECONDS
   DESCRIPTION = "This is the time that the command was issued from
   the spacecraft computer to the MECA subsystem across the serial
   interface. Units are seconds of Spacecraft Clock (SCLK)."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 2
   NAME = cmdTimeremainder
   DATA_TYPE = ASCII_INTEGER
   BYTES = 10
   START_BYTE = 11
   UNIT = "SECONDS/2**32"
   DESCRIPTION = "The remainder, where 2^32 is a full second."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 3
   NAME = readTimewhole
   DATA_TYPE = ASCII_INTEGER
   BYTES = 9
   START_BYTE = 22
   UNIT = SECONDS
   DESCRIPTION = "This is the time that the data was returned to
   the spacecraft computer across the serial interface from the MECA
   subsystem (not used for some telemetry types). Units are seconds
   of Spacecraft Clock (SCLK)."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 4
   NAME = readTimeremainder
   DATA_TYPE = ASCII_INTEGER
   BYTES = 10
   START_BYTE = 32
   UNIT = "SECONDS/2**32"
   DESCRIPTION = "The remainder, where 2^32 is a full second."
END_OBJECT = COLUMN

OBJECT = COLUMN
```

```
   COLUMN_NUMBER = 5
   NAME = dataLength
   DATA_TYPE = ASCII_INTEGER
   BYTES = 6
   START_BYTE = 43
   UNIT = BYTES
   DESCRIPTION = "The length of the following record (and all
   records in this product), not including this header."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 6
   NAME = cols
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 50
   UNIT = POINTS
   DESCRIPTION = "The width (number of points per line) of the AFM image."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 7
   NAME = lines
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 54
   UNIT = LINES
   DESCRIPTION = "The height (number of lines) of the AFM image."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 8
   NAME = direction
   DATA_TYPE = ASCII_INTEGER
   BYTES = 1
   START_BYTE = 58
   DESCRIPTION = "The scan direction, 1 = forward, 2 = backward."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 9
   NAME = channel
   DATA_TYPE = ASCII_INTEGER
   BYTES = 1
   START_BYTE = 60
   DESCRIPTION = "The RDR data channel, 1= error, 2= z-height."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 10
   NAME = channelGain
   DATA_TYPE = ASCII_INTEGER
   BYTES = 1
   START_BYTE = 62
   DESCRIPTION = "Ranges form 0 to 8, with 0=full (13.8 microns),
   and reducing by factors of 2 each time, e.g. gain of
   2 = 3.45 microns."
```

```
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 11
   NAME = refOMimage
   DATA_TYPE = CHARACTER
   BYTES = 33
   START_BYTE = 64
   DESCRIPTION = "File name of the Optical Microscope image
   taken before the scan for sample context."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 12
   NAME = refOMimage2
   DATA_TYPE = CHARACTER
   BYTES = 33
   START_BYTE = 98
   DESCRIPTION = "Filename of the OM image taken after the scan"
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 13
   NAME = opsToken
   DATA_TYPE = ASCII_INTEGER
   BYTES = 8
   START_BYTE = 132
   DESCRIPTION = "Ops Token for this scan."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 14
   NAME = SwtsTemperature
   DATA_TYPE = ASCII_INTEGER
   BYTES = 5
   START_BYTE = 141
   UNIT = KELVIN
   DESCRIPTION = "Temperature of the SWTS just prior to the scan."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 15
   NAME = scanrange
   DATA_TYPE = ASCII_REAL
   BYTES = 6
   START_BYTE = 147
   DESCRIPTION = "AFM scan range."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 16
   NAME = smoothing_factor
   DATA_TYPE = ASCII_INTEGER
   BYTES = 2
   START_BYTE = 154
   DESCRIPTION = "Number of points used in derivative filter."
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
   COLUMN_NUMBER = 17
   NAME = AFM_OM_ref_X
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 157
   DESCRIPTION = "The approximate location of the center of the
   AFM scan field relative to the OM image. X-coordinate in pixels."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 18
   NAME = AFM_OM_ref_Y
   DATA_TYPE = ASCII_INTEGER
   BYTES = 3
   START_BYTE = 161
   DESCRIPTION = "The approximate location of the center of the
   AFM scan field relative to the OM image. Y-coordinate in pixels."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 19
   NAME = X_slope
   DATA_TYPE = ASCII_REAL
   BYTES = 6
   START_BYTE = 165
   DESCRIPTION = "The x-slope of the substrate relative to
   the x-y scanner."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 20
   NAME = Y_slope
   DATA_TYPE = ASCII_REAL
   BYTES = 6
   START_BYTE = 172
   DESCRIPTION = "The y-slope of the substrate relative to
   the x-y scanner."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 21
   NAME = ScanSpeed
   DATA_TYPE = ASCII_REAL
   BYTES = 4
   START_BYTE = 179
   DESCRIPTION = "The y-slope of the substrate relative to
   the x-y scanner."
END_OBJECT = COLUMN
```

AFM REPORT

```
PDS_VERSION_ID                = PDS3
DD_VERSION_ID                 = PDSCAT1R68
LABEL_REVISION_NOTE           = "2008-02-20, MECA AMF TEAM, initial
                                 release;"
```

```
RECORD_TYPE = STREAM

/* IDENTIFICATION DATA ELEMENTS */
RELEASE_ID                      = "0001"
OPS_TOKEN                       = 16#40406720#

/* DESCRIPTIVE DATA ELEMENTS */
INSTRUMENT_HOST_NAME            = "PHOENIX"
INSTRUMENT_NAME                 = "MECA"
SPACECRAFT_ID                   = PHX
TARGET_NAME                     = MARS
MISSION_PHASE_NAME              = "PRIMARY MISSION"
START_TIME                      = 2008-05-01T14:14:32.890
STOP_TIME                       = 2008-05-01T20:09:44.149
SPACECRAFT_CLOCK_START_COUNT    = "208023626065"
SPACECRAFT_CLOCK_STOP_COUNT     = "208035731925"

OBJECT = TEXT
  NOTE = "2007 Mars Phoenix MECA AFM Report Sol 1"
  PUBLICATION_DATE = 2008-05-01
END_OBJECT = TEXT
END


      2007 Mars Phoenix MECA AFM Scan Report Sol 1

Each report will contain the documentation of each days
activities on the surface of Mars or a report of the planning
activities back on Earth.
```

TECP

TECP_EC

```
PDS_VERSION_ID                 = PDS3
LABEL_REVISION_NOTE            = "2008-01-30, Initial"

/* File characteristics */
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 199
FILE_RECORDS                   = 222

/* Pointers to object in file */
^TECP_GEN_COMMENTS_TABLE       = ("PT018EC__01______ABABABABT0.TAB",1)
^TECP_EC_COMMENTS_TABLE        = ("PT018EC__01______ABABABABT0.TAB",6)
^TECP_CONVERSIONS_TABLE        = ("PT018EC__01______ABABABABT0.TAB",11)
^TECP_EC_PC_TABLE              = ("PT018EC__01______ABABABABT0.TAB",19)
^TECP_EC_RM_TABLE              = ("PT018EC__01______ABABABABT0.TAB",22)
^TECP_EC_TABLE                 = ("PT018EC__01______ABABABABT0.TAB",40)

/* Identification */
DATA_SET_ID                    = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                     = "TEST STRING"
PRODUCT_TYPE                   = "MECA_TECP_EC"
PRODUCT_VERSION_ID             = "V1.0"
RELEASE_ID                     = 0001
INSTRUMENT_HOST_NAME           = "PHOENIX"
```

```
INSTRUMENT_HOST_ID              = PHX
INSTRUMENT_NAME                 = "MECA THERMAL AND ELECTRICAL CONDUCTIVITY PROBE"
INSTRUMENT_ID                   = "MECA_TECP"
INSTRUMENT_MODE_ID              = "SCAN"
MISSION_NAME                    = "PHOENIX"
TARGET_NAME                     = MARS


OPS_TOKEN                       = "NULL"
OPS_TOKEN_ACTIVITY              = "NULL"
OPS_TOKEN_PAYLOAD               = "NULL"
OPS_TOKEN_SEQUENCE              = "NULL"


/* Time information */
MISSION_PHASE_NAME              = "PRE-LAUNCH"
SPACECRAFT_CLOCK_START_COUNT    = "TEST STRING"
SPACECRAFT_CLOCK_STOP_COUNT     = "TEST STRING"
START_TIME                      = 2008-03-13T16:09:44
STOP_TIME                       = 2008-03-13T16:09:44
PLANET_DAY_NUMBER               = 356
PRODUCT_CREATION_TIME           = 2008-03-13T16:09:44
LOCAL_TRUE_SOLAR_TIME           = "00:00:00"


/* Data object definition */
OBJECT                          = TECP_GEN_COMMENTS_TABLE
  COLUMNS                       = 1
  INTERCHANGE_FORMAT            = ASCII
  ROW_BYTES                     = 199
  ROWS                          = 5
  DESCRIPTION                   = "General comments pertaining to this TECP
                                   dataset (all four RDRs)."

  OBJECT                        = COLUMN
    COLUMN_NUMBER               = 1
    NAME                        = "GEN_COMMENT"
    DATA_TYPE                   = CHARACTER
    START_BYTE                  = 2
    BYTES                       = 195
  DESCRIPTION                   = "General comments pertaining to this TECP
                                   dataset (all four RDRs)."
  END_OBJECT                    = COLUMN
END_OBJECT                      = TECP_GEN_COMMENTS_TABLE


OBJECT                          = TECP_EC_COMMENTS_TABLE
  COLUMNS                       = 1
  INTERCHANGE_FORMAT            = ASCII
  ROW_BYTES                     = 199
  ROWS                          = 5
  DESCRIPTION                   = "Comments pertaining to this EC RDR"

  OBJECT                        = COLUMN
    COLUMN_NUMBER               = 1
    NAME                        = "EC_COMMENT"
    DATA_TYPE                   = CHARACTER
```

```
    START_BYTE                = 2
    BYTES                     = 195
    DESCRIPTION               = "Comments pertaining to this EC RDR."
  END_OBJECT                  = COLUMN
END_OBJECT                    = TECP_EC_COMMENTS_TABLE

OBJECT                        = TECP_CONVERSIONS_TABLE
  COLUMNS                     = 2
  INTERCHANGE_FORMAT          = ASCII
  ROW_BYTES                   = 86
  ROW_SUFFIX_BYTES            = 113
  ROWS                        = 8
  DESCRIPTION                 = "Equations used to convert DNs to physical
                                 units for EC data. There are 86 bytes of
                                 data followed by 113 spare bytes, the
                                 last two of which are the <CR><LF> characters."

  OBJECT                      = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "EQUATION_NAME"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 2
    BYTES                     = 25
    DESCRIPTION               = "Name of the equation to be calculated
                                 with physical units."
  END_OBJECT = COLUMN

 OBJECT                       = COLUMN
    COLUMN_NUMBER             = 2
    NAME                      = "EQUATION"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 30
    BYTES                     = 56
    DESCRIPTION               = "Equation to be calculated or
                                DN range information"
  END_OBJECT                  = COLUMN

END_OBJECT                    = TECP_CONVERSIONS_TABLE


OBJECT                        = TECP_EC_PC_TABLE
COLUMNS                       = 4
INTERCHANGE_FORMAT            = ASCII
ROW_BYTES                     = 41
ROW_SUFFIX_BYTES              = 158
ROWS                          = 3
DESCRIPTION                   = "apc, bpc, and cpc are constants
                                used in the pc equation found in the
                                conversions table."

OBJECT                       = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "GAIN_SETTING"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 2
    BYTES                     = 9
    DESCRIPTION               = "Use the appropriate variables for the
```

```
                                appropriate gain setting in calculation
                                of pc."
  END_OBJECT                   = COLUMN


OBJECT                        = COLUMN
    COLUMN_NUMBER              = 2
    NAME                       = "apc"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 13
    BYTES                      = 9
    DESCRIPTION                = "apc variable."
  END_OBJECT                   = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER              = 3
    NAME                       = "bpc"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 23
    BYTES                      = 9
    DESCRIPTION                = "bpc variable"
  END_OBJECT                   = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER              = 4
    NAME                       = "cpc"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 33
    BYTES                      = 9
    DESCRIPTION                = "cpc variable."
  END_OBJECT                   = COLUMN

END_OBJECT                    = TECP_EC_PC_TABLE



OBJECT                        = TECP_EC_RM_TABLE
COLUMNS                       = 7
INTERCHANGE_FORMAT            = ASCII
ROW_BYTES                     = 70
ROW_SUFFIX_BYTES              = 129
ROWS                          = 18
DESCRIPTION                   = "Constants to caclulate the Resistance
                                of the medium (Rm) for a given needle
                                temperature. There are 70 bytes of
                                data followed by 129 spare bytes, the
                                last two of which are the <CR> and
                                <LF> characters."

