Laboratory Hood Analysis for the Basement and First Floors of the Rosenau Building

Table of Contents

Abstract

Sarah E. Ash. Evaluation of Laboratory Hoods in the Basement and First Floors of the Rosenau Building. (Under The Direction of Dr. Michael R. Flynn)

The proper location and operation of laboratory fume hoods is essential for effective and efficient protection against exposure to hazardous substances. Two qualitative and two quantitative tests, as well as other observations, were applied in the evaluation of 22 laboratory fume hoods in the basement and first floors of the Rosenau Building. The two qualitative tests allowed for visualization of the air currents inside and outside of the hood. Smoke tubes were used to assess air currents in front of the hood face, while titanium tetrachloride($TiCl_4$) was applied to the inner sides and bench of the laboratory fume hood to visualize the air current's behavior within the hood face. The quantitative tests measured face velocity and hood performance (with the use of Sulfur Hexafluoride(SF_6) as a tracer gas). Other observations include layout of the room, condition of the hood bench, sash position during operation, location of windows, doors, make-up air units and general work practices which could affect cross-draft currents in front of the hood face. The presence of bottom slots leading to plenums were noted and maintenance records were reviewed during each hood evaluation. Recommendations are given for ways to improve each hood's efficiency and effectiveness.

Introduction

Protection of people's health and safety is of utmost importance. Therefore, many methods are applied in controlling exposure to hazardous substances in the workplace. Three of the most widely used methods of control are engineering controls, administrative controls and personal protective equipment (Fundamentals of Industrial Hygiene, 1988). The most effective method of reducing exposure to hazardous substances is through engineering controls. One example of an engineering control is local exhaust ventilation(LEV).

An LEV system is designed to capture or contain contaminants at their point of generation(McDermott, 1985). According to McDermott, an LEV system is comprised of a hood, duct work, air filter and a fan, see Figure 1. Proper design of the hood, duct work and choice of the fan is essential in complex systems in order to achieve the proper balance throughout the system. If proper balance is not maintained or achieved, the hood face velocity required to contain contaminants generated within the hood may not be reached. However, even with proper design and appropriate fan size, hoods may be less than 100% efficient; this results in contaminant escape and possible human exposure.

In the laboratory environment, enclosed fume hoods or laboratory hoods have been designed to decrease exposure by preventing the escape of contaminants generated in the hood. These hoods do not have the ability to capture contaminants created outside of the hood, so proper use is essential. Even if the laboratory fume hood is used properly, other factors such as location, maintenance and make-up air can affect hood efficiency and effectiveness.

Efficiency and effectiveness are two capabilities related to hood performance. According to Vladimir Hampl(Hample,1984), the effectiveness of an LEV system can be defined as the capability to reach a given goal, standard or condition. LEV system efficiency is defined as the fraction of contaminant captured by a hood per given time. The SF_6 test is a measure of the efficiency of the laboratory hoods. Problems in assessing overall safety of a hood may arise when a very efficient system may not be effective when dealing with highly toxic materials. On the other hand, a moderately efficient system may be very effective when handling moderately toxic materials. Therefore, it is also important to consider the toxicity of substances used in each hood analysed.

In order to assess the efficiency of laboratory hoods in the Rosenau Building, a series of qualitative and quantitative tests were performed on 22 hoods in the "as used"(AU) state. The following tests were performed:

1) Smoke Tube Test
2) Titanium Tetrachloride($TiCl_4$) Test
3) Face Velocity Test
4) Sulfur Hexafluoride(SF_6) Test

Each of these tests was essential in providing information on the efficiency of the hoods and in locating potential problem areas in front of the hood face as well as inside the hood. The smoke tube test and the $TiCl_4$ test allowed the air currents to be visualized in front of the hood face and inside the hood. The face velocity test measured air speed in feet per minute(fpm) across the hood face. The SF_6 detection test allowed for assessment of hood performance and magnitude of potential personnel exposure in the breathing zone.

Since face velocity is not a direct measure of the hoods ability to provide protection(Ivany,et.al.,1989), the SF_6 leak test was also performed. The SF_6 test results in a performance rating under "as used "(AU) conditions. The equation representing the performance rating consists of a flow rate, the as used symbol(AU), and the concentration(ppm) of tracer gas(SF_6) measured in the mannequin's breathing zone. The following is an example of the equation:

xx AU yyy

xx=flow rate(lpm) of tracer gas
AU=as used condition of the laboratory hood as opposed to the as manufactured(AM) condition.
yyy=concentration(ppm) of tracer gas(SF_6) in the mannequin's breathing zone.

The above equation was formulated by Caplan and Knudson(1982) and is currently used in the ASHRAE Standard as the method of testing performance of laboratory fume hoods(1985). For example, a flow rate of 4 lpm in the "as used" environment with a detection measurement of 15 ppm would give:

4 AU 15

This means that at a generation rate of 4 lpm of 100% SF_6, the hood can control exposure to 15 ppm. The performance rating is a relative measure of the laboratory hood's ability to protect exposure at a given generation rate(Peck, 1982). The ACGIH recommends levels be kept below 0.10ppm at the given generation rate and %SF_6.

Other factors considered in the analysis of the laboratory fume hoods include the toxicity of materials currently handled in each hood, work practices of individuals using the hoods, conditions of the hood benches, maintenance/upkeep on the fans, layout of the rooms and plenum settings on each hood(when plenums are present).

Experimental Method

· Qualitative Tests

1) Smoke Tube Test

MSA smoke tubes were used to visualize the behavior of air currents four inches in front of the hood face as well as four inches outside the border of the hood face. Smoke was puffed out manually at 6-inch intervals across the hood face. The movement of the smoke created was then noted. The smoke tubes were also utilized during the SF_6 testing to see what affect the mannequin would have on the air currents.

2) Titanium Tetrachloride Test ($TiCl_4$)

Liquid $TiCl_4$ was "painted" along the sides of the laboratory hood and across the hood benches 6-inches behind the plane of the hood face. A 12-inch rod with an alligator clip was used to swab the TiCl4 inside the hood. If items were near the front of the hood face, the $TiCl_4$ was painted in front of the objects(i.e. chemical bottles, ovens, hot plates etc.). The activity of the formed smoke was then recorded. The $TiCl_4$ was used to help visualize air currents inside the hood as well as to help see the effects that cross-drafts have on hood operation. If the smoke is pulled out of the hood face, Caplan and Knudson(1982) suggest the hood should be considered inadequate for personnel use. Air movement towards the hood face is defined as reverse air flow, and lack of air movement is defined as dead air space, according to the ASHRAE Standard 110-1985. When applicable, this terminology will be used in this paper during the analysis of the smoke tests.

Experimental Method

Quantitative Tests

1) Face Velocity Tests

Face velocity and cross-draft velocity(when present) were measured using a calibrated TSI model 1650 thermal anemometer. The unit was calibrated using the Type B Set-up and velocity curves provided by the Industrial Ventilation Laboratory(diagram of Set-up in Appendix A). The hood face was divided into 9 or 16 points(depending upon hood dimensions) equidistant from each other. The measurement points were no greater than 18 inches apart and 4 inches from the hood frame. The measurements were also taken 4 inches behind the plane of the hood face. Caplan and Knudson(1982), claim that individual readings shall not vary greater than 10% when hoods are empty or greater than 25% when hoods have equipment on the bench. Each point was measured in triplicate in order to evaluate the accuracy. Simple statistical evaluation of the results can be completed using the computer program, Mystat. These results can be referenced in Appendix E. Figures in Appendix E depict the spacial arrangement for measuring face velocity on a nine point traverse and a sixteen point traverse.

