Graphic Three-Axes Presentation of Residual Gas Analyzer Data

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ABSTRACT

Residual gas analyzers (RGA) arc 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 arc 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 can't 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 (A MU), Ion Concentration as a function of AMU, and Time, to provide a clear graphic visualization of trends in gas concentration changes and to initiate a valuable analytical tool to interpret test article outgassing rates during thermal vacuum tests.

Raw RGA data was extracted from a delimited ASCII format and then manually converted to a common spread-sheet format. 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 ~1~>-tc)-the-r~~il~~ltc~ 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 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, AM U), and measures and displays the ion concentration at each mass. RGA data is used to track the residual gas composition in a vacuum chamber as a test progresses. Displayed RGA data provides 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 arc used at JPL provide only sequential snapshots, one at a time, of the ion concentration over a range of AM Us. Historically, JPL thermal-vacuum test operators have programmed the RGAs to print a copy of the display to collect printed residual gas composition 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 wry cumbersome to interpret.

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

The au thors sought a bet ter 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 quantities of individual mass 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 and analysis data from its sensor head to a computer where the transmitted signals are converted to a string of delimited ASCII-formatted numbers. The delimited ASCII-formatted numbers can be saved to a text file cm the computer, in time-sliced increments, for later analysis. 'J'he RGA software uses these numbers to develop a variety of analytical data displays which can be viewed cm the computer's monitor screen. Among three formats is a data display where the monitor screen shows ion concentration as a function of AMU. When a particular test has been completed, data from the ASCII text file format can be extracted and loaded into a spreadsheet format. The 3-D plotting functions from the spreadsheet program can then be used to generate 3-D plots of the data. 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 ion concentration 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 bet ween the residual gas composition 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 residual gas composition 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 anomal y. Further in format ion 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-con troller high heat switch got stuck in the on position for no apparent reason. 'J 'he opera tor 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 overtempera t ure failsafe protection had been specified or installed. So, when the high heat switch got stuck in the on position, the temperat ure cent inued to rise quickl y until the operator was successful in switching it off.] t 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 residual gas compositions throughout the test. A review of the period following the pumpdown indicates clearly that the water content (AM U=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 05:30011 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 is available in a 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 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. However, the scan and data storage rates cannot be changed without first stopping the data storage function in the RGA software. When the data storage function is stopped, a new data file must be generated for each change in data storage rates. One thing to keep in mind when tempted to change the data storage rate is that chronological data files with incongruent data storage rates are more difficult to append and plot than data files with uniform storage rates. Therefore, it is advisable to select one data storage rate at the beginning of the test and stick with it throughout the test. Also keep in mind that more frequent data storage rates yield higher RGA data granularity but more data does require a larger hard drive storage volume and more computer number crunching capability.

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 is to have this automated system operating by 1 /97.