OBJECT                        = COLUMN
    COLUMN_NUMBER              = 1
    NAME                       = "NAME"
    DATA_TYPE                  = CHARACTER
    START_BYTE                 = 2
    BYTES                      = 4
    DESCRIPTION                = "Name of coefficient set."
  END_OBJECT                   = COLUMN
```

```
OBJECT                         = COLUMN
    COLUMN_NUMBER               = 2
    NAME                        = "TEMPERATURE"
    UNITS                       = "Kelvin"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 8
    BYTES                       = 3
    DESCRIPTION                 = "Needle temperature corresponding to the
                                   coefficients on this row."
  END_OBJECT                    = COLUMN

OBJECT                         = COLUMN
    COLUMN_NUMBER               = 3
    NAME                        = "a"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 12
    BYTES                       = 11
    DESCRIPTION                 = "Coefficient a in Rm equation."
  END_OBJECT                    = COLUMN

OBJECT                         = COLUMN
    COLUMN_NUMBER               = 4
    NAME                        = "b"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 24
    BYTES                       = 11
    DESCRIPTION                 = "Coefficient b in Rm equation."
  END_OBJECT                    = COLUMN

OBJECT                         = COLUMN
    COLUMN_NUMBER               = 5
    NAME                        = "c"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 36
    BYTES                       = 11
    DESCRIPTION                 = "Coefficient c in Rm equation."
  END_OBJECT                    = COLUMN

OBJECT                         = COLUMN
    COLUMN_NUMBER               = 6
    NAME                        = "d"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 48
    BYTES                       = 11
    DESCRIPTION                 = "Coefficient d in Rm equation."
  END_OBJECT                    = COLUMN

OBJECT                         = COLUMN
    COLUMN_NUMBER               = 7
    NAME                        = "e"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 60
    BYTES                       = 11
    DESCRIPTION                 = "Coefficient e in Rm equation."
  END_OBJECT                    = COLUMN
END_OBJECT                     = TECP_EC_RM_TABLE
```

```
OBJECT                        = TECP_EC_TABLE

   INTERCHANGE_FORMAT         = ASCII
   COLUMNS                    = 13
   ROWS                       = 183
   ROW_BYTES                  = 199
   DESCRIPTION                = "Time-series TECP electrical conductivity
                                 data converted to physical units."

 OBJECT                       = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "TIME"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 1
    BYTES                     = 14
    DESCRIPTION               = "Read time of measurements in seconds."
  END_OBJECT                  = COLUMN

 OBJECT                       = COLUMN
    COLUMN_NUMBER             = 2
    NAME                      = "TIP_POS_R_PF"
    UNIT                     = "meters"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 16
    BYTES                     = 6
    DESCRIPTION               = "Radial coordinate of TECP needle tips
                                centroid in Payload Frame cylindrical
                                coordinates."
  END_OBJECT                  = COLUMN

 OBJECT                       = COLUMN
    COLUMN_NUMBER             = 3
    NAME                      = "TIP_POS_THETA_PF"
    UNIT                      = "degrees"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 23
    BYTES                     = 7
    DESCRIPTION               = "Azimuthal coordinate of TECP needle tips
                                 centroid in Payload Frame cylindrical
                                 coordinates, measured clockwise (as viewed
                                 from above) from the +x-axis."
  END_OBJECT                  = COLUMN

 OBJECT                       = COLUMN
    COLUMN_NUMBER             = 4
    NAME                      = "TIP_POS_Z_PF"
    UNIT                      = "meters"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 31
    BYTES                     = 6
    DESCRIPTION               = "Vertical coordinate of TECP needle tips
                                 centroid in Payload Frame cylindrical
                                 coordinates, measured positive downward."
  END_OBJECT                  = COLUMN
```

```
OBJECT                        = COLUMN
   COLUMN_NUMBER              = 5
   NAME                       = "ANGLE_TECP_RA"
   UNIT                       = "degrees"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 38
   BYTES                      = 7
   DESCRIPTION                = "Angle of TECP long axis (+z axis in TECP
                                frame) relative to a vector that is parallel
                                to the RA forearm and pointing away from the
                                lander.  This angle is measured clockwise as
                                viewed from the TECP side of the RA wrist
                                joint."
 END_OBJECT                   = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 6
   NAME                       = "TIP_POS_X_LLF"
   UNIT                       = "meters"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 46
   BYTES                      = 6
   DESCRIPTION                = "X coordinate of the TECP needle tips centroid
                                 in the Local Level Frame."
 END_OBJECT                   = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 7
   NAME                       = "TIP_POS_Y_LLF"
   UNIT                       = "meters"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 53
   BYTES                      = 6
   DESCRIPTION                = "Y coordinate of the TECP needle tips centroid
                                 in the Local Level Frame."
 END_OBJECT                   = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 8
   NAME                       = "TIP_POS_Z_LLF"
   UNIT                       = "meters"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 60
   BYTES                      = 6
   DESCRIPTION                = "Z coordinate of the TECP needle tips centroid
                                in the Local Level Frame, measured positive
                                downward."
 END_OBJECT                   = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 9
   NAME                       = "ANGLE_TECP_Z_LLF"
   UNIT                       = "meters"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 67
   BYTES                      = 6
   DESCRIPTION                = "Angle of TECP long axis (+z axis in TECP frame)
```

```
                              relative to the positive z-axis of the Local
                              Level Frame (parallel to gravity vector)."
  END_OBJECT                = COLUMN

 OBJECT                     = COLUMN
    COLUMN_NUMBER           = 10
    NAME                    = "TEMP_BOARD"
    UNIT                    = "Kelvin"
    DATA_TYPE               = ASCII_REAL
    START_BYTE              = 75
    BYTES                   = 6
    DESCRIPTION             = "Temperature of the TECP electronics board."
  END_OBJECT                = COLUMN

 OBJECT                     = COLUMN
    COLUMN_NUMBER           = 11
    NAME                    = "ELECTRICAL_CONDUCTIVITY"
    UNITS             = "microsiemens/cm"
    DATA_TYPE               = ASCII_REAL
    START_BYTE              = 82
    BYTES                   = 9
    DESCRIPTION             = "Electrical Conductivity"
  END_OBJECT                = COLUMN

 OBJECT                     = COLUMN
    COLUMN_NUMBER           = 12
    NAME                    = "EC_GAIN_SETTING"
    DATA_TYPE               = CHARACTER
    START_BYTE              = 93
    BYTES                   = 1
    DESCRIPTION             = "Gain setting for electrical conductivity
                              measurement, H, M, L."
  END_OBJECT                = COLUMN

 OBJECT                     = COLUMN
    COLUMN_NUMBER           = 13
    NAME                    = "COMMENT"
    DATA_TYPE               = CHARACTER
    START_BYTE              = 97
    BYTES                   = 100
    DESCRIPTION             = "Terse comment about measurement."
  END_OBJECT                = COLUMN

END_OBJECT                  = TECP_EC_TABLE

END
```

TECP_HUM

```
PDS_VERSION_ID              = PDS3
LABEL_REVISION_NOTE         = "2008-01-30, Initial"

/* File characteristics */
RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 201
FILE_RECORDS                = 199
```

```
/* Pointers to object in file */
^TECP_GEN_COMMENTS_TABLE      = ("PT018HUM_01______ABABABABT0.TAB",1)
^TECP_HUM_COMMENTS_TABLE      = ("PT018HUM_01______ABABABABT0.TAB",6)
^TECP_CONVERSIONS_TABLE       = ("PT018HUM_01______ABABABABT0.TAB",11)
^TECP_HUM_TABLE               = ("PT018HUM_01______ABABABABT0.TAB",18)


/* Identification */
DATA_SET_ID                   = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                    = "PT018TC__01_ABABABABT0"
PRODUCT_TYPE                  = "MECA_TECP_HUM"
PRODUCT_VERSION_ID            = "V1.0"
RELEASE_ID                    = 0001
INSTRUMENT_HOST_NAME          = "PHOENIX"
INSTRUMENT_HOST_ID            = PHX
INSTRUMENT_NAME               = "MECA THERMAL AND ELECTRICAL CONDUCTIVITY PROBE"
INSTRUMENT_ID                 = "MECA_TECP"
INSTRUMENT_MODE_ID            = "SCAN"
MISSION_NAME                  = "PHOENIX"
TARGET_NAME                   = MARS


OPS_TOKEN                     = "NULL"
OPS_TOKEN_ACTIVITY            = "NULL"
OPS_TOKEN_PAYLOAD             = "NULL"
OPS_TOKEN_SEQUENCE            = "NULL"


/* Time information */
MISSION_PHASE_NAME            = "PRE-LAUNCH"
SPACECRAFT_CLOCK_START_COUNT  = "TEST STRING"
SPACECRAFT_CLOCK_STOP_COUNT   = "TEST STRING"
START_TIME                    = 2008-03-13T14:21:56
STOP_TIME                     = 2008-03-13T14:21:56
PLANET_DAY_NUMBER             = 356
PRODUCT_CREATION_TIME         = 2008-03-13T14:21:56
LOCAL_TRUE_SOLAR_TIME         = "00:00:00"


/* Data object definition */
OBJECT                        = TECP_GEN_COMMENTS_TABLE
  COLUMNS                     = 1
  INTERCHANGE_FORMAT          = ASCII
  ROW_BYTES                   = 201
  ROWS                        = 5
  DESCRIPTION                 = "General comments pertaining to this TECP
                                 dataset (all four RDRs)."

  OBJECT                      = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "GEN_COMMENT"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 2
    BYTES                     = 197
  DESCRIPTION                 = "General comments pertaining to this TECP
                                 dataset (all four RDRs)."
```

```
  END_OBJECT                  = COLUMN
END_OBJECT                    = TECP_GEN_COMMENTS_TABLE


OBJECT                        = TECP_HUM_COMMENTS_TABLE
  COLUMNS                     = 1
  INTERCHANGE_FORMAT          = ASCII
  ROW_BYTES                   = 201
  ROWS                        = 5
  DESCRIPTION                 = "Comments pertaining to this HUM RDR"

  OBJECT                      = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "HUM_COMMENT"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 2
    BYTES                     = 197
    DESCRIPTION               = "Comments pertaining to this HUM RDR."
  END_OBJECT                  = COLUMN
END_OBJECT                    = TECP_HUM_COMMENTS_TABLE


OBJECT                        = TECP_CONVERSIONS_TABLE
  COLUMNS                     = 2
  INTERCHANGE_FORMAT          = ASCII
  ROW_BYTES                   = 68
  ROW_SUFFIX_BYTES            = 133
  ROWS                        = 7
  DESCRIPTION                 = "Equations used to convert DNs to physical
                                 units for HUM data. There are 68 bytes of
                                 data followed by 133 spare bytes, the
                                 last two of which are the <CR><LF>
                                 characters."

  OBJECT                      = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "EQUATION_NAME"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 2
    BYTES                     = 17
    DESCRIPTION               = "Name of the equation to be calculated
                                with physical units."
  END_OBJECT = COLUMN

 OBJECT                       = COLUMN
    COLUMN_NUMBER             = 2
    NAME                      = "EQUATION"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 22
    BYTES                     = 46
    DESCRIPTION               = "Equation to be calculated."
  END_OBJECT                  = COLUMN
END_OBJECT                    = TECP_CONVERSIONS_TABLE


OBJECT                        = TECP_HUM_TABLE
   INTERCHANGE_FORMAT         = ASCII
```

```
  COLUMNS                    = 13
  ROWS                       = 182
  ROW_BYTES                  = 201
  DESCRIPTION                = "Time-series TECP needle temperature data
                               converted to physical units."