Experimental Method

Quantitative Testing

2) Sulfur Hexafluoride(SF_6) Test

Equipment

- -Wilkes Mobile Infrared Analyser(Miran) I serial #50944
- -Metrosonics Data Logger
- -1 inch copper tubing diffuser with 6 mm holes spaced 1 inch apart(1 foot by 6-inches in measurement)
- -Calibrated Rotometer
- -Pump
- -SF_6 gas cylinder
- -Tygon tubing
- -10 microliter syringe
- -3-dimensional mannequin
- -Ring-stands
- -Cart

Miran Setting

The Miran was set on the following measurements for sampling SF_6:

Wavelength = 10.7

Pathlength = 20.25 meters

Gain = 10X

Absorbance= 1

Time Response= 1 second

Slit = 1 mm

Sulfur Hexafluoride Leak Test Set-Up

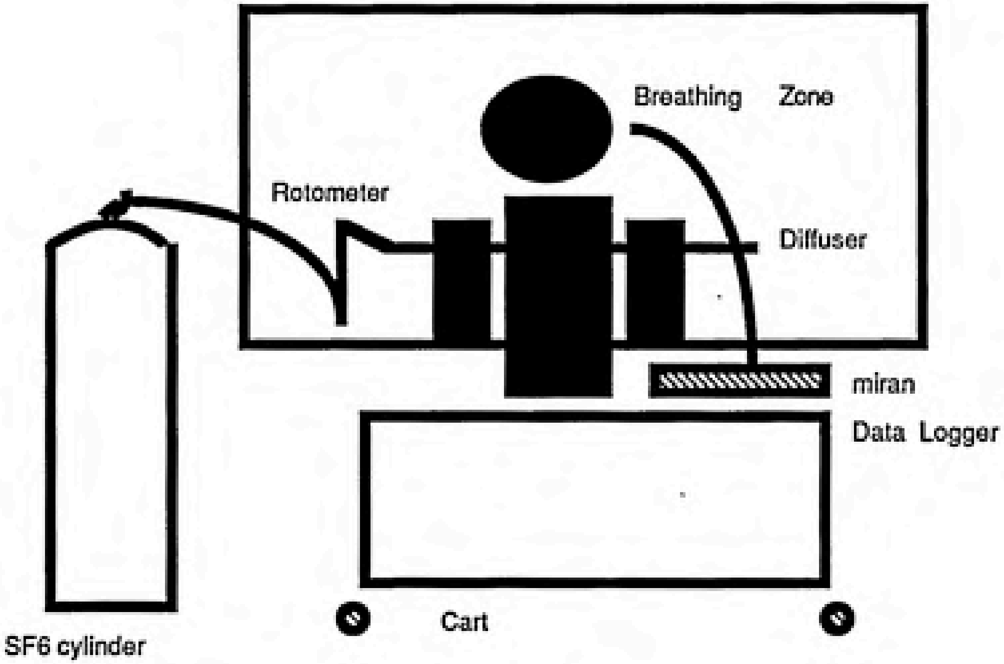


Figure 2

Before sampling is begun, a 5 minute sample is taken and the average is used as the zero which is subtracted from each of the test readings. The data logger setting for the background readings is:

Logging Duration= 5 minutes
Sampling Rate= 1 second
Time Average= 5 minutes

After the Miran stabilizes and a zero value is recorded, measurements for SF_6 leakage from the hood face can be collected. The measurements are collected in the breathing zone of the mannequin with the sampling tube angled in the same manner as the nose. Tygon tubing leading from the breathing zone to the calibrated Miran(see page 13 for calibration instructions) intake valve is the method of SF_6 transport. SF_6 enters the Miran chamber and exits through another section of tygon tubing which leads from the Miran to the back of the laboratory hood. This prevents the collected SF_6 from being directly expelled back into the mannequin's environment, and confounding the results.

Tygon tubing leading from the gas cylinder(containing 10% SF_6) to a calibrated rotometer and a copper tubing diffuser apparatus allows for gas to be expelled at an even, controlled rate. 4 liters per minute(lpm) was the selected rate for diffusing the SF_6 gas. This is representative of moderate activity inside the hood, since 4 lpm is midway between a vapor release rate of 1 lpm and a boiling release rate of 8 lpm(Ivany, et.al.,1989). This rate was later doubled during data analysis in order to calculate the "worst case" situation. The final values were also multiplied by 10 to represent a 100% SF_6 detection.

Sampling for SF_6 leaking out of each hood was conducted over a 10 minute period. The samples were continuously collected from the breathing zone of an adult proportioned mannequin situated in the area designated as having the highest potential for personnel exposure(located by previous testing). The readings were recorded by the data logger and averaged for the final value. The settings for the data logger during laboratory hood measurements are as follows:

Logging Duration= 10 minutes
Sampling Rate= 1 second
Time Averaging= 1 minute

Ten averaged absorbance readings were collected for each run. These measurements were averaged together for an overall leak potential level(ppm). These averaged absorbance units as well as their corresponding concentration values(ppm) are in Appendix F.

Before logging data, allow the gas the run through the diffuser for 5 minutes to allow for even dispersion. Allow the Miran to stabilize for at lease 4 hours between hood readings or until the data logger readings no longer fluctuate. New background measurements and zero values are recorded for each hood tested. Due to the sensitivity of the miran, the unit's zero varied greatly due to jostling during transport and periodic unplugging of the unit. Unfortunately, these conditions could not be avoided due to the nature of the study and the layout of the laboratory hoods tested.

Positioning of the Equipment

SF_6 Test

Mannequin Specifications(ASHRAE Standard 110-1985)

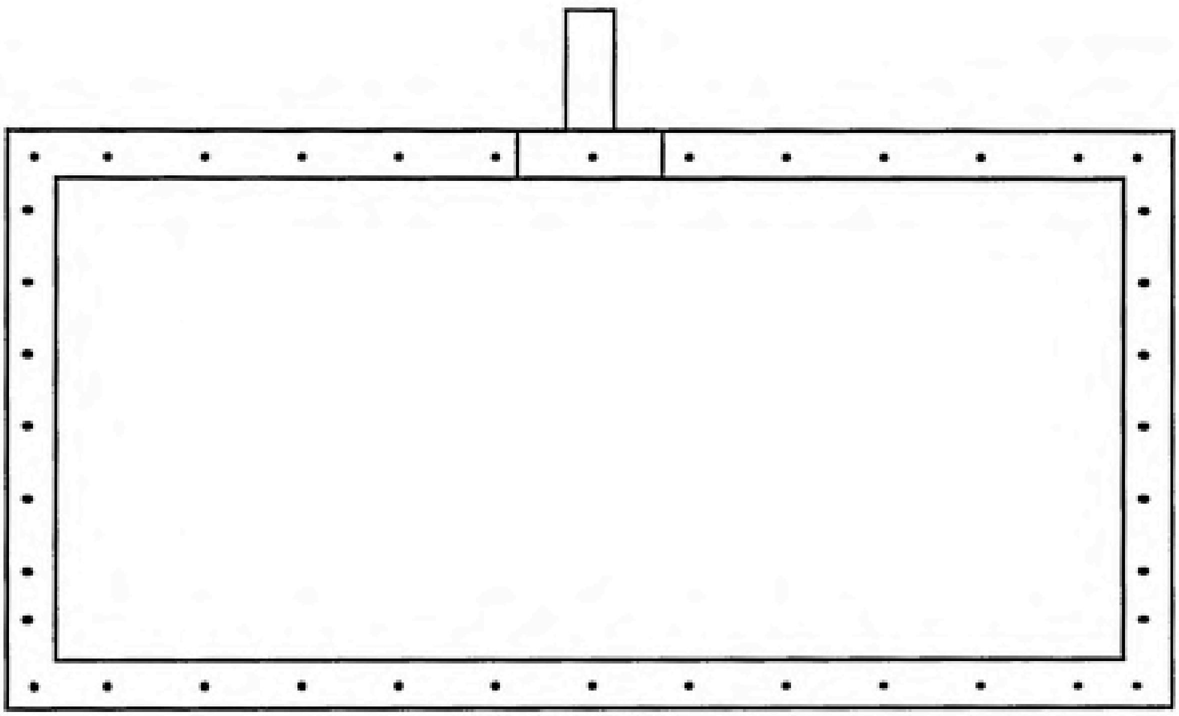
The mannequin used was a three-dimensional, clothed figure measuring 67 inches in height. The shoulders measured 56 inches high(±1 inch) and the shoulder width measured 16 inches(±1 inch). The arms of the mannequin were positioned down at its side. The mannequin's torso was supported on a cart which was moved from room to room in order to test various hoods. The cart was below the level of the hood face to prevent interference in air currents. The mannequin was clothed in a laboratory jacket representative of a hood operator. The mannequin was situated in the area designated by previous tests(smoke tube tests, $TiCl_4$ tests and face velocity tests) as having the highest potential for personal exposure.

