GRAPHIC THREE-AXES PRESENTATION OF RESIDUAL GAS ANALYZER DATA

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ABSTRACT

Residual gas analyzers (RGA) are commonly used to measure the composition of residual gases in thermal-vacuum test chambers. Measurements from RGA's are often used to identify and quantify outgassing contaminants from a test article during thermal-vacuum testing. RGA data is typically displayed as snapshots in time, showing instantaneous concentrations of ions from ionized residual gas molecules at different atomic masses. This ion concentration information can be interpreted to be representative of the composition of the residual gas in the chamber at the instant of analysis. Typically, test personnel are most interested in tracking the time history of changes in the composition of chamber residual gas to determine the relative cleanliness and the clean-up rate of the test article under vacuum. However, displays of instantaneous RGA data cannot provide test personnel with the preferred time history information. In order to gain an understanding of gas composition trends, a series of plots of individual data snapshots must be analyzed. This analysis is cumbersome and still does not provide a very satisfactory view of residual gas composition trends. A method was devised by the authors to present RGA data in a three-axis format, plotting Atomic Mass Unit (AMU), the Ionization Signal Response (ISR) as amps/torr as a function of AMU, and Time, to provide a clear graphic visualization of trends of changes in ISR with respect to time and AMU (representative of residual gas composition). This graphic visualization method provides a valuable analytical tool to interpret test article outgassing rates during thermal vacuum tests.

Raw RGA data was extracted from a series of delimited ASCII files and then converted to a data array in a spreadsheet. Consequently, using the 3-D plotting functionality provided by the spreadsheet program, 3-D plots were produced. After devising the data format conversion process, the authors began developing a program to provide real-time 3-D plotting of RGA data. The intent of this program is to automate the RGA data acquisition process and to generate up-to-the-minute time history 3-D displays of stored RGA data (development of this program was not complete at the time of this writing). This paper provides a brief description of the data format conversion process and presents results from a recent test to illustrate the usefulness of this 3-D RGA data plotting technique.

INTRODUCTION

An RGA is an instrument used in nearly every major thermal vacuum test that is conducted at the Jet Propulsion Laboratory (JPL) as well as at many other space simulation facilities. The RGA sensor, which is exposed to the chamber vacuum environment, ionizes some of the gas molecules in a sample, separates the resultant ions into their respective masses (or atomic mass units, AMU), and measures and displays the ISR at each mass. RGA data is used to track the residual gas composition in a vacuum chamber as a test progresses. Displayed RGA data provide the operations personnel important information which helps them to determine the effectiveness or completion of a bakeout of a test article, to detect the presence of a small leak in the chamber, or to assess the composition of molecular components which are outgassing from a test article during a test.

However, the RGA's which are used at JPL provide only sequential snapshots, one at a time, of the ISRs over a range of AMUs. Historically, JPL thermal-vacuum test operators have programmed the RGAs to print a copy of the display to collect printed ISRs data nominally once each hour. At the end of the test, there is a stack of computer paper presenting a series of plots which, while providing the desired residual gas composition data, yields the data in a format that is very cumbersome to interpret.

The RGA data presentation method described in this paper was developed at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

The authors sought a better way to present RGA data so that interpretation would be made more convenient. As a result, the authors developed a method for presenting the RGA data in a format which would clearly illustrate the time rates of change of various constituents. In this paper, several 3-D plots are presented which show how this method can be used effectively to interpret outgassing responses to various test events. These plots have been generated from RGA data from a single bakeout test. Standard RGA printouts are also presented as a reference for comparison with 3-D plots containing the same data.

METHOD DESCRIPTION

The RGA system transmits its periodic sampling/analysis data from its sensor head to a computer where the transmitted signals are read as a data set and are converted to a string of delimited ASCII-formatted values. For example, one such data set includes values for: 1) File Name; 2) File Time; 3) Total Pressure; 4) Emult; 5) Mode; 6) Scan; 7) Gain; 8) Width; 9) Center Mass; 10) the ISR for the first referenced AMU; 11) the ISR for the second referenced AMU; etc. The RGA software uses these values to display the data in a variety of formats on the computer's monitor screen. One of these data displays shows ISR as a function of AMU.

The RGA software also has a data storage function which saves data sets as a series of sequential ASCII files. When a test has been completed, data is extracted from the series of ASCII files and is converted into a data array from which 3-D plotting functions are used to generate 3-D plots. This simple technique yields dramatic results as will be seen in the figures presented in the example below.

