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COLLECTION AND MEASUREMENT OF ATMOSPHERIC TRACE CONTAMINANTS

BY C. L. DEUEL AND M. L. MOBERG

FINAL REPORT

Prepared Under Contract No. NAS 1-9814 by

AEROJET ELECTROSYSTEMS COMPANY

Analytical Research Laboratory

Azusa, California

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Langley Research Center

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ABSTRACT

The 90-day manned test with the simulated space station at McDonnell-Douglas Corporation required the measurement of trace chemical constituents of the air within the simulator. A description is given of the methods and apparatus used for sampling, sample handling and analysis; analytical results are presented. More than 100 constituents were identified and qualitatively measured using gas chromatograph, mass spectrometry, infrared spectrometry and high vacuum rack manipulation.

FOREWORD

This report completes the requirements for Contract NAS 1-9814 and comprises methods and systems used for sampling, sample handling procedure, and analytical results of the work performed in conjunction with the 90 Day Manned Test of the Simulated Space Station at McDonnell-Douglas Corporation, Huntington Beach, California. The samples were taken on-site by A. H. Hussung and C. L. Deuel, and the analytical work was performed in the Analytical Research Laboratories in Azusa. Mr. C. L. Deuel acted as project manager and chromatographer, D. L. Quick and N. W. Hultgren as mass spectrometrists, L. A. Maucieri as infrared spectrometrist, and N. W. Hultgren as mathematician for data reduction. Mr. M. L. Moberg supervised the test program.

The operating test personnel of McDonnell-Douglas and the NASA technical monitors on-site were exceptionally cooperative in the successful completion of this task.

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INTRODUCTION AND SUMMARY

The purpose of this program was to measure the trace atmospheric constituents found in the Space Station Simulator, expediently report these data to the technical monitor, provide back up and verification data for the automatic monitors, and furnish additional analytical assistance as required by the program manager. The three collection methods and sampler used on this program provided continuous collection of samples for measuring major, minor, and trace components with classical gas volumetric analytical precision throughout the dynamic range. Over 100 components were identified and quantitatively measured using gas chromatography, mass spectrometry, infrared spectrometry, and high-vacuum rack manipulation. With few exceptions, the space chamber atmosphere was found to be of higher quality than the ambient atmosphere.

METHODS AND PROCEDURES

The most important procedure in obtaining reliable analytical data is through reliable sampling. Each sampling method currently accepted for trace gas contaminant study contains inherent weaknesses. In order to provide constant surveillance of the Space Station Simulator atmosphere and to obtain relatively unbiased analytical data, three different procedures were used. These were direct atmospheric or "grab" sampling, cryogenic collection, and activated carbon adsorption. Of these, grab sampling is the simplest procedure. This method is additionally attractive in that it provides an immediate sample of the total atmosphere at any given moment. Non-condensable (at liquid nitrogen temperatures) gasses such as methane, carbon monoxide, nitric oxide, and hydrogen, as well as the major atmospheric components, can only be sampled by this method. Concentration of trace contaminants is so small, however, that many materials may not be detected or resolved by gas chromatography and errors in peak area measurement assume inflated proportions. Shifting of apparent retention volume from differences in concentration become more pronounced, responses fall on the nonlinear portion of the sensitivity curves, and sample concentration is too low to allow component identity verification by mass spectrometer coupling. In addition, this sampling procedure irretrievably removes a portion of the atmosphere that could become serious in closed atmospheric studies. To partially alleviate these difficulties (except for the atmosphere removal) the grab samples were pressurized to approximately 75 psia using a diapump. As will be discussed later, it is possible that this procedure can introduce some error in quantitation of the contaminants; however, the reliability of qualitative data was augmented.

Cryogenic trapping of the condensable vapors provides a convenient means of concentrating low-level contaminants, greatly enhancing detectability limits, and providing marked improvement in the accuracy of quantitation. At the flow conditions standardized for the 90 day portion of this program, this concentration factor was approximately 750 times that of a direct grab, or 150 times that of a pressurized grab sample. This sampling method undoubtedly provided the most accurate information regarding levels of concentration and remains the method of choice when quantitative accuracy is paramount. There are, however, several weaknesses with this system. Flow rates must be adjusted for optimum condensation in the cold chamber or an appreciable portion of the more volatile materials will pass through with the "carrier" gas, in a vapor state or as an aerosol. Water and carbon dioxide of the atmosphere are also concentrated and cause considerable interference with these analyses. Additionally there are many compounds of interest such as hydrogen, carbon monoxide, methane, nitric oxide, ethane, and ethylene with moderate vapor pressures at liquid nitrogen temperatures (approximately -180°C within the trap) that are not quantitatively retained. Some compensation for these shortcomings was achieved by passing the atmospheric flow through successive traps at 0°C, -80°C, and two LN_2 traps. The precooling at 0°C allowed nearly complete water retention in the first two collectors, while the double LN_2 trap effectively stopped the passage of aerosols and more volatile gasses. Noncondensables were returned to the test chamber. Unfortunately oxygen condenses at LN_2 temperatures at atmospheric pressure, and a reduced pressure must be maintained to avoid overpressurization on warming to room temperature. The placement of the diapump on the downstream side of the LN_2 traps with restricted inflow was used to maintain a pressure of approximately 250 torr through the LN_2 collectors. This pressure is well below the minimum pressure required to condense oxygen under the sampling conditions. Long term, continuous surveillance by cryogenic trapping is not feasible since this system requires the constant attention of trained personnel as well as the consumption of large quantities of refrigerants.

Adsorption trapping has long been a primary method for the purification of gasses, and this principle is readily adapted for trace contaminant monitoring. This system allows constant, safe, unattended sampling and reasonable retention of trace contaminants. The chemistry of charcoal adsorption and desorption is still under study, and possible catalytic changes of some compounds through this system cannot be discounted. The affinity of various types of materials for charcoal adsorption seems to affect the trapping efficiency and probably leads to some fractionation of the contaminant profile. If the dwell time of the gas within the bed is sufficient and if the quantity of adsorbent is large enough, nearly complete adsorption of organic vapors will be effected, even though the composition of the adsorbed material will vary at various depths. The traps prepared for this test contained a sufficient quantity of adsorbent to allow a total dwell time of over 2 minutes at the maximum flow rates and up to 20 minutes at the minimum rates, with a theoretical capacity of 30 to 40 grams of foreign material. The problem of stratification of contaminants was ameliorated by desorbing all of the charcoal from each trap in turn in preference to attempting to blend a representative sample. This presented a secondary benefit in that some insight into the migration of various compounds through the traps could be gained. While the ability of charcoal to adsorb large quantities of organic materials is unquestioned, the analyses of the adsorbed compounds present other problems. These compounds must be removed from the charcoal and completely collected using procedures gentle enough to prevent degradation of the desorbate. Vacuum-thermal stripping with cryogenic trapping of the condensable vapors has been used and studied by this laboratory for several years. Information gathered from work performed on the Apollo and Biosatellite programs indicates satisfactory removal of the organic adsorbates by these methods. Several problems that were encountered during this 90 day test will be discussed in detail later in this report. Adsorbent trapping did provide a valuable supplement to cryogenic and direct atmospheric sampling, but some disparity of data suggests that caution should be exercised in the assignment of more than a semi-quantitative designation to values calculated from this system.

The system used for sample collection was the NASA, LRC trapping system used on the Apollo, Biosatellite, and other programs. This unit was modified somewhat for these tests. A bypass was provided for the -80°C trap so that continuous operation could be maintained if this cylinder became plugged by ice. The grab sample system was modified by adding a high-pressure gage and diapump for this mode of sampling without interfering with the flow through the cryogenic traps. Finally, a charcoal trapping system was added. Figures 1 and 2 present pictorial views of the modified sampler. The tubes shown in the side view in Figure 2 are the charcoal traps. The flow systems were arranged so that charcoal trapping could be effected independently, in parallel, or in series with cryogenic sampling. To maintain sampling capability should either diapump fail, a bypass was installed to allow operation of any of the sample modes by use of the upper pump only. The gas flow system is presented in Figure 3. While the presence of a moderate number of valves and lines might appear too complex, the operational procedures are quite straight-forward and little difficulty is experienced in training new personnel in the operation of the sampler. The appendix contains the operational procedures used for all sample modes.

Following the plumbing modifications, new heater tapes were installed where necessary and the electrical loads more evenly distributed to the 4 powerstats. Final check-outs included leak testing to insure sampler integrity, cleaning and leak testing all sample cylinders, and fabricating new connector lines where required to insure interchangeability of sample bottles. During the course of the test, several sample cylinders developed leaks through the valve seat. In all instances, these were packless valves that had been welded to the connecting hardware, making repairs essentially impossible. These cylinders were removed from test and tagged for later attention by NASA.

The charcoal traps were fabricated from 15 inch lengths of 1" stainless steel tubing, fitted on either end with AN nuts and sleeves and a 1 to 1/4" reducing union. A stainless steel screen was placed in each union to prevent movement of charcoal into the 1/4" lines. Each trap contained 85 grams of Barnebey-Cheney type AC charcoal that had been stripped in a vacuum oven before loading. Vacuum rack desorption of the prepared charcoal indicated residual adsorbate content of less than 0.3 $\mu g/g$ charcoal. Type AC charcoal is a cocoanut shell charcoal currently used in the Apollo command module breathing canisters. Preliminary testing by this laboratory indicated this charcoal to be initially less contaminated than either the pelletized charcoal used by the Navy for submarine air purification or the higher capacity cocoanut shell type VG charcoal.

The chamber atmosphere was drawn through an unheated bulkhead plate and through 6 inches of unheated 1/4" stainless steel line before the sample was "teed" to the LRC sampler. The unheated portion was necessary for the ozone monitor that shared this sample line. From this tee, the sample passed through approximately 60 inches of 1/4" stainless steel tubing maintained at 160°F. The return line to the chamber was identical but unheated. The sampler was connected through 36 inch sections of heated, teflon-lined flex lines to both the inlet and exit. The flex lines allowed a degree of mobility of the sampler cabinet to provide ready access to other test equipment located nearer the simulated space chamber and to the gas analysis console used by McDonnell-Douglas personnel. The sample line intake inside the space chamber did not contain a length of flexible tubing for selective site sampling as originally planned. A tube stub was used and was located immediately behind the oven used for food preparation. It is possible this location gave rise to high water recovery values on the charcoal. This problem will be discussed in the analytical section.

On 16 April 1970 the "unmanned" preliminary testing was begun. Unfortunately, personnel traffic into and out of the chamber during this test (3 or more test technicians were in the chamber for 5-8 hours each day) precluded establishing a zero background. On the evening of 18 April, hot coolanol line failure within the chamber caused a test abort. On 26 April, the 96 hour unmanned test phase was resumed and proceeded to completion without futher incident. Sampling was by all three modes and at the frequency suggested in the proposed program.

On 29 April, the five day manned phase was begun. Sampling consisted of 5 sets of cryogenic traps, 5 sets of charcoal traps, and 2 grab samples. On the morning of the fifth day a pump motor within the space chamber overheated, but no evidence of this incident was detected from samples begun approximately 1-1/2 hours later.

These preliminary tests were primarily dress rehearsals to optimize and verify the performance of the ancillary equipment to be used during the extended test run. The accumulated data provided a base line from which changes brought about by the extended occupancy could be more readily determined. Two noteworthy findings were that the entire chamber atmosphere contained fewer contaminants and generally lower concentrations of the detected materials after the coolanol spill clean up, and that the one liter per minute sampling flow rate was too great for adequate sample collection in the LN_2 trap. The cleaner atmosphere noted after the coolanol incident may have been, in part, caused by the physical cleaning of the chamber with volatile solvent that was readily purged, however it more likely reflects the results of recharging the charcoal bed within the chamber with fresh activated charcoal. The flow rate for cryogenic trapping was reduced to 750 cc/min and a second LN_2 trap serially added in the collection line. Subsequent tests showed this second trap to contain approximately an additional 1/3 of the sample condensate.

The four test subjects entered the space station simulator on 13 June 1970. A sampling schedule was prepared for continuous collection by one or more of the three trapping modes. There were minor deviations from the prepared schedule caused by requests for special samples or by obtaining additional samples to resolve analytical problems. Figure 4 presents the schedule for the middle month of the program and is typical of the others. A total of 25 grab samples, 28 cryogenic sample sets, and 28 charcoal sets were analyzed during the 90 day test.

At the laboratory, each sample was divided into three fractions and analyzed, generally within a 24 hour period. Occasionally, special analyses were made within the same 8 hour period of sampling when some question of atmospheric contamination was suspected.

The direct atmospheric and the cryogenic samples were split into equal fractions using a stainless steel vacuum system schematically shown in Figure 5. Each sample was warmed to 80°C and expanded into 3 evacuated stainless steel cylinders of 75 cc capacity. The sample cylinder was "flushed" several times by alternately using vacuum and helium pressurization, and the product added to the receiver manifold. All connecting systems, sample cylinder, and receivers were maintained at 80°C. After each sample split, fresh receivers were attached to the manifold and the system was vacuum-thermally cycled 3 times to insure cleanliness for subsequent runs. Periodic blank samples were prepared by attaching a clean sample bottle and performing the helium purge-splitting procedure. These analyses assured the analyst that the data generated from the test samples were not biased from contamination of the sample splitting system, the sample cylinder, the receivers, or of the sample inlet system on the chromatograph.

Each charcoal trap, and, later, Drierite trap was transferred in an inert atmosphere box to 200 ml round bottom flasks, and attached to the high vacuum rack shown in Figure 6. The total system is fitted with Fischer-Porter teflon high-vacuum stopcocks. Figure 7 shows a sample being placed in position for vacuum-thermal stripping. The heating mantle allowed the temperature programming of the sample from ambient to 170°C at approximately 10°C/min. The effluent was directed through a U-trap maintained at -80°C then through one of two special high efficiency Schultz traps shown in the upper center of Figure 6. The noncondensable gasses, including the inert gas from the dry box, were removed through the vacuum system. After one hour of desorption, the heat was removed and the contents of the -80° and -186°C traps transferred to separate receivers. The water from the -80°C trap contained only trace amounts of certain water soluble compounds such as acetone and alcohol, and was not analyzed regularly. The gas entrained above the water was combined within the gas sample loop with the portion of the sample analyzed on a Carbowax column. The sample trapped at LN_2 temperature was transferred to the metal vacuum system and divided into three portions in the manner of the direct atmospheric and cryogenic samples. Both vacuum systems were maintained at pressures below 10^{-5} torr when not used for sample manipulation.

The major analytical tool supporting this study was the gas chromatograph-mass spectrometer instrument complex. Figure 8 shows an F&M model 5756B chromatograph equipped with flame ionization, electron capture, and thermal conductivity detectors, each separately recorded. An Infotronics HS11 integrator was coupled in parallel to the FID mode, which also was fitted with an automatic attenuator. This redundancy allowed for manual planimetry of peak areas in case of failure of the integrator or its related print-out circuitry. The box-like structure to the right of the chromatograph contains the sample inlet system designed and constructed by the laboratory. The system is designed so that with the sample fraction attached, the connecting tube, sample loop, and inlet system can be evacuated and/or helium purged. All of the valves and connecting lines within the box are maintained at 80-110°C.

The sample fraction is condensed in the sample loop, rapidly warmed to ambient temperature, and directly transferred on column through heated lines and an Aerograph type gas sample valve fitted with viton O-rings. The more polar and less volatile compounds that are entirely lost or present distorted elution peaks through wall adsorption on the conventional inlet system are detected without difficulty from this inlet.

The chromatograph is fitted with a Porapak Q and a Carbowax 1000 column, operated alternately, with one backflushing while the other is analyzing. Flow direction is controlled by two Circle Seal valves located within the oven. Figure 9 depicts the schematic for the flow pattern. As indicated in this figure, the column effluent is divided among the many detectors in the approximate percentages shown, i.e., 2% to E.C., 20% to T.C., 10% to the mass spectrometer, and the balance to F.I.D., the principle analytical detector.

The Consolidated 21-104 mass spectrometer, shown in Figure 10, is attached to the chromatograph by a short, heated capillary line and a packless stainless steel shut-off valve. This line is directed to the spectrometer input, where a fraction of the aliquot sample enters, while the remainder is removed through a secondary vacuum system. The spacing of this column effluent line to the analyzer inlet opening is critical, since optimum response can be achieved only after a Ryhage venturi effect is established. For this program, special sweep selectors for monitoring selected m/e ranges were installed. These were used for following three components that could not be readily monitored by the chromatograph, i.e., ammonia at 17, formaldehyde at 30, and sulfur dioxide at 64 amu. Ammonia, in trace amounts, is essentially impossible to quantitate when it is required to pass through any appreciable length of tubing. Even though ammonia could reasonably be expected in these samples, its presence was never verified in other than occasional trace amounts.

Frequent measurements of methane and carbon monoxide content were made using infrared spectrometry and a long path (10 meter) gas cell. These data were in agreement with mass spectrometric measurements.

DISCUSSION OF ANALYTICAL DATA

Significant increases in atmospheric contaminants within the chamber were not observed during these tests. Presumably this condition is directly related to the chamber air purification system. The presence of a large fresh bed of activated charcoal associated with the Wick Evaporator undoubtedly contributed to the generally low level of contamination, as may be seen from the analyses of desorbants of charcoal removed from this bed during the preliminary test phases. The apparent absence of amines, ammonia, and compounds of higher molecular weights and/or low volatility may be attributed to the location of the sample inlet within the chamber, the unheated segment of the sample line passing through the chamber wall, the relatively long run necessary to reach the sample traps, the inherent difficulty encountered in moving these compounds in any system, and the relative insensitivity of the gas chromatograph detectors to compounds either of this type or with unusually large retention volumes.

The development of an analytical profile of each of the more than 100 compounds found during this test would require a computer study beyond the scope of this contract. However, significant observations on selected data and sample modes, comparison of the collection systems, and the indications of possible trends are presented. The data generated from these tests are contained in Tables 1 through 8, arranged chronologically and according to sample mode. This method of presentation should be of value in following trends for any compound or group of compounds, and in relating analyses to events or procedures occurring within the environmental system.

The data from the preliminary unmanned tests, with associated analysis of the Wick Evaporator charcoal are found in Tables 1 and 2. In general, there was an overall decrease in contaminant level as time increased. This would be expected through continuous "flushing" of the chamber with clean air. The data from the Wick Evaporator charcoal are interesting in that halogenated materials (e.g., freons, haloginated unsaturated hydrocarbons, methyl chloroform types) and low boiling hydrocarbons showed extensive penetration, while the higher boiling hydrocarbons and oxygenated materials were generally adsorbed on the first layers of charcoal. For example, Freon 113 showed a bed penetration in terms of $\mu g/g$ charcoal of 1070 at the inlet, 1690 at the center, and 3280 at the exit of the purifier. In contrast, analysis of the new charcoal for Freon 113 was 3 $\mu g/g$. Similarly, methyl acetylene and methyl chloroform concentrations increased 10 fold and trifluorochloroethylene 30 fold from the inlet to the exit. Conversely, acetone and methyl alcohol were more concentrated at the inlet by a factor of 5. These data might suggest a reason for apparent atmospheric compositional variations occurring during the 90 day study. This point will be discussed in a later section.

The 5 day manned study was begun immediately following the unmanned period in an effort to recover some of the test schedule slippage. This maneuver allowed no time for data evaluation or sampling parameter changes. The charcoal mode was operated in parallel to the cryogenic system, with the sample split 250 cc/min to the charcoal system and 750 cc/min to the cryogenic system for trapping increments of six hours.

The data from these tests, as well as the direct atmospheric samples generally were in good agreement both in compound identity and quantitation. There were no significant differences noted as a result of human occupancy, and all sampling modes were considered to be adequately functioning.

Both the preliminary unmanned and manned tests were run with all compound assignments made only by gas chromatography. Both mass spectrometer units failed just after these tests began. By overriding built in safety switches, the CEC-130 could still be used for permanent gas analyses but was unsuitable for combined gas chromatography-mass spectrometry runs. Scans of the composite sample would have resulted in such an accumulation of mass numbers that individual identifications could not be reliably made. The analyses obtained from the 90 day tests did not indicate gross misidentity of compounds during these earlier tests. Table 7 contains the permanent gas analyses of the direct atmospheric samples taken preceding the 90 day tests.

A sample of Coolanol 35 (related to line failures within the chamber) was analyzed by a mass spectrometer probe technique. Atomic mass units of the significant ions and relative intensities (> 1%) above m/e 50 is presented in Table 8. The spectra indicates impurities and/or a blend of materials possessing a molecular weight near 500. Molecular ions which could be assigned to ethyl butanol or ethyl hexanol esters of orthosilicic acid were not observed, e.g., $Si(OC_6H_{13})_4$ at m/e 432, $Si(OC_8H_{17})_4$ at m/e 516. A prominent ion at m/e 388 could result from the loss of an (OC_8H_{17}) group with a hydrogen rearrangement in $Si(OC_8H_{17})_4$. A similar ion from $Si(OC_6H_{13})_4$ at m/e 332 was not found as a prominent ion. Ions in the lower mass ranges 56, 84, and 112 could be assigned to C_4H_8, C_6H_{12}, and C_8H_{16} fragments obtained from cleavage of the respective alcohol ester forms. From this scan, Coolanol 35 was determined to be a mixture of C_6 to C_8 silane esters of orthosilicic acid. Additional GC-MS analyses of the heated vapors indicated three major components identified as 2-ethyl butyl alcohol, 2-ethyl hexyl alcohol, and the aldehyde, 2-ethyl butanal.

Comparison of the three sample collection methods seems to indicate that direct sampling provides the greatest calculated contaminant concentration although signal responses were quite low and errors in area measurement produced exaggerated calculated differences. Cryogenic sampling provided concentration factors of 100 to 250 times, while the quantity of gas sampled through charcoal was from 300 to 2000 times that of a direct sample. These samples produced large signal responses but low calculated concentrations because of the volumes of gas sampled.

This disparity probably arises from the calculation of concentration as an essentially linear response throughout the detector's dynamic range. However the probability is high that a considerable deviation from linearity occurs at the very low end of this range. Standardizations are regularly performed over a broad range and their linearity justify the application to these calculations. The very low ranges (fractional ppm levels) have not been thoroughly investigated however.