Rotometer

A recently calibrated rotometer was used to monitor gas flow rate; it was checked periodically throughout the testing period. (Calibration data pertaining to the rotometer used in this study is in Appendix B.) The rotometer was placed inside the hood away from the diffuser, mannequin and hood face(6 inches behind the hood face).

<u>Diffuser</u>

A 1-inch copper tubing diffuser measuring 12-inches in length and 6-inches in width with .6mm holes drilled 1-inch apart was positioned 6-inches behind the hood face and 6-inches above the hood bench. In the center of one 12-inch side is a T-bar which allows for entry of the tracer gas to be diffused. Figure 3 is a diagram of the diffuser.



SF_6 Gas Diffuser

Figure 3

This is a diagram of the diffuser used in each of the SF_6 performance tests. The holes are 6mm wide and 1 inch apart in the top, center of 1-inch copper tubing.

Calibration Procedures

Miran Calibration

A Wilkes Mobile Infrared Analyser(Miran) was used to monitor the concentrations of SF_6 generated in the given atmosphere. A calibration curve was plotted by averaging three sets of data consisting of seven cumulative injections of Sf_6(10 ul/injection). Each data point measured a 10ul increase of SF_6 in the Miran chamber. The final curve was calculated using a linear regression equation using the Lotus computer program. This allowed for extension of the curve's line through zero which allowed for readings down below 0.177 ppm and above 1.24 ppm. Since the lowest injection measurement was 0.177 ppm, this measurement was designated as the limit of detection. During data collection, any readings below this concentration were considered non-detect and were assigned a value of zero. In the final data analysis, these concentration readings were multiplied by twenty in order to represent a 'worst case' situation of using an 8 lpm flow rate and a concentration of 100% SF_6.

A 10 ul gastight syringe was used for each injection. The SF_6 samples were injected into a closed loop system consisting of a metal bellows pump and rubber tubing connecting the pump to the Miran. Each injection was cumulative resulting in concentrations ranging from .177 ppm to 1.24 ppm.(The range of leakage from the hoods was assumed to be within this range, therefore, the Miran was calibrated accordingly.) Periodic calibration runs were conducted throughout the testing periods to assure stability of the Miran. Appendix D contains the graphs and data of these check runs. Information on the injection volumes(ul), their additive concentration(ppm) and their corresponding average absorbance units(volts) from the Metrosonics data logger are also in Appendix D.

General Procedure

The Wilkes Miran was allowed to "warm-up" until a stable zero value could be recorded. The samples of 10% SF_6 were collected directly through tygon tubing leading from the SF_6 cylinder. Ten ul volumes of SF_6 were drawn from the tubing into a 10 ul gastight syringe. The volumes were then injected into the septum of the miran's closed loop system(described above). The gas was allowed to mix in the Miran chamber for a period of 15-20 second before recording measurements. After equilibration, the concentration of SF_6 in the closed loop system was recorded for a period of 30 seconds. A data logger was used to collect the readings. The data logger was programmed as follows:

Logging Time= 30 seconds
Sampling Rate= 1/second
Time Averaging= 30 seconds

The averaged value of the 30 readings logged over this 30 second period was used as the final measurement. Three runs consisting of seven, 10 ul injections were completed. Three average absorbance unit values were collected for each of the seven cumulative injections. The three measurements for each of the injections were then averaged and this final value was used in a curve of Average Absorbance Units(volts) vs Concentration(ppm). This formed the initial LInear Regression Calibration Curve(Appendix C). Check calibration curves were created by using only one run, not the average of three runs(Appendix D).

Rotometer Calibration

The rotometer used to monitor the SF_6 flow rate into the diffuser was calibrated using a bubble meter and a stop watch. The data collected for the pre and post calibration can be found in Appendix B.

General Guidelines

1) All tests were completed with the hood sashes fully open. *

2) All tests were completed in the absence of a hood operator.

3) All tests were conducted with doors to the labs open and windows in the labs closed.

4) All hood benches were untouched. No bottles or equipment were removed for testing.

5) Smoke tube tests were performed 4-inches in front of each hood face and 4-inches outside the hood face perimeter.

6) $TiCl_4$ tests were completed 6-inches behind the hood face.

7) Face velocity measurements were made 4-inches behind the hood face.

8) The SF_6 test was completed in the area designated as having the highest potential for human exposure. All samples were collected in the breathing zone of the mannequin.

9) Chemicals currently used in the hoods were noted and MSDS(Material Safety Data Sheets) were collected pertaining to those chemicals.

* Hood 125 B has a permanent 1/3 sash which was not removed during any of the hood tests.

Recommendations for Face Velocity

According to McDermott(1985), the face velocity necessary for a laboratory hood depends upon two primary factors:

1) Toxicity of contaminants, and
2) Airflow needed to remove explosive or flammable gases and vapors.

Other important factors to consider are:

-Location of hood with respect to traffic patterns, doors, windows and inlet air units,
-Amount and location of equipment in the hood,
-Location and velocity of make-up air units, and
-Adequate air supply to the room in general.

A highly toxic chemical or carcinogen requires a higher level of protection than a moderately toxic substance. The same principle can be applied to highly flammable or explosive items in comparison to non-flammable or non-explosive materials. For example, a carcinogen, such a nickel carbonyl (TLV-TWA=0.01ppm), must have much stricter controls than carbon dioxide(TLV-TWA=5,000ppm). The same degree of increased control applies to flammable material such as hydrogen as compared to non-flammable materials like water. Controls must prevent the highly toxic and/or flammable chemicals from reaching dangerous concentrations which may lead to over exposure and/or explosions.

One method of control based on hood performance requirements is suggested by Fuller and Etchells(1979). This is a conservative approach relying upon the Permissible Exposure Limit(PEL) or TLV-TWA values. Assuming a boiling liquid or generation rate of 8 lpm, the following is an example of suggested guidelines under given conditions(Fuller and Etchells, 1979):

PEL> 1000 ppm	Locate contaminant >5cm from hood face.
PEL> 100 ppm	Locate contaminant >10cm from hood face.
PEL> 10 ppm	Locate contaminant > 20cm from hood face.
PEL> 1 ppm	Work with sash 1/2 closed.

The importance of the location of the hood in the room is due to the negative effects that certain air patterns may have on the effectiveness of the hood. Cross-drafts caused by traffic passing by the hood or by air currents from doorways and windows may be strong enough to pull contaminants out of the hood face. To prevent this occurrence, the hood should be placed out of areas prone to potential interfering air currents. Proper placement will also save energy by keeping face velocity requirements at a minimum and will increase effectiveness by keeping the eddies formed about the hood operator to a minimum(the higher the face velocity, the greater the chances of creating disturbing eddies in front of the hood operator).