EXAMPLE ILLUSTRATING USE OF THE 3-D RGA DATA PLOTTING METHOD

Figures 1, 2, and 3 present three sequential hourly printouts in the ISR vs. AMU display format. These printouts are actual data taken from a test involving the bakeout of a material which was subsequently used as part of the sun shade for the test set-up for the Mars Pathfinder cruise stage solar thermal vacuum test (MPF-STV-1). Review of figures 1 and 2 reveals that there is an apparent significant difference between the ISR at 05:07 and that at 06:08 on 3/20/96. However, a review of figures 2 and 3 shows that between 06:08 and 07:08, the ISR returned to approximately the same values that were measured at 5:07. These hourly RGA data printouts do not provide an intuitive understanding of what may have happened during this two hour test period. For instance, perhaps the 7:08 data may have been caused by a temporary spurious RGA anomaly. Further information is needed to more fully understand this RGA data.

Figure 4 presents a plot of the temperature of the sun shade (blanket) material throughout the full duration of the test. A GN2 blower seal failure occurred at about 13:00 on 3/18 and the shroud heating was immediately stopped until the blower seal was fixed. By 06:30 on 3/19 the blower seal had been fixed and by 08:00 the bakeout temperature of 140°C was achieved. Temperature control at 140°C was stable until about 05:30 on 3/20 when the shroud temperature-controller high heat switch got stuck in the on position for no apparent reason. The operator on duty cycled the heater switch on and off several times until the high heat switch finally went off and the temperature-controller began to control shroud temperature properly once again. Since this bakeout test had been devised quickly, and since no flight hardware was involved, no overtemperature failsafe protection had been specified or installed. So, when the high heat switch got stuck in the on position, the temperature continued to rise quickly until the operator was successful in switching it off. It can be seen that at the time the 6:08 RGA data snapshot printout was taken, the shroud temperatures were near the high temperature point. Certainly then, the RGA data printout at 6:08 did give indications of actual residual gas compositions which were significantly different than those from data taken one hour earlier.

Figure 5 shows a 3-D plot of hourly RGA data taken over the entire duration of this test. This plot gives a complete overview of the various ISRs throughout the test. A review of the period following the pumpdown shows that the ISR indicative of water content (AMU=18) quickly drops to a low value. Also, the beginning of the bakeout is clearly evidenced by a water spike at about 08:00 on 3/19. The water content then recedes as the bakeout continues, until at about 05:30 on 3/20 another water spike appears. This additional water spike is a point of interest and warrants a closer look. Since the data which generated this plot are available in an array in spreadsheet format, a smaller data sample, at this point of interest, may yield insights into details of the test at that time.

Figure 6 shows a 3-D plot of hourly RGA data taken over the morning hours of 3/20. This plot very dramatically illustrates a series of steeple-like spikes occurring throughout the 1 to 200 AMU range during the 06:00 time period. This plot also gives the viewer a good general understanding of the effect that the overtemperature condition had on the gas composition inside the chamber.

Figure 7 is a plot of yet a smaller data sample. The figure 7 plot shows data from the same time period as that in figure 6, but only for mass values in the 1 to 100 AMU range. The figure 8 plot stretches out the detail of figure 6 to present the viewer with a more detailed zoom of the lower mass range. Likewise, figure 8 shows a detailed zoom of the 100-150 AMU range for the same time period as figure 6. However, the mass composition scale in figure 8 is different than that of figure 6, providing the viewer even additional insight into the outgassing of the higher AMU constituents during the overtemperature period.

GRANULARITY OF RGA DATA

The RGA software JPL uses to acquire and display RGA data provides for scan rates as frequent as once every 20 seconds or as slow as once every 2 minutes. The slower scan rates tend to yield a better, more accurate sampling throughout the scanned AMU range. The data storage rates can be set at a maximum frequency of once each scan to some lower frequency. By selecting a more frequent data storage rate, RGA plots with finer time scale granularity can be generated. The RGA software that JPL uses allows up to 999 separate ASCII files (data sets) to be stored per each DOS data file name. If the operator wishes to change the data storage rate, he may do so anytime during the test. However, to extend the number of data sets beyond 999, the operator must stop the data storage function temporarily, create a new and unique data file name, then proceed loading data into ASCII files under this new file name. Each separate data file group can then can be analyzed separately with the 3-D plotting function.

CONCLUSIONS

A method for the presentation of RGA in a useful 3-D format has been devised and has been demonstrated to be helpful in easing the interpretation of RGA data. The authors are developing a method to automate the generation of real-time 3-D RGA data plots for display on a monitor screen. This method will provide operators and test personnel a much better tool than is now available for the display and analysis of RGA data trends. It is the authors' intent to have this automated system operating in 1997.