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 1
   NAME                      = "TIME"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 1
   BYTES                     = 14
   DESCRIPTION               = "Read time of measurements in seconds."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 2
   NAME                      = "TIP_POS_R_PF"
   UNIT                     = "meters"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 16
   BYTES                     = 6
   DESCRIPTION               = "Radial coordinate of TECP needle tips
                               centroid in Payload Frame cylindrical
                               coordinates."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 3
   NAME                      = "TIP_POS_THETA_PF"
   UNIT                      = "degrees"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 23
   BYTES                     = 7
   DESCRIPTION               = "Azimuthal coordinate of TECP needle tips
                                centroid in Payload Frame cylindrical
                                coordinates, measured clockwise (as viewed
                                from above) from the +x-axis."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 4
   NAME                      = "TIP_POS_Z_PF"
   UNIT                      = "meters"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 31
   BYTES                     = 6
   DESCRIPTION               = "Vertical coordinate of TECP needle tips
                                centroid in Payload Frame cylindrical
                                coordinates, measured positive downward."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 5
   NAME                      = "ANGLE_TECP_RA"
   UNIT                      = "degrees"
   DATA_TYPE                 = ASCII_REAL
```

```
    START_BYTE                 = 38
    BYTES                      = 7
    DESCRIPTION                = "Angle of TECP long axis (+z axis in TECP
                                 frame) relative to a vector that is parallel
                                 to the RA forearm and pointing away from the
                                 lander.  This angle is measured clockwise as
                                 viewed from the TECP side of the RA wrist
                                 joint."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 6
    NAME                       = "TIP_POS_X_LLF"
    UNIT                       = "meters"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 46
    BYTES                      = 6
    DESCRIPTION                = "X coordinate of the TECP needle tips centroid
                                  in the Local Level Frame."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 7
    NAME                       = "TIP_POS_Y_LLF"
    UNIT                       = "meters"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 53
    BYTES                      = 6
    DESCRIPTION                = "Y coordinate of the TECP needle tips centroid
                                  in the Local Level Frame."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 8
    NAME                       = "TIP_POS_Z_LLF"
    UNIT                       = "meters"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 60
    BYTES                      = 6
    DESCRIPTION                = "Z coordinate of the TECP needle tips centroid
                                 in the Local Level Frame, measured positive
                                 downward."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 9
    NAME                       = "ANGLE_TECP_Z_LLF"
    UNIT                       = "meters"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 67
    BYTES                      = 6
    DESCRIPTION                = "Angle of TECP long axis (+z axis in TECP frame)
                                  relative to the positive z-axis of the Local
                                  Level Frame (parallel to gravity vector)."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
```

```
    COLUMN_NUMBER              = 10
    NAME                       = "TEMP_BOARD"
    UNIT                       = "Kelvin"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 75
    BYTES                      = 6
    DESCRIPTION                = "Temperature of the TECP electronics board."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 11
    NAME                       = "RELATIVE_HUMIDITY"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 82
    BYTES                      = 5
    DESCRIPTION                = "Relative humidity of the air in contact with the
                                  sensor on the TECP electronics board, with
                                  respect to saturation over ice."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 12
    NAME                       = "VAPOR_PRESSURE"
    UNIT                       = "Pascal"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 88
    BYTES                      = 9
    DESCRIPTION                = "Water vapor pressure corresponding to the measured
                                  RH and board temperature. "
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 13
    NAME                       = "COMMENT"
    DATA_TYPE                  = CHARACTER
    START_BYTE                 = 99
    BYTES                      = 100
    DESCRIPTION                = "Terse comment about measurement."
  END_OBJECT                   = COLUMN

END_OBJECT                     = TECP_HUM_TABLE


END
```

TECP_PRM

```
PDS_VERSION_ID                 = PDS3
LABEL_REVISION_NOTE            = "2008-01-30, Initial"

/* File characteristics */
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 192
FILE_RECORDS                   = 43

/* Pointers to object in file */
^TECP_GEN_COMMENTS_TABLE       = ("PT018PRM_01______ABABABABT0.TAB",1)
```

```
^TECP_PRM_COMMENTS_TABLE       = ("PT018PRM_01______ABABABABT0.TAB",6)
^TECP_CONVERSIONS_TABLE        = ("PT018PRM_01______ABABABABT0.TAB",11)
^TECP_PRM_TABLE                = ("PT018PRM_01______ABABABABT0.TAB",13)

/* Identification */
DATA_SET_ID                    = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                     = "TEST STRING"
PRODUCT_TYPE                   = "MECA_TECP_PRM"
PRODUCT_VERSION_ID             = "V1.0"
RELEASE_ID                     = 0001
INSTRUMENT_HOST_NAME           = "PHOENIX"
INSTRUMENT_HOST_ID             = PHX
INSTRUMENT_NAME                = "MECA THERMAL AND ELECTRICAL CONDUCTIVITY PROBE"
INSTRUMENT_ID                  = "MECA_TECP"
INSTRUMENT_MODE_ID             = "SCAN"
MISSION_NAME                   = "PHOENIX"
TARGET_NAME                    = MARS


OPS_TOKEN                      = "NULL"
OPS_TOKEN_ACTIVITY             = "NULL"
OPS_TOKEN_PAYLOAD              = "NULL"
OPS_TOKEN_SEQUENCE             = "NULL"


/* Time information */
MISSION_PHASE_NAME             = "PRE-LAUNCH"
SPACECRAFT_CLOCK_START_COUNT   = "TEST STRING"
SPACECRAFT_CLOCK_STOP_COUNT    = "TEST STRING"
START_TIME                     = 2008-03-13T16:09:44
STOP_TIME                      = 2008-03-13T16:09:44
PLANET_DAY_NUMBER              = 356
PRODUCT_CREATION_TIME          = 2008-03-13T16:09:44
LOCAL_TRUE_SOLAR_TIME          = "00:00:00"


/* Data object definition */
OBJECT                         = TECP_GEN_COMMENTS_TABLE
  COLUMNS                      = 1
  INTERCHANGE_FORMAT           = ASCII
  ROW_BYTES                    = 192
  ROWS                         = 5
  DESCRIPTION                  = "General comments pertaining to this TECP
                                  dataset (all four RDRs)."

  OBJECT                       = COLUMN
    COLUMN_NUMBER              = 1
    NAME                       = "GEN_COMMENT"
    DATA_TYPE                  = CHARACTER
    START_BYTE                 = 2
    BYTES                      = 188
  DESCRIPTION                  = "General comments pertaining to this TECP
                                  dataset (all four RDRs)."
  END_OBJECT                   = COLUMN
END_OBJECT                     = TECP_GEN_COMMENTS_TABLE
```

```
OBJECT                        = TECP_PRM_COMMENTS_TABLE
  COLUMNS                     = 1
  INTERCHANGE_FORMAT          = ASCII
  ROW_BYTES                   = 192
  ROWS                        = 5
  DESCRIPTION                 = "Comments pertaining to this PRM RDR"

  OBJECT                      = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "PRM_COMMENT"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 2
    BYTES                     = 188
    DESCRIPTION               = "Comments pertaining to this PRM RDR."
  END_OBJECT                  = COLUMN
END_OBJECT                    = TECP_PRM_COMMENTS_TABLE

OBJECT                        = TECP_CONVERSIONS_TABLE
  COLUMNS                     = 2
  INTERCHANGE_FORMAT          = ASCII
  ROW_BYTES                   = 79
  ROW_SUFFIX_BYTES            = 113
  ROWS                        = 2
  DESCRIPTION                 = "Equations used to convert DNs to physical
                                 units for PRM data. There are 79 bytes of
                                 data followed by 113 spare bytes, the
                                 last two of which are the <CR><LF> characters."

  OBJECT                      = COLUMN
    COLUMN_NUMBER             = 1
    NAME                      = "EQUATION_NAME"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 2
    BYTES                     = 21
    DESCRIPTION               = "Name of the equation to be calculated
                                 with physical units."
  END_OBJECT                  = COLUMN

 OBJECT                       = COLUMN
    COLUMN_NUMBER             = 2
    NAME                      = "EQUATION"
    DATA_TYPE                 = CHARACTER
    START_BYTE                = 26
    BYTES                     = 53
    DESCRIPTION               = "Equation to be calculated or
                                DN range information"
  END_OBJECT                  = COLUMN

END_OBJECT                    = TECP_CONVERSIONS_TABLE

OBJECT                        = TECP_PRM_TABLE

   INTERCHANGE_FORMAT         = ASCII
   COLUMNS                    = 12
   ROWS                       = 31
   ROW_BYTES                  = 192
   DESCRIPTION                = "Time-series TECP relative permittivity
```

```
                              data converted to physical units."

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 1
   NAME                      = "TIME"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 1
   BYTES                     = 14
   DESCRIPTION               = "Read time of measurements in seconds."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 2
   NAME                      = "TIP_POS_R_PF"
   UNIT                     = "meters"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 16
   BYTES                     = 6
   DESCRIPTION               = "Radial coordinate of TECP needle tips
                               centroid in Payload Frame cylindrical
                               coordinates."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 3
   NAME                      = "TIP_POS_THETA_PF"
   UNIT                      = "degrees"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 23
   BYTES                     = 7
   DESCRIPTION               = "Azimuthal coordinate of TECP needle tips
                                centroid in Payload Frame cylindrical
                                coordinates, measured clockwise (as viewed
                                from above) from the +x-axis."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 4
   NAME                      = "TIP_POS_Z_PF"
   UNIT                      = "meters"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 31
   BYTES                     = 6
   DESCRIPTION               = "Vertical coordinate of TECP needle tips
                                centroid in Payload Frame cylindrical
                                coordinates, measured positive downward."
 END_OBJECT                  = COLUMN

OBJECT                       = COLUMN
   COLUMN_NUMBER             = 5
   NAME                      = "ANGLE_TECP_RA"
   UNIT                      = "degrees"
   DATA_TYPE                 = ASCII_REAL
   START_BYTE                = 38
   BYTES                     = 7
   DESCRIPTION               = "Angle of TECP long axis (+z axis in TECP
                               frame) relative to a vector that is parallel
```

```
                            to the RA forearm and pointing away from the
                            lander.  This angle is measured clockwise as
                            viewed from the TECP side of the RA wrist
                            joint."
  END_OBJECT              = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 6
   NAME                   = "TIP_POS_X_LLF"
   UNIT                   = "meters"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 46
   BYTES                  = 6
   DESCRIPTION            = "X coordinate of the TECP needle tips centroid
                             in the Local Level Frame."
  END_OBJECT              = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 7
   NAME                   = "TIP_POS_Y_LLF"
   UNIT                   = "meters"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 53
   BYTES                  = 6
   DESCRIPTION            = "Y coordinate of the TECP needle tips centroid
                             in the Local Level Frame."
  END_OBJECT              = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 8
   NAME                   = "TIP_POS_Z_LLF"
   UNIT                   = "meters"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 60
   BYTES                  = 6
   DESCRIPTION            = "Z coordinate of the TECP needle tips centroid
                            in the Local Level Frame, measured positive
                            downward."
  END_OBJECT              = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 9
   NAME                   = "ANGLE_TECP_Z_LLF"
   UNIT                   = "meters"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 67
   BYTES                  = 6
   DESCRIPTION            = "Angle of TECP long axis (+z axis in TECP frame)
                             relative to the positive z-axis of the Local
                             Level Frame (parallel to gravity vector)."
  END_OBJECT              = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 10
   NAME                   = "TEMP_BOARD"
   UNIT                   = "Kelvin"
   DATA_TYPE              = ASCII_REAL
```

```
    START_BYTE                  = 75
    BYTES                       = 6
    DESCRIPTION                 = "Temperature of the TECP electronics board."
  END_OBJECT                    = COLUMN

 OBJECT                         = COLUMN
    COLUMN_NUMBER               = 11
    NAME                        = "RELATIVE_PERMITTIVITY"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 82
    BYTES                       = 6
    DESCRIPTION                 = "Relative permittivity at the measurement
                                   frequency of 6.25 MHz."
  END_OBJECT                    = COLUMN