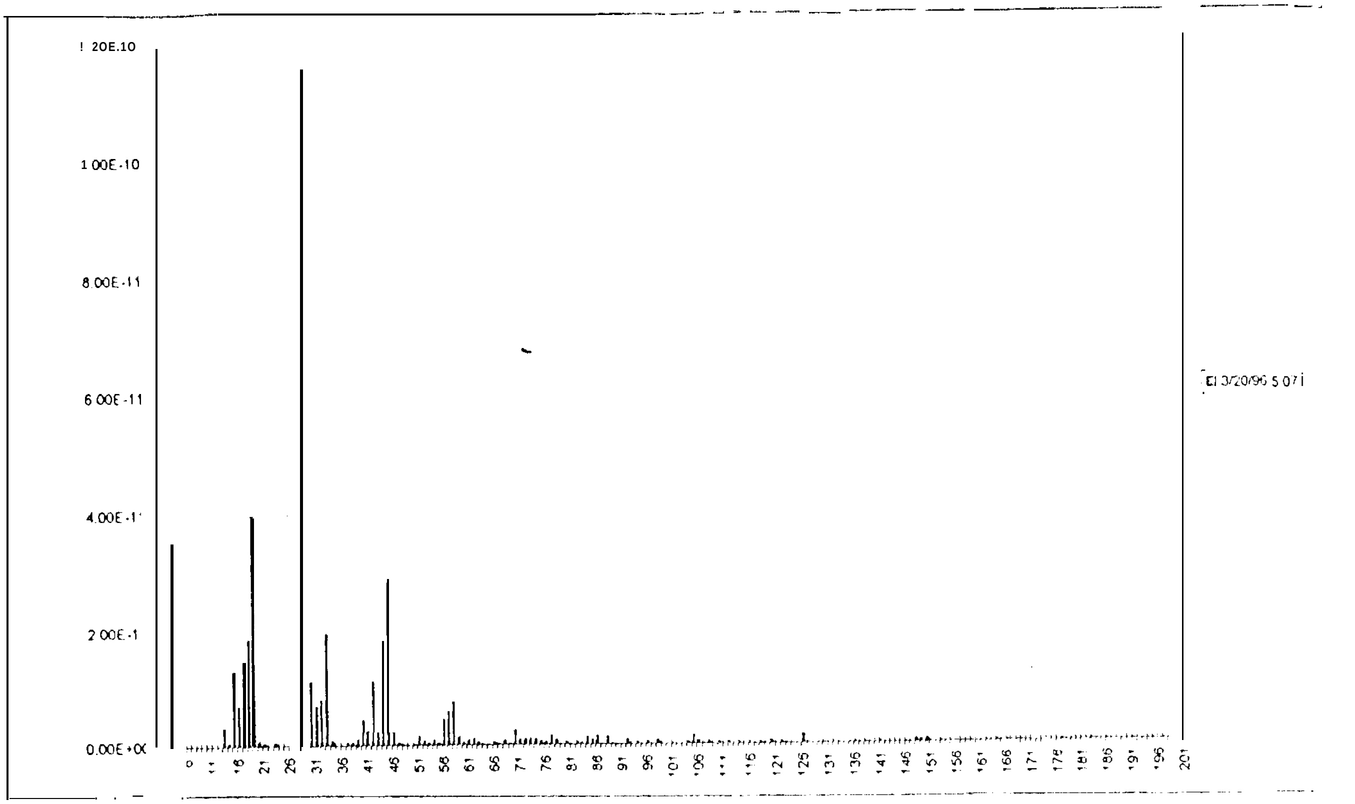

Figure 1. Standard RGA Plot made at 05:07 on 3/20/96

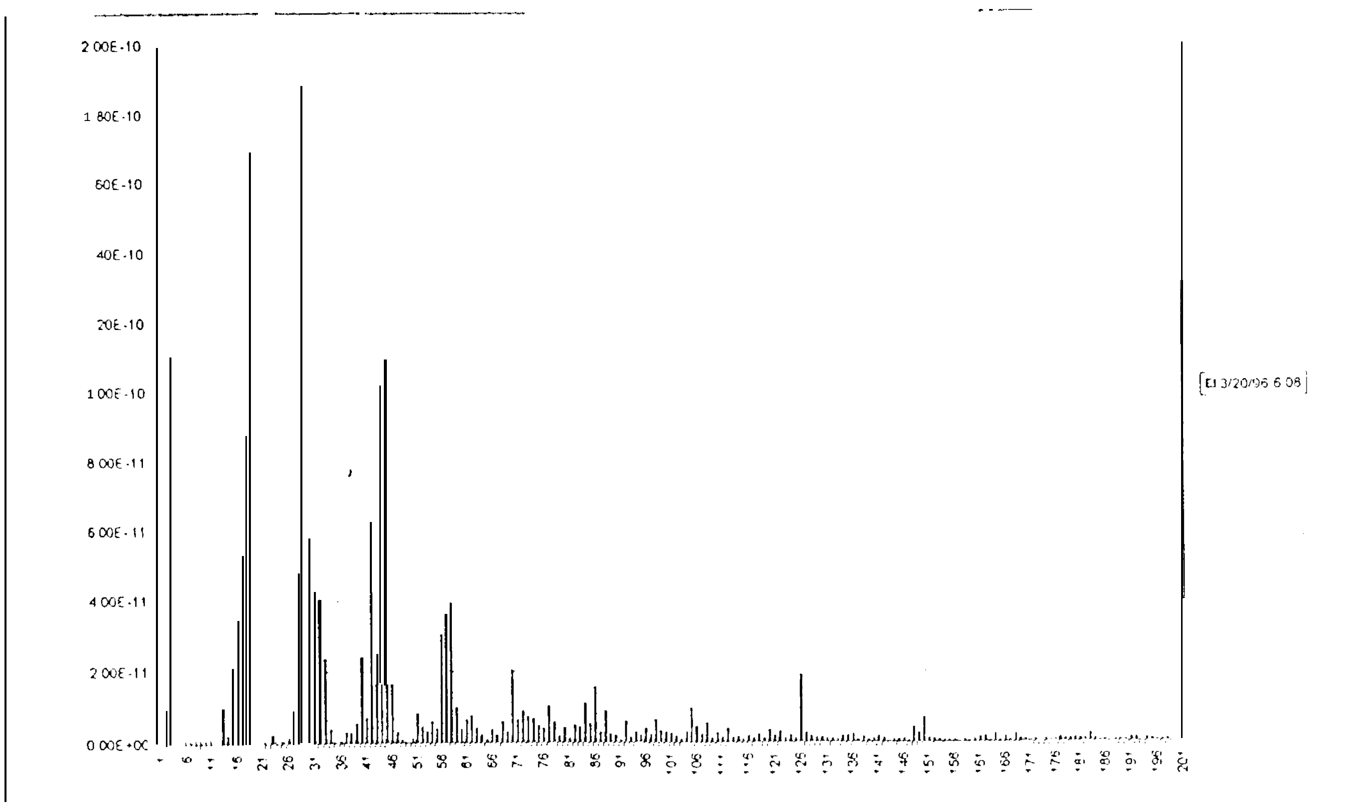