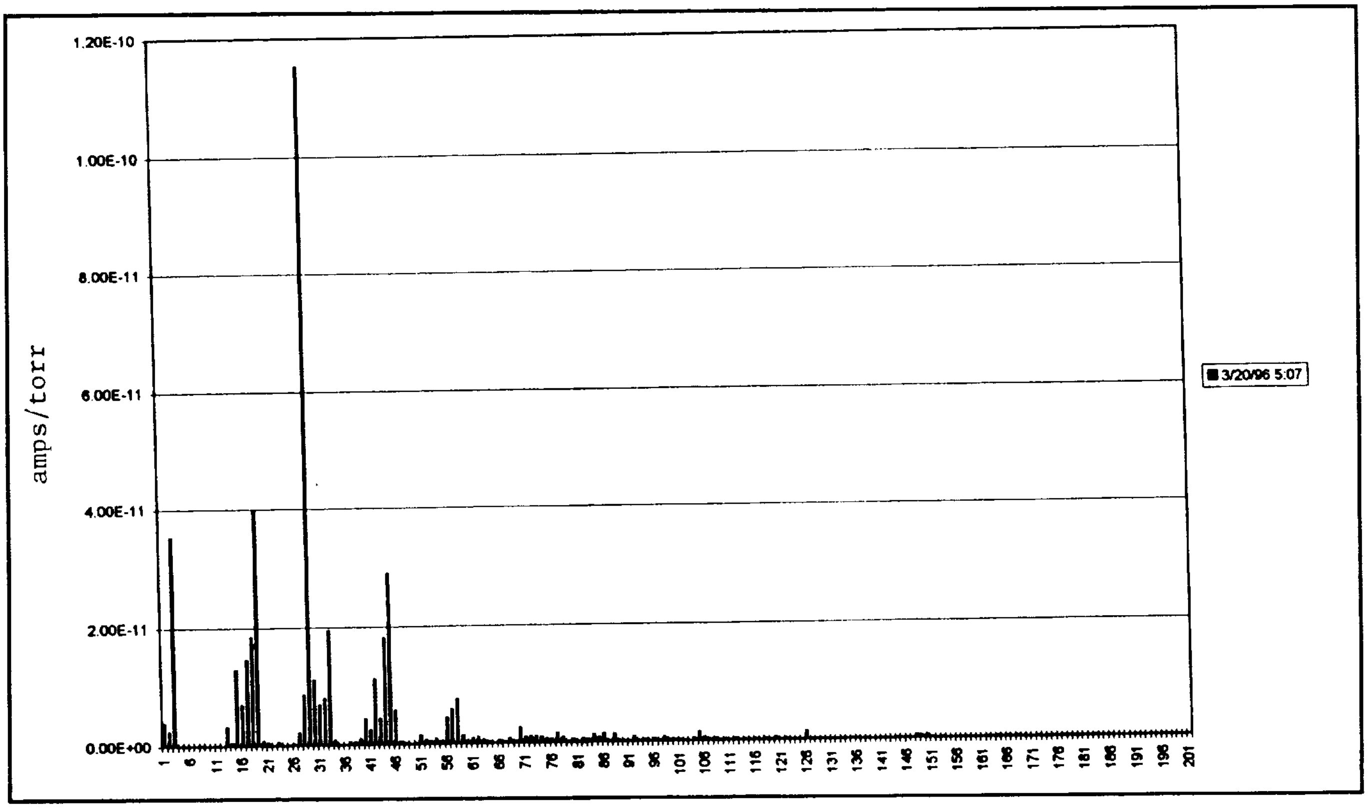

Figure 1. Standard RGA Plot made at 05:07 on 3/20/96

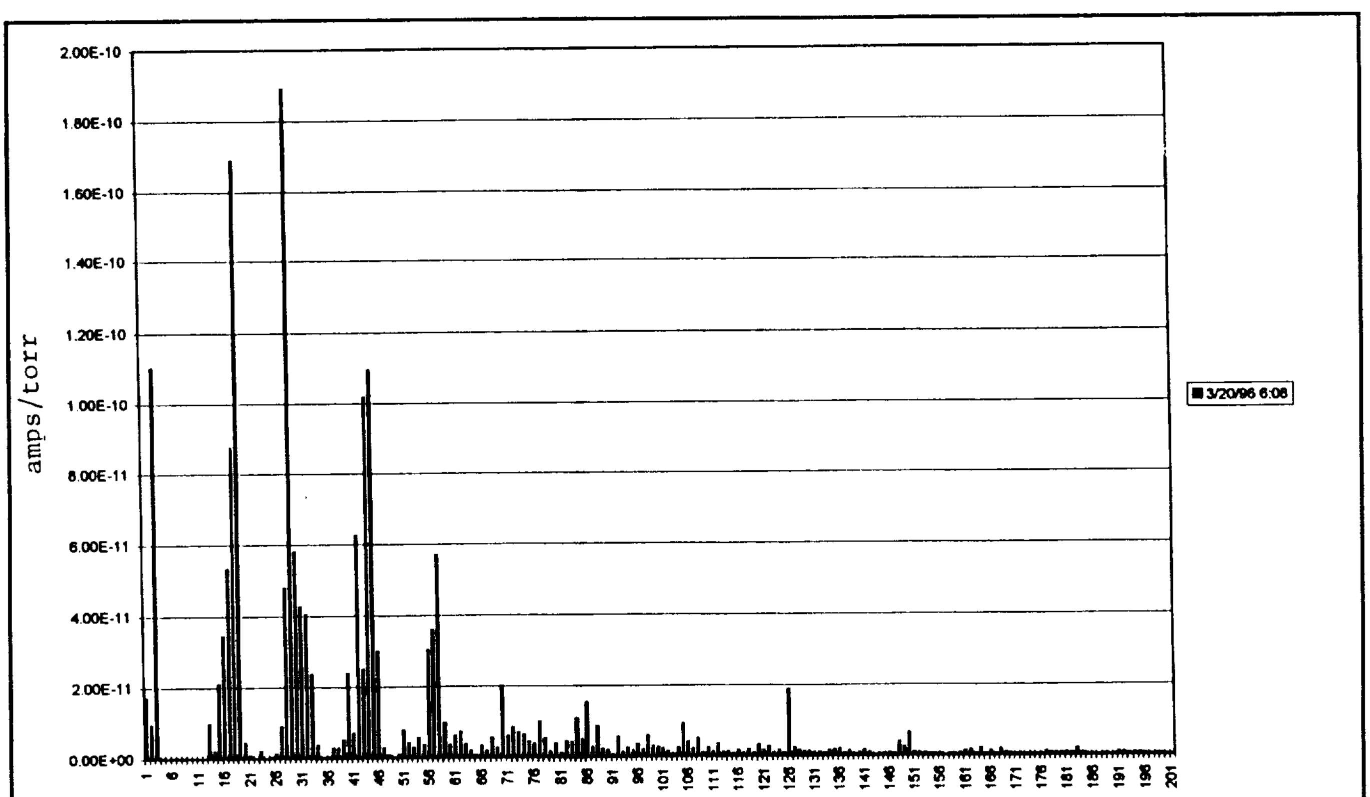