Cryogenic sampling data from the 90 day tests are found in Table 4. There were 95 compounds identified from this mode. Lower than average values could usually be attributed to leaks through the valve seats on packless diaphragm valves. These defective cylinders were removed from further testing whenever discovered, but occasionally not without a partial sample loss. There is no explanation offered for the results from the traps taken on the 83rd day of the test. These values were all higher than usual by a factor of 100. The charcoal sample immediately preceding this day was a little higher in trapped contaminants than the average, but not to the degree approaching this cryogenic sample. The charcoal sample taken after this day was average, as were the following cryogenic samples. The calculations were checked to eliminate the possibility of computational error. The low values obtained on day 59, later traced to a faulty valve on the trapping cylinder, caused some concern as to the effect of the ozone monitor sharing the same sample lines. On the 62nd day, cryogenic sampling with the ozone monitor functioning was performed for 3 hours, followed by an additional 3 hours in another set of traps with the ozone monitor's flow cut off. These tests indicated no differences that could be attributed to the shared lines. Figure 11 illustrates a generally increasing trend of contaminant buildup. Freon 113 data was eliminated from this figure because of large concentration variations which would obscure the trend of all of the other products.

Table 5 lists the data obtained from the charcoal adsorption traps. There were 110 compounds identified from this mode. It is apparent from these values that there are a large number of halogenated materials not generally found in the other two trapping modes. Conversely, the concentration of Freon 113 is considerably less than found by the other systems. While improbable, it is suggested that Freon 113 may have degraded on the charcoal or through the vacuum-thermal desorption process. An overall increase in unsaturates such as ethylene, propylene, and butene is also noted, indicating possible decomposition of larger molecules. These suggestions are offered only as an observation and were not verified during this study.

The charcoal system indicated concentrations of contaminants much lower than found by the other sampling methods. Initially, 3 charcoal traps were connected in series. Analysis of the total desorbate from each of these traps demonstrated that very little organic material passed through the first trap. What did escape the first trap was essentially contained on the second. Each trap contained 8 - 10 grams of water with no appreciable difference attributable to the location within the trapping train. During the first 16 days of this test, sampling was performed at a flow rate of 1000 cc/minute. Sampling times were up to 115 hours, resulting in nearly 7000 liters of gas sampled. Those samples taken between the 20th and 30th days were collected at a flow rate of 750 cc/min. This still resulted in the sampling of 5000 to 6000 liters of gas, but the apparent concentration of contaminants noticeably increased. The flow rate was further reduced to 300 cc/min and sampling was maintained at that rate until the 60th day. Since sampling time varied from 40 to over 100 hours, the volume of gas sampled varied from 650 to 2400 liters. To minimize effects of varying sample sizes, the flow rates during the final 30 days were adjusted to result in a total sample of approximately 1000 liters, or 1 m^3 per set.

The discrepancy between apparent contaminant levels found in charcoal compared to cryogenic trapping continued during the first month. Noting that the charcoal in each trap was apparently becoming nearly saturated with water, which would result in reduced adsorption sites for the organics, precollection of water using a desiccant before charcoal trapping was attempted on sample 35-37. This was accomplished by replacing the charcoal in the initial trap with 180 grams of anhydrous calcium sulfate, marketed as Drierite. The quantity of water removed from the charcoal was greatly reduced, but the anticipated increase in collected organics did not materialize. The set taken between the 38th and 40th day also contained a Drierite column. The desiccant was stripped and the desorbate analyzed in the same manner as the charcoal samples. An appreciable percentage of the total trapped contaminants was recovered from the Drierite. The Drierite from the set taken on day 42-44 was not analytically stripped, with a resulting sharp drop in indicated contaminant level adsorbed on the charcoal. The following set was again equipped with a Drierite column that was stripped along with the charcoal. Once more the contaminant level took a dramatic upward trend toward the levels found in cryogenic trapping. The apparent increase in overall trapping efficiency suggests that a desiccant is required to prevent water from saturating the charcoal. To effect a gentle heating of the Drierite in an effort to remove the retained volatile organics without removing the water, and to eliminate possible carbon dioxide elution effects, advantage was taken of the exothermic carbonate reaction of lithium hydroxide by preparing a precolumn containing 30 grams of the hydroxide and 140 grams of the desiccant. This column was used for the day 55-58 sample. The only noticeable effect was to raise the water recovery to that calculated from the carbonate reaction.

The charcoal used to this time had been reclaimed by additional stripping in a vacuum oven, following the vacuum rack analytical desorption, before repacking the charcoal traps. To insure that no loss of active sites or activity was occurring through these heating cycles, duplicate runs (in so far as successive runs could be duplicated) were taken using new type AC charcoal with a standard vacuum oven pretreatment strip for one run, and the recycled charcoal for the other. These are the samples taken on days 60-62 and 62-64 respectively. There were no apparent differences, suggesting good adsorption-desorption reversibility with no changes in charcoal activity.

While still attempting to reduce organic vapor retention without loss of water, the Drierite column was heated by an external tape wrapper to approximately 160°F on those samples taken from day 69 through day 76. Surprisingly, an opposite effect was achieved. The water retention of the Drierite decreased dramatically, while increasing equally in the charcoal traps. The Drierite desiccant retained an even greater percentage of the organic contaminants. While the ability of calcium sulfate to form alcoholates and etherates is known, their stability should be much less than the hydrate. Apparently the adsorption isotherms for polar organics and water under the test conditions were similar. The failure to readily displace contaminants from the Drierite necessitated the continued stripping of this trap in the manner of the charcoals. The heater tape was removed from the desiccant column and no further changes in trapping technique were attempted on those samples gathered during the final two weeks.

In general, it was found that Drierite retained the esters, ketones, and higher molecular weight alcohols and aromatics. The n-paraffins, unsaturates, and lighter aromatics (through toluene) and alcohols (methyl and ethyl) were not retained by the desiccant and passed on to the charcoal. Freons and associated halogenated hydrocarbons were generally not retained by the Drierite to an appreciable extent.

Figure 12 presents a comparison of the cryogenic and adsorption trapping data. The values shown represent the total collected material less water, carbon dioxide, and Freon 113.

Table 6 presents the data on contaminants from grab sampling, with Table 9 giving the permanent gas analyses from these samples. The much larger apparent concentration of trace constituents of these samples compared to the cryogenic and adsorbed samples has been discussed. The primary gain from this sample mode was the ability to monitor the major atmospheric composition and minor contaminants such as methane, hydrogen, and carbon monoxide. There were 81 compounds identified from these samples not including those gasses analyzed by the mass spectrometer and/or IR spectrometer. As can be seen from the two samples taken at different pressures on both the 74th and 88th days, quantitative precision was rather poor from this mode of sampling. There is a possibility that valve failure was responsible for the inconsistent data obtained on the 88th day. These data indicate a generally lower calculated contamination concentration. Early in the test (beginning the 4th day) there was concern over the indicated hydrocarbon levels obtained from the automatic monitors. To provide verification of these values, the laboratory regularly obtained additional direct atmospheric samples for long path IR analysis. The methane content of these samples rapidly increased from 7 ppm on day 4 to 79 ppm on day 12. Continued sampling showed minor variations, with the concentration of methane finally stabilizing at approximately 85 ppm by the end of the first 30 days. After day 34, no additional sampling for methane was performed since this level was within acceptable limits and the automatic monitor data was reproducible.

Concentration of several constituents were followed throughout the 90 day test. These data are presented in Figure 13. Several observations can be drawn from this figure. Freon 113 quantities are shown for all three collection modes, since this was the main contaminant in all samples. Differences between direct and cryogenic sampling remain generally the same throughout, e.g., a factor of 2. While the charcoal recovery was improved with the addition of a desiccant, recoveries were never equivalent. However, the analytical information obtained on the Wick Evaporator charcoal indicated rather deep bed penetration, possibly accounting for these consistently low values. Trifluorochloroethylene, shown on the charcoal graph, is either an impurity of Freon 113 or a degradation product of a freon. Its concentration varies consistently with that of Freon 113 at about 10% of the latter. Benzene, a material with a relatively high adsorption isotherm, showed a generally increasing trend throughout the test. A measurable increase in even benzene was noted after the water was removed from the sample stream.

Acetaldehyde and isoprene, two known human exudates, were followed. The expected concentration buildup failed to materialize, possibly because of the relative chemical instability of these compounds. Ethyl benzene and isopropyl alcohol were followed in the direct sampling data sheets. Ethyl benzene varied randomly, but the isopropyl alcohol showed a generally increasing level. This might indicate a decreasing capacity of the purification system, however, a sharp increase in contaminant concentration was not observed suggesting a remaining usable capacity of the atmospheric purification system.

Figure 14 presents two typical chromatograms to demonstrate the complementary nature of the two columns. The duo-column operation allows good separation of the very low boiling compounds, i.e., acetylene and butane, while providing the elution of high boiling materials, i.e., methyl napthalene, within a reasonable time. The sharp spikes occurring on either side of some of the larger peaks are from the automatic attenuation. The "lazy" second trace on each chromatogram is the electron capture signal providing an additional qualifying tool for the observed chromatographic eluents.

Analytical instrumentation has been so improved during the past decade that sensitivity levels are routinely utilized that would have been considered impossible to achieve 10 years ago. However, the instrumental capabilities are only valid to the extent of representative and reliable sampling. If certain complex organic constituents can be identified by human olfactory detection and not analytically observed in the collected and analyzed sample it is suggested that failure occurs in collection or transfer of collected material to the analyzers. Even olfactory identification or detection has limited usefulness because of response "burnout." If fresh human exposure to odorous material is possible useful detection and identification can be achieved with training. For this reason, the technical monitor requested a chemist with an especially sensitive olfactory system to observe by smell the chamber within minutes of the test crews' egress. This report is considered pertinent enough to include verbatim.

A qualitative and ROM judgment on detectable odors is offered as a result of surveying the Space Station Simulator immediately after the 90 day 4 man crew egress on 11 September 1970.

In general, the cabin odor level was surprisingly low and rather innocuous considering the length of time of human confinement. This would be attributable to the air purification system and apparent continuous use of bactericides during the test. If a general concentration level of odorants would be assessed to the cabin atmosphere, the range of ppb to fractional ppm would be realistic.

The airlock and general cabin atmosphere odor appeared to be metallic, a mild hydrocarbon (aromatic) odor and disinfectant like. Compounds that appeared to make up this rather mild odor appeared to be a quinone, phenol or substituted phenol, substituted aromatics (mesitylene type) and a faint vegetable oil base. The bunk area had noticeable body odors including higher molecular weight amines and more quinones. The quinone and phenol odor was directly traceable to 8-hydroxy quinoline (sulfate salt), the bactericide. Apparently one or more crew members had applied this bactericide to the bedding, or with some on their hands had touched the material.

The general work area had several specific odors on the counters, in cabinets and around the table area. The lower "yellow" cabinets had a decided cocoa or chocolate odor plus a fruit odor (esters of higher molecular weight saturated and unsaturated organic acids). The corners and back of the counter immediately above had an acetic acid odor. The left of the room, around the oven, was comparatively free of odor except for the quinoline and a slight perfume odor associated with Zephiran chloride - a second disinfectant.

The hygienic area had a slight ammoniacal odor, acetaldehyde and acetic acid in addition to human waste and the quinoline. The top of the waste water tube was the highest concentration of the above compounds - probably in the ppm range.

The equipment room had the highest levels of composite odors, possibly 1-10 ppm. Starting on the right side (facing the control console), a slight Coolanol odor was noticed on the back corners of the work bench area. A slightly pungent odor resembling hydrochloric acid (a very low level of mineral acid or acidic gas like chlorine and a metallic odor are similar) was also noted with concentrations below ppm levels. The aluminum tray on the floor area near the VDVF unit had a strong urine odor as well as the sponges on the floor nearby. In addition, a square aluminum container on the floor under the equipment (Sabatier or Toxin Systems) had a strong urine odor, > 50 ppm, plus propylaldehyde and methyl or ethyl amine. The solid waste disposal container had very little odor except on the gasket seal of the lid. A moderately high Coolanol odor was evident. Probably the odor associated with Coolanol comes from higher molecular weight alcohols present as impurities or degradants. The area around the Sabatier reactor and Toxin burner had an acid odor resembling HCl or HNO_3 absorbed in plastic plus a degraded styrene or polycarbonate like odor. Overheated Kel F is similar also.

Finally, the control console area had a slight naphthalene odor, < ppm levels, and plastic odor resembling a plasticizer oil (phthalates). A slight amine odor was noted to the left of the control console.

The probable odor of 8-hydroxy quinoline hydrosulfate results from hydrolysis to the free hydroxy quinoline plus phenols, quinoline, and quinone.

CONCLUSIONS

Even though over 100 compounds were identified and quantitated during this test, the overall chamber atmosphere remained of much purer quality than the average troposphere. The gradual increase in contamination indicated that the air purification system, while continuing to function satisfactorily for this test, would probably be overwhelmed at some point in time unless rejuvenated.

The sampling systems utilized for this test performed satisfactorily. There were minor problems encountered with equipment but by maintaining a redundancy of key components, sampling was not interrupted. This program also demonstrated that sampling of this type can be accommodated without interference with test procedures or other sampling methods. In terms of long time exposure, as proposed for future operations, background studies of this type are essential as an adjunct to continuous automatic monitoring for classes of compounds.

Some weaknesses of this sample system should be recognized. Most inorganic compounds, high molecular weight or nonvolatile materials, very polar hard-to-move substances such as some of the amines and ammonia, and particulates were all poorly monitored with these trapping procedures. It is quite probable that adequate monitoring of these materials will require the use of a suitable adsorbant located within the test chamber since these materials are all very difficult to move through sample lines of any appreciable length.

The use of charcoal as an adsorbant did provide a simple trapping system and the only one suitable for continuous, unattended operation; however unexplained events seem to occur that influence analytical data. Until more information is available on adsorption-desorption characteristics of various materials and the effect of water, temperature, and space velocity of carrier gas on charcoal collection, this method should be used only as a supplement to cryogenic sampling, and not as a sole source for analytical data.

The consistent presence of some compounds, not necessarily related to human occupancy, throughout this test can give rise to interesting speculation as to their source. The widespread use of Freon 113 throughout the space industry may adequately account for its abundance and the presence of related halogenated hydrocarbons. Methane, ethyl and methyl alcohols, isoprene, toluene, the n-paraffins, and dimethyl sulfide are all human related, as is acetone to an extent. Various other hydrocarbons, especially the aromatics, may well have been introduced through their widespread use as solvents. Dioxane, while it can be formed by the reaction of ethylene glycol with an acid, is used rather commonly as a solvent, in cleaning agents, in deodorants, and as a stabilizer for chlorinated solvents. Ethyl and methyl acetates may have been formed by the action of their respective alcohols with acetic acid and heat, but their presence in solvents and foods is a more likely source. Acetaldehyde is an easily formed oxidation product of ethyl alcohol, propane, and/or butane and may well have been formed during this test. The presence of the entire list of compounds identified could be subjected to a similar treatment. Particularly toxic compounds resulting from equipment failure were not observed.

Aerojet Electrosystems Company
Analytical Research Laboratories
Azusa, California, December 15, 1970

APPENDIX

OPERATING INSTRUCTIONS FOR NASA, LRC SAMPLER AS MODIFIED

(Refer to Figure 3)

Operating Instructions For Grab Sampling

1. Turn on upper pump.
2. Open V-20.
3. Open V-10.
4. Open V-9.
5. Open both valves on grab bottle.
6. Close upper valve on grab bottle.
7. Open V-23.
8. Open V-1.
9. Let pump until pressure in lower gage rises to desired pressure, not exceeding 60 psig.
10. Close V-23.
11. Close lower grab bottle valve.
12. Close V-9.
13. Close V-10.
14. Close V-20.
15. Turn off pump.

Operating Procedure For Cryogenic Trapping

1. Close all valves. Make certain bottles are properly attached to sampler.
2. Turn on upper pump.
3. Open V-20.
4. Open V-10.
5. Open V-9.
6. Open V-2 and lower valve on ice trap.
7. Open upper valve on ice trap and V-3.
8. Open V-5 and lower valve on CO_2 trap.
9. Open upper valve on CO_2 trap and V-6.
10. Open, in series, the valves on the two sample bottles immersed in LN_2.
11. Open V-21.
12. Pump until both vacuum gages read 27" or more.
13. Close V-10.
14. Close V-9.
15. Close V-20.
16. Open V-22.
17. Close V-21.
18. Open V-8 and V-15.
19. Start lower pump.
20. Turn off upper pump.
21. Turn on Flow meter "A."
22. Adjust flow to desired rate by opening V-1.
23. Ice down traps starting with ice, then CO_2, then LN_2.
24. Check and readjust flow as necessary. Adjust rotameter to 10 by V-8.
25. Vacuum gages should read approximately 23-24".

APPENDIX (cont.)

Shutdown Procedure For Cryogenic Collection Unit

1. Close V-1.
2. Turn off flowmeter "A."
3. Close V-2.
4. Close valves on ice trap.
5. Close V-3.
6. Close V-5.
7. Close valves on CO_2 trap.
8. Close V-6.
9. Pump until rotameter indicates no flow.
10. Close LN_2 valves.
11. Close V-8, V-15, and V-22.
12. Turn off pump.
13. Remove and replace traps.

Operating Procedure For Charcoal Trap

1. Turn on upper pump.
2. Open V-12.
3. Open V-16.
4. Open V-17.
5. Open V-18.
6. Open V-19
7. Pump until no appreciable flow is indicated on flowmeter.
8. Close all valves, then open each approximately 1/4 turn.
9. Turn on flowmeter "B."
10. Adjust flow to desired rate by manipulation of V-13.

Shutdown Procedure For Charcoal Collection Unit

1. Turn off flowmeter "A."
2. Close V-12.
3. Close V-18.
4. Close V-17.
5. Close V-16.
6. Close V-19.
7. Close V-21.
8. Turn off pump.

Operating Procedure For Parallel Flow Sample Collection

1. Pump out cryosystem as for cryoflow.
2. Adjust cryosystem as described.
3. Turn on flowmeter "B."
4. Open V-13.
5. Open V-16, V-17, and V-18.
6. Open V-21.
7. Close V-22.
8. Turn on upper pump.
9. Adjust flow by manipulating V-19, V-1, and V-13 to achieve 1000 cc/min through flowmeter "A" and 250 cc/min through flowmeter "B."

TABLE 1

ATMOSPHERIC TRACE CONSTITUENTS FROM THE 4-MAN SIMULATED SPACE CHAMBER, UNMANNED PRELIMINARY TESTS

(ppm)

	Cryogenic Sample Mode			Direct Atmospheric Sample Mode			
				Pre-Entry			
	1	2	3	1	2	3	4
Freon 11	-	0.00016	0.014	3.81	1.45	-	1.05
Freon 12	-	0.0012	0.0011	-	-	-	-
Freon 21	-	-	-	-	-	-	-
Freon 113	1.2	0.78	9.88	4.5	1.3	1.91	2.13
Freon 114	<0.00001	-	<0.00001	-	-	-	-
Trifluoromethane	-	-	-	-	-	-	-
Carbon tetrafluoride	-	-	-	-	-	-	-
Ethyl fluoride	-	-	-	-	-	-	-
Trifluoroethylene	-	-	-	-	-	-	-
Difluoroethylene	-	-	-	-	-	-	-
Dimethyldifluorosilane	-	-	-	-	-	-	-
Trimethylfluorosilane	-	-	-	-	-	-	-
Chloroform	0.007	-	-	-	-	-	-
Methylene chloride	0.032	0.0042	-	-	-	-	-
Methyl chloride	<0.00001	-	-	-	-	-	-
Methyl chloroform	0.0079	0.00016	0.002	0.34	0.24	0.0022	-
1,2 Dichloroethane	0.00021	<0.00001	-	-	-	-	-
Trichloroethylene	0.0092	0.024	0.0022	1.60	1.82	0.24	0.58
Tetrachloroethylene	0.0036	0.0016	<0.00001	0.18	-	-	0.15

TABLE 1 (cont.)

	Cryogenic Sample Mode			Direct Atmospheric Sample Mode			
				Pre-Entry			
	1	2	3	1	2	3	4
Ethyl chloride	-	-	-	-	-	-	-
Vinyl chloride	-	-	0.00016	-	-	-	-
Vinylidene chloride	0.017	0.00037	0.00097	-	-	0.1	-
Tetrachloroethane	-	-	-	-	-	-	-
Dichlorobenzene	-	-	<0.00001	-	0.0099	-	-
Tetrafluorochloroethane	-	-	-	-	-	-	-
Chlorodifluoroethane	-	-	<0.00001	-	-	-	-
Trifluorochloroethylene	-	-	-	-	-	-	-
Fluorochloroethylene	-	-	-	-	-	-	-
Dichlorodifluoroethylene	-	-	0.002	-	0.061	0.011	-
Ethane	0.0001	-	0.00005	0.0034	0.012	-	-
Propane	0.0033	0.0024	-	0.33	0.19	-	0.018
Butane	0.0049	0.0021	0.014	0.028	0.25	0.0025	0.00084
Isobutane	0.00032	0.00006	-	-	-	-	-
Pentane	0.0028	0.00082	0.0025	-	-	-	-
Isopentane	-	0.052	0.0089	-	-	-	-
Hexane	0.0005	-	-	-	-	-	0.065
Acetylene	0.00039	-	-	0.024	0.022	-	-
Ethylene	0.008	-	-	0.034	0.014	-	-
Propylene	0.002	0.13	0.00027	0.33	0.27	-	-
Methyl acetylene	0.00009	0.016	-	-	0.023	-	-

TABLE 1 (cont.)

	Cryogenic Sample Mode			Direct Atmospheric Sample Mode			
				Pre-Entry			
	1	2	3	1	2	3	4
1 Butene	0.012	0.0012	0.0081	0.077	0.36	0.0076	0.0022
2 Butene (cis)	0.0073	0.0034	0.0020	0.19	—	—	—
2 Butene (trans)	0.0001	0.00014	0.00004	—	0.16	—	0.0028
2 Pentene	0.0012	—	—	—	—	—	—
Isoprene	0.028	0.034	0.001	0.22	1.62	2.11	0.026
2 Hexene	0.0028	—	0.00062	0.60	0.040	—	0.09
Cyclohexene	—	—	—	—	—	—	—
Octyne	0.015	0.00003	0.00047	0.0084	—	—	—
Cyclopentane	0.001	0.00052	—	0.67	—	—	—
Cyclohexane	0.00002	—	—	—	0.011	—	—
Styrene	0.0023	0.00005	0.00073	—	0.062	0.06	—
Methylcyclohexane	—	—	0.0029	0.12	0.12	—	—
Dimethylcyclohexane	0.00014	0.0001	0.00004	0.044	0.13	0.08	0.018
Benzene	0.004	0.0068	0.012	0.56	0.77	0.16	0.57
Toluene	0.015	0.0053	0.0016	2.13	0.97	0.15	0.31
m-Xylene	0.0019	0.0011	0.0018	0.086	0.094	0.086	0.0017
o-Xylene	0.0018	0.0071	0.00016	0.052	0.081	0.027	—
p-Xylene	0.0027	0.00062	0.0053	0.048	0.062	0.053	0.0017
Ethyl benzene	0.0037	0.00058	0.0058	0.46	0.14	0.058	0.012
C_9 Aromatics	0.0005	0.015	0.0005	0.056	0.034	0.033	—
Trimethylbenzene	—	0.00011	—	—	—	—	—
Mesitylene	0.0022	0.00048	0.00029	—	0.045	—	0.0011

TABLE 1 (cont.)