Figure 2. Standard RGA Plot made at 06:08 on 3/20/96

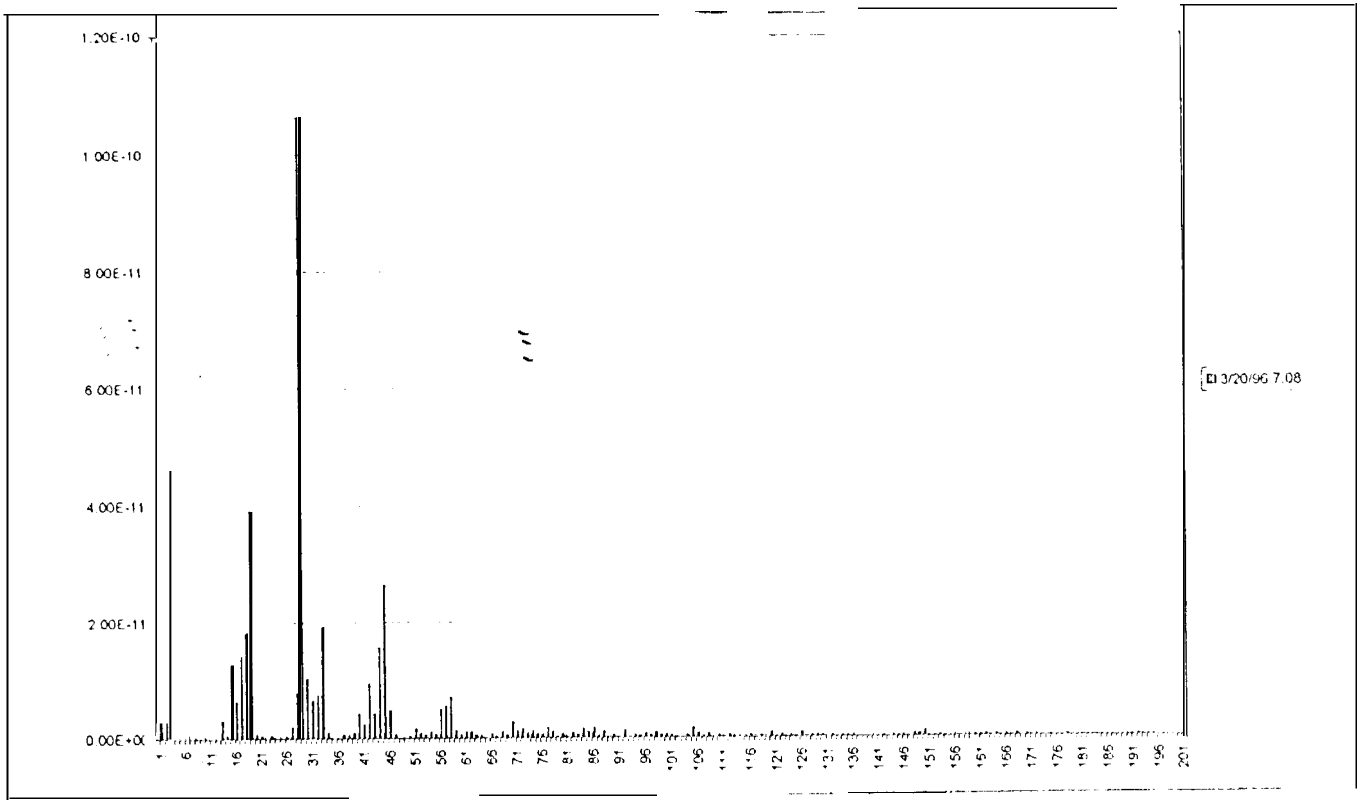

Figure 3. Standard RGA Plot made at 07:08 on 3/20/96