  OBJECT                         = COLUMN
      COLUMN_NUMBER              = 12
      NAME                       = "COMMENT"
      DATA_TYPE                  = ASCII_REAL
      START_BYTE                 = 90
      BYTES                      = 100
      DESCRIPTION                = "Terse comment about PRM data."
  END_OBJECT                    = COLUMN



  END_OBJECT                      = TECP_PRM_TABLE

END
```

TECP_TC

```
PDS_VERSION_ID                = PDS3
LABEL_REVISION_NOTE           = "2008-01-30, Initial"

/* File characteristics */
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 218
FILE_RECORDS                  = 569


/* Pointers to object in file */
^TECP_GEN_COMMENTS_TABLE      = ("PT018TC__01______ABABABABT0.TAB",1)
^TECP_TC_COMMENTS_TABLE       = ("PT018TC__01______ABABABABT0.TAB",6)
^TECP_CONVERSIONS_TABLE       = ("PT018TC__01______ABABABABT0.TAB",11)
^TECP_TC_TABLE                = ("PT018TC__01______ABABABABT0.TAB",18)


/* Identification */
DATA_SET_ID                   = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                    = "PT018TC__01_ABABABABT0"
PRODUCT_TYPE                  = "MECA_TECP_TC"
PRODUCT_VERSION_ID            = "V1.0"
RELEASE_ID                    = 0001
INSTRUMENT_HOST_NAME          = "PHOENIX"
INSTRUMENT_HOST_ID            = PHX
```

```
INSTRUMENT_NAME                = "MECA THERMAL AND ELECTRICAL CONDUCTIVITY PROBE"
INSTRUMENT_ID                  = "MECA_TECP"
INSTRUMENT_MODE_ID             = "SCAN"
MISSION_NAME                   = "PHOENIX"
TARGET_NAME                    = MARS


OPS_TOKEN                      = "NULL"
OPS_TOKEN_ACTIVITY             = "NULL"
OPS_TOKEN_PAYLOAD              = "NULL"
OPS_TOKEN_SEQUENCE             = "NULL"


/* Time information */
MISSION_PHASE_NAME             = "PRE-LAUNCH"
SPACECRAFT_CLOCK_START_COUNT   = "TEST STRING"
SPACECRAFT_CLOCK_STOP_COUNT    = "TEST STRING"
START_TIME                     = 2008-03-13T14:21:56
STOP_TIME                      = 2008-03-13T14:21:56
PLANET_DAY_NUMBER              = 356
PRODUCT_CREATION_TIME          = 2008-03-13T14:21:56
LOCAL_TRUE_SOLAR_TIME          = "00:00:00"


/* Data object definition */
OBJECT                         = TECP_GEN_COMMENTS_TABLE
  COLUMNS                      = 1
  INTERCHANGE_FORMAT           = ASCII
  ROW_BYTES                    = 218
  ROWS                         = 5
  DESCRIPTION                  = "General comments pertaining to this TECP
                                  dataset (all four RDRs)."

  OBJECT                       = COLUMN
    COLUMN_NUMBER              = 1
    NAME                       = "GEN_COMMENT"
    DATA_TYPE                  = CHARACTER
    START_BYTE                 = 2
    BYTES                      = 214
  DESCRIPTION                  = "General comments pertaining to this TECP
                                  dataset (all four RDRs)."
  END_OBJECT                   = COLUMN
END_OBJECT                     = TECP_GEN_COMMENTS_TABLE


OBJECT                         = TECP_TC_COMMENTS_TABLE
  COLUMNS                      = 1
  INTERCHANGE_FORMAT           = ASCII
  ROW_BYTES                    = 218
  ROWS                         = 5
  DESCRIPTION                  = "Comments pertaining to this TC RDR"

  OBJECT                       = COLUMN
    COLUMN_NUMBER              = 1
    NAME                       = "TC_COMMENT"
    DATA_TYPE                  = CHARACTER
    START_BYTE                 = 2
```

```
    BYTES                         = 214
    DESCRIPTION                   = "Comments pertaining to this TC RDR."
  END_OBJECT                      = COLUMN
END_OBJECT                        = TECP_TC_COMMENTS_TABLE


OBJECT                            = TECP_CONVERSIONS_TABLE
  COLUMNS                         = 2
  INTERCHANGE_FORMAT              = ASCII
  ROW_BYTES                       = 84
  ROW_SUFFIX_BYTES                = 134
  ROWS                            = 7
  DESCRIPTION                     = "Equations used to convert DNs to physical
                                     units for TC data. There are 84 bytes of
                                     data followed by 134 spare bytes, the
                                     last two of which are the <CR><LF>
                                     characters."

  OBJECT                          = COLUMN
    COLUMN_NUMBER                 = 1
    NAME                          = "EQUATION_NAME"
    DATA_TYPE                     = CHARACTER
    START_BYTE                    = 2
    BYTES                         = 14
    DESCRIPTION                   = "Name of the equation to be calculated
                                    with physical units."
  END_OBJECT = COLUMN

 OBJECT                           = COLUMN
    COLUMN_NUMBER                 = 2
    NAME                          = "EQUATION"
    DATA_TYPE                     = CHARACTER
    START_BYTE                    = 19
    BYTES                         = 65
    DESCRIPTION                   = "Equation to be calculated."
  END_OBJECT                      = COLUMN
END_OBJECT                        = TECP_CONVERSIONS_TABLE


OBJECT                            = TECP_TC_TABLE
   INTERCHANGE_FORMAT             = ASCII
   COLUMNS                        = 16
   ROWS                           = 552
   ROW_BYTES                      = 218
   DESCRIPTION                    = "Time-series TECP needle temperature data
                                    converted to physical units."

 OBJECT                           = COLUMN
    COLUMN_NUMBER                 = 1
    NAME                          = "TIME"
    DATA_TYPE                     = ASCII_REAL
    START_BYTE                    = 1
    BYTES                         = 14
    DESCRIPTION                   = "Read time of measurements in seconds."
  END_OBJECT                      = COLUMN

 OBJECT                           = COLUMN
```

```
   COLUMN_NUMBER              = 2
   NAME                       = "TIP_POS_R_PF"
   UNIT                      = "meters"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 16
   BYTES                      = 6
   DESCRIPTION                = "Radial coordinate of TECP needle tips
                                centroid in Payload Frame cylindrical
                                coordinates."
  END_OBJECT                  = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 3
   NAME                       = "TIP_POS_THETA_PF"
   UNIT                       = "degrees"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 23
   BYTES                      = 7
   DESCRIPTION                = "Azimuthal coordinate of TECP needle tips
                                 centroid in Payload Frame cylindrical
                                 coordinates, measured clockwise (as viewed
                                 from above) from the +x-axis."
  END_OBJECT                  = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 4
   NAME                       = "TIP_POS_Z_PF"
   UNIT                       = "meters"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 31
   BYTES                      = 6
   DESCRIPTION                = "Vertical coordinate of TECP needle tips
                                 centroid in Payload Frame cylindrical
                                 coordinates, measured positive downward."
  END_OBJECT                  = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 5
   NAME                       = "ANGLE_TECP_RA"
   UNIT                       = "degrees"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 38
   BYTES                      = 7
   DESCRIPTION                = "Angle of TECP long axis (+z axis in TECP
                                frame) relative to a vector that is parallel
                                to the RA forearm and pointing away from the
                                lander.  This angle is measured clockwise as
                                viewed from the TECP side of the RA wrist
                                joint."
  END_OBJECT                  = COLUMN

OBJECT                        = COLUMN
   COLUMN_NUMBER              = 6
   NAME                       = "TIP_POS_X_LLF"
   UNIT                       = "meters"
   DATA_TYPE                  = ASCII_REAL
   START_BYTE                 = 46
```

```
    BYTES                       = 6
    DESCRIPTION                 = "X coordinate of the TECP needle tips centroid
                                   in the Local Level Frame."
  END_OBJECT                    = COLUMN

 OBJECT                         = COLUMN
    COLUMN_NUMBER               = 7
    NAME                        = "TIP_POS_Y_LLF"
    UNIT                        = "meters"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 53
    BYTES                       = 6
    DESCRIPTION                 = "Y coordinate of the TECP needle tips centroid
                                   in the Local Level Frame."
  END_OBJECT                    = COLUMN

 OBJECT                         = COLUMN
    COLUMN_NUMBER               = 8
    NAME                        = "TIP_POS_Z_LLF"
    UNIT                        = "meters"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 60
    BYTES                       = 6
    DESCRIPTION                 = "Z coordinate of the TECP needle tips centroid
                                  in the Local Level Frame, measured positive
                                  downward."
  END_OBJECT                    = COLUMN

 OBJECT                         = COLUMN
    COLUMN_NUMBER               = 9
    NAME                        = "ANGLE_TECP_Z_LLF"
    UNIT                        = "meters"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 67
    BYTES                       = 6
    DESCRIPTION                 = "Angle of TECP long axis (+z axis in TECP frame)
                                   relative to the positive z-axis of the Local
                                   Level Frame (parallel to gravity vector)."
  END_OBJECT                    = COLUMN

 OBJECT                         = COLUMN
    COLUMN_NUMBER               = 10
    NAME                        = "TEMP_BOARD"
    UNIT                        = "Kelvin"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 75
    BYTES                       = 6
    DESCRIPTION                 = "Temperature of the TECP electronics board."
  END_OBJECT                    = COLUMN

 OBJECT                         = COLUMN
    COLUMN_NUMBER               = 11
    NAME                        = "TEMP_NEEDLE_1"
    UNIT                        = "Kelvin"
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 82
    BYTES                       = 7
```

```
    DESCRIPTION                = "Temperature of  needle 1."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 12
    NAME                       = "TEMP_NEEDLE_2"
    UNIT                       = "Kelvin"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 90
    BYTES                      = 7
    DESCRIPTION                = "Temperature of needle 2."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 13
    NAME                       = "TEMP_NEEDLE_4"
    UNIT                       = "Kelvin"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 98
    BYTES                      = 7
    DESCRIPTION                = "Temperature of needle 4."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 14
    NAME                       = "HEATER_CURRENT"
    UNIT                       = "mA"
    DATA_TYPE                  = ASCII_REAL
    START_BYTE                 = 106
    BYTES                      = 6
    DESCRIPTION                = "Electrical current through needle heating
                                  resistor when 2.5 V DC power is applied."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 15
    NAME                       = "NEEDLE_HEATED"
    DATA_TYPE                  = ASCII_INTEGER
    START_BYTE                 = 113
    BYTES                      = 1
    MISSING_CONSTANT           = 0
    DESCRIPTION                = "Numeric label of the needle currently
                                 selected
                                 for heating 1, 2, or 4."
  END_OBJECT                   = COLUMN

 OBJECT                        = COLUMN
    COLUMN_NUMBER              = 16
    NAME                       = "COMMENT"
    DATA_TYPE                  = CHARACTER
    START_BYTE                 = 116
    BYTES                      = 100
    DESCRIPTION                = "Terse comment about measurement."
  END_OBJECT                   = COLUMN

END_OBJECT                     = TECP_TC_TABLE
```

```
END
```

WCL

ISE

```
PDS_VERSION_ID                          = PDS3
LABEL_REVISION_NOTE                     = "2008-04-14, Initial"

/* File Characteristics */
RECORD_TYPE                             = FIXED_LENGTH
RECORD_BYTES                            = 198
FILE_RECORDS                            = 11788

/*Pointers to Data Objects */
^WCL_HEADER_TABLE                       = ("ws030c0ise__00___13690000w0.tab",2)
^WCL_EVENT_TABLE                        = ("ws030c0ise__00___13690000w0.tab",17)
^WCL_DATA_HEADER_TABLE                  = ("ws030c0ise__00___13690000w0.tab",28)
^WCL_DATA_TABLE                         = ("ws030c0ise__00___13690000w0.tab",31)

/* Identification */
DATA_SET_ID                             = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                              = "WS030C0ISE__00___13690000W0"
PRODUCT_VERSION_ID                      = "V1.0"
PRODUCT_TYPE                            = "MECA_WCL_ISE"
RELEASE_ID                              = "0001"
INSTRUMENT_HOST_NAME                    = "PHOENIX"
INSTRUMENT_NAME                         = "MECA WET CHEMISTRY LABORATORY"
INSTRUMENT_HOST_ID                      = PHX
TARGET_NAME                             = "MARS"
INSTRUMENT_ID                           = "MECA_WCL"
INSTRUMENT_MODE_ID                      = "ISES"
MISSION_NAME                            = "PHOENIX"

OPS_TOKEN                               = 16#13690000#
OPS_TOKEN_ACTIVITY                      = 16#00001369#
OPS_TOKEN_PAYLOAD                       = 16#00000000#
OPS_TOKEN_COMMAND                       = 16#00000000#

/* Time information */
MISSION_PHASE_NAME                      = "PRIMARY MISSION"
SPACECRAFT_CLOCK_START_COUNT            = "898866772.185"
SPACECRAFT_CLOCK_STOP_COUNT             = "898892845.592"
START_TIME                              = 2008-06-25T13:11:41.283
STOP_TIME                               = 2008-06-25T20:26:15.818
EARTH_RECEIVED_START_TIME               = "UNK"
EARTH_RECEIVED_STOP_TIME                = "UNK"
PLANET_DAY_NUMBER                       = 30
LOCAL_TRUE_SOLAR_TIME                   = "10:34:19"
PRODUCT_CREATION_TIME                   = 2008-12-19T23:59:03.025

/* Data Object Definitions */

OBJECT                                  = WCL_HEADER_TABLE
  COLUMNS                               = 2
  INTERCHANGE_FORMAT                    = ASCII
```

```
  ROW_BYTES                           = 93
  ROWS                                = 13
  ROW_SUFFIX_BYTES                    = 105
  DESCRIPTION                         = "Two column ISE header table with 93
bytes of
                                        data followed by 105 spare bytes, the
last
                                        two of which are the <CR><LF>
characters."