	Cryogenic Sample Mode			Direct Atmospheric Sample Mode			
				Pre-Entry			
	1	2	3	1	2	3	4
Indene	0.00074	—	0.00009	—	—	—	—
Propylbenzene	—	0.00036	—	—	—	0.07	—
Cumene	—	—	—	—	—	0.033	—
C_{10} Aromatics	0.0009	0.0016	0.0012	—	—	—	—
Napthalene	—	—	—	—	—	—	—
Butylbenzene	—	0.00052	—	—	—	—	—
Furan	0.0018	0.00041	0.011	0.09	0.067	0.053	0.018
Tetrahydrofuran	0.0013	0.0017	0.001	—	—	0.0066	—
Dioxane	0.012	0.007	0.00026	0.72	1.42	0.69	0.033
Methyl alcohol	0.13	0.044	0.0053	0.29	0.38	0.092	0.24
Ethyl alcohol	0.48	0.13	0.074	5.47	15.8	2.39	0.67
Propyl alcohol	0.0042	0.003	0.0027	—	—	0.15	0.17
Isopropyl alcohol	0.037	0.023	0.011	1.31	3.05	0.47	4.34
Butyl alcohol	0.0067	0.0051	0.0019	0.79	0.17	0.11	0.011
tert-Butyl alcohol	0.0016	0.0028	0.0036	0.67	0.25	—	0.07
sec-Butyl alcohol	0.0012	0.0011	0.00037	0.072	0.14	0.075	0.1
Isobutyl alcohol	0.011	0.0021	0.0032	0.38	—	0.094	0.053
Ethyl Cellosolve	—	—	—	—	—	—	—
Amyl alcohol	0.013	0.00021	0.0016	—	0.046	0.076	—
Isoamyl alcohol	—	0.00005	—	0.093	0.086	0.076	—
Capryl alcohol	0.0009	0.0015	—	—	0.019	—	0.00025
2 Ethylbutyl alcohol	0.016	0.041	0.047	0.055	0.044	0.88	0.17

TABLE 1 (cont.)

	Cryogenic Sample Mode			Direct Atmospheric Sample Mode			
				Pre-Entry			
	1	2	3	1	2	3	4
2 Ethylhexyl alcohol	0.0091	0.0092	0.081	0.026	0.052	0.33	0.13
Acetone	0.096	0.041	0.07	2.97	6.9	2.09	0.89
Methylethyl ketone	0.0031	0.00065	0.00009	0.066	0.14	—	—
Methylpropyl ketone	—	—	0.0014	—	—	—	—
Methylisobutyl ketone	0.015	0.0033	0.0067	—	0.52	0.18	0.16
Cyclohexanone	—	—	0.012	—	—	—	1.5
Acetaldehyde	0.038	0.017	0.07	0.17	0.49	0.56	1.55
Acrolein	0.00032	0.00002	0.00008	—	0.17	—	0.0011
Propionaldehyde	—	—	—	—	—	—	0.052
Methyl acetate	0.0022	0.00051	—	0.28	—	—	0.68
Ethyl acetate	0.015	0.00041	0.00018	0.38	0.53	0.069	—
Propyl acetate	0.022	—	0.0036	—	—	0.29	0.56
Butyl acetate	—	0.0042	0.00087	—	—	—	—
Cellosolve acetate	—	—	0.0033	—	—	—	—
Acetonitrile	0.0003	0.0021	0.0014	0.61	0.096	—	—
Acetic acid	—	—	0.0072	—	—	—	—
Carbon oxysulfide	—	—	—	—	—	—	—
Sulfur dioxide	—	—	—	—	—	—	—

TABLE 2

ATMOSPHERIC TRACE CONSTITUENTS FROM THE 4-MAN SIMULATED SPACE CHAMBER, UNMANNED PRELIMINARY TESTS, CHARCOAL SAMPLING MODE

	Charcoal Used During Coolanol Spill, ug/g Charcoal			Test Samples, ppm		Wick Evaporator Charcoal ug/g Charcoal			
	Trap 1	Trap 2	Trap 3	1	2	New	First Out	Middle	Last Out
Freon 11	-	-	-	0.01	-	-	3.56	0.00001	0.00002
Freon 12	0.093	0.022	0.0075	0.00002	-	0.021	0.47	0.19	-
Freon 21	-	-	-		-	-	1.53	0.056	0.0092
Freon 113	29.6	0.0012	0.00075	0.17	0.03	3.02	3280	1690	1070
Freon 114	-	-	-	-	0.00002	-	-	0.00002	-
Trifluoromethane	-	-	-	-	-	-	0.024	0.0038	-
Carbon tetrafluoride	-	-	-	-	-	-	0.17	0.08	0.091
Ethyl fluoride	-	-	-	-	-	-	-	-	0.00094
Trifluoroethylene	-	-	-	-	-	-	0.025	0.0037	0.0044
Difluoroethylene	-	-	-	-	-	-	0.028	0.0047	0.32
Dimethyldifluorosilane	-	-	-	-	-	-	-	0.55	15.8
Trimethylfluorosilane	-	-	-	-	-	-	1.68	0.15	2.41
Chloroform	-	-	-	0.00005	-	-	-	-	-
Methylene chloride	0.14	-	-	<0.00001	0.0014	2.32	-	-	-
Methyl chloride	0.0037	-	-	-	-	-	-	-	-
Methyl chloroform	0.54	0.00002	-	0.00039	<0.00001	0.24	1.09	0.023	0.30
1,2 Dichloroethane	-	-	-	-	-	-	-	-	-
Trichloroethylene	0.95	-	-	0.0025	0.00003	0.26	-	-	0.00002
Tetrachloroethylene	-	-	-	-	-	0.11	-	-	-
Ethyl chloride	-	-	-	-	-	-	<0.00001	<0.00001	0.051
Vinyl chloride	-	-	-	-	-	-	-	-	-
Vinylidene chloride	<0.00001	-	-	-	-	-	-	-	-
Tetrachloroethane	-	-	-	-	-	-	-	-	0.00055
Dichlorobenzene	-	-	-	-	-	-	-	-	0.41
Tetrafluorochloroethane	-	-	-	-	-	-	0.16	-	-
Chlorodifluoroethane	-	-	-	-	-	-	0.045	0.0096	0.0067
Trifluorochloroethylene	0.019	-	-	0.0082	-	-	38.6	9.12	1.36
Fluorochloroethylene	-	-	-	-	-	-	0.05	0.0071	0.0014

TABLE 2 (cont.)

	Charcoal Used During Coolanol Spill, ug/g Charcoal			Test Samples, ppm		Wick Evaporator Charcoal ug/g Charcoal			
	Trap 1	Trap 2	Trap 3	1	2	New	First Out	Middle	Last Out
Dichlorodifluoroethylene	0.33	-	-	0.00039	0.00008	-	-	0.065	0.022
Ethane	0.015	-	-	0.0018	-	-	0.041	-	0.26
Propane	0.46	-	-	-	0.0012	0.016	-	-	2.05
Butane	0.38	-	-	0.00062	0.00008	0.091	0.45	0.25	1.21
Isobutane	0.34	-	-	0.0012	0.00008	-	0.038	0.011	0.0044
Pentane	0.41	-	-	-	-	-	-	-	2.28
Isopentane	-	-	-	-	-	-	-	-	-
Hexane	-	-	-	0.018	0.00012	-	-	0.084	0.4
Acetylene	0.017	-	-	0.0013	-	-	-	0.007	0.0039
Ethylene	0.088	-	-	0.004	-	-	-	-	-
Propylene	0.29	-	-	0.0011	0.00014	0.0062	0.21	0.055	2.65
Methyl acetylene	0.034	-	-	-	-	0.008	0.27	0.037	0.021
1 Butene	0.99	-	-	0.012	0.00023	-	-	0.16	8.09
2 Butene (cis)	0.20	-	-	0.0013	-	0.041	-	-	-
2 Butene (trans)	0.097	-	-	0.00008	<0.00001	0.004	0.31	0.32	-
2 Pentene	0.22	-	-	0.00008	-	-	-	-	-
Isoprene	10.4	0.00021	-	0.00017	0.00008	0.15	-	-	-
2 Hexene	2.25	-	-	-	-	-	-	-	-
Cyclohexene	-	-	-	-	-	-	-	-	0.025
Octyne	-	-	-	0.00017	0.00012	0.00079	0.0093	-	0.14
Cyclopentane	-	-	-	-	-	-	-	-	1.36
Cyclohexane	3.93	-	-	-	-	-	-	-	8.96
Styrene	-	-	-	0.00011	0.00005	-	-	-	0.39
Methylcyclohexane	1.5	-	-	0.002	-	0.0046	1.62	0.92	5.26
Dimethylcyclohexane	-	-	-	-	-	-	-	-	8.34
Benzene	5.88	0.12	0.0009	0.0053	0.00025	0.092	0.43	0.047	1.36
Toluene	1.08	0.0051	0.00033	0.00079	<0.00001	0.1	0.077	0.023	2.03
m-Xylene	0.044	0.0005	0.00011	0.0015	<0.00001	0.062	0.0049	-	1.86
o-Xylene	0.28	0.00085	-	-	0.00002	0.013	-	-	4.86
p-Xylene	0.32	0.0017	0.00032	0.0014	<0.00001	0.014	-	-	2.34

TABLE 2 (cont.)

	Charcoal Used During Coolanol Spill, ug/g Charcoal			Test Samples, ppm		Wick Evaporator Charcoal ug/g Charcoal			
	Trap 1	Trap 2	Trap 3	1	2	New	First Out	Middle	Last Out
Ethylbenzene	0.026	0.00002	–	0.0023	–	0.0044	–	0.0008	1.37
C_9 Aromatics	0.0085	0.0064	0.0031	0.00002	–	0.01	0.028	0.00059	0.4
Trimethylbenzene	0.31	–	–	0.00001	–	–	–	–	0.2
Mesitylene	0.0046	0.0038	0.0010	0.0011	–	0.01	–	–	–
Indene	–	–	–	0.00004	–	–	–	–	0.047
Propylbenzene	–	–	–	–	–	–	–	–	2.16
Cumene	–	–	–	–	–	–	–	–	–
C_{10} Aromatics	–	–	–	0.00002	–	0.011	–	–	1.44
Napthalene	–	–	–	–	–	–	–	–	–
Butylbenzene	–	–	–	–	–	–	–	–	–
Furan	0.81	0.0028		0.0009	<0.00001	0.0013	–	–	0.18
Tetrahydrofuran	0.15	–	–	0.00015	–	–	–	–	–
Dioxane	0.008	0.0044	0.0003	0.00018	<0.00001	0.011	0.0029	0.00047	0.38
Methyl alcohol	0.33	–	–	0.00039	<0.00001	0.16	1.73	1.26	4.85
Ethyl alcohol	2.28	0.0065	0.0031	0.0051	0.00031	0.15	0.086	0.05	1.45
Propyl alcohol	–	–	–	–	–	–	–	–	–
Isopropyl alcohol	6.64	0.003	0.0021	0.00017	0.00011	0.052	–	–	0.52
Butyl alcohol	0.046	0.0012	–	0.0063	–	0.013	0.0032	–	–
tert-Butyl alcohol	0.9	–	–	–	–	–	–	–	–
sec-Butyl alcohol	0.12	–	–	–	–	0.011	–	0.00063	0.13
Isobutyl alcohol	0.091	–	–	0.00039	0.0002	0.0016	–	0.0079	0.79
Ethyl cellosolve	–	–	–	–	–	–	–	–	–
Amyl alcohol	–	–	–	–	–	–	–	–	–
Isoamyl alcohol	–	–	–	–	–	–	–	–	–
Capryl alcohol	–	–	–	–	–	–	–	–	0.17
2 Ethylbutyl alcohol	0.32	–	–	–	0.00006	–	–	0.013	5.16
2 Ethylhexyl alcohol	0.81	–	–	0.00002	–	–	–	0.00034	0.28
Acetone	0.96	0.0022	0.0025	0.0042	0.00006	0.16	0.96	1.46	6.45
Methylethyl ketone	0.13	0.00023	0.00004	0.00014	–	0.0036	–	–	–
Methylpropyl ketone	–	–	–	–	–	–	–	–	–

TABLE 2 (cont.)

	Charcoal Used During Coolanol Spill, ug/g Charcoal			Test Samples, ppm		Wick Evaporator Charcoal ug/g Charcoal			
	Trap 1	Trap 2	Trap 3	1	2	New	First Out	Middle	Last Out
Methylisobutyl ketone	1.0	0.0056	0.0012	0.00043	<0.00001	0.01	0.019	0.0028	1.57
Cyclohexanone	–	–	–	–	–	–	–	–	–
Acetaldehyde	0.8	–	–	0.035	0.00001	0.4	–	0.018	0.45
Acrolein	0.069	–	–	–	–	–	0.91	–	0.054
Propionaldehyde	–	–	–	0.0001	–	–	–	–	–
Methyl acetate	–	–	–	–	–	0.001	–	–	–
Ethyl acetate	0.2	0.00009	–	0.00057	–	–	–	–	–
Propyl acetate	3.5	0.00098	–	–	–	–	–	–	–
Butyl acetate	–	–	–	0.00086	<0.00001	–	0.0023	–	0.75
Cellosolve acetate	–	–	–	–	–	–	–	–	–
Acetonitrile	0.13	–	–	0.00046	–	–	0.0048	0.00036	0.56
Acetic acid	–	–	–	–	–	–	–	–	–
Carbon oxysulfide	–	–	–	–	–	–	0.097	0.073	0.011
Sulfur dioxide	–	–	–	–	–	–	0.43	0.22	0.13

TABLE 3

ATMOSPHERIC TRACE CONSTITUENTS FOUND IN THE 4-MAN SIMULATED SPACE CHAMBER

5 DAY PRELIMINARY MANNED TESTS

(ppm)

	Cryogenic					Grab		Charcoal	
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 5	Day 2	Day 3
Freon 11	0.0057	—	0.0073	0.0058	0.00021	0.83	0.017	1.24	1.13
Freon 12	—	—	0.00004	0.00001	0.00081	—	0 —	0.018	0.38
Freon 21	—	—	—	—	—	—	—	—	—
Freon 113	0.39	1.77	1.38	0.6	0.57	0.73	1.24	10.3	30.1
Freon 114	—	—	—	—	—	—	—	—	—
Trifluoromethane	—	—	—	—	—	—	—	—	—
Carbon tetrafluoride	—	—	—	—	—	—	—	—	—
Ethyl fluoride	—	—	—	—	—	—	—	—	—
Trifluoroethylene	—	—	—	—	—	—	—	—	—
Difluoroethylene	—	—	—	—	—	—	—	—	—
Dimethyldifluorosilane	—	—	—	—	—	—	—	—	—
Timethylfluorosilane	—	—	—	—	—	—	—	—	—
Chloroform	—	—	—	0.00003	—	—	—	0.36	0.063
Methylene chloride	—	—	—	0.0025	—	—	—	0.00012	0.054
Methyl chloride	—	—	—	—	—	—	—	—	—
Methyl chloroform	—	0.0018	0.007	0.00014	0.00013	—	—	0.055	0.00026
1, 2 Dichloroethane	0.00032	—	—	0.00001	0.00002	—	—	—	—
Trichloroethylene	0.001	0.00001	—	0.00013	0.0002	—	—	0.12	0.15
Tetrachloroethylene	0.00082	—	0.0057	0.00054	0.00004	—	—	0.10	0.00001
Ethyl chloride	—	—	—	—	—	—	—	—	—
Vinyl chloride	—	—	—	—	—	—	—	—	—
Vinylidene chloride	—	0.00095	—	—	—	—	—	—	—
Tetrachloroethane	—	—	—	—	—	—	—	—	—
Dichlorobenzene	—	—	—	—	—	—	—	0.02	—
Tetrafluorochloroethane	—	—	—	—	—	—	—	—	—
Chlorodifluoroethane	—	—	—	—	—	—	—	—	—
Trifluorochloroethylene	—	—	—	—	—	—	—	0.075	0.17
Fluorochloroethylene	—	—	—	—	—	—	—	—	—
Dichlorodifluoroethylene	—	—	—	—	—	—	—	0.038	0.065
Ethane	—	—	—	—	—	—	0.0023	—	0.39

TABLE 3 (cont'd)

	Cryogenic					Grab		Charcoal	
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 5	Day 2	Day 3
Propane	—	—	0.00004	—	0.00042	—	—	0.23	2.84
Butane	0.00035	0.0001	0.00042	0.00008	0.00019	0.022	0.0067	0.28	0.34
Isobutane	—	—	—	—	—	—	—	—	—
Pentane	—	—	—	0.00023	—	—	—	0.27	—
Isopentane	—	—	—	—	—	—	—	—	—
Hexane	0.00021	—	0.00073	—	0.00001	—	—	0.93	1.08
Acetylene	—	—	—	—	—	—	—	—	0.86
Ethylene	0.0031	—	—	—	—	—	—	0.0013	0.80
Propylene	—	—	—	—	—	—	—	0.63	2.34
Methyl acetylene	0.00001	—	—	—	0.00009	—	—	—	1.36
1 Butene	0.00042	0.00061	0.00081	0.00001	0.0032	0.085	0.043	3.29	0.63
2 Butene(cis)	—	—	0.00001	—	0.0032	0.021	0.034	—	—
2 Butene (trans)	0.00005	—	0.00001	—	0.00001	—	—	0.0086	0.094
2 Pentene	—	—	—	—	—	—	—	—	—
Isoprene	0.00003	0.0025	—	0.00018	0.00014	—	—	0.19	—
2 Hexene	—	—	—	—	—	—	—	0.12	—
Cyclohexene	—	—	—	—	—	—	—	—	—
Octyne	—	—	0.00024	—	0.00003	—	—	0.036	—
Cyclopentane	—	—	0.053	—	—	—	—	—	—
Cyclohexane	0.00009	0.00001	0.00005	—	0.00008	0.017	—	—	—
Styrene	0.00067	0.0016	0.0001	0.00006	0.00018	0.0059	—	0.11	0.005
Methylcyclohexane	0.00012	0.00024	0.0072	0.00035	0.00006	—	—	0.20	0.00056
Dimethylcyclohexane	—	—	—	0.00004	—	—	—	—	—
Benzene	0.0075	0.0069	0.0069	0.004	0.0035	0.01	—	1.04	0.66
Toluene	0.00020	0.0076	0.0031	0.0014	0.0023	0.0043	—	0.36	0.16
m-Xylene	0.00018	0.0024	0.001	0.0054	0.0016	0.034	0.0085	0.50	—
o-Xylene	0.00034	0.00027	-.00077	0.00011	0.00018	0.0012	—	0.13	0.015
p-Xylene	0.00061	0.002	0.00081	0.00032	0.0014	0.00039	0.00073	0.63	0.00002
Ethyl benzene	0.0044	0.00062	0.00055	0.0068	0.0026	0.0084	0.00066	—	0.00018
C_9 Aromatics	0.0008	0.002	0.0005	0.00003	0.0002	—	0.0008	0.12	0.00004

TABLE 3 (cont'd)

	Cryogenic					Grab		Charcoal	
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 5	Day 2	Day 3
Trimethylbenzene	–	–	–	–	–	–	–	–	0.0026
Mesitylene	0.00024	0.00088	0.00015	0.0009	0.0003	0.0093	0.00019	–	–
Indene	–	0.00001	–	0.00001	–	–	–	0.017	–
Propylbenzene	–	–	–	–	0.00014	–	–	0.031	–
Cumene	0.00001	–	–	–	–	–	–	–	–
C_{10} Aromatics	0.0007	0.0015	0.0003	0.00004	0.0001	0.009	–	0.036	0.0007
Napthalene	0.00004	0.00009	0.00001	–	–	–	–	–	–
Butylbenzene	–	–	–	–	–	–	–	–	–
Furan	0.00013	0.0016	0.0027	0.00066	0.00095	–	–	0.0068	0.064
Tetrahydrofuran	0.00041	–	0.00031	0.00002	0.0012	–	–	0.23	–
Dioxane	0.0025	–	0.0016	0.00013	0.0022	–	–	0.33	0.013
Methyl alcohol	0.11	0.035	0.11	0.034	0.16	0.0068	0.22	0.22	0.074
Ethyl alcohol	0.024	0.32	0.088	0.022	0.048	0.052	0.046	0.70	0.48
Propyl alcohol	0.0019	0.0034	0.0022	0.00005	0.00057	0.0014	–	–	–
Isopropyl alcohol	0.034	0.082	0.02	0.0061	0.014	0.008	0.013	0.52	0.17
Butyl alcohol	0.0021	0.00088	0.0015	0.00072	0.0013	0.013	–	0.53	0.0057
tert-Butyl alcohol	0.00003	0.00072	0.001	0.00007	0.00023	–	–	–	–
sec-Butyl alcohol	0.0022	0.002	0.00075	0.00001	0.00047	0.0069	–	0.46	–
Isobutyl alcohol	0.0015	0.002	0.0014	0.0007	0.0011	0.024	–	0.24	0.074
Ethyl Cellosolve	0.0052	0.00005	–	–	–	–	–	–	–
Amyl alcohol	0.0002	–	–	0.00047	0.00009	–	–	0.54	–
Isoamyl alcohol	0.0001	0.0024	0.0057	0.00003	0.0003	–	–	0.0045	0.00012
Capryl alcohol	0.00026	0.00036	0.00019	–	0.00002	0.0009	–	0.05	0.00065
2 Ethylbutyl alcohol	0.053	0.024	0.027	0.0094	0.0085	0.17	0.0085	0.081	0.0043
2 Ethylhexyl alcohol	0.081	0.021	0.018	0.0051	0.0082	1.72	0.022	0.076	0.00008
Acetone	0.034	0.12	0.028	0.016	0.026	0.029	0.11	7.37	0.35
Methylethyl ketone	0.008	0.02	0.016	0.00008	0.0011	–	–	0.52	0.0003
Methylpropyl ketone	–	–	–	–	0.0022	–	–	0.46	–
Methylisobutyl ketone	0.0075	0.011	0.0096	0.0051	0.0035	0.0059	–	1.09	0.074
Cyclohexanone	0.0064	0.002	–	–	–	–	–	–	–
Acetaldehyde	0.0036	0.013	0.006	0.00053	0.0063	1.94	0.087	0.075	0.069
Acrolein	0.00001	0.00025	–	–	0.00003	–	–	–	–

TABLE 3 (cont'd)