Figure 2. Standard RGA Plot made at 06:08 on 3/20/96

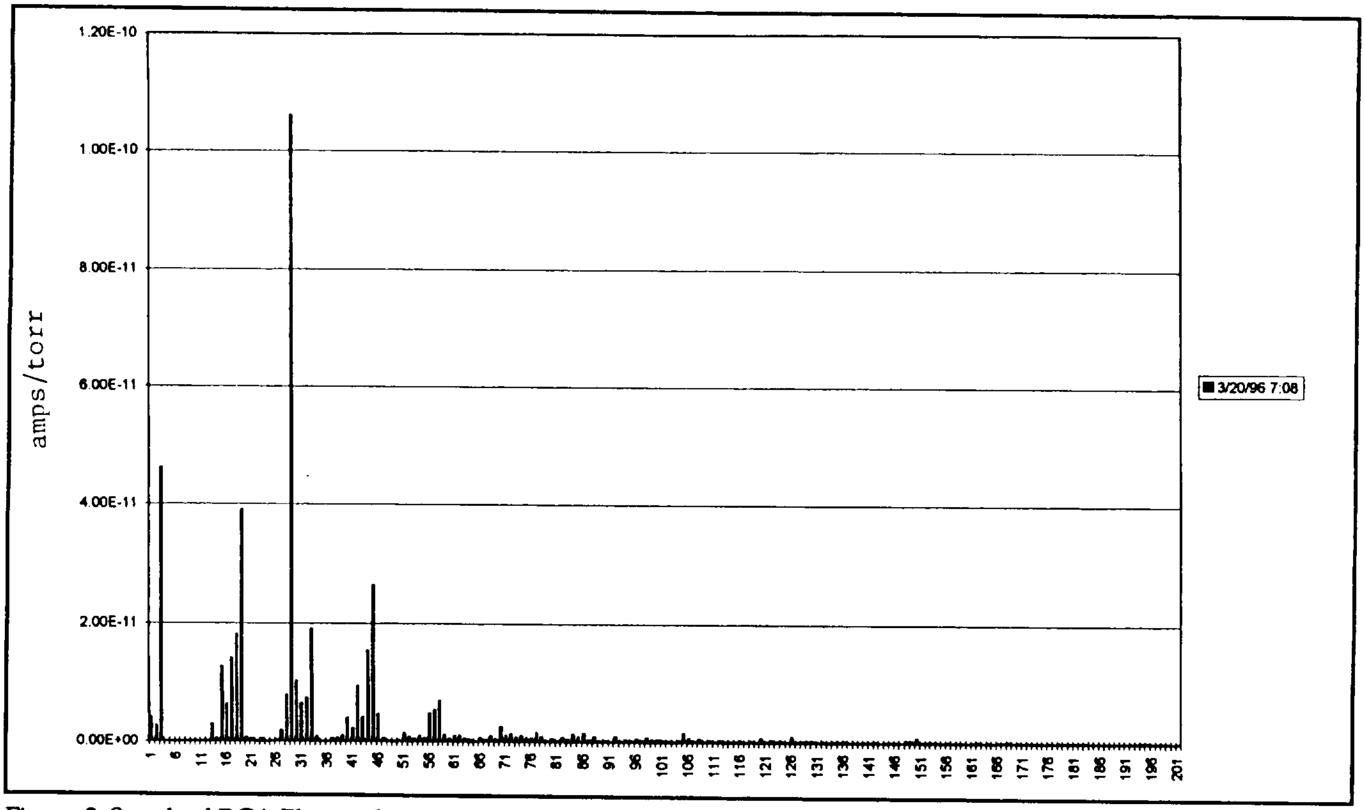

Figure 3. Standard RGA Plot made at 07:08 on 3/20/96