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 1
    NAME                              = "HEADER FIELD NAME"
    DATA_TYPE                         = CHARACTER
    START_BYTE                        = 2
    BYTES                             = 25
  END_OBJECT                          = COLUMN

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 2
    NAME                              = "HEADER FIELD VALUE"
    DATA_TYPE                         = CHARACTER
    START_BYTE                        = 30
    BYTES                             = 60
  END_OBJECT                          = COLUMN
END_OBJECT                            = WCL_HEADER_TABLE

OBJECT                                = WCL_EVENT_TABLE
  COLUMNS                             = 3
  INTERCHANGE_FORMAT                  = ASCII
  ROW_BYTES                           = 149
  ROW_SUFFIX_BYTES                    = 49
  ROWS                                = 9
  DESCRIPTION                         = "Three column ISE events table with 149
bytes
                                        of data followed by 49 spare bytes, the
last
                                        two of which are the <CR><LF>
characters."

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 1
    NAME                              = "EVENT_NAME"
    DATA_TYPE                         = ASCII_REAL
    START_BYTE                        = 2
    BYTES                             = 20
    DESCRIPTION                       = "Name of event - solution dispense,
                                        drawer open, drawer close,
                                        reagent release"
  END_OBJECT                          = COLUMN

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 2
    NAME                              = "CMD_TIME"
    DATA_TYPE                         = ASCII_REAL
    START_BYTE                        = 24
    BYTES                             = 14
```

```
    MISSING_CONSTANT                      = 99999999999
    DESCRIPTION                           = "SCLK time the event was commanded by
                                            Phoenix"
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 3
    NAME                                  = "EVENT_NOTES"
    DATA_TYPE                             = CHARACTER
    START_BYTE                            = 40
    BYTES                                 = 108
    DESCRIPTION                           = "Description of the event."
  END_OBJECT                              = COLUMN
END_OBJECT                                = WCL_EVENT_TABLE

OBJECT                                    = WCL_DATA_HEADER_TABLE
  COLUMNS                                   = 16
  INTERCHANGE_FORMAT                        = ASCII
  ROW_BYTES                                 = 114
  ROW_SUFFIX_BYTES                          = 84
  ROWS                                      = 1
  DESCRIPTION                               = "Sixteen column ISE header table."

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 1
    NAME                                  = "TIME_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 2
    BYTES                                 = 4
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 2
    NAME                                  = "Li_a_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 9
    BYTES                                 = 4

  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 3
    NAME                                  = "Li_b_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 16
    BYTES                                 = 4
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 4
    NAME                                  = "pH_a_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 23
    BYTES                                 = 4
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
```

```
    COLUMN_NUMBER                        = 5
    NAME                                 = "pH_b_HEADER"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 30
    BYTES                                = 4
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 6
    NAME                                 = "pH_irid_HEADER"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 37
    BYTES                                = 7
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 7
    NAME                                 = "Na_HEADER"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 47
    BYTES                                = 2
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 8
    NAME                                 = "K_HEADER"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 52
    BYTES                                = 1
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 9
    NAME                                 = "NH4_HEADER"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 56
    BYTES                                = 3
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 10
    NAME                                 = "Ca_HEADER"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 62
    BYTES                                = 2
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 11
    NAME                                 = "Mg_HEADER"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 67
    BYTES                                = 2
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 12
```

```
    NAME                                  = "Ba_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 72
    BYTES                                 = 2
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 13
    NAME                                  = "Cl_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 77
    BYTES                                 = 2
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 14
    NAME                                  = "ClO4_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 82
    BYTES                                 = 4
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 15
    NAME                                  = "Br_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 89
    BYTES                                 = 2
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 16
    NAME                                  = "I_HEADER"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 94
    BYTES                                 = 1
  END_OBJECT                              = COLUMN

END_OBJECT                                = WCL_DATA_HEADER_TABLE



OBJECT                                    = WCL_DATA_TABLE
  COLUMNS                                   = 16
  INTERCHANGE_FORMAT                        = ASCII
  ROW_BYTES                                 = 198
  ROWS                                      = 11758
  DESCRIPTION                               = "Sixteen column ISE data table."

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 1
    NAME                                  = "TIME"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 1
    BYTES                                 = 14
    DESCRIPTION                           = "series of measurement SCLK read times"
```

```
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 2
    NAME                                = "Li_a"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 16
    BYTES                               = 11
    DESCRIPTION                         = "series of lithium electrode
                                           potentials (1 of 2)."
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 3
    NAME                                = "Li_b"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 28
    BYTES                               = 11
    DESCRIPTION                         = "series of lithium electrode
                                           potentials (2 of 2)."
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 4
    NAME                                = "pH_a"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 40
    BYTES                               = 11
    DESCRIPTION                         = "series of polymer pH electrode
                                           potentials (1 of 2)."
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 5
    NAME                                = "pH_b"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 52
    BYTES                               = 11
    DESCRIPTION                         = "series of polymer pH electrode
                                          potentials (2 of 2)."
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 6
    NAME                                = "pH_irid"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 64
    BYTES                               = 11
    DESCRIPTION                         = "series of iridium pH electrode
potentials."
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 7
    NAME                                = "Na"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 76
```

```
    BYTES                                    = 11
    DESCRIPTION                              = "series of sodium electrode potentials."
  END_OBJECT                                 = COLUMN

  OBJECT                                     = COLUMN
    COLUMN_NUMBER                            = 8
    NAME                                     = "K"
    DATA_TYPE                                = ASCII_REAL
    START_BYTE                               = 88
    BYTES                                    = 11
    DESCRIPTION                              = "series of potassium electrode
potentials."
  END_OBJECT                                 = COLUMN

  OBJECT                                     = COLUMN
    COLUMN_NUMBER                            = 9
    NAME                                     = "NH4"
    DATA_TYPE                                = ASCII_REAL
    START_BYTE                               = 100
    BYTES                                    = 11
    DESCRIPTION                              = "series of ammonium electrode
potentials."
  END_OBJECT                                 = COLUMN

  OBJECT                                     = COLUMN
    COLUMN_NUMBER                            = 10
    NAME                                     = "Ca"
    DATA_TYPE                                = ASCII_REAL
    START_BYTE                               = 112
    BYTES                                    = 11
    DESCRIPTION                              = "series of calcium electrode potentials."
  END_OBJECT                                 = COLUMN

  OBJECT                                     = COLUMN
    COLUMN_NUMBER                            = 11
    NAME                                     = "Mg"
    DATA_TYPE                                = ASCII_REAL
    START_BYTE                               = 124
    BYTES                                    = 11
    DESCRIPTION                              = "series of magnesium electrode
potentials."
  END_OBJECT                                 = COLUMN

  OBJECT                                     = COLUMN
    COLUMN_NUMBER                            = 12
    NAME                                     = "Ba"
    DATA_TYPE                                = ASCII_REAL
    START_BYTE                               = 136
    BYTES                                    = 11
    DESCRIPTION                              = "series of barium electrode potentials."
  END_OBJECT                                 = COLUMN

  OBJECT                                     = COLUMN
    COLUMN_NUMBER                            = 13
    NAME                                     = "Cl"
    DATA_TYPE                                = ASCII_REAL
    START_BYTE                               = 148
```

```
    BYTES                                  = 11
    DESCRIPTION                            = "series of chloride electrode
potentials."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 14
    NAME                                   = "ClO4"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 160
    BYTES                                  = 11
    DESCRIPTION                            = "series of perchlorate electrode
potentials."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 15
    NAME                                   = "Br"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 172
    BYTES                                  = 11
    DESCRIPTION                            = "series of bromide electrode potentials."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 16
    NAME                                   = "I"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 184
    BYTES                                  = 11
    DESCRIPTION                            = "series of iodide electrode potentials."
  END_OBJECT                               = COLUMN

END_OBJECT                                 = WCL_DATA_TABLE

END
```

CND

```
PDS_VERSION_ID                             = PDS3
LABEL_REVISION_NOTE                        = "2008-04-14, Initial"

/* File Characteristics */
RECORD_TYPE                                = FIXED_LENGTH
RECORD_BYTES                               = 198
FILE_RECORDS                               = 1219

/*Pointers to Data Objects */
^WCL_HEADER_TABLE                          = ("ws030c0cnd__00___13690000w0.tab",2)
^WCL_EVENT_TABLE                           = ("ws030c0cnd__00___13690000w0.tab",18)
^WCL_DATA_HEADER_TABLE                     = ("ws030c0cnd__00___13690000w0.tab",29)
^WCL_DATA_TABLE                            = ("ws030c0cnd__00___13690000w0.tab",32)

/* Identification */
DATA_SET_ID                                = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                                 = "WS030C0CND__00___13690000W0"
```

```
PRODUCT_VERSION_ID                        = "V1.0"
PRODUCT_TYPE                              = "MECA_WCL_COND"
RELEASE_ID                                = "0001"
INSTRUMENT_HOST_NAME                      = "PHOENIX"
INSTRUMENT_NAME                           = "MECA WET CHEMISTRY LABORATORY"
INSTRUMENT_HOST_ID                        = PHX
TARGET_NAME                               = "MARS"
INSTRUMENT_ID                             = "MECA_WCL"
INSTRUMENT_MODE_ID                        = "COND"
MISSION_NAME                              = "PHOENIX"

OPS_TOKEN                                 = 16#13690000#
OPS_TOKEN_ACTIVITY                        = 16#00001369#
OPS_TOKEN_PAYLOAD                         = 16#00000000#
OPS_TOKEN_COMMAND                         = 16#00000000#

/* Time information */
MISSION_PHASE_NAME                        = "PRIMARY MISSION"
SPACECRAFT_CLOCK_START_COUNT              = "898867342.007"
SPACECRAFT_CLOCK_STOP_COUNT               = "898892921.436"
START_TIME                                = 2008-06-25T13:21:10.586
STOP_TIME                                 = 2008-06-25T20:27:31.209
EARTH_RECEIVED_START_TIME                 = "UNK"
EARTH_RECEIVED_STOP_TIME                  = "UNK"
PLANET_DAY_NUMBER                         = 30
LOCAL_TRUE_SOLAR_TIME                     = "10:43:33"
PRODUCT_CREATION_TIME                     = 2008-12-19T23:59:10.619


/* Data Object Definitions */

OBJECT                                    = WCL_HEADER_TABLE
  COLUMNS                                 = 2
  INTERCHANGE_FORMAT                      = ASCII
  ROW_BYTES                               = 93
  ROWS                                    = 14
  ROW_SUFFIX_BYTES                        = 105
  DESCRIPTION                             = "Two column conductivity header table
                                            with 93 bytes of data followed by 105
                                            spare bytes, the last two of which are
                                            the <CR><LF> characters."