	Cryogenic					Grab		Charcoal	
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 5	Day 2	Day 3
Propionaldehyde	0.0014	0.00037	0.00073	0.0004	0.0015	–	–	0.25	0.046
Methyl acetate	0.00001	0.0014	0.021	–	0.00026	0.042	–	–	0.09
Ethyl acetate	0.0016	0.022	0.013	0.0015	0.003	0.0072	0.056	0.14	–
Propyl acetate	0.00003	0.0089	0.019	0.011	–	–	0.0051	0.34	–
Butyl acetate	0.0019	0.00031	0.0014	0.00003	0.00032	–	–	0.08	–
Cellosolve acetate	0.0026	–	0.00013	–	0.00013	–	–	–	–
Acetonitrile	0.0043	0.022	0.00052	0.0018	0.00023	–	–	0.91	0.012
Acetic acid	–	0.00025	–	–	–	–	–	–	–
Carbon oxysulfide	–	–	–	–	–	–	–	–	–
Sulfur dioxide	–	–	–	–	–	–	–	–	–

TABLE 1

ATMOSPHERIC TRACE CONSTITUENTS FROM THE 4 MAN SIMULATED SPACE CHAMBER, 90 DAY TEST

Cryogenic Trapping Mode, ppm

	Day 3	Day 5	Day 10	Day 13	Day 15	Day 20	Day 24	Day 31	Day 34	Day 38	Day 41	Day 45	Day 48	Day 52	Day 55	Day 59	Day 62*	Day 62**	Day 68	Day 69	Day 73	Day 75	Day 76	Day 80	Day 82	Day 83	Day 88
Freon 11	0.0012	-	-	0.044	0.016	0.045	0.043	0.083	-	0.081	0.076	0.13	0.020	0.049	0.14	0.0099	0.065	0.055	0.085	0.16	0.074	0.054	0.067	0.16	0.034	6.7	0.063
Freon 21	-	-	-	-	-	-	-	-	-	-	0.00002	-	-	-	-	-	-	-	-	-	0.0007	-	-	-	-	-	-
Freon 22	-	-	-	-	-	-	-	-	-	-	0.0028	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freon 113	1.57	0.66	0.19	0.86	0.79	0.51	1.3	2.8	3.9	3.2	4.0	1.2	1.3	3.6	5.5	0.48	10.	3.4	4.5	2.7	8.2	2.2	7.2	4.6	2.6	724.	4.3
Freon 114	-	-	-	-	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0025	-	-	-	0.00017	0.00002	-	-	-	-	-
Pentafluoroethane	-	-	-	-	-	-	-	-	trace	-	0.009	-	-	-	-	-	-	-	-	-	0.002	-	-	-	-	-	-
Ethyl fluoride	-	-	-	-	-	-	-	-	-	-	0.0018	-	-	-	0.00078	-	-	-	-	-	0.0079	-	-	-	-	-	-
Tetrafluoroethylene	0.00005	-	-	-	-	-	-	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	-
Difluoroethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00017
Dimethyldifluorosilane	0.00015	0.0065	0.00026	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	trace	-	trace	0.00009	0.00047	-	0.00001	0.001	0.0029	0.00083	0.0017	0.0017	0.018	0.0041	0.00073	-	0.052	0.0088	0.0096	0.0067	0.0046	0.00027	0.002	0.00056	0.0045	0.63	0.0069
Methylene chloride	-	-	0.0065	0.0072	0.019	0.007	trace	0.043	0.067	trace	0.025	0.013	0.041	0.0024	0.02	-	-	-	0.039	0.0059	0.13	-	0.049	-	-	0.33	-
Methyl chloride	0.0007	0.0011	0.00001	-	-	trace	-	-	trace	trace	0.00012	-	trace	trace	0.00008	-	-	-	0.00076	0.00007	-	-	-	-	-	-	0.00004
1,1,1 Trichloroethane	0.00037	0.00039	0.00006	0.00011	0.00044	0.00001	trace	0.00028	0.0066	0.00014	0.00021	trace	0.00002	0.00056	0.003	-	0.0038	0.0023	0.0042	0.00089	0.00043	0.00017	0.00005	0.00014	0.006	-	0.0063
1,2 Dichloroethane	0.0011	0.00008	0.00016	0.00019	0.0011	0.00095	0.0019	0.005	0.003	0.0073	0.0088	0.0033	0.0049	0.0063	0.015	0.0014	0.018	0.012	0.011	0.021	0.025	0.0058	0.015	0.017	0.0068	0.64	0.013
Trichloroethylene	0.0007	0.00048	0.00009	0.00053	0.00027	0.00001	0.00002	0.00002	trace	0.00001	0.001	0.00005	0.00002	0.00025	0.00021	-	0.003	-	0.00004	0.00006	0.00006	0.00013	0.00002	-	-	0.00062	-
Tetrachloroethylene	0.00032	0.0002	0.00007	0.00026	0.00021	0.00031	0.00068	0.00098	0.00059	0.00053	0.0008	0.00043	0.00007	0.00038	0.0011	-	0.00024	-	0.00014	0.00004	0.00005	0.00008	0.00009	0.0013	0.0004	0.0091	-
1,1 Dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00001	-	-	-
Chloroacetylene	-	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethyl chloride	-	-	-	-	-	-	-	-	-	0.00002	-	-	-	-	-	-	-	-	-	-	-	trace	-	-	-	-	-
Vinyl chloride	0.0025	0.0023	0.00016	0.0016	0.003	0.00009	0.00009	0.00093	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinylidene chloride	0.002	0.0018	0.0013	-	-	-	0.0013	0.0033	0.0082	0.0025	0.002	-	-	-	-	-	-	-	-	0.0051	0.0033	-	0.0011	-	-	-	-
Dichlorobenzene	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifluorochloroethylene	-	-	-	0.0014	-	-	-	0.00003	-	0.004	0.00096	trace	0.00065	0.00078	0.0037	-	0.00077	0.0027	-	0.0053	0.00011	0.0022	0.0048	0.00053	-	-	0.0041
Fluorochloroethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoroethylene	0.0015	-	0.00075	-	-	-	trace	0.00001	-	-	trace	-	-	trace	trace	-	-	-	-	-	trace	0.00008	0.00004	-	-	0.034	-
Ethane	0.0049	0.0038	0.001	0.00014	0.00033	0.00001	-	0.00027	-	0.012	0.0027	-	-	0.00009	0.00058	-	0.00013	0.0028	-	0.0053	0.0011	0.00025	0.0017	-	0.0038	0.0069	0.0012
Propane	0.00095	0.0011	0.0002	0.00088	0.00048	trace	0.00037	0.0029	0.00021	0.0043	0.0059	trace	0.0018	0.0057	0.0051	0.0008	0.023	0.0071	0.0093	0.015	-	0.00038	0.0043	0.0019	0.00031	0.2	0.0021
Butane	0.00053	0.00068	0.00039	0.0013	0.00066	trace	0.00003	0.00093	0.00022	0.00075	0.00029	0.00082	0.00066	0.0011	0.0033	0.00067	0.0055	0.0032	0.0027	0.004	0.0049	0.0025	0.0035	0.0047	0.00021	0.1	0.0028
Isobutane	-	-	-	-	-	-	-	-	-	0.00094	0.001	0.00022	0.00018	0.00052	0.00087	0.00005	0.0021	0.0016	0.00096	0.002	-	0.0006	0.002	0.0022	0.00002	0.1	0.00028
Isopentane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0034	-	-	-	-
Hexane	-	-	-	0.00064	0.00024	-	0.0009	-	-	-	-	-	-	-	-	-	0.028	-	0.005	-	-	-	-	0.0084	-	0.23	0.026
Trimethylhexane	-	-	-	-	-	-	-	-	-	-	0.00027	-	-	-	-	-	-	-	-	-	-	0.00037	-	-	-	-	-
Acetylene	0.002	0.0028	0.00033	-	-	-	-	trace	-	0.0083	0.008	-	-	-	-	-	0.00053	0.018	0.00018	0.00045	0.0023	0.00002	-	-	0.00009	0.096	0.00066
Ethylene	-	-	0.0014	0.00029	-	-	-	trace	0.006	0.002	0.0046	-	-	-	0.0021	0.0005	0.0099	0.058	0.00023	0.0018	-	0.00043	0.013	-	-	0.070	-
Propylene	0.00072	0.0011	0.00019	0.0011	0.00004	trace	0.00003	0.0041	0.00006	0.0028	0.0041	-	0.00076	0.0036	0.0067	-	0.011	0.0069	0.0046	0.0025	0.0086	0.0012	0.0069	0.0046	0.00026	0.085	0.00086
Methylacetylene	-	-	0.00049	0.00087	-	0.00003	-	0.0061	-	-	-	-	-	-	-	-	-	0.015	0.0026	-	-	-	0.00023	0.00002	-	-	-
1-Butene	0.00034	0.00082	0.00068	0.0033	0.0023	0.001	0.0011	0.0094	0.0024	0.008	0.0051	0.0023	0.0027	0.0065	0.014	0.0016	0.018	0.015	0.011	0.016	0.019	0.0077	0.0089	0.011	0.0028	1.2	0.012
2-Butene (cis)	0.00054	-	-	0.00009	-	-	-	-	0.00099	trace	-	-	-	-	-	0.00039	0.00033	0.0014	0.00017	-	-	-	0.0015	0.0056	-	-	-
2-Butene (trans)	0.00002	0.00008	0.00003	-	0.00022	-	0.00002	0.00019	-	0.00033	0.0001	0.00013	0.00003	0.00005	0.00041	0.00021	0.00055	0.00006	-	0.0004	0.00043	0.00044	0.00008	0.00026	-	0.082	0.001
2-Pentene	-	-	-	-	-	-	-	0.0016	-	-	-	-	-	0.00062	0.0004	-	-	-	-	-	-	-	0.00069	-	-	0.55	-
Isoprene	0.00087	0.00058	0.00021	0.036	0.0089	0.0041	-	0.014	0.034	-	0.002	0.0012	0.00085	0.0029	0.072	0.002	0.27	0.026	0.0048	0.043	0.085	0.0043	0.014	0.070	0.00007	4.1	0.048
2-Hexene	-	-	-	-	-	-	-	0.00004	-	-	-	-	-	-	-	-	-	-	-	-	0.0018	-	-	0.001	0.0005	-	-
Cyclohexene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0031	-	-	0.0098	-	-	-
Octyne	0.00039	0.00069	0.00029	0.0021	0.00033	0.0015	0.00025	0.00076	0.0025	0.00072	0.00061	0.0022	0.0018	0.00033	0.00053	0.00061	-	0.0045	-	0.0049	0.0029	0.002	0.00089	0.003	0.0019	0.048	0.00061
Styrene	0.00013	0.00009	0.00002	0.00009	0.00009	0.00003	0.00001	trace	-	-	trace	-	0.00007	-	0.00001	-	trace	0.00001	-	-	trace	-	trace	-	-	0.0026	0.00007
Cyclopentane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0025	-	-	-	-	-	-
Cyclohexane	-	-	-	-	trace	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl cyclopentane	-	0.00042	0.00022	-	0.0067	-	-	-	-	0.00006	-	-	-	-	-	-	0.17	-	-	-	-	0.00007	-	0.00006	0.00082	-	0.0075
Methyl cyclohexane	0.00005	0.00015	-	-	-	-	-	-	-	-	-	0.00027	-	-	-	0.0026	-	-	0.0038	0.037	-	-	0.034	0.001	-	-	-
Dimethyl cyclohexane	-	-	-	-	-	-	-	0.03	-	-	-	-	0.0027	-	-	-	0.01	0.027	-	-	0.039	0.00071	-	-	0.00044	-	-
Benzene	0.0004	0.00014	0.00005	0.00068	0.0016	0.0012	0.0003	-	0.00086	0.00012	0.00029	0.00039	-	-	-	0.00073	0.0068	0.0039	0.0072	-	0.0094	0.0026	0.0025	0.0027	0.0037	0.9	0.0079
Toluene	0.006	0.005	0.00047	0.0014	0.0014	0.0018	0.0023	0.0035	0.0027	0.004	0.0038	0.0011	0.0012	0.00035	0.0051	0.00041	0.01	0.0047	0.0056	0.0069	0.004	0.0023	0.0029	0.0063	0.0041	0.59	0.003
m-Xylene	0.00047	-	-	-	0.00005	0.00026	0.00006	0.00009	0.00007	0.00022	0.0003	0.00006	0.00005	0.00002	0.00091	trace	0.0011	0.0021	0.00026	0.29	0.00005	0.00007	0.00005	0.00018	0.00031	0.0061	0.00018
o-Zylene	0.00027	0.00008	0.00005	0.00002	0.00015	0.00035	-	0.00011	0.00054	0.00044	0.00055	0.00028	0.00023	0.00015	0.00059	0.00035	-	0.00029	0.00064	0.0013	0.00037	0.0013	0.00067	0.0011	0.0017	0.049	0.0012
p-Xylene	0.00022	0.00006	-	-	0.00006	0.00001	trace	trace	-	0.0002	0.00033	0.00001	0.00006	0.00001	0.00003	0.00002	0.00058	0.0015	0.00006	0.00015	0.00012	0.00041	0.00015	0.00081	0.0013	0.036	0.0015
Ethylbenzene	0.00008	0.00006	0.00001	0.001	0.00009	0.0026	0.00062	0.00072	0.00019	0.00043	0.00026	0.00025	0.00024	0.00047	0.0028	trace	0.0012	0.0027	0.00027	0.00028	0.00048	0.001	0.0001	0.00036	0.00043	0.029	0.00028
C_9 Aromatics	0.00023	0.00023	-	0.0024	0.001	0.00018	0.00001	0.00004	0.00001	0.00004	0.00063	-	0.00057	0.00014	0.0031	0.00007	0.0011	0.00077	0.00054	0.00031	0.00006	0.00021	0.00005	0.00009	0.00017	0.0062	0.00019
Trimethylbenzene	0.00006	0.00003	-	0.00003	0.00003	-	trace	trace	trace	0.00002	-	-	-	-	0.00001	0.00001	-	0.00004	-	0.00023	-	0.00016	-	trace	0.00005	0.0021	-

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*With ozone monitor sharing sample

**Without ozone monitor sharing sample

Note: Trace indicates any quantity less than 0.00001 ppm.

TABLE 4 (Cont.)

Cryogenic Trapping Mode, ppm

	Day 3	Day 5	Day 10	Day 13	Day 15	Day 20	Day 24	Day 31	Day 34	Day 38	Day 41	Day 45	Day 48	Day 52	Day 55	Day 59	Day 62*	Day 62**	Day 68	Day 69	Day 73	Day 75	Day 76	Day 80	Day 82	Day 83	Day 88
Mesitylene	0.00006	0.00018	-	-	trace	-	-	-	-	-	0.00004	0.00012	-	-	0.00003	-	0.00005	0.00004	trace	0.00011	trace	0.00006	-	0.00003	trace	-	0.00002
Indene	-	-	-	-	-	-	-	-	-	-	0.00001	-	0.00014	-	-	trace	-	-	-	-	-	0.00002	-	trace	trace	-	-
Propylbenzene	-	-	-	-	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C_{10} Aromatics	0.00023	0.00028	0.00051	0.00005	0.0071	trace	0.00032	0.00063	0.0046	0.00098	0.00083	0.00071	0.00008	0.00027	0.00015	0.0012	0.00042	0.02	0.00084	0.0031	0.00081	0.0046	0.00021	0.0026	0.0047	0.12	0.0015
C_{11} Aromatics	0.00005	0.00004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0022	-
Furan	0.00016	0.0001	-	0.00047	0.00029	0.00027	trace	0.039	0.02	0.0072	0.00008	0.00055	0.00012	0.001	0.0045	-	-	0.0044	0.0028	0.00053	-	0.003	0.024	0.0037	0.005	0.76	0.015
Tetrahydrofuran	-	-	-	-	0.00007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dioxane	0.00015	0.00005	0.00005	0.0019	-	0.00067	0.00008	0.00007	0.054	-	-	0.00015	0.00053	-	-	-	-	0.01	0.0025	-	-	0.00054	-	-	0.014	1.8	0.012
Methyl alcohol	0.0016	0.0016	0.0002	0.078	0.012	trace	trace	0.01	0.0054	0.00036	0.0074	0.00071	0.02	-	0.0056	-	0.017	0.16	0.0094	0.0015	0.023	0.0097	0.0052	0.016	-	2.2	0.012
Ethyl alcohol	0.0044	0.001	0.0017	0.019	0.041	0.052	0.036	0.025	0.030	0.0085	0.023	0.016	0.022	0.014	0.036	0.0073	0.04	0.018	0.019	0.0057	0.03	0.011	0.01	0.048	0.02	1.6	0.023
Allyl alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00007	-	-	-	-	-
Isopropyl alcohol	0.0014	0.0014	0.00024	0.006	0.003	0.003	0.0032	0.022	0.025	0.0036	0.0029	0.0017	0.0015	0.004	0.0044	0.0034	-	0.0029	0.01	0.00032	0.0018	0.0005	0.0018	0.00053	0.0058	0.6	0.0043
Butyl alcohol	0.00027	-	-	-	0.00014	0.00001	0.00044	0.00075	-	0.002	0.0014	0.00064	0.00026	-	-	-	0.00021	-	0.001	0.00035	0.0018	-	0.0019	0.00043	0.00081	0.061	0.0016
s-Butyl alcohol	0.00017	-	-	-	-	-	-	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	trace
Isobutyl alcohol	0.00019	0.00003	0.00004	0.00014	0.00028	0.00014	0.0012	-	0.0096	0.00005	0.00093	-	0.00005	-	-	0.00025	0.01	0.023	-	0.00045	0.0026	0.00093	0.0028	0.0024	0.0015	0.24	0.00003
Amyl alcohol	0.00013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoamyl alcohol	-	-	-	-	-	-	-	0.00008	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	0.00012	-	-	0.00006	-
Capryl alcohol	0.00004	-	-	-	0.00003	-	-	-	0.00008	0.00008	-	-	0.00003	-	-	-	-	-	-	-	-	0.00008	-	0.0002	0.00002	0.0016	0.00004
2-Ethylhexyl alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0014
Acetone	0.0062	0.0085	0.0046	0.064	0.074	0.14	0.14	0.39	1.0	0.13	0.2	0.11	0.096	0.24	0.27	0.069	0.56	0.32	0.33	0.84	0.57	0.32	0.43	0.46	0.35	49.	0.59
Methyl ethyl ketone	0.00044	0.0014	0.00009	-	0.00095	0.0014	0.0013	0.0017	0.0014	0.0001	0.0039	0.00052	0.00078	0.0027	0.011	0.0029	0.0096	0.0039	0.0055	0.017	0.0027	0.0033	0.0025	0.0023	0.017	0.82	0.022
Methyl propyl ketone	0.0001	-	-	-	-	-	0.00045	0.00003	-	-	0.00078	0.00035	0.00034	-	0.00029	-	0.0031	0.0019	0.0029	0.00042	0.001	0.0017	0.0015	0.0011	0.002	0.18	0.0043
Methyl isobutyl ketone	0.00008	-	-	0.00006	0.00022	-	-	trace	-	0.00006	-	0.00016	0.00005	-	-	trace	0.0037	0.00081	0.0086	0.00056	0.0031	0.021	0.00088	0.0014	0.00029	0.12	0.00048
Dimethyl ether	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0037	-	0.00017	-	-	-	-
Acetaldehyde	0.0034	0.0016	0.0025	0.0046	0.025	0.037	0.043	0.045	0.029	0.034	0.071	0.063	0.023	0.086	0.11	0.0065	0.1	0.054	0.066	0.1	0.1	0.028	0.047	0.06	0.0088	4.4	0.11
Benzaldehyde	-	-	-	-	-	-	-	-	-	-	-	-	0.00006	trace	0.00006	-	-	-	-	-	-	0.00005	-	-	-	-	-
Methyl acetate	-	-	-	0.00039	-	0.015	0.00013	-	0.0014	-	0.038	0.0028	0.00068	0.0028	-	0.0033	0.067	0.031	0.015	0.062	-	-	0.0092	0.0066	-	15.	-
Ethyl acetate	0.00031	-	0.00006	0.00006	0.00008	-	-	0.003	0.0045	0.0051	0.0012	0.001	0.00018	0.0067	0.0039	-	0.014	0.015	0.014	0.0013	0.0079	0.00033	0.0012	0.0036	0.0062	0.5	0.039
Propyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0014
Butyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00063	-	-	-	-	-	-	-	-	-	-	-	-
Acetonitrile	-	-	-	-	0.0002	0.00012	-	0.00051	-	0.0011	0.00063	-	-	0.00046	0.0029	-	-	-	0.0047	0.0017	0.0018	0.0019	0.00095	0.0011	0.00072	0.08	0.00041
Methoxyacetic acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	trace	-	-	-	-	-
Dimethylsulfide	0.00048	0.0008	0.00029	0.0004	0.00064	0.0011	0.00015	0.00033	0.0015	0.00012	0.0016	0.00017	0.001	0.0031	0.0022	0.0037	0.018	0.00078	0.02	0.00032	-	0.0011	-	-	0.00037	-	-
Methylethyl thiphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfur dioxide	< 1	< 1	< 1	< 1	< 1	-	< 1	trace	trace	trace	-	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-
Nitrous oxide	< 1	< 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 5