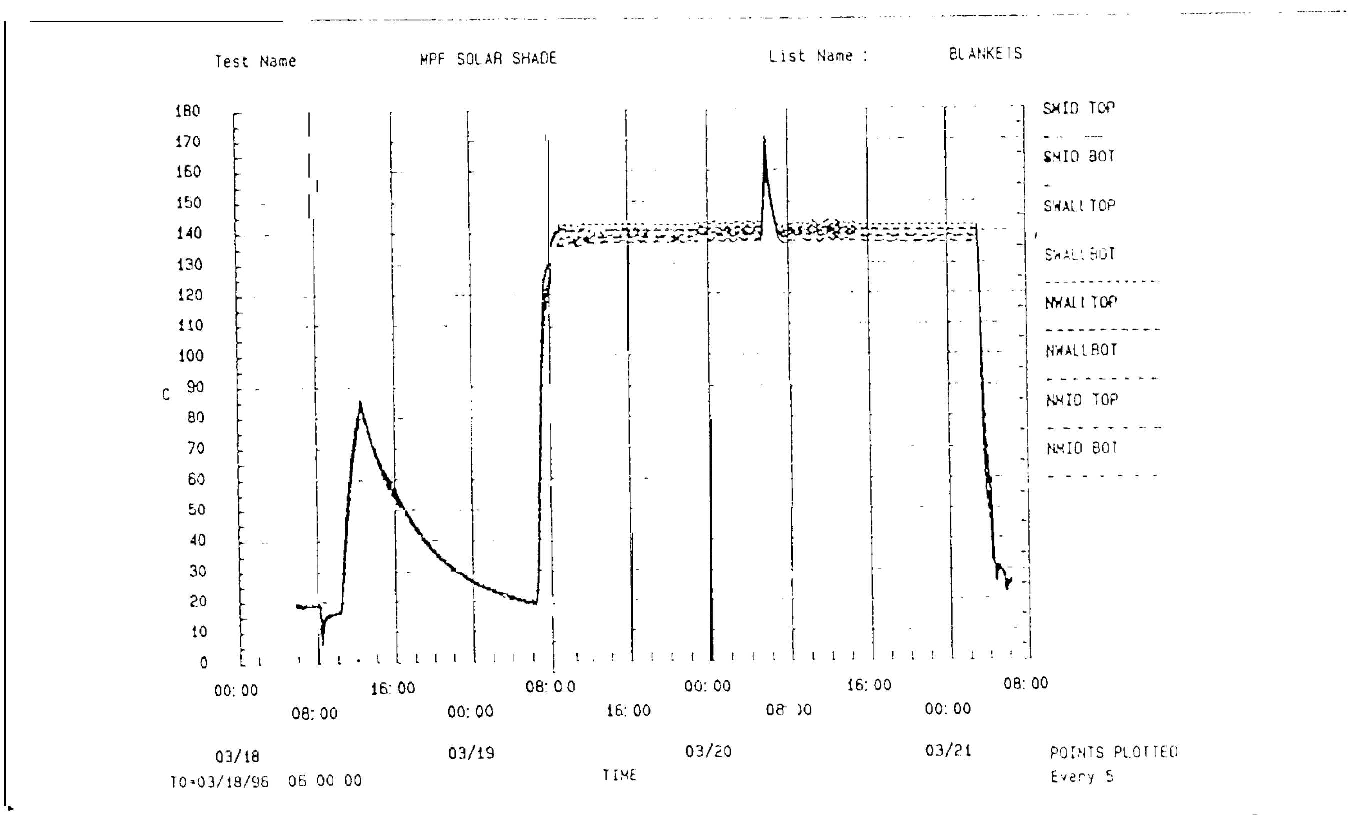

Figure 4 Plot o the Sunshade Material Temperature Throughout the Full Duration of the Sunshade Bakeout Test