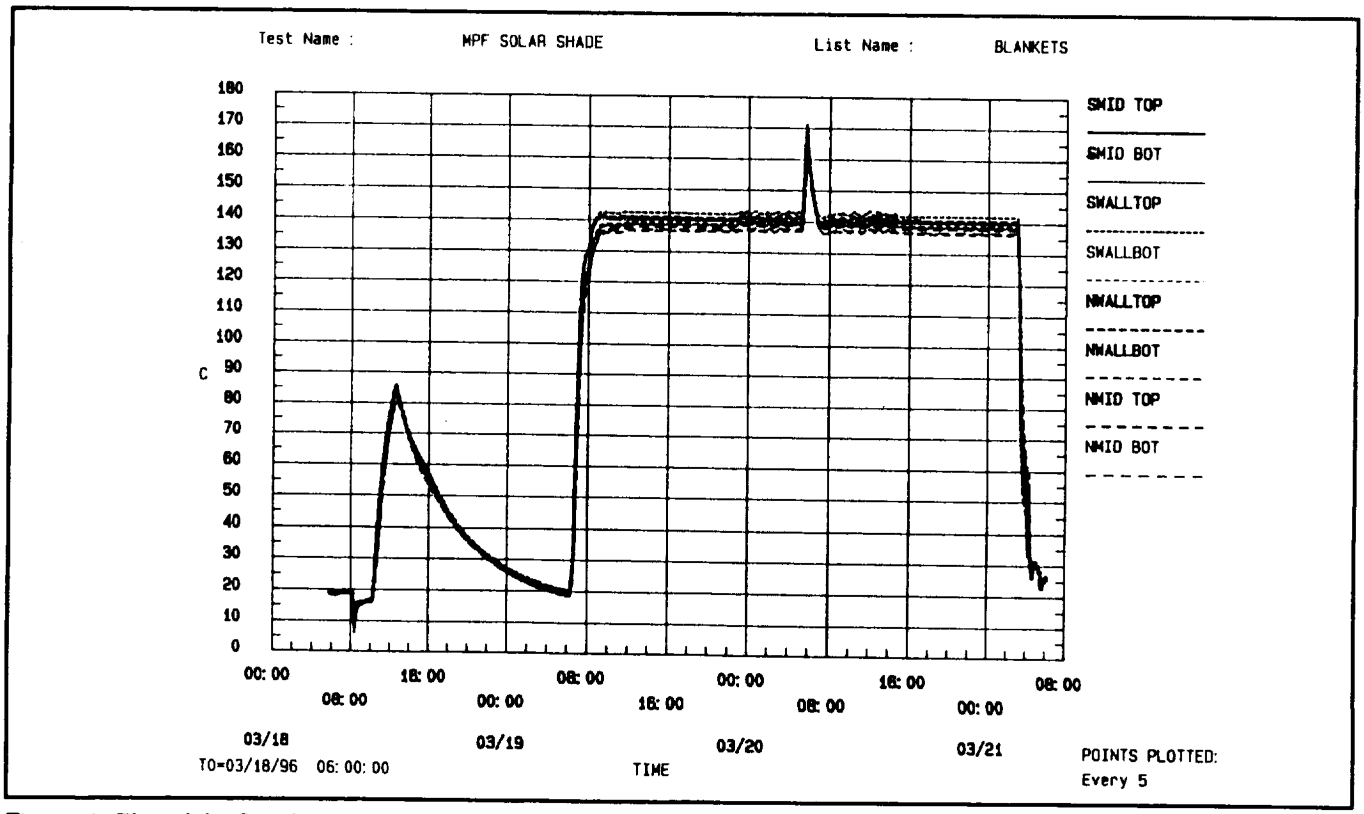

Figure 4. Plot of the Sunshade Material Temperature Throughout the Full Duration of the Sunshade Bakeout Test