ATMOSPHERIC TRACE CONSTITUENTS FROM THE 4-MAN SIMULATED SPACE CHAMBER, 90 DAY TEST

Charcoal Trapping Mode, ppm

	Day 1-2	Day 7-9	Day 14-16	Day 21-23	Day 28-30	Day 31-33	Day 35-37	Day 38-40	Day 42-44	Day 45-46	Day 47	Day 49-51	Day 52-54	Day 55-58	Day 60-62	Day 63-64	Day 65-68	Day 69-73	Day 74-76	Day 76-80	Day 81-83	Day 84-88	Day 89-90
Freon 11	0.00009	-	0.00003	0.0054	0.0036	0.0044	0.012	0.045	0.0089	0.014	0.0085	0.036	0.012	0.021	0.0031	0.0025	0.057	0.0045	0.0016	0.0034	0.0079	0.024	0.0035
Freon 21	-	-	-	-	-	-	0.031	0.00001	0.042	-	-	0.036	-	-	0.00059	-	-	-	-	0.037	0.00011	-	-
Freon 22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	trace	-	-	-	-
Freon 113	0.015	0.041	0.013	0.018	0.21	0.06	0.61	0.32	0.42	1.5	0.54	0.93	0.48	0.31	0.29	0.26	0.31	0.14	0.08	0.24	0.87	0.37	0.22
Fluoroform	0.00013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifluoromethane	-	-	-	-	trace	-	trace	-	0.00003	0.00003	-	0.00016	0.00005	0.00009	0.0043	0.00015	0.018	0.0052	0.00013	0.0022	0.00039	0.0042	0.00054
Pentafluoroethane	-	trace	-	-	trace	trace	-	-	trace	0.00018	0.00002	trace	trace	0.00005	trace	0.00005	0.00013	0.00002	0.00004	trace	-	0.00016	-
Ethyl fluoride	-	-	-	-	-	-	-	-	-	0.0013	-	0.00005	0.00001	trace	-	-	0.00026	0.00008	trace	trace	-	trace	trace
Tetrafluoroethylene	0.00043	0.00072	-	-	-	-	-	-	-	0.00048	-	0.00029	-	-	0.003	0.002	0.0038	-	-	0.00004	-	-	-
Trifluoroethylene	trace	0.00001	0.00005	trace	0.00006	-	0.00002	-	0.00016	0.00092	0.00002	0.00018	0.00029	-	0.00027	0.00048	0.0017	0.00057	0.0004	0.00012	0.0004	trace	trace
Difluoroethylene	-	-	-	-	-	-	-	-	-	0.00049	-	-	-	-	-	-	-	-	0.00041	-	-	-	-
Dimethyldifluorosilane	-	-	0.00022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifluoropropane	-	-	-	-	0.00002	-	trace	-	trace	-	-	-	trace	-	trace	0.00005	0.00004	-	-	trace	-	0.00001	-
Fluoropropane	-	-	-	-	-	-	-	-	-	-	-	0.00015	-	0.00045	0.00004	trace	-	-	-	-	0.00004	trace	-
Chloroform	0.00002	trace	-	-	-	0.0001	-	-	-	-	-	-	-	-	-	-	-	-	0.00013	-	-	-	-
Methylene chloride	0.00014	0.00018	0.0044	0.00035	0.00093	0.01	0.0011	0.2	0.025	0.089	0.026	0.035	0.006	-	-	-	0.0015	0.033	0.00081	0.009	-	-	0.0072
Methyl chloride	-	-	0.00004	-	0.0015	-	0.00014	0.00005	0.00016	0.0022	0.00004	-	0.00013	0.00016	0.00014	0.00051	0.00015	0.00002	-	-	0.00003	0.00011	trace
1,1,1 Trichloroethane	0.00008	trace	trace	trace	trace	trace	0.00002	trace	trace	0.00002	0.00002	0.00038	0.00001	0.00095	-	0.0017	0.0027	0.00007	0.00004	0.00041	0.00001	0.0013	-
1,2 Dichloroethane	trace	-	0.00001	-	0.00002	0.00027	0.00008	0.00003	0.00014	0.00048	0.00006	0.00039	0.00021	0.00001	0.00001	0.00018	0.00079	0.00094	0.00018	0.00004	0.00018	0.00034	0.00061
Trichloroethylene	0.00001	trace	-	-	trace	-	trace	0.00004	-	-	trace	trace	0.00004	trace	-	-	-	-	trace	-	-	-	-
Tetrachloroethylene	-	-	0.00001	-	0.00041	trace	trace	trace	-	0.00004	0.00004	0.00044	0.00007	-	-	0.00017	-	-	0.00001	-	-	-	-
1,1 Dichloroethane	0.00002	-	trace	-	0.0042	-	-	-	-	-	-	trace	0.0077	-	-	-	-	-	trace	-	-	-	-
Ethyl chloride	-	-	trace	-	trace	-	-	-	-	-	-	-	0.00005	0.00002	-	-	-	-	trace	0.00009	0.00005	0.00018	0.00003
Vinyl chloride	0.00021	0.00012	0.00001	0.00008	0.00001	trace	trace	0.00002	-	-	-	-	0.00001	-	-	-	-	0.00069	-	-	-	-	-
Vinylidene chloride	0.00007	0.00012	0.00018	trace	0.0018	0.00003	0.0003	-	-	0.0046	-	-	0.00012	-	-	0.00043	0.00023	0.00062	trace	-	0.0002	trace	0.0017
Monochlorobenzene	-	0.00006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00012	-	-	-
Tetrafluorochloroethane	-	-	-	-	-	0.00031	-	-	-	0.0043	-	-	-	-	-	0.0062	0.00001	-	-	trace	-	-	-
Dichlorodifluoroethane	0.00009	0.00008	0.00028	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0014	-	-	-
Chlorodifluoroethane	-	-	0.0015	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifluorochloroethylene	0.00024	0.0019	0.0029	0.0032	0.025	0.013	0.01	0.00002	0.014	0.019	0.0072	0.064	0.04	0.046	0.011	0.028	0.071	0.021	0.0026	0.0072	0.043	0.013	0.0043
Fluorochloroethylene	-	-	trace	0.00009	-	trace	-	trace	-	-	-	0.00056	-	-	-	-	-	-	-	trace	-	-	-
Dichlorodifluoroethylene	-	-	-	0.00055	trace	trace	trace	0.00086	0.00077	0.0014	0.00066	0.0026	0.0017	0.0006	0.001	0.0012	0.0025	0.00003	0.00021	0.00055	0.0024	0.00033	0.00051
Ethane	trace	0.00002	0.00032	0.00004	trace	0.00001	0.00002	trace	0.00017	0.00002	0.00034	0.00082	0.00007	trace	0.0073	0.00083	0.0076	0.00002	0.0018	0.00011	0.0031	0.00071	0.00034
Propane	0.00013	0.00025	0.005	-	0.00017	0.00028	0.00033	0.00013	0.0022	0.0053	0.0026	0.00087	0.0014	0.0008	0.0065	0.0039	0.0057	0.044	0.00028	0.00073	0.00025	0.00048	0.00028
Butane	0.00003	0.00005	0.00011	0.00041	0.00014	0.00017	0.00059	0.00025	0.0011	0.0028	0.0036	0.0031	0.0024	0.0072	0.0021	0.0058	0.0042	0.0032	0.00086	0.0026	0.0044	0.0028	0.002
Isobutane	-	-	-	0.0001	0.0011	0.00054	0.00087	0.00021	0.0013	0.0039	0.0011	0.0043	0.0023	0.00069	0.0021	0.0021	0.0031	0.0015	0.00026	0.00085	0.0027	0.00046	0.00013
Isopentane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	-	-	-
Hexane	-	-	-	-	-	-	-	0.001	-	-	-	-	-	0.00066	0.0017	0.0073	-	0.00029	0.00043	0.0046	0.0012	0.00005	-
Trimethylhexane	-	-	-	-	-	0.0027	-	0.0011	-	-	-	0.00062	-	-	-	0.00056	0.00003	0.00012	-	-	0.00013	0.00002	0.00007
Acetylene	0.00003	0.00001	0.00051	-	0.00064	trace	0.00002	-	0.00075	0.00032	0.0018	0.00096	0.00028	-	0.022	0.009	0.023	-	0.007	0.014	0.018	0.00044	0.00054
Ethylene	0.00003	0.00001	0.00045	-	0.00058	-	-	-	0.0017	0.0033	0.017	0.0021	0.00041	-	0.023	0.0049	0.11	0.0019	0.0027	0.021	0.01	0.0021	0.08
Propylene	0.00046	0.00016	0.0006	0.0027	0.0019	0.00096	0.0018	-	0.0042	0.017	0.011	0.02	0.008	0.022	0.039	0.033	0.15	0.0047	0.004	0.015	0.032	0.0037	0.0043
Propadiene (allene)	-	-	-	-	-	-	-	-	-	0.00026	-	0.00002	-	-	-	-	0.00067	-	-	-	0.00005	-	-
Methylacetylene	0.00002	0.00007	trace	0.00027	0.00003	-	trace	0.00045	0.00029	0.0007	0.00053	0.00077	0.00031	trace	0.00054	0.00068	0.0023	0.00041	0.00003	0.00014	0.00078	0.00009	0.00003
1-Butene	0.00012	0.0001	0.0039	0.00089	0.0011	0.0009	0.0018	0.0015	0.0022	0.018	0.0085	0.01	0.0081	0.013	0.0087	0.013	0.05	0.019	0.0035	0.0043	0.012	0.012	0.0087
2-Butene (cis)	0.00001	trace	0.00024	0.00033	0.00025	0.00004	-	-	-	trace	0.00046	0.00082	0.00014	0.002	0.00032	0.0014	0.023	0.0053	0.00064	0.0019	0.00018	0.0017	0.0013
2-Butene (trans)	-	0.00002	0.00006	0.00005	trace	-	0.00013	0.00009	0.00025	0.00056	0.00031	0.00087	0.00094	0.0029	0.0012	0.0011	0.0014	0.00091	0.00051	0.00042	0.0017	0.0034	0.0015
1,3-Butadiene	-	-	-	-	-	-	-	-	-	-	-	0.00015	-	-	-	-	-	-	-	-	-	-	0.00016
1-Pentene	-	-	-	-	-	-	-	-	-	-	-	-	0.00074	0.00035	-	-	-	-	-	-	-	-	-
2-Pentene	-	-	-	-	-	-	-	-	-	-	-	0.00009	0.0003	-	0.0003	0.00077	0.00021	0.00001	0.00004	0.00085	-	-	0.00032
Isoprene	0.00003	-	0.00004	0.00022	0.00032	0.00005	-	0.0011	0.00098	0.004	0.00073	0.0024	0.0087	0.0042	0.0027	0.0028	0.011	0.0045	0.0014	0.0091	0.0043	0.023	0.0039
2-Hexene	-	-	-	-	-	-	-	-	-	0.00032	0.003	-	0.00035	-	0.00089	0.00044	0.00094	0.00002	-	-	-	-	0.0021
Cyclohexene	-	-	-	-	trace	-	-	-	-	-	0.0016	0.00011	-	0.00032	-	-	0.00079	0.00043	0.00058	0.0014	0.0014	-	-
Octyne	0.0001	0.00002	0.00001	0.00006	0.00002	0.0013	0.00004	0.00003	0.00054	0.00085	0.0004	0.00003	0.00005	trace	trace	0.00054	0.00004	trace	0.00005	0.00005	-	0.00046	0.00014
Styrene	0.00002	0.00001	trace	trace	trace	0.0001	trace	-	trace	-	trace	0.00003	-	0.00004	0.00005	trace	trace	-	-	-	-	0.00013	0.00008
Cyclopentane	-	-	-	-	-	-	-	-	-	-	-	0.00006	-	-	0.0011	0.0018	0.0012	-	-	-	-	-	0.0011
Cyclohexane	0.00001	-	-	-	-	-	-	-	-	0.0011	-	-	0.00034	-	-	-	-	-	-	-	-	0.0002	0.0079
Methyl cyclopentane	-	-	-	trace	-	-	-	0.00001	0.00007	-	-	trace	-	-	0.00023	0.00065	-	-	-	-	-	-	0.0017
Methyl cyclohexane	0.00013	0.00002	-	trace	0.00001	0.0018	-	0.00012	-	0.00033	0.00026	0.0022	-	0.0022	-	0.00058	0.012	0.0008	0.0034	0.0018	0.0019	0.00001	0.0063
Dimethyl cyclohexane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0014	-	-	0.00029	-	-	0.0006	0.0075
Benzene	0.0011	0.00035	0.0002	0.0055	0.00089	0.016	0.0041	0.0037	0.0032	0.011	0.038	0.021	0.0085	0.025	0.013	0.043	0.2	0.063	0.051	0.04	0.048	0.0071	0.029

Note: Trace indicates any quantity less than 0.00001 ppm.

TABLE 5 (Cont.)

Charcoal Trapping Mode, ppm

	Day 1-2	Day 7-9	Day 14-16	Day 21-23	Day 28-30	Day 31-33	Day 35-37	Day 38-40	Day 42-44	Day 45-46	Day 47	Day 49-51	Day 52-54	Day 55-58	Day 60-62	Day 63-64	Day 65-68	Day 69-73	Day 74-76	Day 76-80	Day 81-83	Day 84-88	Day 89-90
Toluene	0.00011	-	0.00006	0.00016	0.00021	0.00067	0.00004	0.0002	0.00003	0.00014	0.0031	0.00092	0.00031	0.0009	0.021	0.0018	0.014	0.0024	0.00086	0.0016	0.0014	0.00052	0.0029
m-Xylene	0.00024	-	-	trace	trace	0.00002	trace	trace	-	trace	0.00026	0.00007	trace	0.00002	0.00038	0.00014	0.00052	0.00026	0.00002	0.00015	0.00007	0.00025	0.0004
o-Xylene	0.00087	-	0.00002	trace	trace	trace	trace	0.00002	trace	trace	0.00015	0.00003	0.00001	0.00006	0.00024	0.00033	0.00014	0.00047	0.00001	0.00016	0.00003	0.00026	0.00055
p-Xylene	0.00021	trace	trace	-	trace	-	trace	trace	trace	trace	0.0004	0.00003	trace	0.00006	0.00014	0.00026	0.00028	0.00008	-	0.00007	trace	0.00012	0.00034
Ethylbenzene	0.0002	trace	trace	trace	trace	0.00018	trace	trace	trace	0.00005	0.00016	0.00003	trace	0.00005	0.00015	0.00044	0.0011	0.00015	0.00004	0.00003	0.00018	0.00018	0.00031
C_9 Aromatics	0.00001	trace	trace	-	0.00001	0.00002	trace	trace	trace	0.0011	0.00007	0.00002	-	0.00005	0.00011	0.00003	0.00024	0.00011	0.00005	0.00001	0.00002	0.00006	0.00018
Trimethylbenzene	0.00003	trace	trace	-	-	-	-	-	-	-	trace	trace	trace	-	-	0.00012	0.00023	trace	-	0.00001	-	0.00005	trace
Mesitylene	0.00031	-	trace	-	trace	0.0025	-	trace	-	0.00019	-	-	-	0.00003	trace	0.00005	0.00026	trace	-	-	0.00005	0.00013	0.00032
Indene	trace	-	-	-	-	-	-	-	-	0.0041	trace	-	-	trace	trace	-	0.00006	-	-	trace	-	0.00003	0.00004
Propylbenzene	0.00012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00013	-
Cumene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00002	-
C_{10} Aromatics	0.00008	0.00002	0.00003	0.00002	0.00001	0.00037	0.00002	0.00003	0.00005	0.00032	0.00011	0.00003	0.00003	0.00008	0.00006	0.00035	0.00007	0.0001	0.00005	0.00021	0.00006	0.00008	0.00029
Napthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00006	trace
C_{11} Aromatics	0.00001	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl napthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00004	-
Dimethyl napthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00004	-
Furan	0.00003	-	0.00005	0.00006	0.00046	0.00041	0.0016	0.00075	0.00057	0.0017	0.0062	0.0067	0.0016	0.0031	0.00077	0.0031	0.022	0.0022	0.0037	0.0027	0.0025	0.00038	0.01
Tetrahydrofuran	-	-	trace	-	-	-	-	-	-	-	-	0.00009	-	-	0.0037	0.015	0.001	-	0.00092	-	0.0016	-	-
Dioxane	0.00008	trace	0.00001	trace	trace	-	-	-	-	0.00001	0.00009	-	0.00007	0.00012	0.00038	0.00005	0.00015	-	-	-	0.00015	0.00036	0.012
Methylfuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0015
Dibenzofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00025	-
Methyl alcohol	0.0017	0.00001	0.00039	0.0062	0.0019	0.0027	0.018	0.00042	0.0037	0.0051	0.0015	0.0066	0.0031	0.0029	0.0086	0.0057	0.06	0.012	0.0012	0.0019	0.021	0.0082	0.0042
Ethyl alcohol	0.00021	0.00001	0.0013	0.0026	0.00064	0.013	0.0012	0.0034	0.0054	0.0046	0.0057	0.002	0.0017	0.0015	0.0016	0.011	0.0027	0.0099	0.0008	0.0024	0.0011	0.0033	0.0078
Allyl alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00017
Propyl alcohol	0.00001	-	-	-	-	0.0053	-	-	-	-	-	0.00002	-	-	-	-	-	0.0013	-	-	-	-	0.0005
Isopropyl alcohol	0.00012	0.00008	0.00004	0.00086	0.00054	0.00031	0.002	0.00023	-	0.00034	0.0021	0.0036	0.00019	0.0017	0.0056	0.0055	0.0035	0.01	0.00052	0.0004	0.0032	0.0014	0.008
Butyl alcohol	-	-	-	trace	0.00002	0.00004	trace	0.00002	0.002	trace	-	-	0.00002	-	0.00003	0.0012	0.0026	0.00003	0.00003	0.00002	0.00029	0.00024	0.00024
s-Butyl alcohol	0.00006	-	-	trace	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	-
Isobutyl alcohol	0.00001	0.00001	0.00003	trace	0.00005	0.00004	-	0.0002	trace	0.00066	0.0046	0.0011	0.003	0.00003	0.0027	0.00097	0.0022	0.0017	0.0004	0.00002	0.00094	0.0022	0.005
Amyl alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00001	0.00003	-	-	-	-	-	-	-
Isoamyl alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00002	-	-	trace	-	trace
Phenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00018	0.00047
Capryl alcohol	trace	trace	0.00001	trace	trace	0.00004	trace	-	-	-	-	-	-	-	-	-	-	-	-	-	trace	0.00004	trace
2-Ethylbutyl alcohol	0.00003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00006	trace
Acetone	0.0018	0.00013	0.00027	0.00049	0.0014	0.0046	0.004	0.0084	0.0027	0.01	0.053	0.05	0.026	0.029	0.011	0.047	0.025	0.031	0.026	0.02	0.034	0.056	0.32
Methyl ethyl ketone	0.00007	-	trace	0.00002	trace	trace	-	0.00005	0.00011	0.00009	0.0033	0.0027	trace	0.00042	0.00007	-	0.0063	0.00007	0.00005	0.00019	0.00012	0.00041	0.018
Methyl propyl ketone	0.00018	-	-	-	-	-	trace	-	-	-	0.0005	0.0003	-	-	-	-	0.0013	0.00047	-	0.00017	0.00014	0.00056	0.0039
Methyl isobutyl ketone	0.00013	0.00007	-	-	trace	-	trace	0.00005	-	-	0.00006	0.00088	-	0.00004	0.0012	0.0011	0.0026	0.052	0.00006	0.0031	0.0001	0.00028	0.0051
Dimethyl ether	-	-	-	-	-	-	-	-	-	-	0.00011	-	-	0.00018	0.00001	0.00012	0.0001	0.00008	-	0.00002	0.00014	0.00001	-
Acetaldehyde	0.0001	0.00009	0.00053	0.0078	0.026	0.00017	0.0061	0.0024	0.0058	0.02	0.019	0.022	0.0091	0.018	0.012	0.033	0.033	0.018	0.0025	0.0064	0.012	0.022	0.042
Benzaldehyde	-	-	-	-	-	-	-	-	-	0.00003	0.00016	0.00002	-	-	-	-	-	-	-	-	-	-	-
Methyl acetate	0.00005	-	-	0.00001	0.00015	0.00005	0.00028	0.0017	-	0.00076	0.022	0.022	0.0025	0.0032	0.0019	0.013	0.032	0.0092	0.0018	0.0037	0.0058	0.0022	0.00002
Ethyl acetate	0.00011	-	trace	-	trace	trace	-	-	0.0012	0.00009	0.0038	0.0029	0.00005	0.0013	0.00008	0.0015	0.015	0.00049	0.00059	0.0019	-	0.00039	0.0083
Propyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00027	0.00007	-
Butyl acetate	0.00014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00014	-	-	-	-	0.00047	-
Acetonitrile	0.00001	-	-	-	-	-	0.00088	-	0.00051	0.00073	0.0036	0.00029	-	0.00082	0.00091	0.0019	0.0025	-	0.00033	-	0.00021	0.0002	0.0046
Methoxyacetic acid	-	-	-	-	-	-	-	-	-	0.00012	-	-	-	-	-	-	-	-	-	-	-	0.00009	-
Dimethyl sulfide	0.00051	0.00003	0.00006	trace	0.0016	-	-	0.00048	-	0.00015	0.0012	0.0018	0.00089	0.0025	0.0016	0.012	0.0026	0.0016	0.0004	0.002	0.00036	0.0017	0.00007
Sulfur dioxide	trace	trace	-	-	trace	-	-	trace	-	-	-	-	-	-	-	-	-	-	-	trace	-	-	-

TABLE 6

ATMOSPHERIC TRACE CONSTITUENTS FROM THE 4-MAN SIMULATED SPACE CHAMBER, 90 DAY TEST

Direct Sampling Mode, ppm

	Day 1	Day 4	Day 12	Day 19	Day 26	Day 33	Day 40	Day 46	Day 54	Day 60	Day 66	Day 74*	Day 74**	Day 82	Day 88**	Day 88*	Post Egress
Freon 11	0.048	0.06	-	0.00001	0.23	0.16	-	0.0093	4.2	0.01	-	2.1	0.49	0.29	0.26	0.0035	26.
Freon 21	-	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	-
Freon 113	0.012	0.64	0.51	0.44	2.5	5.4	0.43	3.2	15.	0.25	1.3	0.43	5.1	11.	11.	1.5	3.2
Dimethyldifluorosilane	-	-	0.0038	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1,1 Trichloroethane	-	0.0001	0.00001	-	0.0022	0.00013	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloroethane	-	-	trace	-	-	-	-	0.018	0.035	-	-	0.029	0.39	-	-	0.39	-
Trichloroethylene	0.0048	0.00051	0.00002	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	0.00008	0.002	0.00001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	-	0.0016	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinylidene chloride	-	-	-	-	-	-	0.0034	-	-	-	-	-	-	-	-	-	0.00002
Dichlorodifluoroethane	-	-	0.00046	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifluorochloroethylene	-	-	-	-	-	-	-	-	0.00002	-	-	-	-	-	-	-	-
Dichlorodifluoroethylene	-	-	-	-	-	-	0.00005	-	-	-	-	-	0.0033	0.012	-	-	-
Ethane	-	0.016	0.016	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
Propane	-	0.00075	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17
Butane	0.018	-	-	0.0039	0.001	0.00025	-	-	0.26	-	0.038	0.00007	0.027	0.026	0.19	0.012	0.069
Hexane	-	0.0014	-	0.0016	-	-	-	-	-	-	-	-	-	-	-	-	-
Trimethylhexane	-	-	-	-	0.0018	-	0.0059	-	-	-	-	-	-	-	0.062	-	-
Acetylene	-	0.0019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylene	0.11	0.021	0.026	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Propylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.024	-	0.33
Methyl acetylene	-	-	-	0.0019	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Butene	0.0064	0.0035	0.0014	0.03	0.029	0.0036	-	0.0087	0.12	-	0.016	0.038	0.018	0.13	0.099	0.0081	0.13
2-Butene (cis)	0.017	-	-	-	-	-	-	-	-	-	-	-	-	-	0.033	-	-
Isoprene	0.00012	0.049	-	-	-	-	0.064	-	2.9	-	0.0014	-	0.12	-	-	-	0.3
2-Hexene	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-
Cyclohexene	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-
Octyne	-	-	0.019	0.022	0.023	0.013	0.0089	-	0.009	-	-	0.032	0.065	0.3	0.17	0.024	0.042
Styrene	0.00011	0.0017	-	-	0.00061	0.0023	-	0.0044	0.00024	-	-	0.0002	-	0.049	-	-	0.0078

---

*Sample pressurized to 14.7 psig

**Sample pressurized to 60 psig

Note: Trace indicates any quantity less than 0.00001 ppm.