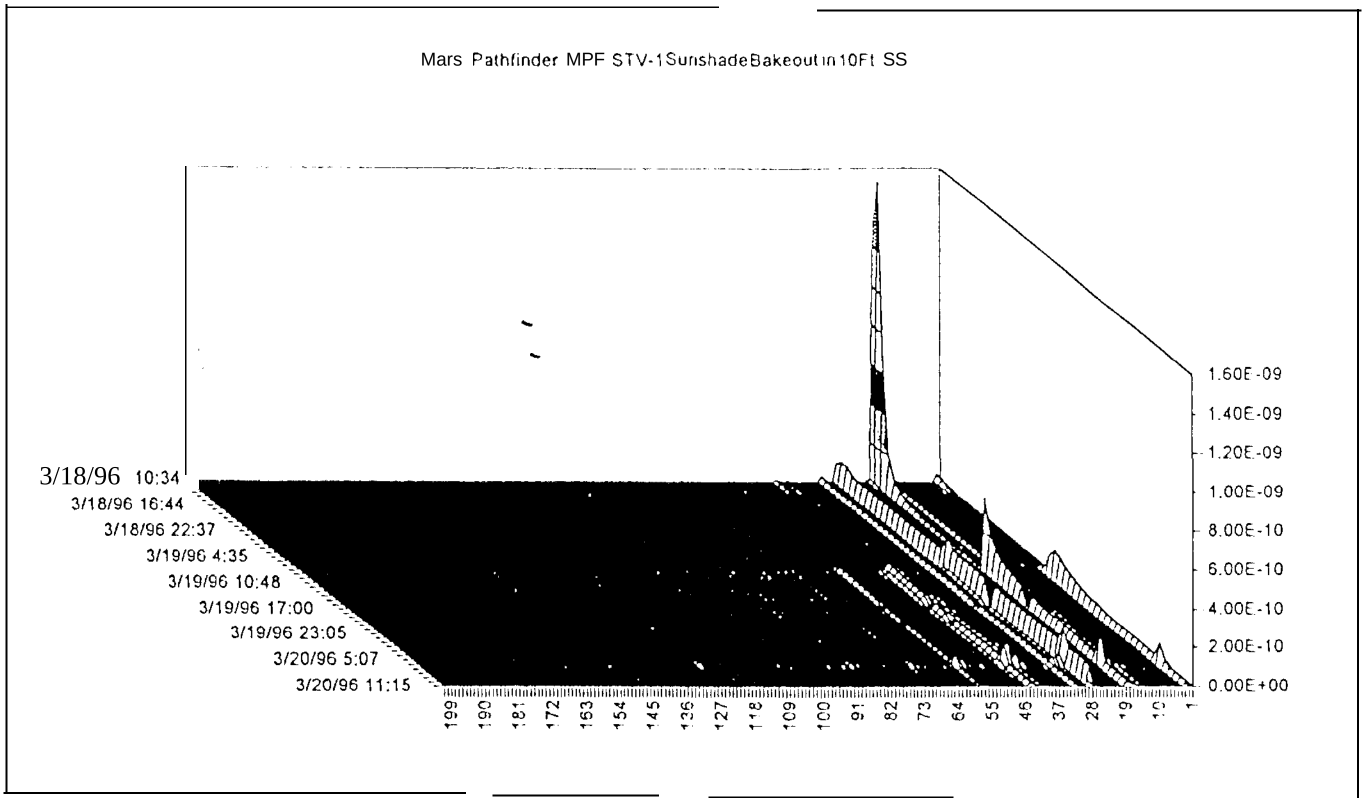

Figure 5. A 3-D RGA Plot made from Data Collected Over the Full Duration of the Sunshade Bakeout Test