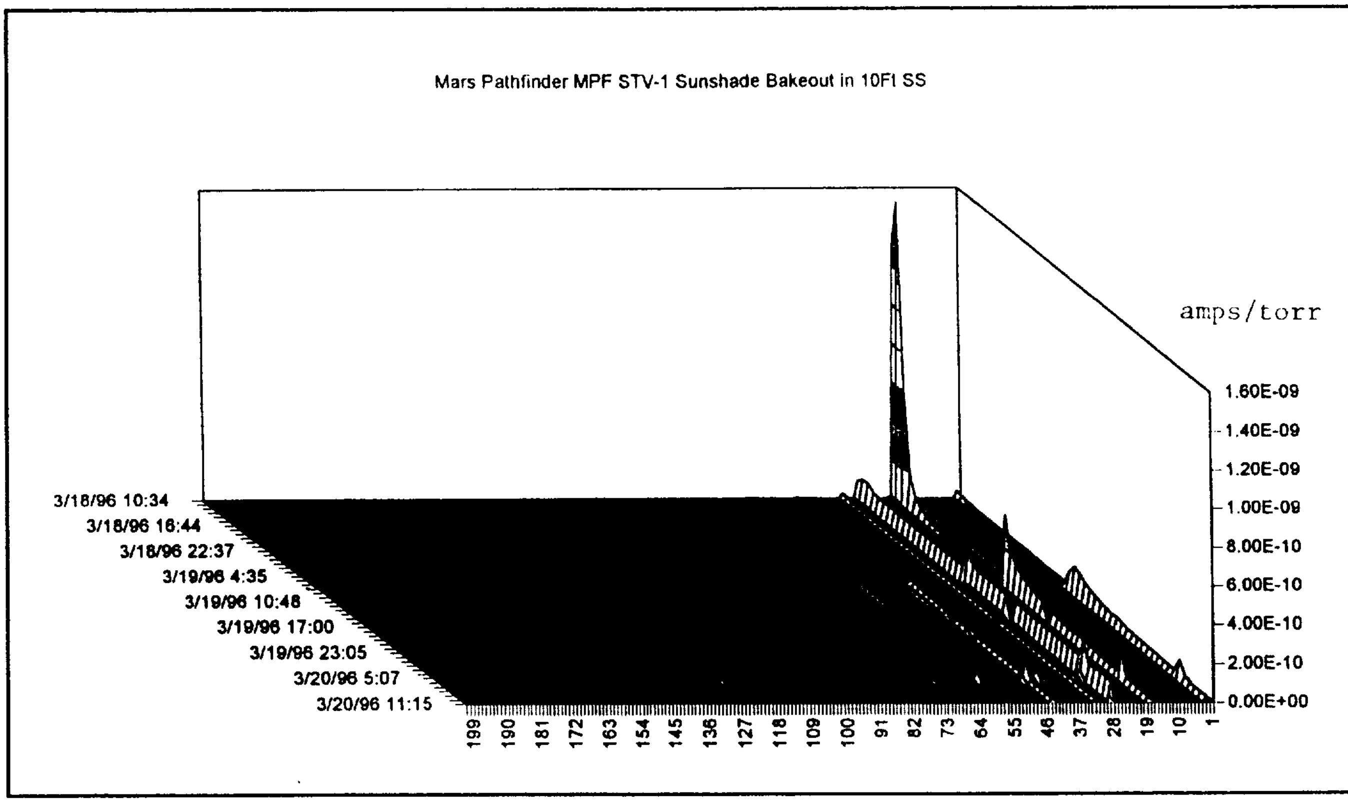

Figure 5. A 3-D RGA Plot made from Data Collected Over the Full Duration of the Sunshade Bakeout Test