TABLE 6 (Cont.)

Direct Sampling Mode, ppm

	Day 1	Day 4	Day 12	Day 19	Day 26	Day 33	Day 40	Day 46	Day 54	Day 60	Day 66	Day 74*	Day 74**	Day 82	Day 88**	Day 88*	Post Egress
Cyclopentane	-	-	-	-	0.001	-	-	-	-	-	-	-	-	-	-	-	-
Cyclohexane	-	-	-	-	0.0011	-	-	-	-	-	-	-	-	-	-	-	-
Methyl cyclopentane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023	-	-
Methyl cyclohexane	-	0.00095	0.0029	0.0026	0.0015	-	-	0.0027	-	-	0.017	-	0.014	0.24	0.24	-	0.00002
Dimethyl cyclohexane	-	-	-	0.048	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	0.00001	0.0022	0.0098	0.077	0.038	0.16	0.077	0.024	0.0057	0.03	0.012	0.032	0.21	0.19	1.4	0.068	-
Toluene	0.025	0.0043	0.0087	0.27	0.038	0.066	0.062	0.051	0.04	0.049	0.18	0.00051	0.37	2.0	1.5	0.053	0.18
m-Xylene	0.00083	0.0052	0.0078	0.054	0.0014	0.0079	0.024	0.0056	0.0041	0.0039	1.4	0.026	0.049	0.27	0.28	0.026	0.0036
o-Xylene	0.015	-	0.00077	0.061	0.0011	0.0003	0.011	0.0057	-	-	0.05	0.015	0.037	0.03	0.19	0.0078	-
p-Xylene	0.00058	0.00032	0.031	0.063	0.003	0.11	0.071	0.0068	0.007	0.02	0.33	0.0023	0.19	1.9	1.5	0.15	0.00002
Ethylbenzene	0.00023	0.033	0.0061	0.14	0.0025	0.018	0.014	0.007	0.0044	0.015	0.064	0.0011	0.03	0.24	0.21	0.16	0.035
C_9 Aromatics	0.0015	-	0.0047	0.13	0.00021	-	0.0042	0.0021	0.00038	0.0063	0.097	0.047	0.0099	0.35	0.22	0.0018	0.021
Trimethylbenzene	-	-	0.001	0.015	0.0014	0.41	-	-	-	-	-	0.0036	0.004	0.051	0.032	0.0038	-
Mesitylene	0.00013	0.00033	0.0023	0.0061	0.0011	0.0016	-	0.0026	0.00009	-	0.009	0.004	0.00047	0.056	-	0.017	-
Indene	-	0.0016	0.00047	-	-	-	-	-	-	-	-	-	-	0.0021	-	-	-
Propylbenzene	-	-	-	0.0074	-	-	-	-	-	-	-	-	-	-	-	-	-
C_{10} Aromatics	-	-	0.0042	0.14	0.00085	0.0029	trace	0.0081	0.0028	0.0064	0.0023	-	0.058	0.48	0.56	0.00006	0.0032
Napthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0033	0.012
C_{11} Aromatics	-	-	0.00066	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Furan	-	-	0.0048	0.006	0.00064	-	0.036	0.0072	0.0066	-	-	0.011	0.041	0.039	1.2	0.03	-
Tetrahydrofuran	-	-	0.025	0.071	0.00046	0.012	0.11	0.042	0.022	0.011	0.2	-	-	3.2	-	-	-
Dioxane	0.00004	0.0025	0.055	0.48	0.023	0.11	0.25	0.0016	0.013	0.069	0.025	0.00006	0.062	5.9	5.1	0.2	0.095
Methylfuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-
Dibenzofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00032	-
Methyl alcohol	0.0012	0.083	0.0089	0.52	0.43	0.19	0.35	0.021	0.11	0.57	1.5	-	0.013	3.7	27.	1.0	2.6
Ethyl alcohol	0.0028	0.028	0.087	0.74	0.17	0.16	0.5	0.12	0.093	0.2	0.9	0.21	0.055	8.4	12.	0.58	4.7
Propyl alcohol	-	-	-	-	0.011	-	0.13	-	0.029	0.034	0.16	0.0051	-	-	3.1	0.063	-
Isopropyl alcohol	0.00005	0.0093	0.012	0.27	0.095	0.081	0.26	0.086	0.06	0.055	0.52	-	0.033	7.6	1.6	0.13	0.93
Butyl alcohol	0.0042	0.0014	0.015	0.089	0.0025	-	0.041	0.01	0.005	0.049	0.0058	0.025	0.016	0.5	-	0.0072	0.00087
t-Butyl alcohol	-	-	-	-	0.022	-	-	-	-	-	-	-	-	1.1	-	-	-
s-Butyl alcohol	-	-	0.0089	0.027	-	0.063	-	-	-	-	-	-	-	-	1.4	0.036	0.0042
Isobutyl alcohol	0.00009	0.0014	0.018	0.15	0.011	0.56	0.081	0.031	0.028	0.047	0.14	0.19	0.28	0.84	3.6	-	-
Amyl alcohol	-	-	0.0011	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002

TABLE 6 (Cont.)

Direct Sampling Mode, ppm

	Day 1	Day 4	Day 12	Day 19	Day 26	Day 33	Day 40	Day 46	Day 54	Day 60	Day 66	Day 74*	Day 74**	Day 82	Day 88**	Day 88*	Post Egress
Isoamyl alcohol	-	-	0.003	0.0019	-	-	-	-	-	-	-	-	-	-	0.048	-	-
Phenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.68	0.025	-
Capryl alcohol	-	-	0.005	0.0046	-	-	-	-	-	-	-	-	-	0.021	-	-	0.0027
2-Ethylbutyl alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0098	-	0.34
Acetone	0.0023	0.053	0.048	0.35	0.91	0.73	0.13	0.19	1.3	0.31	0.6	0.21	0.43	3.5	10.	0.23	22.
Methyl ethyl ketone	0.00028	0.0028	0.02	0.27	0.0062	0.056	0.058	0.084	0.0037	0.098	0.18	0.0072	0.03	5.7	3.2	0.12	0.00003
Methyl propyl ketone	-	-	0.062	0.28	0.0043	0.079	0.11	-	0.038	0.0071	-	0.081	0.46	-	-	0.41	-
Methyl isobutyl ketone	-	0.0019	0.0029	0.19	0.0067	0.0073	0.067	0.007	0.018	0.055	0.041	0.06	0.42	3.9	2.4	0.0025	-
Acetaldehyde	-	0.047	-	0.26	1.4	0.083	0.033	0.0035	2.8	-	0.067	2.2	0.16	0.67	0.5	-	6.4
Acrolein	-	-	0.013	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzaldehyde	-	-	-	-	-	-	-	-	0.00019	-	-	-	-	-	-	-	-
Methyl acetate	-	-	0.041	-	0.0078	0.049	0.032	0.11	0.025	0.011	0.17	-	0.17	-	4.9	0.1	-
Ethyl acetate	-	-	0.025	0.058	0.068	0.0058	0.073	0.12	0.0061	0.22	0.16	0.057	0.17	3.8	3.5	0.13	0.00005
Propyl acetate	-	-	-	0.02	-	-	-	-	0.017	-	-	-	-	-	-	-	-
Acetonitrile	-	-	0.04	0.12	0.0064	0.072	0.13	0.039	0.02	-	0.11	-	0.6	7.9	3.4	-	-
Dimethyl sulfide	-	-	0.0013	0.00043	0.0071	0.11	0.011	0.012	0.003	-	0.007	0.051	-	1.3	0.027	0.0056	-
Methylethyl thiophene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-	-

TABLE 7

PERMANENT GAS ANALYSES FROM THE 4-MAN SIMULATED SPACE CHAMBER, PRELIMINARY TESTING

Concentration in Volume Percent

	Sample Identification						
Component	Unmanned 1	Unmanned 2	Unmanned 3	Unmanned 4	Manned 1	Manned 2	Oxygen Accumulator
Hydrogen	-	0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01
Helium	-	0.2	< 0.01	-	-	-	-
Nitrogen	71.9	70.8	69.1	68.7	69.6	69.7	4.7
Oxygen	27.1	27.7	29.3	29.8	28.1	28.6	94.9
Argon	0.87	0.84	0.83	0.73	0.77	0.64	0.06
Carbon dioxide	0.1	0.4	0.6	0.8	0.5	0.99	0.1
Carbon monoxide	-	-	-	-	-	-	-
Hydrocarbons	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Water	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2

TABLE 8

MASS SPECTROMETER DATA OF COOLANOL 35

(an ester of orthosilicic acid)

Instrument - CEC 21-104
Temperature ionization chamber - 270°C
Ionizing voltage - 70 v
Ionizing current - 10 μA
Ion accelerating voltage - 800 v
Magnetic scan - 4A to 20A/8 sec

Slit measurement - 5 mil
Electron multiplier - 140 v/stage
Recorder speed - 16"/sec
Sample introduction - probe
Sample temperature during analysis - approximately 150°C

Major m/e - 54, 55, 56, 68, 69, 70, 78, 82, 83, 84, 92, 110, 111, 112, 150, 192, 388

m/e	Relative Intensities*	m/e	Relative Intensities	m/e	Relative Intensities
54	460	109	20	206	36
55	208	110	376	207	15
56	660	111	404	218	17
57	39	112	298	220	59
58	32	113	24	222	12
62	124	114	17	234	39
66	36	116	32	246	10
67	34	118	36	248	12
68	788	120	64	262	29
69	389	122	51	276	29
70	502	124	37	290	14
71	29	130	24	304	34
76	56	132	22	318	12
78	327	134	54	332	15
80	42	136	59	346	12
81	20	138	17	360	68
82	860	144	22	361	15
83	425	146	32	374	17
84	1000	148	42	388	122
85	74	150	107	389	30
86	15	160	15	402	14
88	17	162	51	416	61
90	25	164	29	417	19
91	15	174	14	430	5
92	171	176	34	444	14
94	22	178	36	458	3
96	51	180	52	459	2
97	36	184	49	472	1
100	14	191	14	486	2
102	51	192	139	487	2
104	47	193	15	500	< 1
106	68	194	42	501	< 1
108	15	204	12	502	< 1

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*Based on m/e 84 at 1000

TABLE 9

PERMANENT GAS ANALYSES FROM THE 4-MAN SIMULATED SPACE CHAMBER, 90 DAY TESTS

Concentration in Volume Percent

Components	Day 1	Day 4	Day 12	Day 17*	Day 19	Day 26	Day 31*	Day 33	Day 34*
Nitrogen	72.6	68.3	65.4	-	68.8	67.6	-	67.0	-
Oxygen	26.5	29.9	32.6	-	29.4	30.8	-	31.6	-
Carbon dioxide	0.06	0.93	1.2	-	1.2	1.1	-	1.0	-
Argon	0.8	0.7	0.6	-	0.6	0.5	-	0.38	-
Hydrogen	0.003	0.04	0.05	-	0.03	0.005	-	0.005	-
Methane**	-	7.	79.	54.	65.	-	87.	83.	86.
Carbon monoxide**	-	< 5.	< 5.	< 5.	< 5.	-	< 5.	< 5.	< 5.

Components	Day 40	Day 46	Day 54	Day 60	Day 66	Day 74	Day 82	Day 88
Nitrogen	66.8	66.0	66.6	66.5	66.4	66.9	66.7	67.3
Oxygen	31.9	31.8	32.0	31.2	31.9	31.1	31.6	31.4
Carbon dioxide	0.8	1.9	1.0	2.0	1.5	1.7	1.5	1.1
Argon	0.38	0.33	0.35	0.28	0.25	0.21	0.21	0.22
Hydrogen	0.004	0.005	0.007	0.007	0.008	0.005	0.02	0.01
Methane	0.002***	0.005***	0.006***	0.003***	0.006***	0.007***	0.007***	0.009***
Carbon monoxide	-	-	-	-	-	-	-	-

---

*Sample analyzed by IR spectrometry for methane and carbon monoxide only, no SO_x or NO_x noted.

**Values determined by IR spectrometry and reported in ppm normalized to 1 atmosphere.

***Values by mass spectrometry and reported in volume percent.

TABLE 10

ANALYSIS OF THREE BREATH SAMPLES FROM SUBMITTED TEFLON SAMPLE TUBES

ppm

Compound	Sample 1-4	Sample 2-4	Sample 3-4
Nitrogen*	78.2	73.9	71.8
Oxygen*	20.9	25.0	25.6
Argon*	0.95	0.90	0.60
Carbon dioxide*	0.04	0.2	1.95
Hydrogen*	< 0.001	< 0.001	< 0.001
Methane*	< 0.001	< 0.001	< 0.001
Freon 113*	0.004	0.008	0.005
Freon 113	206.	4.6	171.
Methyl chloroform	0.043	-	-
2-Hexene	-	0.00074	0.015
Octyne	0.0043	-	0.013
Dimethylcyclohexane	0.056	-	0.0086
Toluene	0.015	0.027	0.0051
o-Xylene	0.0092	-	-
C_9 Aromatics	-	0.02	-
Mesitylene	0.00003	0.013	-
Indene	0.014	-	0.003
Cumene	0.053	-	-
C_{10} Aromatics	0.0033	0.033	-
Napthalene	-	-	0.014
Furan	0.17	-	-
Dioxane	0.034	0.018	0.023
Ethyl alcohol	0.84	1.8	9.2
Isopropyl alcohol	0.92	1.8	-
n-Butyl alcohol	1.6	0.0048	0.18
Amyl alcohol	0.01	-	-
Isoamyl alcohol	-	-	0.0031
Capryl alcohol	-	0.018	0.0037
Acetone	1.7	0.83	0.58
Methyl ethyl ketone	0.18	0.66	-
Methyl acetate	-	0.09	-
Ethyl acetate	0.45	0.71	0.021
Propyl acetate	0.42	-	-
Ethyl lactate	0.0021	-	0.0097
Butyl lactate	-	-	0.007
Dimethyl sulfide	0.35	-	-

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*Mass spectrometry data reported in volume percent.

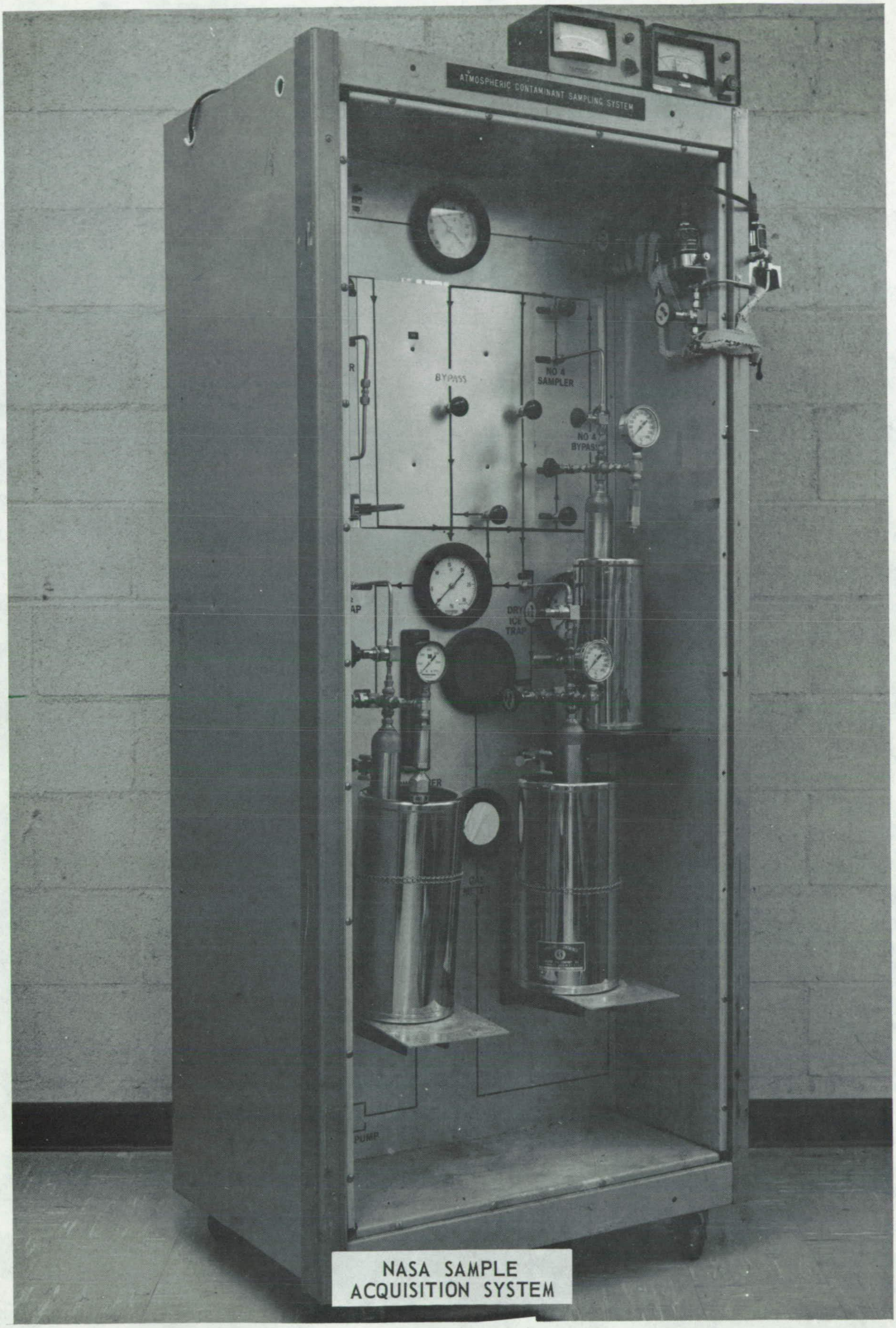

ATMOSPHERIC CONTAMINANT SAMPLING SYSTEM
BYPASS
NO 4 SAMPLER
NO 4 BYPASS
DRY ICE TRAP
GAS METER
PUMP
NASA SAMPLE ACQUISITION SYSTEM