Make-up air and ceiling diffusers also have an affect on the effectiveness and efficiency of laboratory hoods. If there is not enough make-up air supplied to the room, the level of face velocity does not matter. For example, a hood with a face velocity of 50 fpm can attain lower concentrations in the breathing zone with adequate make-up air and even distribution than a hood with a face velocity of 150 fpm with poor make-up air and distribution. If the velocity of the make-up air in front of the hood face is greater than 1/2-2/3 the face velocity of the hood, then there may be problems with contaminant being pulled out of the hood face(ACGIH Ventilation

Manual, 1988). The following chart from the ACGIH Ventilation Manual can be helpful in establishing an appropriate face velocity for a given laboratory hood:

Condition	cfm sq ft open hood face
1. Ceiling panels properly located with average panel face velocity <40 fpm (see Ref. 137). Horizontal-sliding sash hoods. No equipment in hood closer than 12 in to face of hood. Hoods located away from doors and trafficways.*	60
2. Same as 1 above, some traffic past hoods. No equipment in hood closer than 6 in to face of hood. Hoods located away from doors and trafficways.*	80
3. Ceiling panels properly located with average panel face velocity <60 fpm (see Ref. 137) or ceiling diffusers properly located, no diffuser immediately in front of hoods, quadrant facing hood blocked, terminal throw velocity <60 fpm. No equipment in hood closer than 6 in to face of hood. Hoods located away from doors or trafficways.*	80
4. Same as 3 above, some traffic past hoods. No equipment in hood closer than 6 in to face of hood.	100
Wall grilles. Possible but not recommended for advance planning of new facilities.	

Even though the chart indicates increasing face velocities when hood conditions become more complex, higher face velocities increase the amount of eddy currents in front of the hood operator. This can result in contaminants being pulled into the operators breathing zone. Due to this effect, higher face velocities may not result in better protection.

Selection of a hood face velocity may be done through using the above chart or by applying the equation for Hood Performance Ratings. The performance rating equation specifies a given generation rate(lpm) of contaminant and concentration(ppm) allowed to escape the hood face. The face velocity is then adjusted to control exposure to that concentration(ppm) at that rate of generation(lpm). The ACGIH Manual of Industrial Ventilation recommends face velocity levels ranging from 60-150 cfm/sq. ft. with the sash fully open. OSHA recommends a face velocity of >150 fpm for hoods where carcinogens are handled. But, some studies indicate that face velocities>100 fpm do not increase one's level of protection.

Other studies done by Lewis(1979) have shown that 80 to 100 fpm control velocity at the face of the hood gives adequate protection if the flow is kept fairly laminar and drafts inn front of the hood are kept at a minimum(,20 fpm). The American Chemical Society recommends a minimum face velocity of 100 fpm. Studies completed over 40 years ago show that a face velocity of 60 fpm was adequate to control contaminants as long as there was an adequate auxiliary air supply(Fuller and Etchells, 1979). An adequate amount of auxiliary air would be that amount which would replace the air which is exhausted by the laboratory hood without creating positive pressure in the room.

Studies dealing with hood face velocities have not designated any one value as the value for protection. The selection of an adequate face velocity depends upon many variables which must be considered during and after the design of the hood. A definite range has been defined from 60 fpm to 150 fpm depending upon the condition, location, use and operation of the hood.

Keeping the above face velocity recommendations in mind, the adequacy of the current face velocities for the 22 hoods tested in the Rosenau building will be assessed according to the following test results and observations:

- -Smoke Tube Test
- -$TiCl_4$ Test
- -Face Velocity Measurements
- -SF_6 Test
- -Make-up air
- -Toxicity of chemicals used
- -General work practices.
- -Traffic patterns
- -Location of Windows/doors
- -Condition of the hood bench

Hood Performance Analysis

Hood 4

The location of the hood in room four is rather poor with respect to traffic patterns. Anyone who enters this room must walk directly in front of the hood face to get into the main working area. Traffic becomes very congested if someone is working at the hood. The air diffuser into the room is located above the main entrance to the room which is far enough away to avoid cross-draft problems. The make-up air unit is located directly above the hood face. Figure 4 on the previous page shows the layout of the room and the location of make-up air units with respect to the hood. The velocity of the make-up air flowing down across the hood face ranges from 220 fpm at the left side to 10 fpm at the right side of the hood. This high down draft velocity at the left portion of the hood is more than enough to compete with the hood face velocity. The average hood face velocity for hood four is only 31 fpm. Even under ideal conditions, the recommended face velocity is 50 fpm. This hood does not represent optimum conditions nor sufficient face velocity to adequately protect the personnel operating this hood. The down-draft measurements were taken 4-inches in front of the hood face in the same areas that the face velocity measurements were taken(except the f.v. measurements were taken 4-inches inside the hood face). The areas of down-draft which are higher in velocity than the face velocity pose a threat to pulling out contaminants from inside the hood. An isopleth graph for hood four shows the face velocity currents in more detail(Appendix G).

Smoke tubes were then used to visualize the air currents in from of the hood face. The smoke was pushed down and out of the hood on the left area of the hood face(facing the hood). The distinct smell of the smoke was detected when testing this part of the hood. The right 2/3 of the hood performed well. The smoke was pulled quickly into the hood showing no signs of turbulence as noted on the left side of the hood.

The $TiCl_4$ test gave similar results. The liquid $TiCl_4$ was brushed on the inside walls and hood bench 6-inches behind the hood face. The resulting smoke was pushed out under the air foil at the left, bottom area of the hood. A great deal of turbulence was observed in this area; smoke swirled out of the hood face-both over and under the air foil. The right side of the hood showed no signs of turbulence. No smoke was allowed to escape in this region.

Quantitative measurement of the hood's effectiveness were taken using the SF_6 test and face velocity test(previously discussed). The mannequin for the SF_6 test was positions on the left side of the hood where the highest potential for exposure exists. The resulting hood performance rating is 8 AU 6.48. This means that at a generation rate of 8 lpm, personnel can be exposed to 6.48 ppm of contaminant. The actual concentrations measured were multiplied by 20 to represent a 'worst case' situation (generation rate=8 lpm; SF_6 concentration diffused=100%)

Recommendations for hoods with hood benches filled with equipment up to the hood face, high traffic area and strong cross-drafts are for the hood face velocity to be>100fpm. This hood also contains chemicals that are considered highly toxic. The following is a listing of the chemicals used in this hood and certain characteristics:

Chemical Name	Characteristics
Methanol	Flammable; TLV-TWA 200ppm
Mercaptans	Flammable; TLV-TWA .05 ppm
Hydrochloric Acid	Corrosive; TLV-TWA 5ppm Ceiling
Chloroform (A2)	Susp. Carc.; TLV-TWA 10 ppm

The chemicals used in this hood are of high enough concern to require face velocities of 150 fpm(suggested when handling carcinogens). According the the PEL chart, the materials in this hood should only be handled with the hood sash 1/2 closed.

Overall assessment of hood four gives very poor ratings in all areas; qualitative and quantitative. There is substantial turbulence observed and measured on the left portion of the hood. The SF_6 detection test showed that he hood can only control contaminant to 6.48 ppm at a generation rate of 8 lpm. The current recommended exposure level, according to the ACGIH Manual, is below 0.10 ppm at a generation rate of 8 lpm using 100%SF_6.. Therefore, any hood performance rating at or above 0.10 ppm will not be considered acceptable. The location of the hood is poor and the make-up air is a definite interference with the hoods containment and capture capability. The hood practices observed could be improved by lowering the sash and by pushing equipment further back in the hood. Currently, the equipment sits flush with the hood face.

Hood 6

The location of hood six is good with respect to traffic patterns and air supply. The traffic past the hood is minimal and there are no interfering cross-drafts caused by make-up air units or diffusers. The presence of cross-drafts was tested for qualitatively with the use of MSA smoke tubes. All visible smoke was pulled directly into the hood face. No smell of the smoke was noted during or after testing. There were no visible areas of turbulence or back flow of smoke out of the hood face. The $TiCl_4$ test qualitatively assessed the activity of air flow inside the hood. Problems of the smoke being pushed out from under the air foil occurred in front of the heating plate. This was remedied by pushing the unit behind the sash plane. All other areas of the hood contained the smoke and pulled it up into the exhaust.