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 1
    NAME                                  = "HEADER FIELD NAME"
    DATA_TYPE                             = CHARACTER
    START_BYTE                            = 2
    BYTES                                 = 25
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 2
    NAME                                  = "HEADER FIELD VALUE"
    DATA_TYPE                             = CHARACTER
    START_BYTE                            = 30
    BYTES                                 = 62
```

```
  END_OBJECT                              = COLUMN
END_OBJECT                                = WCL_HEADER_TABLE

OBJECT                                    = WCL_EVENT_TABLE
  COLUMNS                                 = 3
  INTERCHANGE_FORMAT                      = ASCII
  ROW_BYTES                               = 149
  ROW_SUFFIX_BYTES                        = 49
  ROWS                                    = 9
  DESCRIPTION                             = "Three column conductivity events
                                            table."

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 1
    NAME                                  = "EVENT_NAME"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 2
    BYTES                                 = 20
    DESCRIPTION                           = "Name of event - general_note,calibrant
                                            crucible, sample addition, acid
                                            crucible, BaCl2 crucible"
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 2
    NAME                                  = "CMD_TIME"
    DATA_TYPE                             = ASCII_REAL
    START_BYTE                            = 24
    BYTES                                 = 14
    MISSING_CONSTANT                      = 99999999999
    DESCRIPTION                           = "SCLK time the event was commanded by
                                            Phoenix"
  END_OBJECT                              = COLUMN

  OBJECT                                  = COLUMN
    COLUMN_NUMBER                         = 3
    NAME                                  = "EVENT_NOTES"
    DATA_TYPE                             = CHARACTER
    START_BYTE                            = 40
    BYTES                                 = 108
    DESCRIPTION                           = "Description of the event."
  END_OBJECT                              = COLUMN
END_OBJECT                                = WCL_EVENT_TABLE


OBJECT                                    = WCL_DATA_HEADER_TABLE
  COLUMNS                                 = 3
  INTERCHANGE_FORMAT                      = ASCII
  ROW_BYTES                               = 29
  ROWS                                    = 1
  ROW_SUFFIX_BYTES                        = 169
  DESCRIPTION                             = "Three column conductivity data header
                                            table with 29 bytes of data followed by
                                            169 spare bytes, the last two of which
                                            are the <CR><LF> characters."

  OBJECT                                  = COLUMN
```

```
    COLUMN_NUMBER                   = 1
    NAME                            = "TIME_HEADER"
    DATA_TYPE                       = ASCII_REAL
    START_BYTE                      = 2
    BYTES                           = 4
  END_OBJECT                        = COLUMN

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 2
    NAME                            = "COND_LOW_HEADER"
    DATA_TYPE                       = ASCII_REAL
    START_BYTE                      = 9
    BYTES                           = 8
  END_OBJECT                        = COLUMN

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 3
    NAME                            = "COND_HIGH_HEADER"
    DATA_TYPE                       = ASCII_REAL
    START_BYTE                      = 20
    BYTES                           = 9
  END_OBJECT                        = COLUMN

END_OBJECT                          = WCL_DATA_HEADER_TABLE

OBJECT                              = WCL_DATA_TABLE
  COLUMNS                           = 3
  INTERCHANGE_FORMAT                = ASCII
  ROW_BYTES                         = 39
  ROWS                              = 1188
  ROW_SUFFIX_BYTES                  = 159
  DESCRIPTION                       = "Three column conductivity data table
                                      with 39 bytes of data followed by 159
                                      spare bytes, the last two of which are
                                      the <CR><LF> characters."

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 1
    NAME                            = "TIME"
    DATA_TYPE                       = ASCII_REAL
    START_BYTE                      = 1
    BYTES                           = 14
    DESCRIPTION                     = "series of SCLK CMD_read times"
  END_OBJECT                        = COLUMN

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 2
    NAME                            = "COND_LOW"
    DATA_TYPE                       = ASCII_REAL
    START_BYTE                      = 16
    BYTES                           = 11
    DESCRIPTION                     = "series of low range conductance
                                      measurements in micro-siemens."
  END_OBJECT                        = COLUMN

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 3
```

```
    NAME                                    = "COND_HIGH"
    DATA_TYPE                               = ASCII_REAL
    START_BYTE                              = 28
    BYTES                                   = 11
    DESCRIPTION                             = "series of high range conductance
                                              measurements in micro-siemens."
  END_OBJECT                                = COLUMN


END_OBJECT                                  = WCL_DATA_TABLE

END
```

CV

```
PDS_VERSION_ID                              = PDS3
LABEL_REVISION_NOTE                         = "2008-04-14, Initial"

/* File Characteristics */
RECORD_TYPE                                 = STREAM
FILE_RECORDS                                = 2032

/* Pointers to Data Objects */
^WCL_HEADER_TABLE                           = ("ws030c0cv_3_00___13690000w0.tab",199)
^CV_CALIBRATION_TABLE                       = ("ws030c0cv_3_00___13690000w0.tab",3763)
^WCL_EVENT_TABLE                            = ("ws030c0cv_3_00___13690000w0.tab",5941)
^WCL_SCAN_HEADER_TABLE                      = ("ws030c0cv_3_00___13690000w0.tab",7129)
^WCL_SCAN_TABLE                             = ("ws030c0cv_3_00___13690000w0.tab",23709)

/* Identification Data Elements */
/* Identification */
DATA_SET_ID                                 = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                                  = "WS030C0CV_3_00___13690000W0"
PRODUCT_VERSION_ID                          = "V1.0"
PRODUCT_TYPE                                = "MECA_WCL_CV"
RELEASE_ID                                  = "0001"
INSTRUMENT_HOST_NAME                        = "PHOENIX"
INSTRUMENT_NAME                             = "MECA WET CHEMISTRY LABORATORY"
INSTRUMENT_HOST_ID                          = PHX
TARGET_NAME                                 = "MARS"
INSTRUMENT_ID                               = "MECA_WCL"
INSTRUMENT_MODE_ID                          = "CV"
MISSION_NAME                                = "PHOENIX"

OPS_TOKEN                                   = 16#13690000#
OPS_TOKEN_ACTIVITY                          = 16#00001369#
OPS_TOKEN_PAYLOAD                           = 16#00000000#
OPS_TOKEN_COMMAND                           = 16#00000000#

/* Time information */
MISSION_PHASE_NAME                          = "PRIMARY MISSION"
SPACECRAFT_CLOCK_START_COUNT                = "898876488.651"
SPACECRAFT_CLOCK_STOP_COUNT                 = "898883797.284"
START_TIME                                  = 2008-06-25T15:53:39.083
STOP_TIME                                   = 2008-06-25T17:55:26.634
EARTH_RECEIVED_START_TIME                   = "UNK"
```

```
EARTH_RECEIVED_STOP_TIME                = "UNK"
PLANET_DAY_NUMBER                       = 30
LOCAL_TRUE_SOLAR_TIME                   = "13:11:58"
PRODUCT_CREATION_TIME                   = 2008-12-19T23:59:30.557



/* Data Object Definitions */

OBJECT                                  = WCL_HEADER_TABLE
  COLUMNS                               = 2
  INTERCHANGE_FORMAT                    = ASCII
  ROW_BYTES                             = 93
  ROWS                                  = 16
  ROW_SUFFIX_BYTES                      = 105
  DESCRIPTION                           = "Two column CV header table with 93 bytes
of
                                          data followed by 105 spare bytes, the
last
                                          two of which are the <CR><LF>
characters."

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 1
    NAME                                = "HEADER FIELD NAME"
    DATA_TYPE                           = CHARACTER
    START_BYTE                          = 2
    BYTES                               = 25
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 2
    NAME                                = "HEADER FIELD VALUE"
    DATA_TYPE                           = CHARACTER
    START_BYTE                          = 30
    BYTES                               = 62
  END_OBJECT                            = COLUMN
END_OBJECT                              = WCL_HEADER_TABLE

OBJECT                                  = CV_CALIBRATION_TABLE
   COLUMNS                              = 5
   INTERCHANGE_FORMAT                   = ASCII
   ROW_BYTES                            = 41
   ROW_SUFFIX_BYTES                     = 157
   ROWS                                 = 9
   DESCRIPTION                          = "Five column CV conversion table with 41
bytes
                                          of data followed by 157 spare bytes, the
last
                                          two of which are the <CR><LF>
characters."

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 1
    NAME                                = "ELECTRODE"
    DATA_TYPE                           = CHARACTER
    START_BYTE                          = 2
```

```
    BYTES                                  = 4
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 2
    NAME                                   = "GAIN"
    DATA_TYPE                              = CHARACTER
    START_BYTE                             = 9
    BYTES                                  = 3
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 3
    NAME                                   = "SLOPE"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 14
    BYTES                                  = 11
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 4
    NAME                                   = "INTERCEPT"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 26
    BYTES                                  = 11
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 5
    NAME                                   = "PHYSICAL_UNIT"
    DATA_TYPE                              = CHARACTER
    START_BYTE                             = 39
    BYTES                                  = 2
  END_OBJECT                               = COLUMN
END_OBJECT                                 = CV_CALIBRATION_TABLE

OBJECT                                     = WCL_EVENT_TABLE
  COLUMNS                                  = 3
  INTERCHANGE_FORMAT                       = ASCII
  ROW_BYTES                                = 149
  ROW_SUFFIX_BYTES                         = 49
  ROWS                                     = 4
  DESCRIPTION                              = "Three column CV events table."

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 1
    NAME                                   = "EVENT_NAME"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 2
    BYTES                                  = 20
    DESCRIPTION                            = "Name of event - solution dispense,
                                             drawer open, drawer close,
                                             reagent release"
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 2
```

```
    NAME                                    = "CMD_TIME"
    DATA_TYPE                               = ASCII_REAL
    START_BYTE                              = 24
    BYTES                                   = 14
    MISSING_CONSTANT                        = 99999999999
    DESCRIPTION                             = "SCLK time the event was commanded by
                                              Phoenix"
  END_OBJECT                                = COLUMN

  OBJECT                                    = COLUMN
    COLUMN_NUMBER                           = 3
    NAME                                    = "EVENT_NOTES"
    DATA_TYPE                               = CHARACTER
    START_BYTE                              = 40
    BYTES                                   = 108
    DESCRIPTION                             = "Description of the event."
  END_OBJECT                                = COLUMN
END_OBJECT                                  = WCL_EVENT_TABLE

OBJECT                                      = WCL_SCAN_HEADER_TABLE
  COLUMNS                                   = 2
  INTERCHANGE_FORMAT                        = ASCII
  ROW_BYTES                                 = 2312
  ROWS                                      = 7

  OBJECT                                    = CONTAINER
    NAME                                    = SCAN_HEADER_INFO
    REPETITIONS                             = 66
    START_BYTE                              = 1
    BYTES                                   = 35
    DESCRIPTION                             = "Scan parameter information for
                                               each CV scan data set."