Figure 1

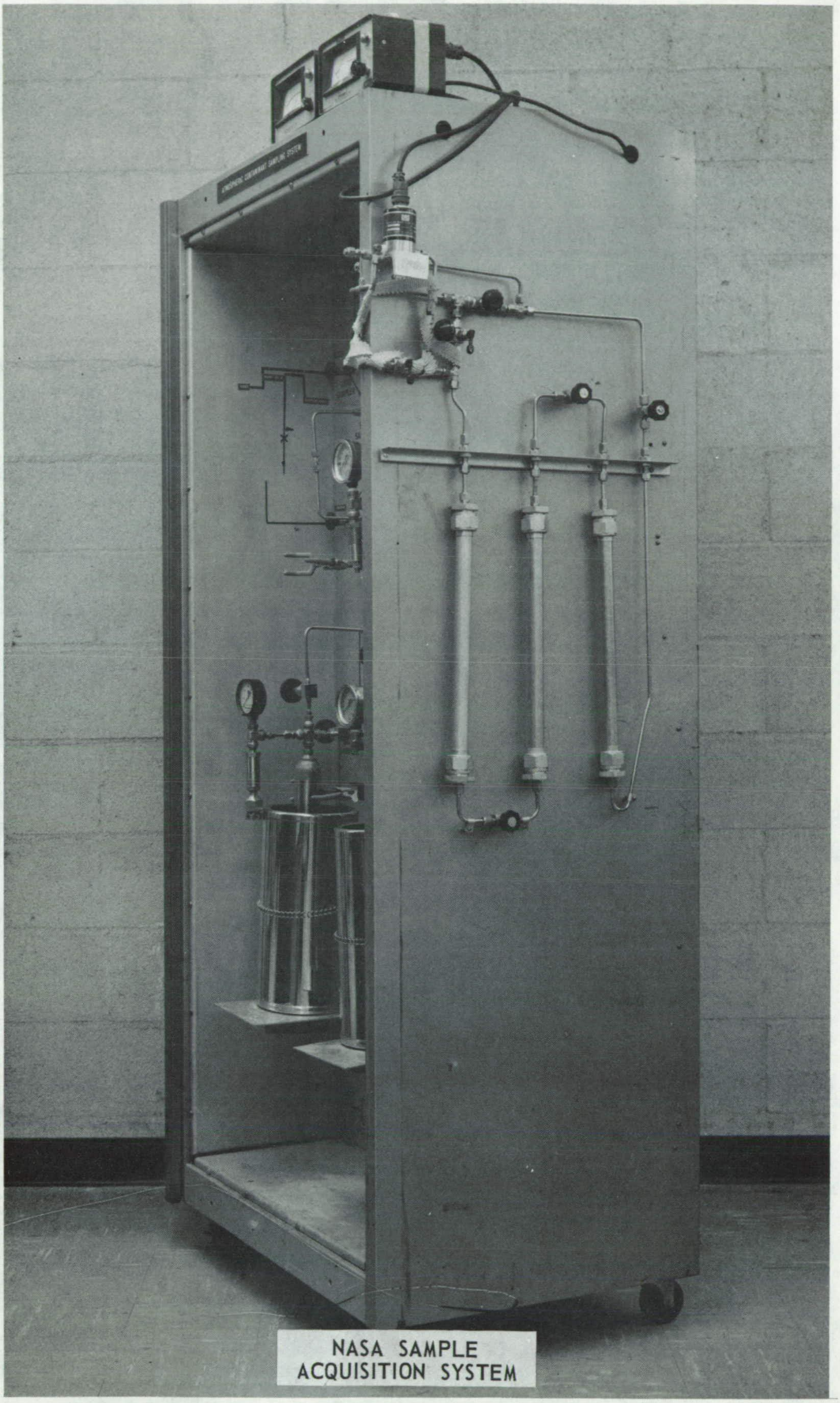
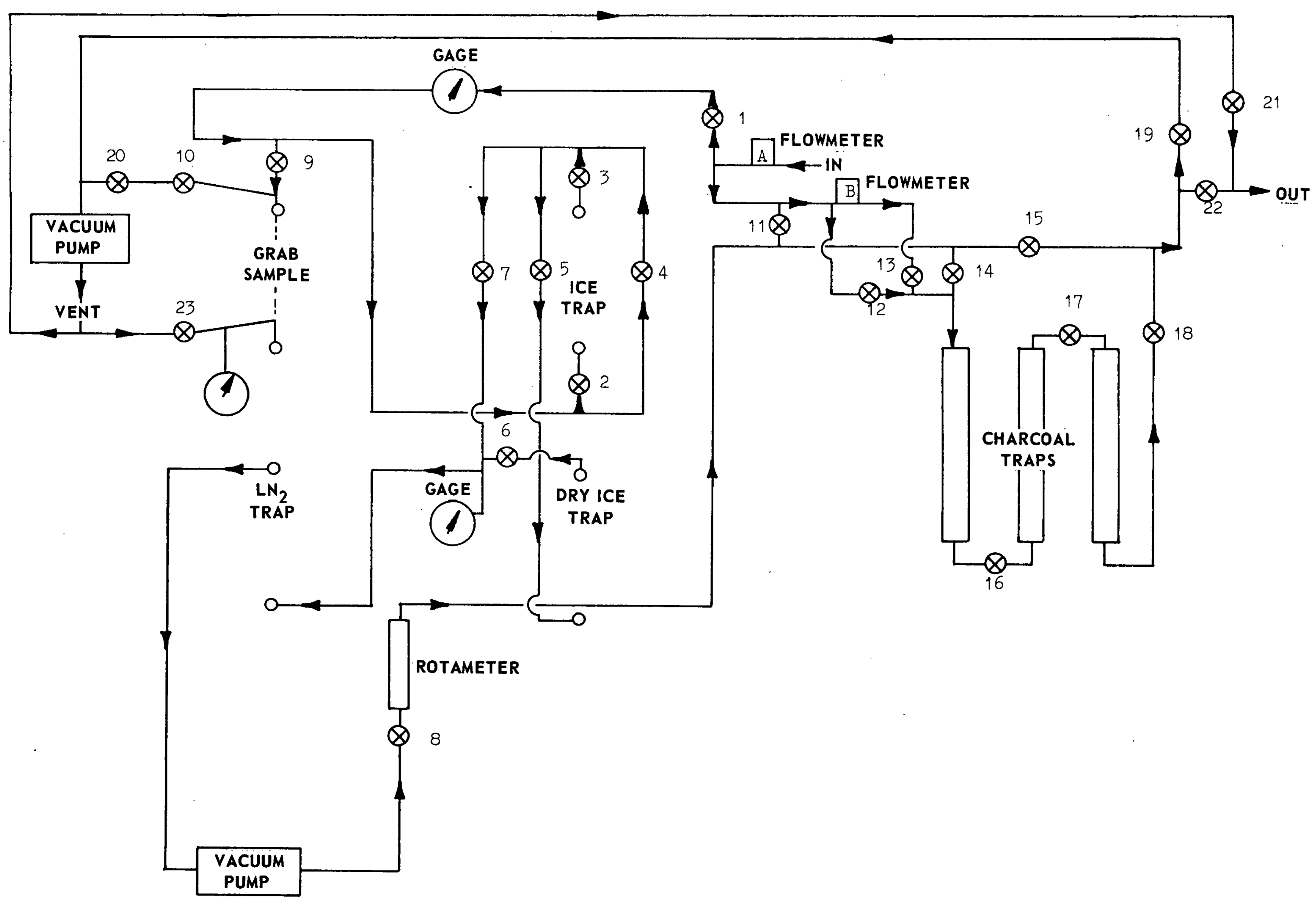
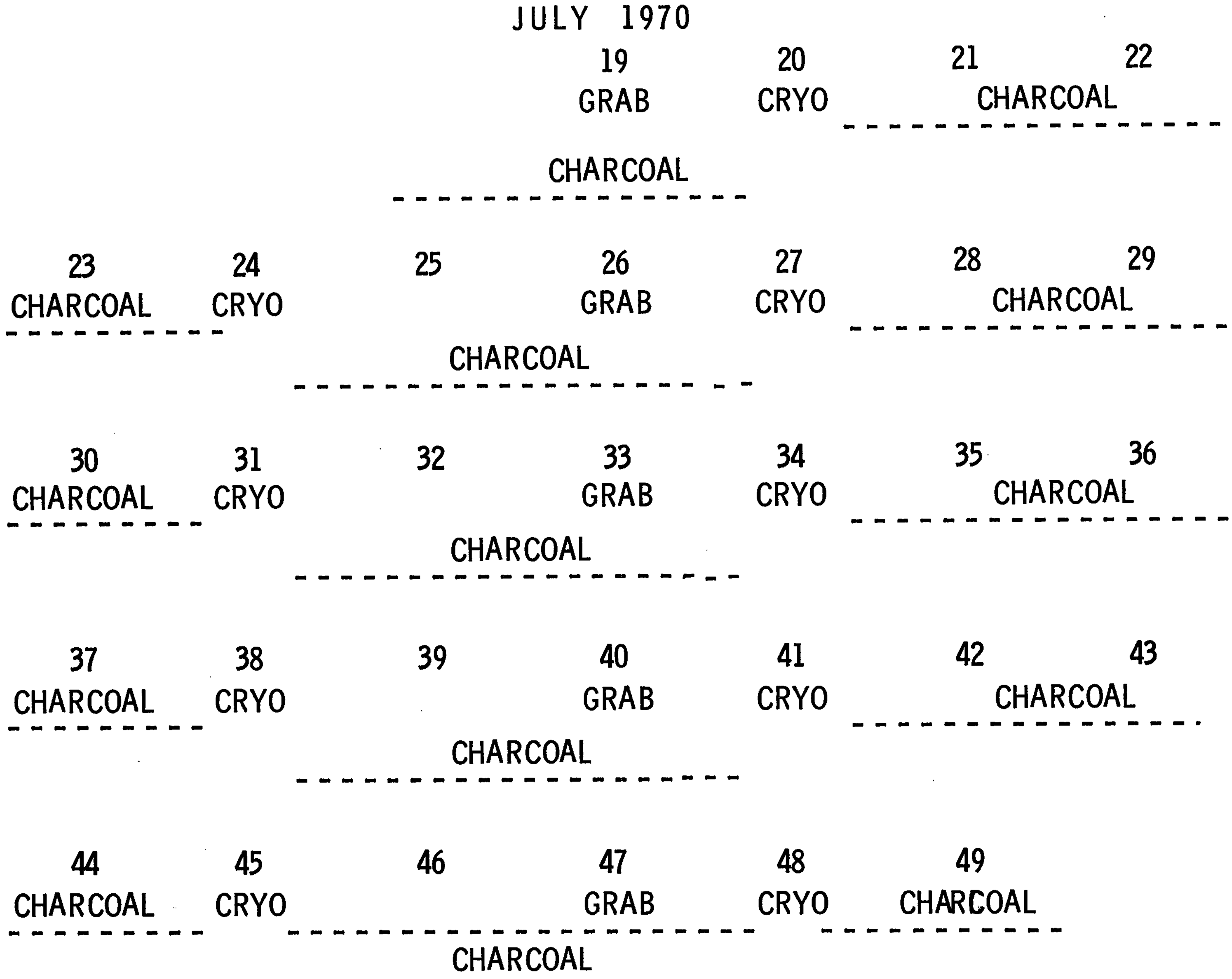

ATMOSPHERIC CONTAMINANT SAMPLING SYSTEM
NASA SAMPLE
ACQUISITION SYSTEM

Figure 2



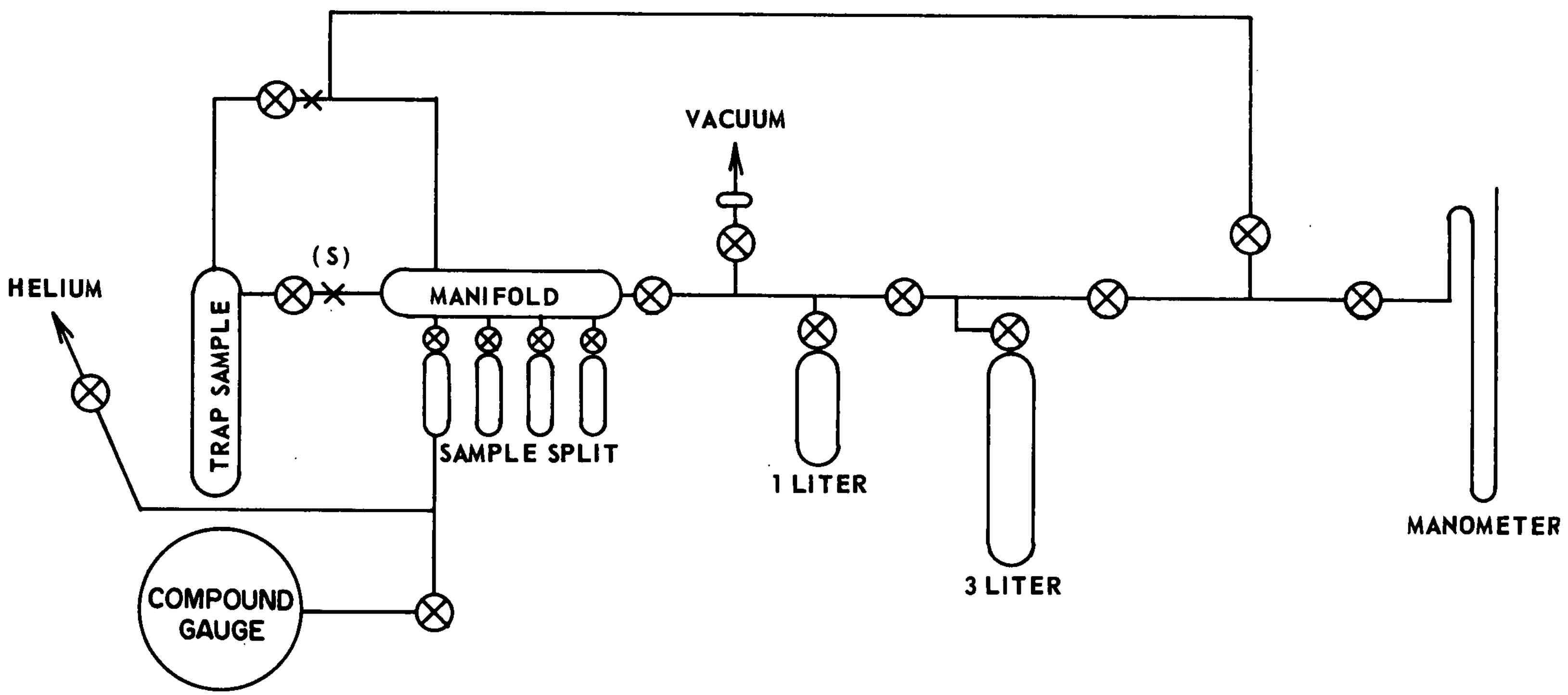
ATMOSPHERIC CONTAMINANT SAMPLING SYSTEM

Figure 3



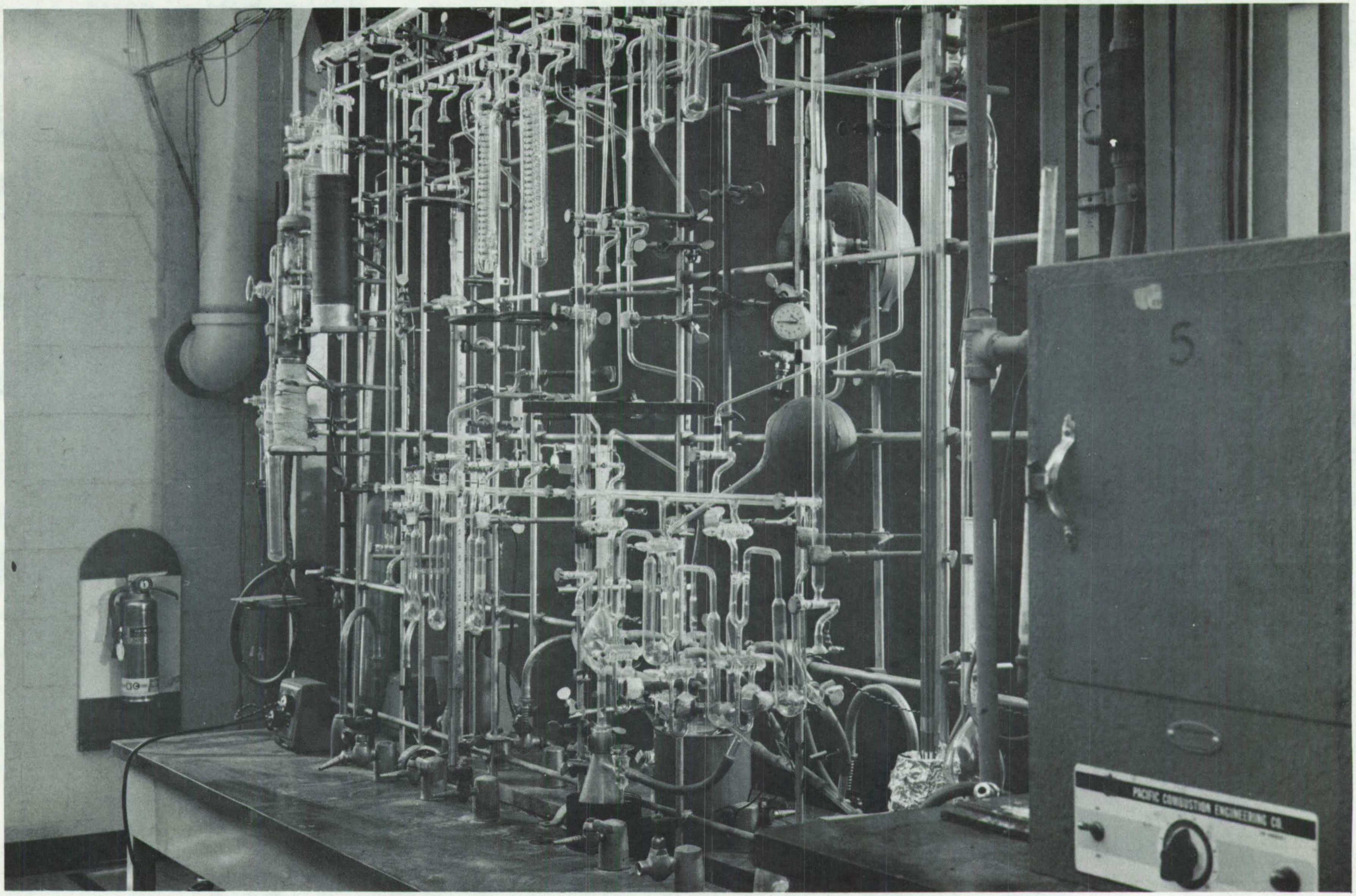
SCHEDULE OF SAMPLE COLLECTION

Figure 4



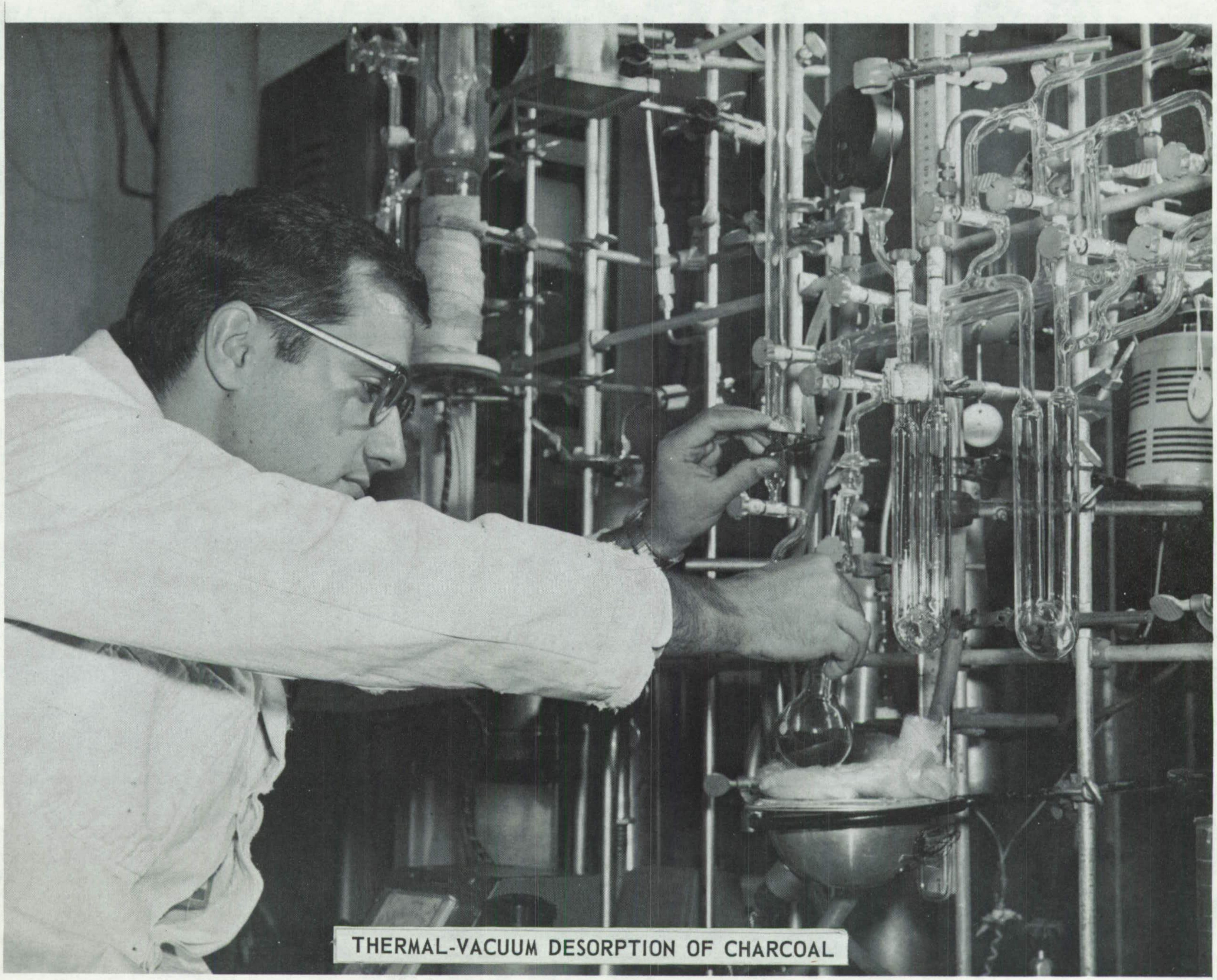
SAMPLE SPLITTING FOR GRAB & CRYO SAMPLES

Figure 5



VACUUM RACK USED IN TRACE GAS MANIPULATION

Figure 6



THERMAL-VACUUM DESORPTION OF CHARCOAL

Figure 7

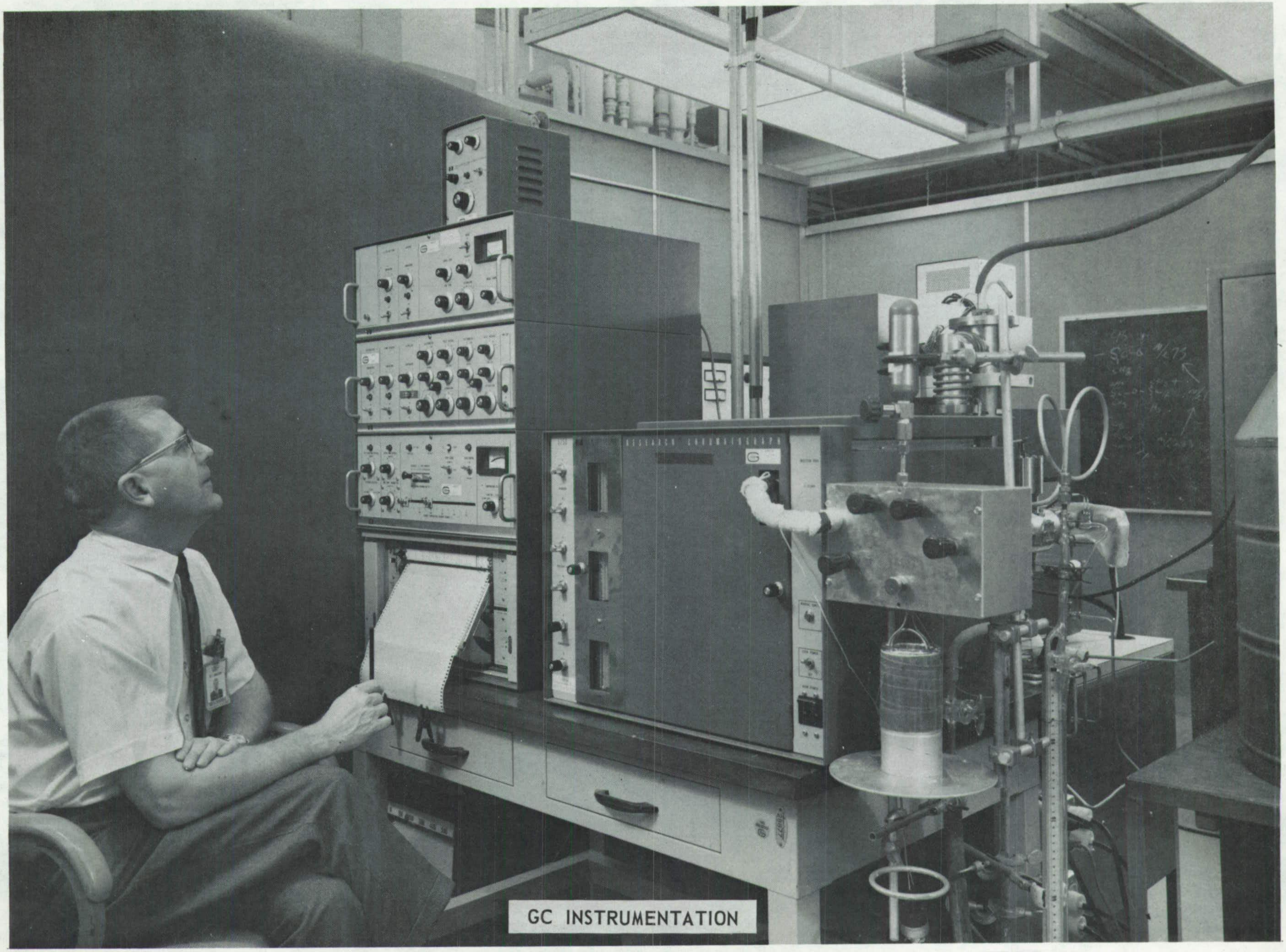
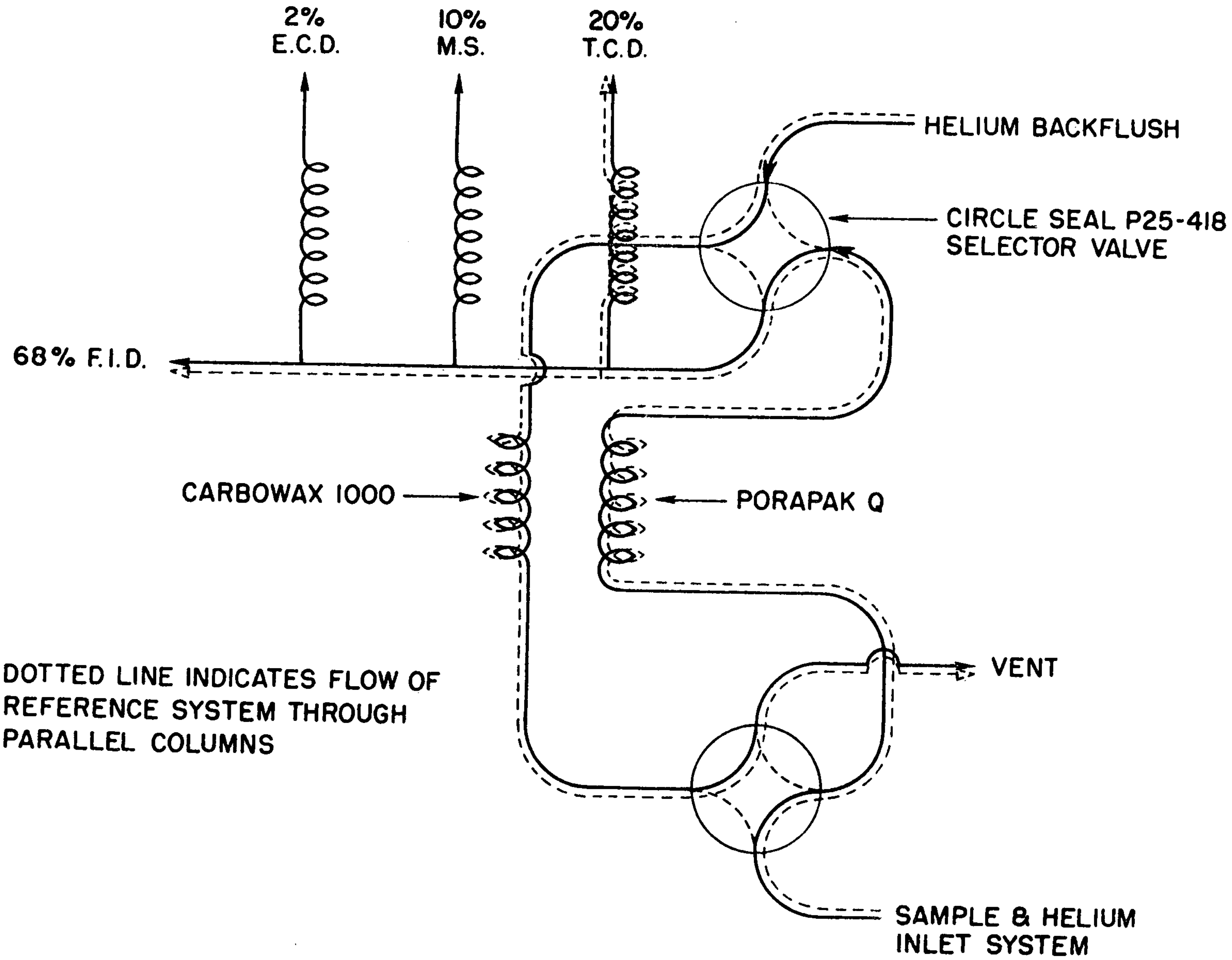