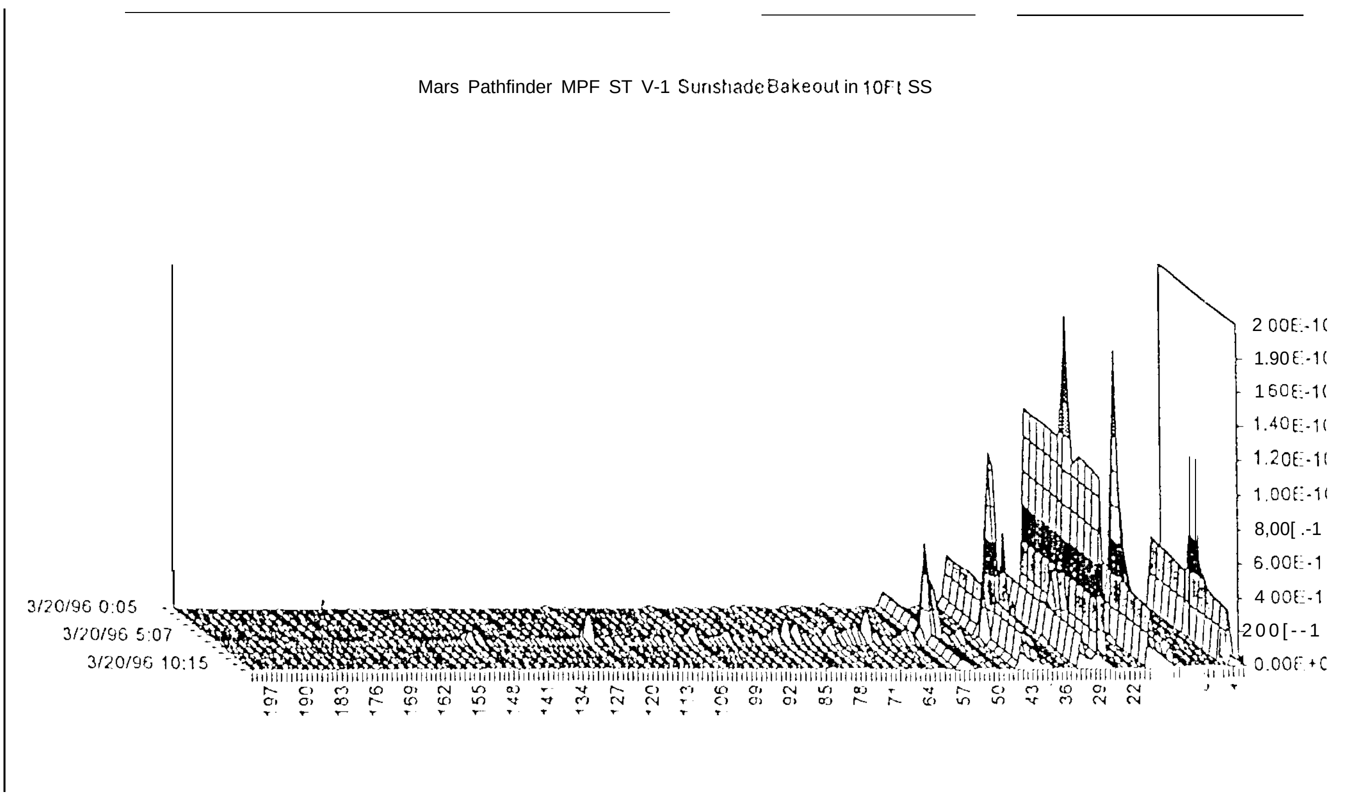

Figure 6. A 3-D RGA Plot made from Data Collected During the Morning of 3/20/96