    OBJECT                                  = COLUMN
      COLUMN_NUMBER                         = 1
      NAME                                  = "SCAN_HEADER FIELD NAME"
      DATA_TYPE                             = CHARACTER
      START_BYTE                            = 2
      BYTES                                 = 17
    END_OBJECT                              = COLUMN

    OBJECT                                  = COLUMN
      COLUMN_NUMBER                         = 2
      NAME                                  = "SCAN_HEADER FIELD VALUE"
      DATA_TYPE                             = ASCII_REAL
      START_BYTE                            = 21
      BYTES                                 = 14
    END_OBJECT                              = COLUMN
  END_OBJECT                                = CONTAINER
END_OBJECT                                  = WCL_SCAN_HEADER_TABLE

OBJECT                                      = WCL_SCAN_TABLE
  COLUMNS                                   = 2
  INTERCHANGE_FORMAT                        = ASCII
  ROW_BYTES                                 = 1586
  ROWS                                      = 1987
```

```
    OBJECT                                 = CONTAINER
      NAME                                 = "WCL DATA VALUES"
      REPETITIONS                          = 66
      START_BYTE                           = 1
      BYTES                                = 24
      DESCRIPTION                          = "Cyclic voltammetry data"

      OBJECT                               = COLUMN
        COLUMN_NUMBER                      = 1
        NAME                               = "MILLIVOLTS"
        DATA_TYPE                          = ASCII_REAL
        START_BYTE                         = 1
        BYTES                              = 11
        MISSING_CONSTANT                   = 99999999999
        DESCRIPTION                        = "Potential in mV"
      END_OBJECT                           = COLUMN

      OBJECT                               = COLUMN
        COLUMN_NUMBER                      = 2
        NAME                               = "NANOAMPS"
        DATA_TYPE                          = ASCII_REAL
        START_BYTE                         = 13
        BYTES                              = 11
        MISSING_CONSTANT                   = 99999999999
        DESCRIPTION                        = "Current in nA"
      END_OBJECT                           = COLUMN
    END_OBJECT                             = CONTAINER
  END_OBJECT                               = WCL_SCAN_TABLE

  END
```

CP

```
PDS_VERSION_ID                           = PDS3
LABEL_REVISION_NOTE                      = "2008-04-14, Initial"

/* File Characteristics */
RECORD_TYPE                              = STREAM
FILE_RECORDS                             = 2062

/* Pointers to Data Objects */
^WCL_HEADER_TABLE                        = ("ws030c0cp_0_00___13690000w0.tab",199)
^CP_CALIBRATION_TABLE                    = ("ws030c0cp_0_00___13690000w0.tab",3169)
^WCL_EVENT_TABLE                         = ("ws030c0cp_0_00___13690000w0.tab",5347)
^WCL_SCAN_HEADER_TABLE                   = ("ws030c0cp_0_00___13690000w0.tab",7525)
^WCL_SCAN_TABLE                          = ("ws030c0cp_0_00___13690000w0.tab",18470)

/* Identification */
DATA_SET_ID                              = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                               = "WS030C0CP_0_00___13690000W0"
PRODUCT_VERSION_ID                       = "V1.0"
PRODUCT_TYPE                             = "MECA_WCL_CP"
RELEASE_ID                               = "0001"
INSTRUMENT_HOST_NAME                     = "PHOENIX"
INSTRUMENT_NAME                          = "MECA WET CHEMISTRY LABORATORY"
INSTRUMENT_HOST_ID                       = PHX
```

```
TARGET_NAME                        = "MARS"
INSTRUMENT_ID                      = "MECA_WCL"
INSTRUMENT_MODE_ID                 = "CP"
MISSION_NAME                       = "PHOENIX"

OPS_TOKEN                          = 16#13690000#
OPS_TOKEN_ACTIVITY                 = 16#00001369#
OPS_TOKEN_PAYLOAD                  = 16#00000000#
OPS_TOKEN_COMMAND                  = 16#00000000#

/* Time information */
MISSION_PHASE_NAME                 = "PRIMARY MISSION"
SPACECRAFT_CLOCK_START_COUNT       = "898868068.177"
SPACECRAFT_CLOCK_STOP_COUNT        = "898884815.916"
START_TIME                         = 2008-06-25T13:33:17.249
STOP_TIME                          = 2008-06-25T18:12:27.101
EARTH_RECEIVED_START_TIME          = "UNK"
EARTH_RECEIVED_STOP_TIME           = "UNK"
PLANET_DAY_NUMBER                  = 30
LOCAL_TRUE_SOLAR_TIME              = "10:55:20"
PRODUCT_CREATION_TIME              = 2008-12-20T00:00:08.055


/* Data Object Definitions */

OBJECT                             = WCL_HEADER_TABLE
  COLUMNS                          = 2
  INTERCHANGE_FORMAT               = ASCII
  ROW_BYTES                        = 93
  ROWS                             = 13
  ROW_SUFFIX_BYTES                 = 105
  DESCRIPTION                      = "Two column CV header table with 93
                                     bytes of data followed by 105 spare
                                     bytes, the last two of which are the
                                     <CR><LF> characters."

  OBJECT                           = COLUMN
    COLUMN_NUMBER                  = 1
    NAME                           = "HEADER FIELD NAME"
    DATA_TYPE                      = CHARACTER
    START_BYTE                     = 2
    BYTES                          = 25
  END_OBJECT                       = COLUMN

  OBJECT                           = COLUMN
    COLUMN_NUMBER                  = 2
    NAME                           = "HEADER FIELD VALUE"
    DATA_TYPE                      = CHARACTER
    START_BYTE                     = 30
    BYTES                          = 62
  END_OBJECT                       = COLUMN
END_OBJECT                         = WCL_HEADER_TABLE


OBJECT                             = CP_CALIBRATION_TABLE
  COLUMNS                          = 5
```

```
  INTERCHANGE_FORMAT                     = ASCII
  ROW_BYTES                              = 41
  ROW_SUFFIX_BYTES                       = 157
  ROWS                                   = 9
  DESCRIPTION                            = "Five column CP conversion table with
                                           41 bytes of data followed by 157 spare
                                           bytes, the last two of which are the
                                           <CR><LF> characters."

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 1
    NAME                                 = "ELECTRODE"
    DATA_TYPE                            = CHARACTER
    START_BYTE                           = 2
    BYTES                                = 4
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 2
    NAME                                 = "GAIN"
    DATA_TYPE                            = CHARACTER
    START_BYTE                           = 9
    BYTES                                = 3
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 3
    NAME                                 = "SLOPE"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 14
    BYTES                                = 11
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 4
    NAME                                 = "INTERCEPT"
    DATA_TYPE                            = ASCII_REAL
    START_BYTE                           = 26
    BYTES                                = 11
  END_OBJECT                             = COLUMN

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 5
    NAME                                 = "PHYSICAL_UNIT"
    DATA_TYPE                            = CHARACTER
    START_BYTE                           = 39
    BYTES                                = 2
  END_OBJECT                             = COLUMN
END_OBJECT                               = CP_CALIBRATION_TABLE

OBJECT                                   = WCL_EVENT_TABLE
  COLUMNS                                = 3
  INTERCHANGE_FORMAT                     = ASCII
  ROW_BYTES                              = 149
  ROW_SUFFIX_BYTES                       = 49
  ROWS                                   = 9
  DESCRIPTION                            = "Three column CV events table."
```

```
  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 1
    NAME                              = "EVENT_NAME"
    DATA_TYPE                         = ASCII_REAL
    START_BYTE                        = 2
    BYTES                             = 20
    DESCRIPTION                       = "Name of event - solution dispense,
                                        drawer open, drawer close,
                                        reagent release"
  END_OBJECT                          = COLUMN

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 2
    NAME                              = "CMD_TIME"
    DATA_TYPE                         = ASCII_REAL
    START_BYTE                        = 24
    BYTES                             = 14
    MISSING_CONSTANT                  = 99999999999
    DESCRIPTION                       = "SCLK time the event was commanded by
                                        Phoenix"
  END_OBJECT                          = COLUMN

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 3
    NAME                              = "EVENT_NOTES"
    DATA_TYPE                         = CHARACTER
    START_BYTE                        = 40
    BYTES                             = 108
    DESCRIPTION                       = "Description of the event."
  END_OBJECT                          = COLUMN
END_OBJECT                            = WCL_EVENT_TABLE


OBJECT                                = WCL_SCAN_HEADER_TABLE
  COLUMNS                             = 2
  INTERCHANGE_FORMAT                  = ASCII
  ROW_BYTES                           = 1507
  ROWS                                = 7

  OBJECT                              = CONTAINER
    NAME                              = WCL_HEADER_INFO
    REPETITIONS                       = 43
    START_BYTE                        = 1
    BYTES                             = 35
    DESCRIPTION                       = "Scan parameter information for
                                         each CP analysis set."

    OBJECT                            = COLUMN
      COLUMN_NUMBER                   = 1
      NAME                            = "HEADER FIELD NAME"
      DATA_TYPE                       = CHARACTER
      START_BYTE                      = 2
      BYTES                           = 17
    END_OBJECT                        = COLUMN

    OBJECT                            = COLUMN
```

```
      COLUMN_NUMBER                        = 2
      NAME                                 = "HEADER FIELD VALUE"
      DATA_TYPE                            = ASCII_REAL
      START_BYTE                           = 21
      BYTES                                = 14
    END_OBJECT                             = COLUMN
  END_OBJECT                               = CONTAINER
END_OBJECT                                 = WCL_SCAN_HEADER_TABLE

OBJECT                                     = WCL_SCAN_TABLE
  COLUMNS                                  = 2
  INTERCHANGE_FORMAT                       = ASCII
  ROW_BYTES                                = 1034
  ROWS                                     = 2015

  OBJECT                                   = CONTAINER
    NAME                                   = "WCL DATA VALUES"
    REPETITIONS                            = 43
    START_BYTE                             = 1
    BYTES                                  = 24
    DESCRIPTION                            = "Chronopotentiometry data"

    OBJECT                                 = COLUMN
      COLUMN_NUMBER                        = 1
      NAME                                 = "NANOAMPS"
      DATA_TYPE                            = ASCII_REAL
      START_BYTE                           = 1
      BYTES                                = 11
      MISSING_CONSTANT                     = 99999999999
      DESCRIPTION                          = "Current in nA"
    END_OBJECT                             = COLUMN

    OBJECT                                 = COLUMN
      COLUMN_NUMBER                        = 2
      NAME                                 = "MILLIVOLTS"
      DATA_TYPE                            = ASCII_REAL
      START_BYTE                           = 13
      BYTES                                = 11
      MISSING_CONSTANT                     = 99999999999
      DESCRIPTION                          = "Potential in mV"
    END_OBJECT                             = COLUMN
  END_OBJECT                               = CONTAINER
END_OBJECT                                 = WCL_SCAN_TABLE

END
```

PT

```
PDS_VERSION_ID                             = PDS3
LABEL_REVISION_NOTE                        = "2008-04-14, Initial"

/* File Characteristics */
RECORD_TYPE                                = FIXED_LENGTH
RECORD_BYTES                               = 198
FILE_RECORDS                               = 8811
```

```
/*Pointers to Data Objects */
^WCL_HEADER_TABLE                        = ("ws030c0pt___00___13690000w0.tab",2)
^PT_CALIBRATION_TABLE                    = ("ws030c0pt___00___13690000w0.tab",17)
^WCL_EVENT_TABLE                         = ("ws030c0pt___00___13690000w0.tab",24)
^WCL_DATA_HEADER_TABLE                   = ("ws030c0pt___00___13690000w0.tab",36)
^WCL_DATA_TABLE                          = ("ws030c0pt___00___13690000w0.tab",39)

/* Identification */
DATA_SET_ID                              = "PHX-M-MECA-4-NIRDR-V1.0"
PRODUCT_ID                               = "WS030C0PT___00___13690000W0"
PRODUCT_VERSION_ID                       = "V1.0"
PRODUCT_TYPE                             = "MECA_WCL_PT"
RELEASE_ID                               = "0001"
INSTRUMENT_HOST_NAME                     = "PHOENIX"
INSTRUMENT_NAME                          = "MECA WET CHEMISTRY LABORATORY"
INSTRUMENT_HOST_ID                       = PHX
TARGET_NAME                              = "MARS"
INSTRUMENT_ID                            = "MECA_WCL"
INSTRUMENT_MODE_ID                       = "PT"
MISSION_NAME                             = "PHOENIX"

OPS_TOKEN                                = 16#13690000#
OPS_TOKEN_ACTIVITY                       = 16#00001369#
OPS_TOKEN_PAYLOAD                        = 16#00000000#
OPS_TOKEN_COMMAND                        = 16#00000000#

/* Time information */
MISSION_PHASE_NAME                       = "PRIMARY MISSION"
SPACECRAFT_CLOCK_START_COUNT             = "898863739.067"
SPACECRAFT_CLOCK_STOP_COUNT              = "898892845.116"
START_TIME                               = 2008-06-25T12:21:07.828
STOP_TIME                                = 2008-06-25T20:26:13.959
EARTH_RECEIVED_START_TIME                = "UNK"
EARTH_RECEIVED_STOP_TIME                 = "UNK"
PLANET_DAY_NUMBER                        = 30
LOCAL_TRUE_SOLAR_TIME                    = "09:45:06"
PRODUCT_CREATION_TIME                    = 2008-12-20T00:00:58.561


/* Data Object Definitions */

OBJECT                                   = WCL_HEADER_TABLE
  COLUMNS                                = 2
  INTERCHANGE_FORMAT                     = ASCII
  ROW_BYTES                              = 93
  ROWS                                   = 13
  ROW_SUFFIX_BYTES                       = 105
  DESCRIPTION                            = "Two column PT header table with 93
                                            bytes of data followed by 105 spare
                                            bytes, the last two of which are the
                                            <CR><LF> characters."