Quantitative tests showed the average face velocity to be 23 fpm, much lower than the lowest recommended face velocity value of 50 fpm. The isopleth graph depict the air flow pattern for hood six(Appendix G). The isopleth graph shows the right portion of the hood measures velocities in the upper teens while the left side reaches values in the low 30's. The face velocity measurements were fairly consistent across the hood face, so the mannequin for the SF_6 test was placed in the center of the hood.

Results of the SF_6 detection test gave and averaged performance rating of 8 AU 0.167. This means that the hood can control exposure to 0.167 ppm at a generation rate of 8 lpm. According to ACGIH recommendations, this is not acceptable. The chemicals currently handled in this hood are as follows:

Chemical Names	Characteristics
Nitric Acid	Corrosive; TLV-TWA 2 ppm
Acetone	Flammable; ACGIH TLV-TWA 750 ppm
Hexanes	Flammable; ACGIH TLV-TWA 500 ppm
n-Hexane	Flammable; ACGIH TLV-TWA 50 ppm

According to the ACGIH table(p.19), 23 fpm would not be acceptable. Good work practices(outlined in Appendix H) are essential for safe operation of this hood. It is also recommended to keep chemicals at least 20 cm behind the hood sash.

Hood 7

Hood seven has excellent location in the room. There is no traffic past the hood and the make-up air unit has an air deflector to prevent down-draft interference across the hood face. The only drawback to the room conditions is the possible lack of supply air. The only mode of air supply to the room is through the doorway and the make-up air unit. But, this potential draw back did not affect the effectiveness of the hood. A layout of the room indicating the location of the hood , entrance, make-up air units and diffusers is on the previous page.

The smoke from the smoke tube was quickly pulled into the hood. The smoke from the $TiCl_4$ swab test lingered at the bottom, left, front corner, but was eventually pulled back and into the rear plenum. To prevent such dead air space, the bottles at the back of the hood should be removed to clear the rear slot opening to the plenum. No smoke was pushed out of the hood or under the air foil. The smoke was well contained and was even pulled up and around the hot plate and bottles at the front, right portion of the hood.

The face velocity in these areas can be seen on the isopleth graphs in Appendix G. The average face velocity for hood seven is 71 fpm. Under the given conditions, this face velocity is quite acceptable. The SF_6 leak test confirms the effectiveness of this hood by giving a hood performance rating of 8 AU 0. No exposure from the hood is detected at the generation rate of 8 lpm(the value measured was below the limit of detection(.177ppm) and was therefore assigned an exposure concentration of zero).

The following chemicals are handled in this hood:

Chemical Names	Characteristics
Polychlorobiphenyl	Known human carcinogen(A1); TLV .5mg/m3
Acetone	Flammable; ACGIH TLV-TWA 750 ppm
Methanol	Flammable; TLV-TWA 200 ppm

Due to the toxicity of these chemicals, it is recommended that the hood be used only with the sash 1/2 closed and that a face velocity of 150 fpm be met(due to the presence of a carcinogen). According to the results attained during the testing, the current face velocity is adequate to protect the hood operators against exposure by inhalation.

Hood 8

The location of hood eight is fairly good. There is moderate traffic past the hood , but the make-up air unit could be a problem if run at high velocities. During the time of testing, the unit was not running. Apparently, the units are used for comfort reasons, not as an auxiliary air source. Since the unit was not on, there were no noticeable areas of turbulence. To see where hood 8 is located, refer to the previous page.

The smoke tube test revealed good capture ability by the hood. No smoke was allowed to swirl in front of the hood or inside the hood. The smoke was pulled directly into the duct work. The $TiCl_4$ test gave similar results. There was quick, strong pull of the smoke directly back and up into the duct work. The line of $TiCl_4$ in front of the bottles at the sash boundary was pulled around the bottles and into the back of the hood.

The average face velocity measured for hood eight is 139 fpm. For detailed information on the air currents, refer to Appendix G. Essentially, the left half of the hood exceeded 140 fpm while the right portion ranged from 50 to 130 fpm. Since the overall area of the hood face meets or exceeds recommended face velocity levels, the mannequin for the SF_6 test was placed in the area most used by the hood operators(center of the hood). The resulting performance rating is 8 AU 3.40. This means that at a generation rate of 8 lpm, the hood controls exposures to 3.40 ppm. This exposure level of 3.40 ppm is not acceptable by the ACGIH guidelines even though this hood handles low to moderately toxic chemicals and many highly flammable chemicals. The following is a list of the chemicals used in this hood:

Chemical Names	Characteristics
Acetone	Flammable; ACGIH TLV-TWA 750 ppm
Ethyl Ether	Flammable; TLV-TWA 400 ppm
Hexanes	Flammable; TLV-TWA 500 ppm
n-Hexane	Flammable; ACGIH TLV-TWA 50 ppm
Sulfuric Acid	Corrosive; TLV-TWA 1 mg/m3
Tetrachloroethylene	Nonflammable; TLV-TWA 50 ppm

Lowering of the sash is highly recommended while using this hood. Following the guidelines in Appendix H will also improve ones protection against exposure.

Hood 8A and 8B

The location of hoods 8A and 8B(joined) is excellent. There is virtually no traffic pattern near the hood due to sheltering from a book case and a large glove-box. These hoods are not in current use, but they were tested since they connect to the exhaust system servicing hoods 9A and 9B. The make-up air unit is located 4 and 1/2 feet away from the units and poses no interference with the face velocity. The only other air supply to the room is located around the corner over the main exit. A detailed floor plan on the previous page may be referenced for location.

The smoke tube tests for each hood A and B were excellent. The smoke was pulled swiftly and directly into the hoods. No swirling or indication of turbulence was noted. Similar results were achieved for the $TiCl_4$ test. For both A and B, the smoke created was retained in each hood. In hood A, slight swirling occurred in the right side of the unit. Hood B showed no swirling in the hood.

The average face velocities for 8A and 8B were comparable. 8A has an average face velocity of 97 fpm while hood 8B has an average face velocity of 104 fpm. The SF_6 test also gave similar readings. Hood 8A has a performance rating of 8 AU 0.67 and hood 8B has a performance rating of 8 AU 0.48. This means that exposure is kept to .67ppm and .48ppm while working at hood 8A or hood 8B, respectfully. Hood 8A was only accessible on the far right side due to the presence of a large glove-box in the vicinity. In general, hoods 8A and 8B offer comparable levels of protection. No chemical assessments were made on toxicity or flammability since these hoods are not currently in use. Even though the concentrations detected were low, they do exceed the 0.10 ppm level recommended as the upper limit by the ACGIH. Therefore, caution should be taken when operating these hoods.

Hood 9A

The location for hood nine A is fair. The only traffic that passes by are those using hood nine B. The main problem in this area is a lack of make-up air. This room has very high levels of negative pressure noted by the pull on the door into the room. There is an air diffuser in the ceiling 6 feet from the hood face and a make-up air unit directly above the hood face, but they seem to be inadequate. Although it is good to maintain a certain amount of negative pressure to prevent the escape of contaminants into the hallway, this room has excessive negative pressure. Refer to the floor plan on the previous page for further details. During testing there were no interfering air currents from the make-up air unit or the air diffuser.

The hood has good capture velocity as visualized by the smoke tubes. The $TiCl_4$ test also gave excellent results. The smoke from the swab test was pulled quickly up and into the exhaust and rear slots. Smoke that formed around the front of a large chemical bottle at the sash boundary was contained within the hood. There were no visible signs of turbulence in front of the hood face or within the hood.