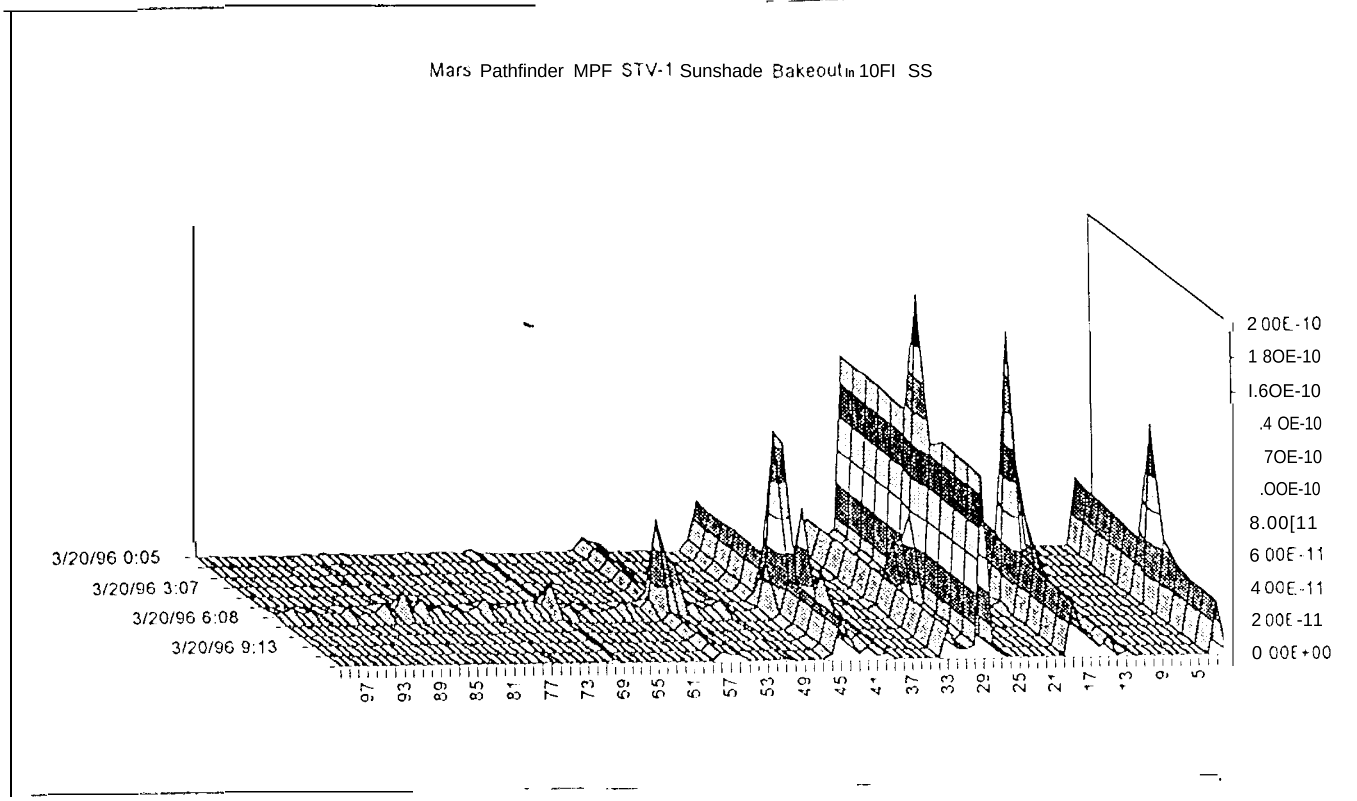

Figure 7. A 3-D RGA Plot made from Data Collected During the Morning of 3/20/96; 1-100 AMU Range