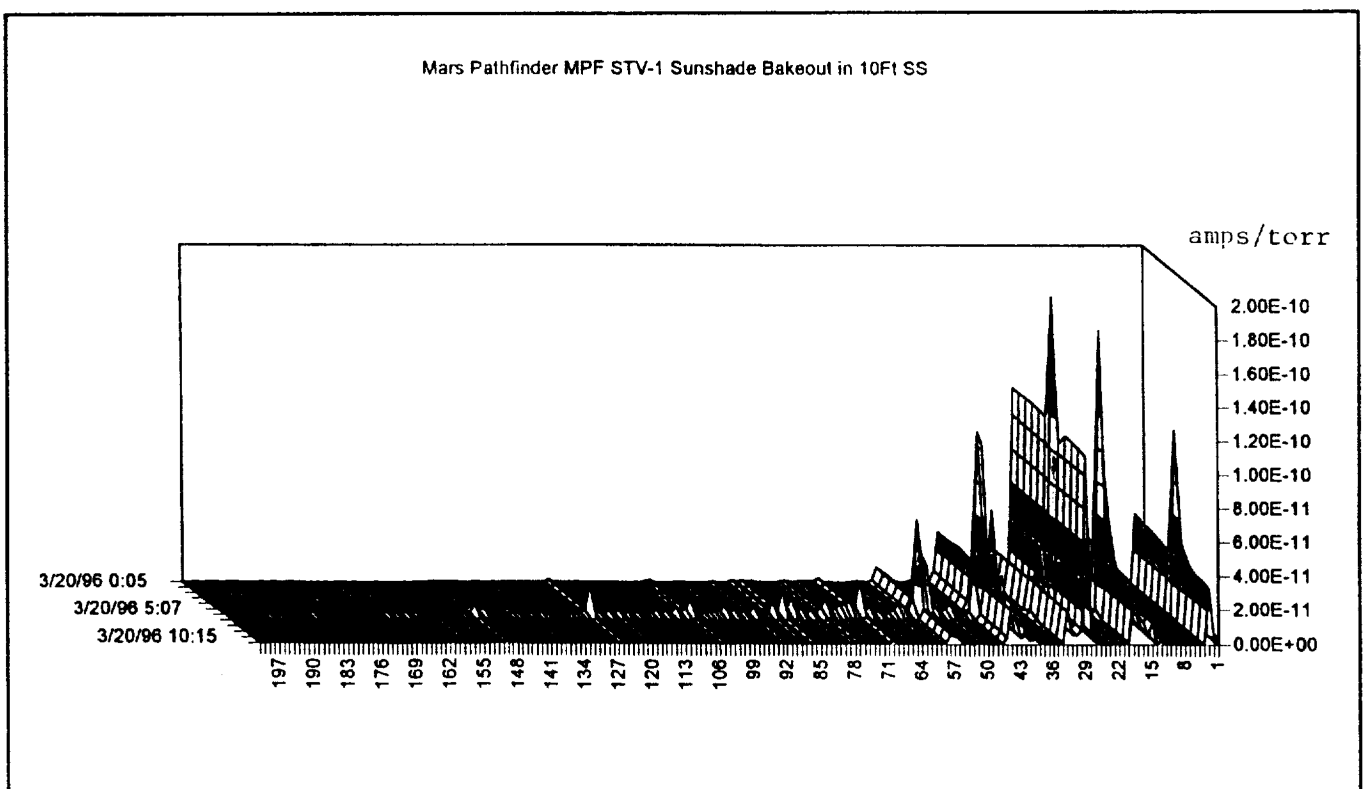

Figure 6. A 3-D RGA Plot made from Data Collected During the Morning of 3/20/96

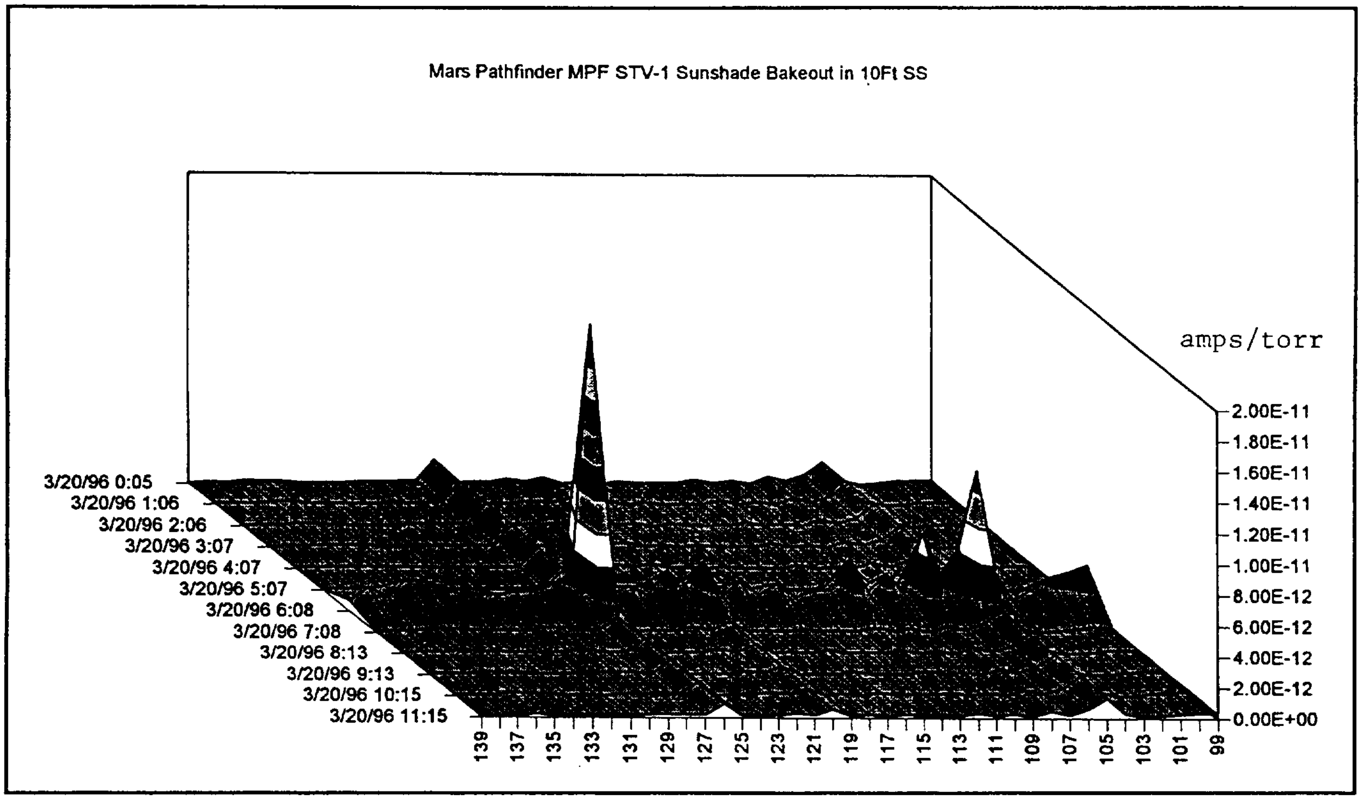

Figure 7. A 3-D RGA Plot made from