The quantitative tests were contradicting. The average hood face velocity was 89 fpm which is within recommendations. From these measurements, an isopleth graph was constructed(Appendix G). From this graph, the area of lowest face velocity was selected for location of the mannequin for the SF_6 test. The mannequin was placed just right of center to monitor the amount of SF_6 allowed to escape the hood, if any. The results of the SF_6 test gave a performance rating of 8 AU 7.07. This means that at a high rate of generation, an operator can be exposed to 7.07 ppm of contaminant.

These results were surprising due to the good indication of the hood's effectiveness from the previous tests. Therefore, smoke was released the the location of the tracer gas diffuser. The smoke was initially pulled up and then swirled out into the breathing zone of the mannequin. The smoke was also pulled out in the torso area of the mannequin. The face velocity of the hood apparently create some eddy currents causing the contaminant to be pulled out of the hood and into the breathing zone of the mannequin. This is a good example of why face velocity tests alone should not be relied upon as the only test for hood effectiveness.

The following is a list of chemicals and their important characteristics:

Chemical Name	Characteristics
Acetone	Flammable; ACGIH TLV-TWA 750ppm
Ether	Flammable; TLV-TWA 400ppm
Methylene Chloride	Susp. Carc.(A2); TLV-TWA 50ppm
Scintiverse	ACGIH TLV-TWA 25ppm

Since a suspected human carcinogen(A2) and highly flammable materials are handled in this hood, the performance rating measured is not acceptable. The performance rating also greatly exceeds recommeded linits of 0.10 ppm set by the ACGIH.

This hood should only be used with the sash 1/2 closed when handling methylene chloride or any other highly toxic chemicals. If possible, the bench should be cleared of the large chemical bottles and any unnecessary boxes to improve the flow into the hood. An increase in make-up air would also improve the hood operation.

Hood 9B

Hood nine B has an excellent location with respect to traffic patterns because the only traffic in this area if for use of the hood. The major draw back of this location is the lack of auxiliary air. There is a make-up air unit above the hood face and an inlet air grille on the opposite wall, but there is still a great deal of negative pressure(floor plan on previous page). The lack of make-up air did affect the operation of the hood.

The smoke tube test showed excellent capture capability. There was no visible disturbance of air flow into the hood due to cross-drafts or sharp movements near the hood face. Good capture was noted 4 inches away from the hood face and around the perimeter of the hood. The $TiCl_4$ test gave similar results. The formed smoke was pulled towards the back of the hood quickly from all areas, even from in front of a long box at the hood face. All the smoke formed was contained within the hood even though the rear slot is broken and unable to be kept open.

The quantitative tests also indicated an effective laboratory hood. The averaged face velocities gave and overall value of 80 fpm. For the conditions of a fairly clear hood bench and minimal cross-drafts, this is an acceptable hood face velocity(according the the ACGIH chart on p19). The SF_6 test confirmed the above tests by giving a performance rating of 8 AU 0. The actual results were below detectable limits, therefore the exposure level was assigned a value of zero ppm. This means that there is no exposure to the tracer gas at a generation rate of 8 lpm. The test was conducted at the center of the hood where face velocity measurements were the lowest(Appendix G).

The chemicals used in hood nine B are the same as those used in nineA. Please refer to hood nine A for information on the chemicals.

Hood 12

The location of hood 12 is fair. It is behind the entrance to the room and not in the main traffic pattern. The make-up air unit poses a problem with strong down-drafts ranging from 110 to 450 fpm. The damper was adjusted after these measurements were made to give final cross-draft ranging from 15-90 fpm. After this adjustment was made, the other tests were performed. Currently, this hood is not in use so no chemical inventory was made.

The smoke tube test and $TiCl_4$ test revealed some eddies. The smoke tube test allowed visualization of eddies created in the lower left corner. These occurred due to the presence of a large, square basin in this area. The smoke in this corner was also pushed down and away from the hood due to the down-draft created by the make-up air unit. The $TiCl_4$ test within the hood revealed air currents which swirled outside of the hood face on the right and left sides. The escaped smoke was immediately captured and pulled back into the hood. Smoke which formed at the bottom of the hood face was well contained, even in front of the plastic basin.

The face velocity measurements resulted in an average of 100 fpm. This fairly high average may be the cause of some of the turbulence, in addition to that caused by the make-up air unit. The SF_6 test gave a sound hood performance rating of 8 AU 0.54 with the mannequin located at the center of the hood face where there is a 90 fpm cross-draft and the lowest face velocity measurement of 88 fpm(isopleth graph in Appendix G). According to the hood performance rating, the hood operators should not be exposed to these levels of contaminant. In this case, further testing using more sophisticated equipment is recommended.

Hood 14

The location of hood 14 is in moderate traffic flow, but away from the main entrance. The make-up air unit is the primary source for down-draft complication. The left portion of the unit puts out velocities of 250 fpm in front of the hood face. This air current velocity is over 10x greater than the face velocity of the laboratory hood. The average face velocity calculated for hood 14 is 14 fpm-essentially no pull, just normal air currents in the room.

The smoke tube test allowed visualization of the down-draft currents. There was no capture of the smoke on the left portion of the hood. There was minimal capture of the smoke at the right side of the hood face. The pull from the hood was not strong enough to over come the down-draft. The smoke was pushed down and away from the hood entrance. The $TiCl_4$ test also revealed problems due to the down-draft from the make-up air unit. The smoke created in the left side of the hood was pulled out of the hood face. The right portion of the hood and bench area contained the smoke.

The SF6 test was conducted in the area of greater turbulence. The hood performance rating was low; 8 AU 0.54. This low reading may be due to the pushing down of the air currents, preventing the contaminants from entering the breathing zone. A smoke tube was used to visualize the air currents to see what was happening. The smoke was released at the area of tracer gas diffusion. The smoke was contained within the hood face.

This hood was not in use during initial testing so it was not shut down. Currently, research is on-going in this hood. Sodium thiosulfate (non-toxic) and n-pentane(flammable) are the chemicals handled in this hood. The potential problem in this hood is an explosion hazard if n-pentane is exposed to or travels to an ignition source if it is not properly controlled.

According to the test results, work should be avoided at the left portion of the hood. Any work that must be completed using this hood should be done with the hood sash 1/2 down and with material as far back in the hood as possible. Use of highly toxic materials in this hood is not recommended. The face velocity of this hood needs to be increases. In addition, adjustments should be made to the make-up air system to decrease turbulence. The hood should also be checked by maintenance to assure it is in proper working order.

<u>Hood 123</u>

The location of hood 123 is excellent with respect to traffic patterns but is very poor due to the presence of a window and door directly across from each other and next to the hood(refer to the previous page for a detailed floor plan). The cross-drafts formed from this set-up are very strong and can easily pull contaminants out of the hood face. All tests were completed with windows closed. It is highly recommended to keep the window(s) closed at all times in room 123 when the hood is in use.

Hood 123 is unique in that is is only used to burn off possible trace volatiles inside a furnace. The furnace takes up approximately half of the hood bench space and 1/3 of the hood face area. The furnace is located in the right portion of the hood.

Smoke tube tests showed no indication of dead spots or areas of turbulence. The air foils provided smooth entry of air into the unit. Good pull of air into he hood was also noted around the oven unit. The $TiCl_4$ test gave similar results. All smoke formed was pulled around the oven and back into the hood. No smoke was allowed to escape or linger.

The results of the quantitative test were also positive. The average face velocity is 68 fpm. Since there are no cross-draft interferences, no traffic and no handling of chemicals in the hood, this is an acceptable value. The isopleth graph depicting areas of low and high velocities can be found in Appendix G. The SF_6 test was not completed in the area of highest risk because the furnace was too big to allow for the diffuser set-up. Therefore, the diffuser was set-up in the left side of the hood. The hood performance rating gave a non-detect value resulting in 8 AU 0. This means that at a generation rate of 8 lpm there is no exposure to the tracer gas.