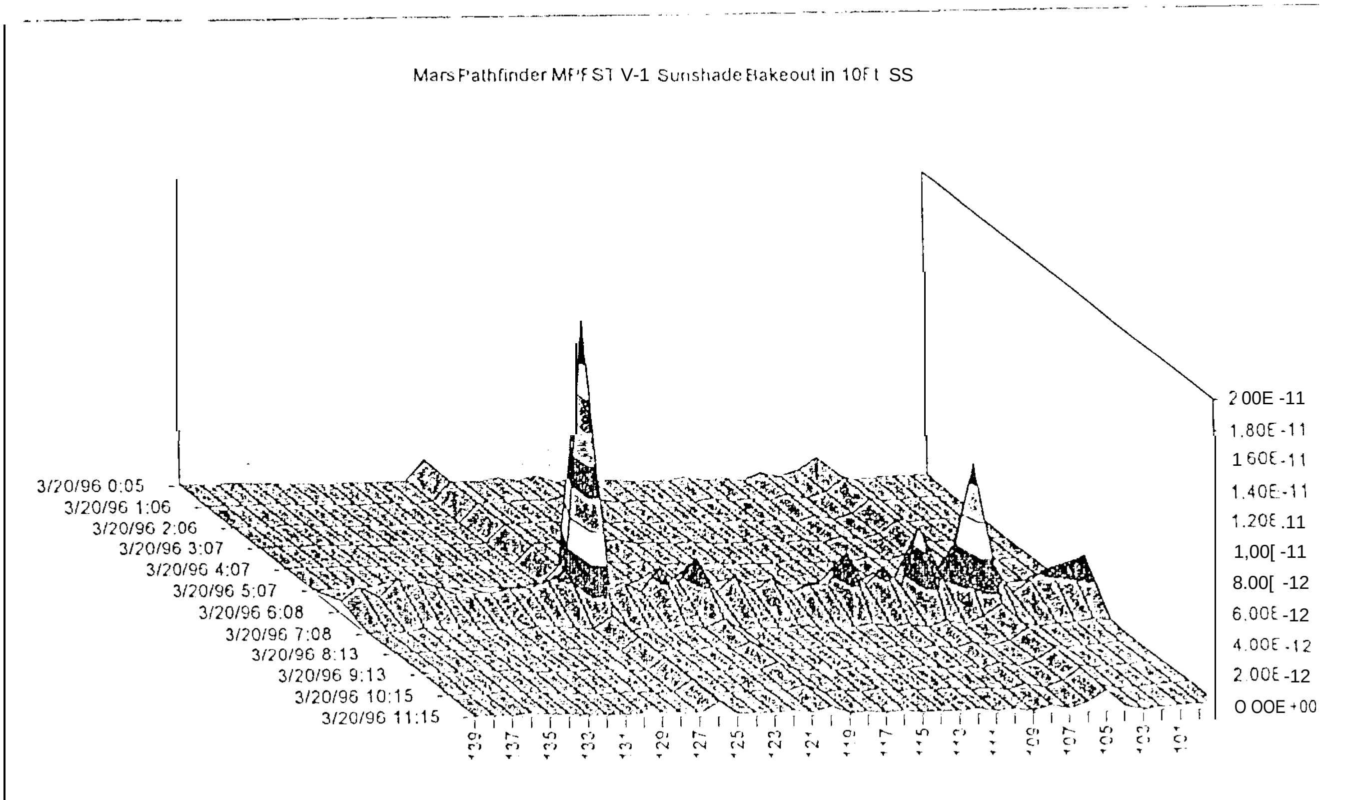

Figure 8. A 3-D RGA Plot made from Data Collected During the Morning of 3/20/96; 100-150 AMU Range