Data Collected During the Morning of 3/20/96; 1-100 AMU Range

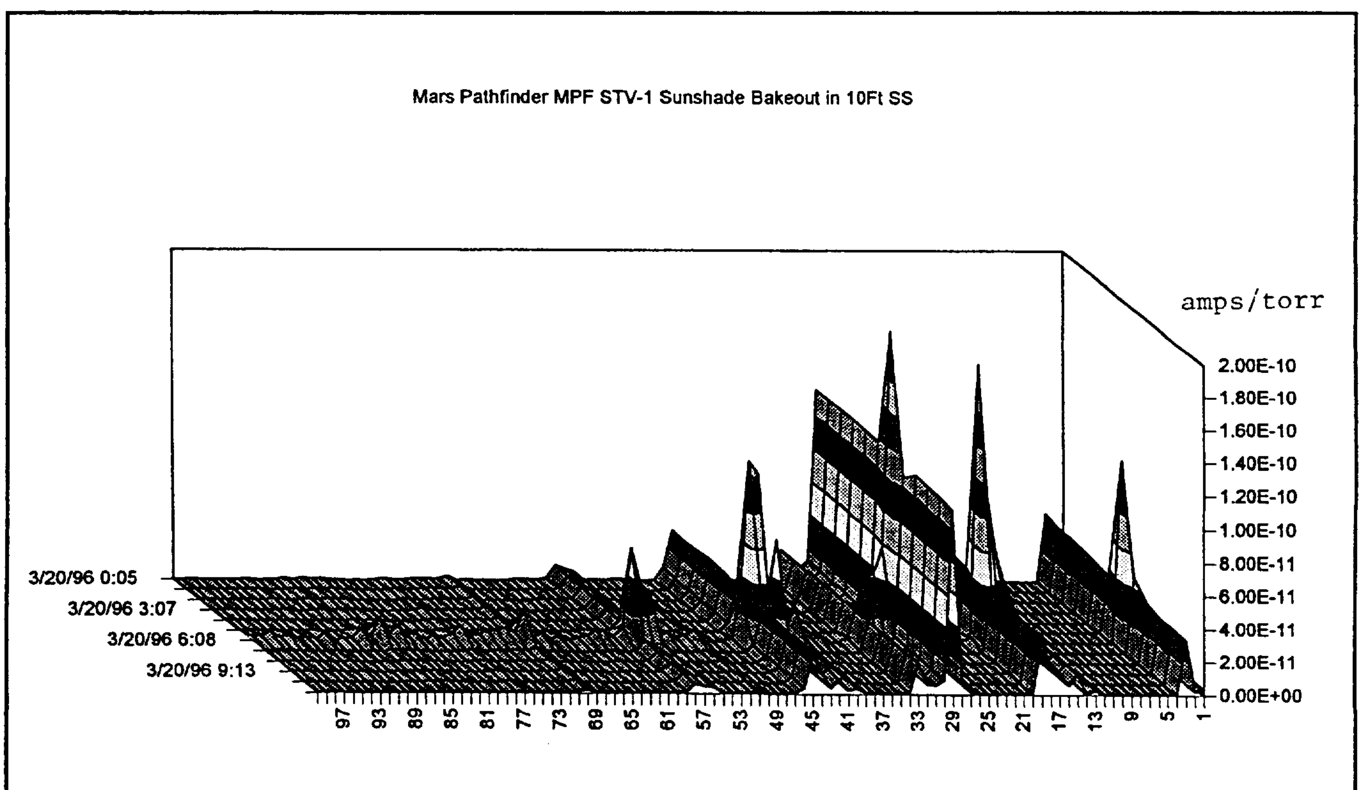

Figure 8. A 3-D RGA Plot made from Data Collected During the Morning of 3/20/96; 100-150 AMU Range