According to these test results, the current chemicals may be used in this hood and the hood operator will be protected(if the windows remain closed).

Hood 125A and 125B

No traffic occurs past this hood. The only people in this area are those using the hood. The only interfering cross-drafts possible come from the window next to the hood. An entrance to the room is located directly across from the window, facilitating cross-drafts from the window. A detailed floor plan can be referenced on the previous page It is highly recommended to keep this window closed at all times since chemicals are always present in this hood.

These hoods are very unique in design. Basically, they are chemical benches converted into make-shift hoods. There are no air foils(no smooth entrances) and no sashes. Hood 125B has a permanent shield on the upper 1/3 of the hood face acting as a partial sash. This does help increase the face velocity of the hood.

The average face velocity for hood 125A(no sash) is 41 fpm. The average face velocity for hood 125B is 103 fpm. This difference in face velocity causes a unique problem between these two adjacent hoods. Hood 125B pulls air out from hood 125A. This was seen during the smoke tube test and the $TiCl_4$ test. The smoke created on the left side of the partition was drawn out and around the divider from hood A into hood B. Essentially, the air on the right side of hood A is pulled in by hood B. Slight swirling of smoke inside the upper, right corner of hood A was noted, but no smoke was allowed to escape into the room.

The SF_6 test for hood A was located at the right side of the hood face. Leakage from the hood was controlled to exposures of 6.27ppm. The entire hood performance rating for hood 125A is 8 AU 6.27. Hood B performed much better with a hood performance rating of 8 AU .058, which is acceptable according to the ACGIH guidelines.

Increasing the face velocity of hood 125A to be competitive with that of hood 125B may help solve the problem of contaminant being pulled out of hood A into hood B. In turn, this would decrease personnel exposure to contaminants coming out of A into B. Until this can be accomplished, do not work with carcinogenic chemicals in hood A or chemicals of TLV's less than 10ppm. Working with any chemicals in the right portion of hood 125A should be avoided altogether.

The following chemicals are currently being handled in hoods 125A and 125B:

Chemical Name	Characteristics
Acetone	Flammable; ACGIH TLV 750ppm
Chromerge(Cr^{+6})	Known Human Carcinogen(A1); TLV .5mg/m3
Ether	Flammable; TLV 400 ppm
n-Hexane	Flammable; TLV 500 ppm
Sulfuric Acid	Corrosive; TLV 1 mg/m3

Chromerge is of main concern since it is designated as an A1 because it contains hexavalent chromium.

Hood 129

Hood 129 is located in an excellent overall position. There are no traffic patterns around it and the location of doors and windows do not pose a threat for creating cross-drafts(refer to the previous page for detailed floor plan). The only negative condition of this hood upon initial observation is that the bench is filled with large chemical bottles. The bench was being used as a storage area and could not be used for any other procedure. This condition no longer exists. The bench has been cleared and is being used for chemical transfers and extractions.

This hood is in excellent working order. All smoke from the smoke tube test was pulled directly into the hood, even around the chemical bottles. The $TiCl_4$ test also showed excellent containment and pull back into the hood. The average face velocity is 89 fpm. A face velocity recommended under these conditions is 60 fpm. The SF_6 test detected no contaminant in the breathing zone of the mannequin. The hood performance rating is 8 AU 0(the measured value was below the limit of detection). This hood is effective as well as efficient. Used properly, any chemical may be handled without worry of exposure.

Hood 148

Room 148 has a problem with excessive make-up air. The room is under such high positive pressure that air rushes out of the main entry. Since the hood is located next to the entry, a problem is created with air currents pulling contaminants from the left corner of the hood out into the hallway. Removal of the large box in this corner greatly improves containment in this area. Fortunately, no contaminants are generated in this area. Refer to the previous page for a detailed floor plan.

The smoke tube test showed moderate capture of smoke generated in front of the hood face and above the hood sash. Slight turbulence and back flow was seen at the right side of the hood. The $TiCl_4$ test showed the inability of hood 148 to contain contaminants in the bottom, left corner and half-way up the side of the hood. The smoke formed was pulled out of the hood face, outside to the back of the hood and through the door to the hallway. All other areas of the hood contained the smoke. The problem in the left corner is due to the presence of a large box located at the plane of the sash. The positive pressure in the room furthers the problem by allowing the contaminants to escape into the hallway. If the box could be removed from the hood, the problem could be eliminated.

The isopleth graphs in Appendix G can be referred to for visualization of the hood face velocity. The average face velocity is 55 fpm. This does not meet recommended values according the ACGIH guidelines. Under the given conditions, the face velocity recommended by ACGIH is at least 100 fpm.

The SF_6 test was conducted in the work area most frequented by the hood operators. The left area of the hood was not selected because there is no free bench space for workers to utilize.

Therefore, the mannequin and diffuser were set-up in the center of the hood. The hood performance rating for hood 148 is 8 AU 0.077. Minimal exposure to contaminants is expected and it meets the guideline recommended by ACGIH. It is highly recommended that no work be carried out in the left portion of the hood until the large box is removed. It is also recommended that all work done in this hood should be done with the sash 1/2 closed since mutagenic radioactive materials(Flours) are handled in this hood.

Hood 149 Left and Right

The location of these adjacent, make-shift hoods is excellent. There is not interference from cross-drafts and the traffic pattern is minimal. The unit has extremely high face velocities, but there is a lack of smooth-edged entries. The qualitative and quantitative tests completed show that these hoods are both effective and efficient. The work practices in this lab are also commendable. The hood sashes were always closed when not in use and, when in use, were only 1/2 open.

The smoke tube tests and $TiCl_4$ swab tests showed very quick capture and strong pull into the hood. No swirling or lingering of smoke from either test occurred. The average measured face velocity for the left side is 271 fpm. The average measured face velocity for the left side is 281 fpm. With respect to energy conservation, theses hoods could be improved. one hundred fpm would be more than sufficient to control the chemicals used in these hoods. The chemicals in current use are:

Chemical Names	Characteristics
Brominated Dioxins	OSHA- TLV 10 mg/m3(Potentially Carc. A2)
Hexanes	Flammable; TLV 500 ppm
n-Hexane	Flammable; ACGIH TLV 50 ppm
Toluene	Flammable; ACGIH TLV 100 ppm

The SF_6 test was non-detect for both left and right sides of hood 149. The performance rating for the hoods are 8 AU 0 for the left hood and 8 AU 0 for the right hood. The chance of any exposure to chemicals being handled properly inside these hoods is remote. The only recommendations pertain to hood design and face velocity. The entrances to the hoods should be smooth, not sharp, and the current hood face velocities for each hood could be greatly decreased.

Hood 158A

This small hood is out of traffic patterns and cross-drafts created by doors, windows or make-up air units. The hood face is angled with the bottom jutting out further than the top. The sash on this hood is plexi-glas and notched for set increments for adjustment. The sash is always 2/3 closed, but the tests were conducted with the sash fully open.

The smoke tube test revealed some problems with smoke capture near the right side of the hood. There were also complications with smoke being pushed away from the hood face at the bottom, left half of the hood. Smoke generated in the sash area was pulled into the hood. The $TiCl_4$ test showed problems of smoke containment at the bottom, right area of the hood. There is a great deal of turbulence in the left, bottom portion of the hood, but the smoke was contained within the hood.

The isopleth graphs(Appendix G) also show areas of concern. The average face velocity is 68 fpm. The face velocity measurements on this hood are very different. Therefore, there are areas of high and low velocities in this hood which induce turbulence. Since this hood is only large enough for one person to use, the mannequin was placed at the center of the hood. The hood performance rating is 8 AU 1.41.