Figure 8



DOTTED LINE INDICATES FLOW OF REFERENCE SYSTEM THROUGH PARALLEL COLUMNS

GC COLUMN ARRANGEMENT

Figure 9

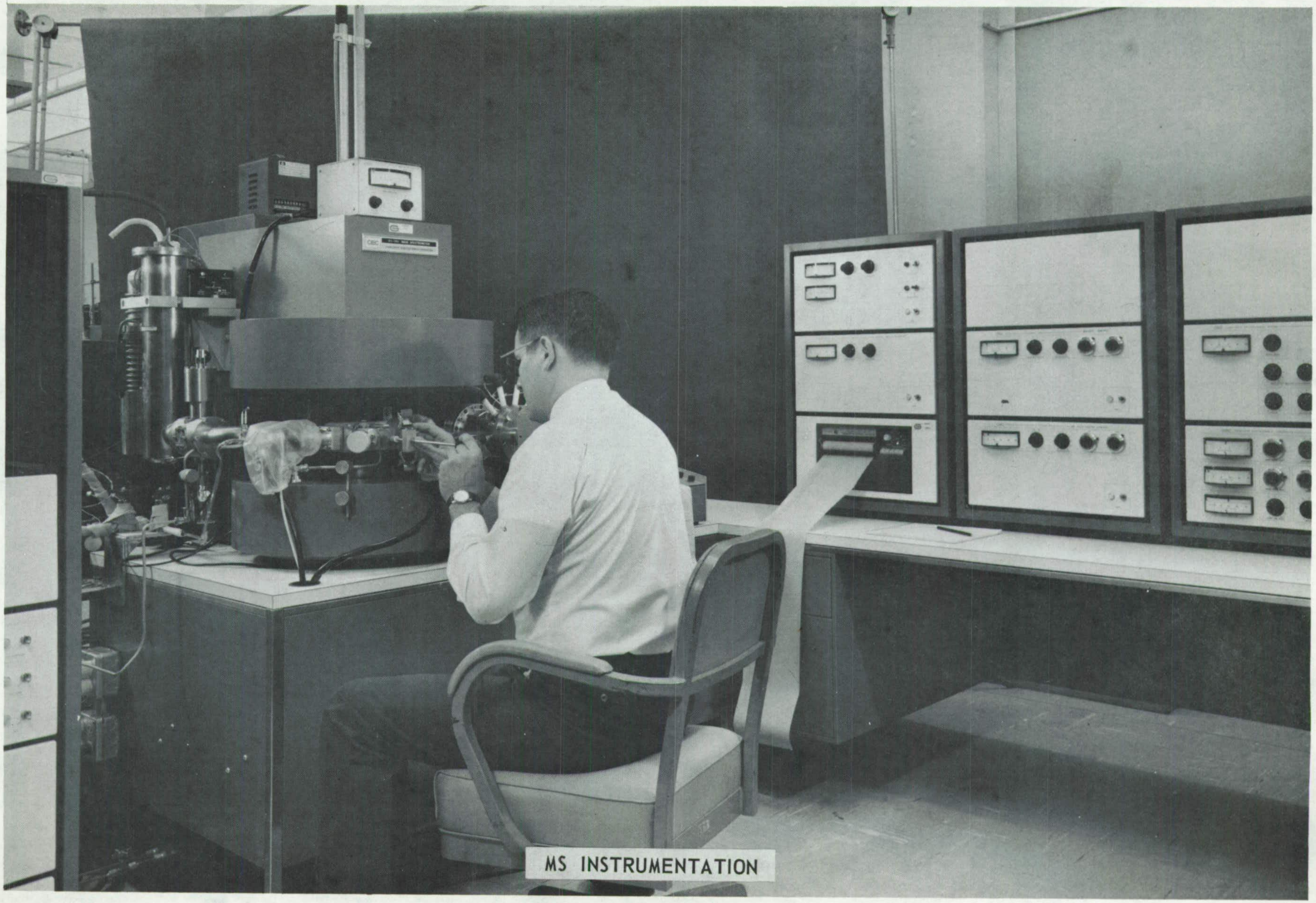
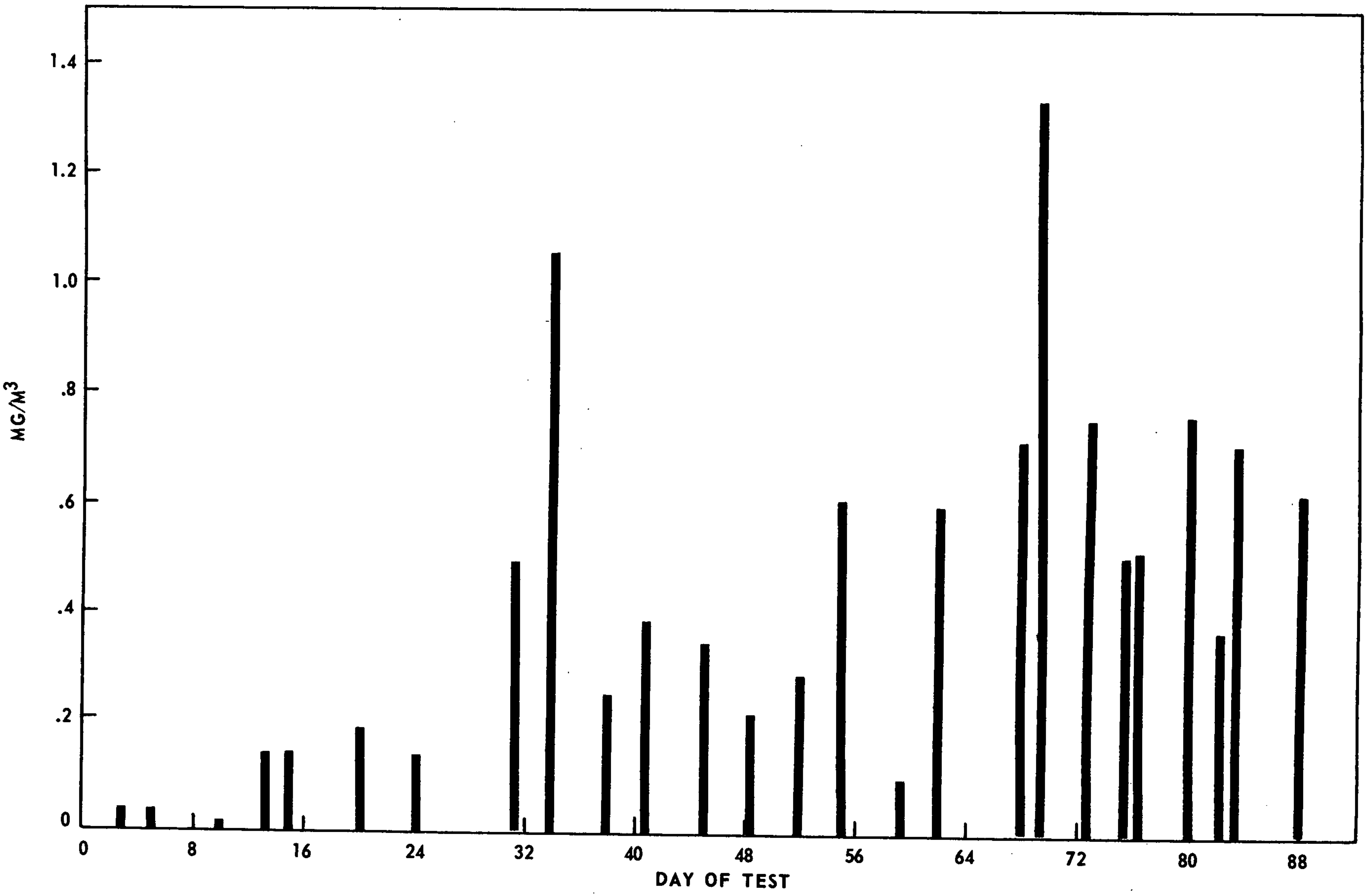
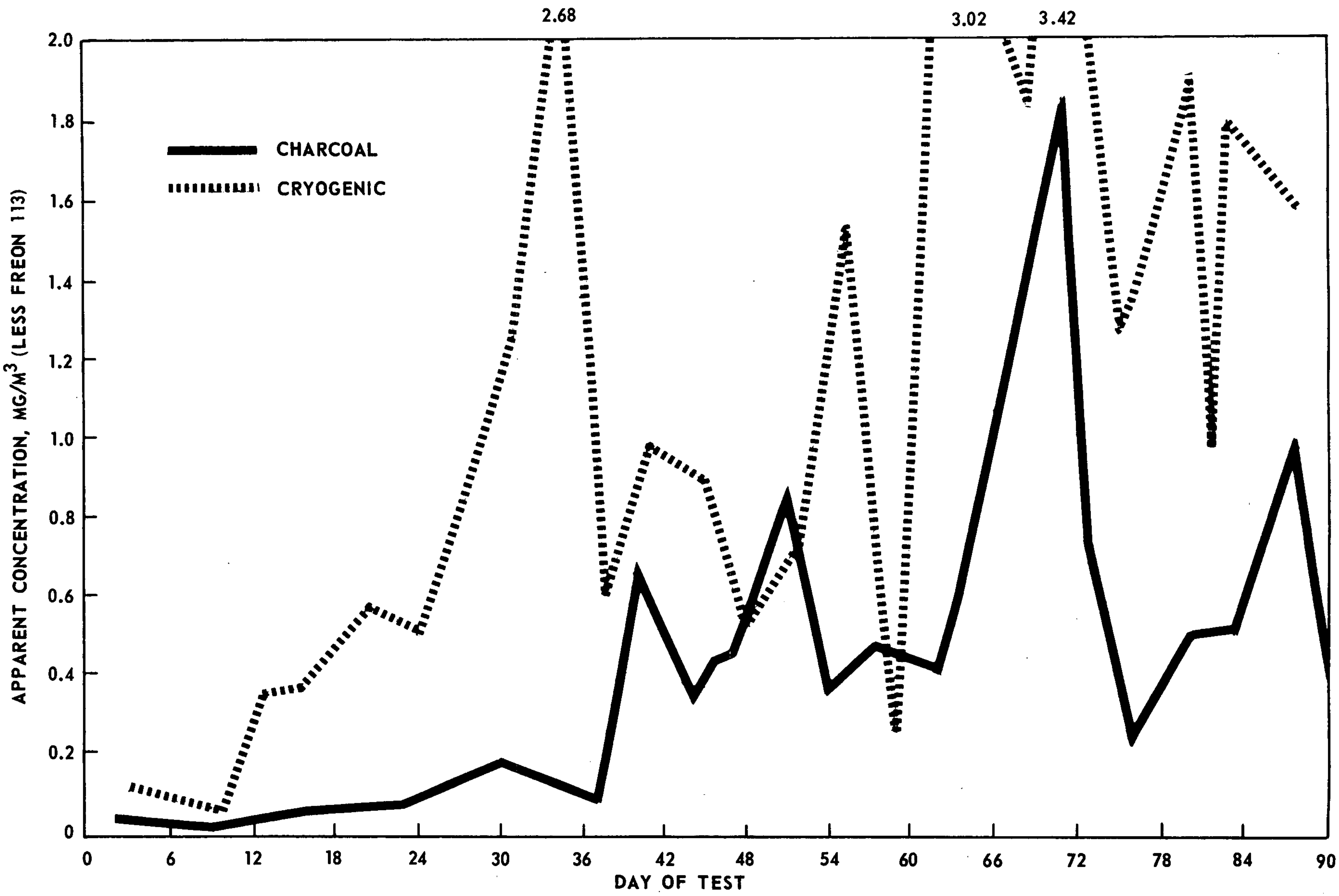


Figure 10



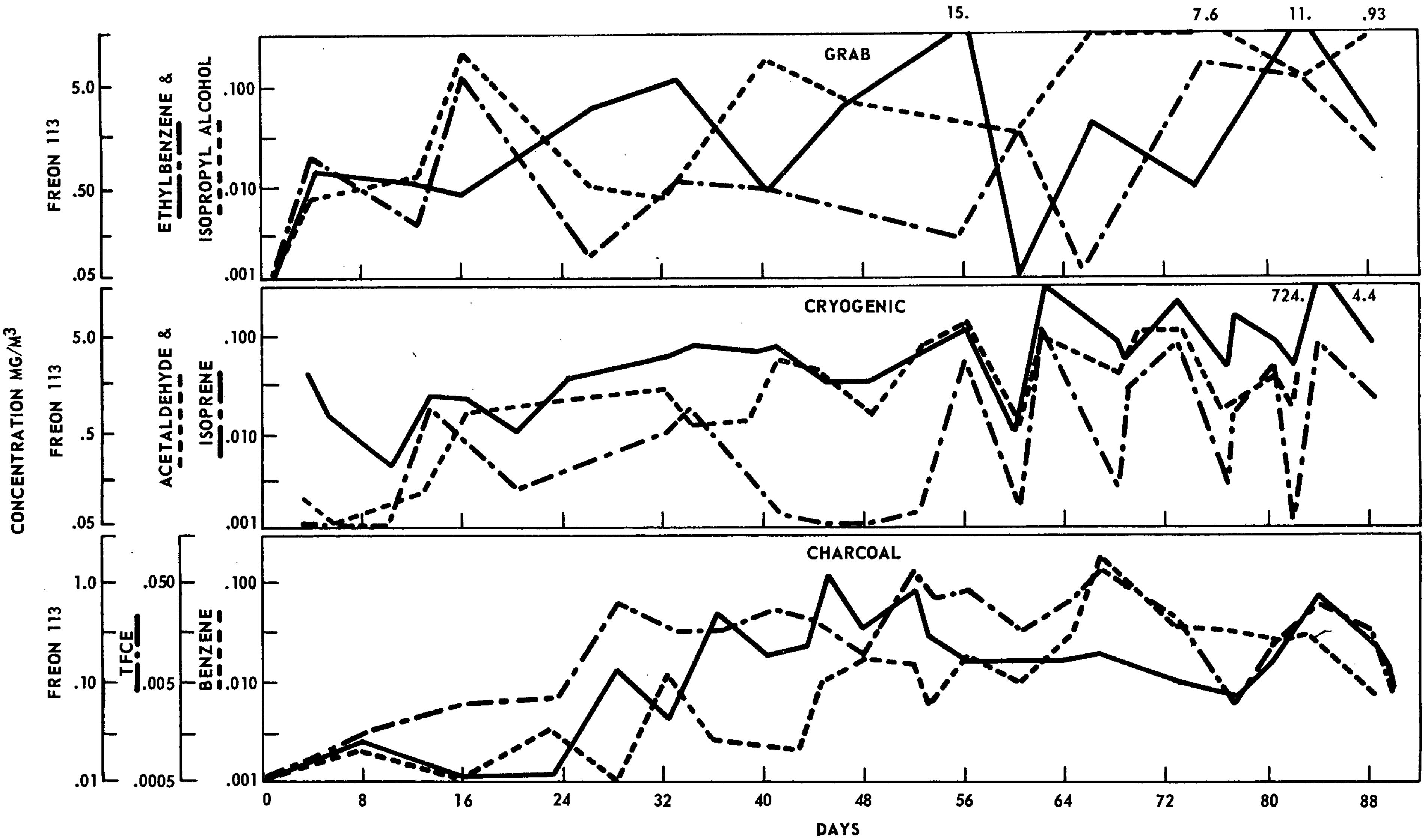
TOTAL WEIGHT OF RECOVERED MATERIAL
(EXCLUDING FREON 113)
USING CRYOGENIC COLLECTION

Figure 11



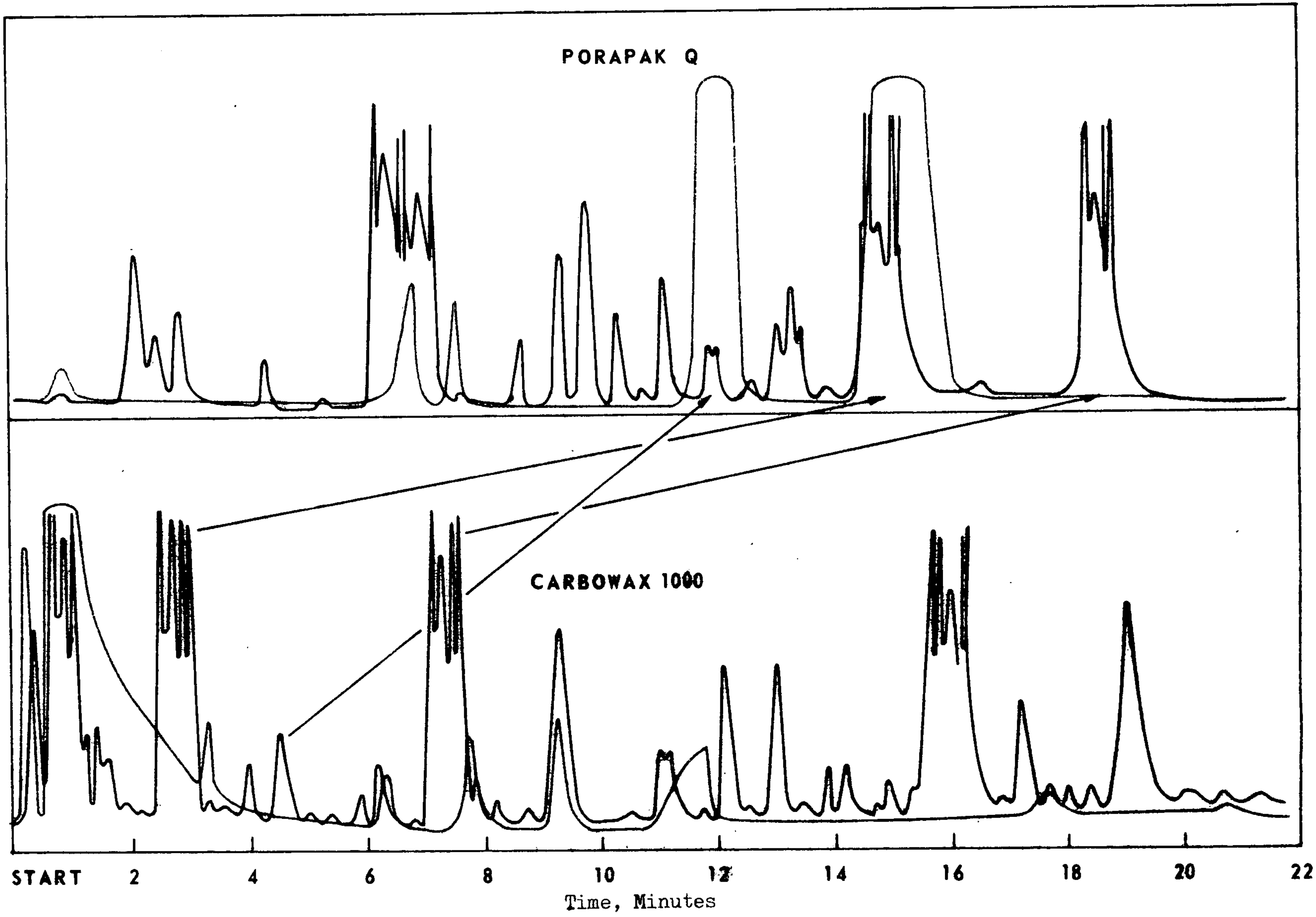
SAMPLE RECOVERY USING TWO COLLECTION METHODS

Figure 12



CONCENTRATION CHANGE OF SELECTED COMPONENTS

Figure 13



SELECTED CHROMATOGRAM OF TRACE CONTAMINANTS

Figure 14