  OBJECT                                 = COLUMN
    COLUMN_NUMBER                        = 1
    NAME                                 = "HEADER FIELD NAME"
    DATA_TYPE                            = CHARACTER
```

```
    START_BYTE                      = 2
    BYTES                           = 25
  END_OBJECT                        = COLUMN

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 2
    NAME                            = "HEADER FIELD VALUE"
    DATA_TYPE                       = CHARACTER
    START_BYTE                      = 30
    BYTES                           = 62
  END_OBJECT                        = COLUMN
END_OBJECT                          = WCL_HEADER_TABLE


OBJECT                              = PT_CALIBRATION_TABLE
  COLUMNS                           = 4
  INTERCHANGE_FORMAT                = ASCII
  ROW_BYTES                         = 49
  ROW_SUFFIX_BYTES                  = 149
  ROWS                              = 5
  DESCRIPTION                       = "Table of values used to convert sensor
                                      DNs to physical units. Pressures in mB,
                                      temperature in C. There are 49 bytes
                                      of data in this table followed by 149
                                      spare bytes, the last two of which are
                                      the <CR><LF> characters."

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 1
    NAME                            = "SENSOR_NAME"
    DATA_TYPE                       = CHARACTER
    START_BYTE                      = 2
    BYTES                           = 15
    DESCRIPTION                     = "Name of sensor reading to be
                                      converted."
  END_OBJECT                        = COLUMN

 OBJECT                             = COLUMN
    COLUMN_NUMBER                   = 2
    NAME                            = "SLOPE_VALUE"
    DATA_TYPE                       = ASCII_REAL
    START_BYTE                      = 19
    BYTES                           = 11
    DESCRIPTION                     = "SLOPE value used in conversion
                                      equation P(mbar) = SLOPE*DN + INTERCEPT
                                      for pressure or T(degC) = SLOPE*DN +
                                      INTERCEPT temperature."
  END_OBJECT                        = COLUMN

  OBJECT                            = COLUMN
    COLUMN_NUMBER                   = 3
    NAME                            = "INTERCEPT_VALUE"
    DATA_TYPE                       = ASCII_REAL
    START_BYTE                      = 31
    BYTES                           = 11
    DESCRIPTION                     = "INTERCEPT value used in conversion
                                      equation P(mbar) = SLOPE*DN + INTERCEPT
```

```
                                        for pressure or T(degC) = SLOPE*DN +
                                        INTERCEPT for temperature."
  END_OBJECT                          = COLUMN


  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 4
    NAME                              = "PHYSICAL_UNIT"
    DATA_TYPE                         = CHARACTER
    START_BYTE                        = 44
    BYTES                             = 5
    DESCRIPTION                       = "physical unit of calibrated value"
  END_OBJECT                          = COLUMN
END_OBJECT                            = PT_CALIBRATION_TABLE


OBJECT                                = WCL_EVENT_TABLE
  COLUMNS                             = 3
  INTERCHANGE_FORMAT                  = ASCII
  ROW_BYTES                           = 149
  ROW_SUFFIX_BYTES                    = 49
  ROWS                                = 10
  DESCRIPTION                         = "Three column PT events table."

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 1
    NAME                              = "EVENT_NAME"
    DATA_TYPE                         = ASCII_REAL
    START_BYTE                        = 2
    BYTES                             = 20
    DESCRIPTION                       = "Name of event - solution dispense,
                                        drawer open, drawer close,
                                        reagent release"
  END_OBJECT                          = COLUMN

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 2
    NAME                              = "CMD_TIME"
    DATA_TYPE                         = ASCII_REAL
    START_BYTE                        = 24
    BYTES                             = 14
    MISSING_CONSTANT                  = 99999999999
    DESCRIPTION                       = "SCLK time the event was commanded by
                                        Phoenix"
  END_OBJECT                          = COLUMN

  OBJECT                              = COLUMN
    COLUMN_NUMBER                     = 3
    NAME                              = "EVENT_NOTES"
    DATA_TYPE                         = CHARACTER
    START_BYTE                        = 40
    BYTES                             = 108
    DESCRIPTION                       = "Description of the event."
  END_OBJECT                          = COLUMN
END_OBJECT                            = WCL_EVENT_TABLE
```

```
OBJECT                                  = WCL_DATA_HEADER_TABLE
  COLUMNS                               = 9
  INTERCHANGE_FORMAT                    = ASCII
  ROW_BYTES                             = 113
  ROWS                                  = 1
  ROW_SUFFIX_BYTES                      = 85
  DESCRIPTION                           = "Nine column pressure, temperature
                                          and heater state data header table
                                          with 113 bytes of data followed by
                                          85 spare bytes, the last two of which
                                          are the <CR><LF> characters."

 OBJECT                                 = COLUMN
    COLUMN_NUMBER                       = 1
    NAME                                = "TIME_HEADER"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 2
    BYTES                               = 4
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 2
    NAME                                = "PRESSURE_HEADER"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 9
    BYTES                               = 8
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 3
    NAME                                = "T_BEAKER_HEADER"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 20
    BYTES                               = 8
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 4
    NAME                                = "T_TANK_HEADER"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 31
    BYTES                               = 6
  END_OBJECT                            = COLUMN

  OBJECT                                = COLUMN
    COLUMN_NUMBER                       = 5
    NAME                                = "T_DRAWER_HEADER"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 40
    BYTES                               = 8
  END_OBJECT                            = COLUMN

 OBJECT                                 = COLUMN
    COLUMN_NUMBER                       = 6
    NAME                                = "T_STAGE_HEADER"
    DATA_TYPE                           = ASCII_REAL
    START_BYTE                          = 51
```

```
    BYTES                         = 7
  END_OBJECT                      = COLUMN

 OBJECT                           = COLUMN
    COLUMN_NUMBER                 = 7
    NAME                          = "BEAKER_HTR_STATE_HEADER"
    DATA_TYPE                     = ASCII_REAL
    START_BYTE                    = 61
    BYTES                         = 16
  END_OBJECT                      = COLUMN

 OBJECT                           = COLUMN
    COLUMN_NUMBER                 = 8
    NAME                          = "TANK_HTR_STATE_HEADER"
    DATA_TYPE                     = ASCII_REAL
    START_BYTE                    = 80
    BYTES                         = 14
  END_OBJECT                      = COLUMN

 OBJECT                           = COLUMN
    COLUMN_NUMBER                 = 9
    NAME                          = "DRAWER_HTR_STATE_HEADER"
    DATA_TYPE                     = ASCII_REAL
    START_BYTE                    = 97
    BYTES                         = 16
  END_OBJECT                      = COLUMN


END_OBJECT                        = WCL_DATA_HEADER_TABLE


OBJECT                            = WCL_DATA_TABLE
  COLUMNS                         = 9
  INTERCHANGE_FORMAT              = ASCII
  ROW_BYTES                       = 81
  ROWS                            = 8773
  ROW_SUFFIX_BYTES                = 117
  DESCRIPTION                     = "Nine column pressure and temperature
                                    data table with 79 bytes of data
                                    followed by 119 spare bytes, the last
                                    two of which are the <CR><LF>
                                    characters."

  OBJECT                          = COLUMN
    COLUMN_NUMBER                 = 1
    NAME                          = "TIME"
    DATA_TYPE                     = ASCII_REAL
    START_BYTE                    = 1
    BYTES                         = 14
    DESCRIPTION                   = "series of SCLK read times"
  END_OBJECT                      = COLUMN

  OBJECT                          = COLUMN
    COLUMN_NUMBER                 = 2
    NAME                          = "PRESSURE"
    DATA_TYPE                     = ASCII_REAL
    START_BYTE                    = 16
```

```
    BYTES                                  = 11
    DESCRIPTION                            = "series of pressure measurements for
                                              the selected WCL cell in millibars."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 3
    NAME                                   = "T_BEAKER"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 28
    BYTES                                  = 11
    DESCRIPTION                            = "series of beaker temperature
                                              measurements for the selected WCL
                                              cell in C."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 4
    NAME                                   = "T_TANK"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 40
    BYTES                                  = 11
    DESCRIPTION                            = "series of tank temperature
                                              measurements for the selected WCL
                                              cell in C."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 5
    NAME                                   = "T_DRAWER"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 52
    BYTES                                  = 11
    DESCRIPTION                            = "series of drawer temperature
                                              measurements for the selected WCL
                                              cell in C."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 6
    NAME                                   = "T_STAGE"
    DATA_TYPE                              = ASCII_REAL
    START_BYTE                             = 64
    BYTES                                  = 11
    DESCRIPTION                            = "series of microscopy stage
                                              temperature measurements."
  END_OBJECT                               = COLUMN

  OBJECT                                   = COLUMN
    COLUMN_NUMBER                          = 7
    NAME                                   = "BEAKER_HEATER_STATE"
    DATA_TYPE                              = BOOLEAN
    START_BYTE                             = 76
    BYTES                                  = 1
    DESCRIPTION                            = "State of the beaker heater.
                                              0-heater off, 1-heater on"
  END_OBJECT                               = COLUMN
```

```
  OBJECT                                      = COLUMN
    COLUMN_NUMBER                             = 8
    NAME                                      = "TANK_HEATER_STATE"
    DATA_TYPE                                 = BOOLEAN
    START_BYTE                                = 78
    BYTES                                     = 1
    DESCRIPTION                               = "State of the tank heater.
                                                 0-heater off, 1-heater on"
  END_OBJECT                                  = COLUMN

  OBJECT                                      = COLUMN
    COLUMN_NUMBER                             = 9
    NAME                                      = "DRAWER_HEATER_STATE"
    DATA_TYPE                                 = BOOLEAN
    START_BYTE                                = 80
    BYTES                                     = 1
    DESCRIPTION                               = "State of the drawer heater.
                                                 0-heater off, 1-heater on"
  END_OBJECT                                  = COLUMN

END_OBJECT                                    = WCL_DATA_TABLE

END
```

APPENDIX E - ACRONYMS

AA	Actuator Assembly
ADC	Analog to Digital Converter
AFM	MECA Atomic Force Microscope
ASCII	American Standard Code for Information Interchange
CME	MECA Control and Measurement Electronics
CP	Chronopotentiometry
CSV	Comma Separated Variable
CV	Cyclic Voltammetry
DN	Data numbers (arbitrary units to be resolved through calibration)
EC	Electrical Conductivity
EDR	Experiment Data Record
FEI	File Exchange Interface, a secure files subscription service developed at JPL
FSW	Flight Software
GDS	Ground Data System
ICD	Interface Control Document
ISE	Ion-Selective Electrode
JPL	Jet Propulsion Laboratory
MECA	Microscopy, Electrochemistry, and Conductivity Analyzer
MGSS-IOS	Multi-mission Ground Systems and Services, Instrument Operations element
MIPL	Multi-mission Instrument Processing Laboratory
NASA	National Aeronautics and Space Administration
OM	MECA Optical Microscope
OPGS	Operations Product Generation Subsystem
PAWG	Phoenix Archive Working Group
PDS	Planetary Data System
PT	Pressure and Temperature
RA	Robotic Arm
RAC	Robotic Arm Camera
RDR	Reduced Data Record
RSVP	Rover Sequencing and Visualization Program
SCLK	Spacecraft Clock
SFDU	Standard Format Data Unit
SIS	Software Interface Specification
SOC	Science Operations Center
SPICE	Spacecraft, Planet, Instrument, C-matrix, Events kernels
SSI	Surface Stereoscopic Imager
TBD	To Be Determined
TECP	Thermal and Electrical Conductivity Probe
WCL	MECA Wet Chemistry Laboratory