Even though exposure of 1.41 ppm is not acceptable according to the ACGIH guidelines, this is of small concern since this hood is only used to store samples before running them in the gas chromatograph. No extensive work is completed in this hood. The small samples of chemicals stored in this hood are well sealed and are not handled in this area. Exposure to chemicals from this hood is unlikely unless actual work is completed in this hood. The following is a listing of chemicals stored in this hood:

Chemical Names	Characteristics
Acetone	Flammable; ACGIH-TLV 750 ppm
Acetonitrile	ACGIH-TLV 40 ppm
9,10-Anthroquinone	Nonflammable; No TLV data
Benzo(a)Pyrene	Known Human Carcinogen(A1)
Hexane	Flammable; TLV-500 ppm
n-Hexane	Flammable; ACGIH-TLV 50 ppm
Methanol	Flammable; TLV 200 ppm
Methylene Chloride	Suspected Human Carcinogen(A2); TLV 50 ppm

Hood 158B

Hood 158B is divided into 3 adjacent, equal portions(separated by partitions).These are also make-shift plexi-glas laboratory hoods of similar design to those in room 149. This section of laboratory hoods is well out of traffic patterns and other causes of cross-drafts. The benches of these hoods are very cluttered, the left being completely filled with gallon bottles of various chemicals. The center and right hoods are filled with boxes containing sample vials and ring-stand set-ups.

Regardless of the bench conditions, all three sections of hood 158B pulled smoke from the smoke tubes into the hood without hesitation. There was no indication of lingering smoke or turbulence at any point. The $TiCl_4$ test also showed direct pull of the smoke back and up into the exhaust, even around the chemical bottles and boxes. No escape of contaminants generated within the hood is allowed.

The quantitative tests support the above observations. The average face velocities for the left, center and right portions of this hood set are 150 fpm, 157 fpm and 166 fpm, respectively. Isopleth graphs in Appendix G show areas of high and low face velocity. The SF_6 hood performance test on each section were non-detect for the left and center section. The right hood detected a very small amount of leakage at 0.96 ppm. The reason for this exposure may be due to the interaction of the mannequin with the high face velocity at this hood. Eddies may be created in front of the mannequin causing some contaminant to be pulled out of the hood and into the breathing zone.

Since the chemicals handled in these hoods are highly toxic and/or flammable, it is recommended to handle these chemicals 20 cm back in the hood and only use the hood with the sashes 1/2 closed. Refer to the chemical listing for hood 158A

Hood 163

Hood 163 is in a fair location for minimal amount of traffic, but it is located next to a window which causes extremely strong cross-drafts when the window is open. The window next to the hood should remain closed whenever the hood is in use. The hood does not have strong capture capability, so keeping cross-drafts to a minimum is important if contaminants are ever pulled outside of the hood.

The smoke tests performed show that the pull of smoke into the unit was slow, but effective. The smoke was not dispersed by cross-drafts and was completely pulled into the hood . The $TiCl_4$ test crated a layer of fog over the hood bench. This layer was eventually pulled through the rear slot into the plenum. Any sharp movements made in front of the hood pulled the smoke out of the hood. From these tests, it is highly recommended to work with the hood sash 1/2 closed, and thatgood hood operation practices be exercized when handling toxic or moderately toxic materials in this hood.

According to the ACGIH face velocity selection chart, the average face velocity value of 63 fpm is acceptable if the contaminants are generated no closer than 12 inches from the hood face. The SF_6 detection test resulted in a hood performance rating of 8 AU 1.51. Even exposure to levels of 1.51 ppm of contaminant is not acceptable when dealing with such chemicals as 1-methyl-3-nitro-1-nitrosoguanadine, a known human carcinogen. Therfore, as recommended above, work with the sash 1/2 closed and with material no closer than 12 inches from the hood face. Refer to the isopleth graph in Appendix G to locate the best position for working at hood 163.

Summary Table

Hood#	Rating	Avg F.V.(fpm)	Assessment
4	8 AU 6.48	31	Needs Improvement
6	8 AU 0.167	23	Needs Improvement
7	8 AU 0.00	71	Acceptable
8	8 AU 3.40	139	Needs Improvement
8A	8 AU 0.67	97	Needs Improvement
8B	8 AU 0.48	104	Needs Improvement
9A	8 AU 7.07	89	Needs Improvement
9B	8 AU 0.00	80	Acceptable
12	8 AU 0.54	100	Needs Improvement
14	8 AU 0.26	14	Needs MUCH Improvement
123	8 AU 0.00	68	Acceptable
125A	8 AU 6.27	41	Needs MUCH Improvement
125B	8 AU .058	103	Acceptable

Hood#	Rating	Avg F.V.(fpm)	Assessment
129	8 AU 0.00	89	Acceptable
148	8 AU .078	55	Needs Improvement
149Left	8 AU 0.00	271	Acceptable
149R	8 AU 0.00	281	Acceptable
158A	8 AU 1.41	68	Needs Improvement
158B Left	8 AU 0.00	150	Acceptable
158B Center	8 AU 0.00	157	Acceptable
158B Right	8 AU 0.96	166	Needs Improvement
163	8 AU 1.51	63	Needs Improvement

Refer to pages 52 through 56 for detalied recommendations on improvement for indicated hoods.

Summary Recommendations

Hood 4

-Avoid generation of contaminants in the left 1/3 of the hood.
-Do not turn the make-up air unit on "high" or to a level where a noticeable down-draft is created.
-Only work in this hood with the sash partially closed..
-Increase of face velocity is highly recommended(needs doubling or more).
-Modifications of the make-up air unit for more even distribution would decrease turbulence.

Hood 6

-Place contents of hood at least 6 inches behind the hood face.
-Increase of face velocity is recommended(currently below recommendations by 40 fpm).

Hood 7

-No improvement necessary.

Hood 8

-Decrease face velocity to decrease occurrence of eddies.
-Work with items 20 cm behind the hood sash.

Hood 8A and 8B

-No improvement necessary.

Hood 9A

-Work with hood sash 1/2 closed at all times.
-Do not use highly toxic or carcinogenic substances in this hood.
-Work in the left side of the hood(F.V. >50 fpm).
-Clear the hood bench of large bottles, boxes etc..
-Increase the amount of make-up air to this room.

Hood 9B

-Increase the amount of make-up air to this room.

Hood 12

-Do not work with chemicals in the left hand corner of the hood unless basin is removed.
-Face velocity needs to be increased.
-Avoid the use of toxic materials or flammable substances.

<u>Hood 14</u>

-Use is not recommended.
-Face velocity needs to be increased.
-Make-up air needs to be evenly dispersed and its velocity needs to be decreased.
-Do not work with toxic materials or flammable substances.

<u>Hood 123</u>

-Do not open the window when using the hood.

<u>Hood 125A and 125B</u>

-Do not open the window when using the hood(s).
-Do not use highly toxic chemicals in hood 125.
-Increase the face velocity of 125A to be competitive with 125B.
-Work with contaminants as far back in the hoods as possible.
-Handle toxic and/or flammable materials in hood 125B.
-Air foils would improve laminar flow into these hoods.

<u>Hood 129</u>

-No recommendations necessary.

Hood 148

-Remove large box from left side of hood.
-Work with sash 1/2 closed.
-Avoid generation of contaminants in the left portion of the hood.
-Decrease the amount of positive pressure in the room(decrease make-up air).

Hood 149 Left and Right

-Decrease face velocities to conserve energy.
-Air foils would improve laminar flow into the hoods.

Hood 158A

-Only use this hood for temporary storage of well sealed samples.
-Keep hood sash 2/3 closed.
-Avoid storing samples at the front of the hood bench.

Hood 158B Left/Center/Right

-Decrease face velocity to conserve energy and decrease possibility of eddy formation.
-Air foils would improve laminar flow into the hood.
-Keep other sashes closed when not using other portions of the hood.

Hood 163

-Do not open the window.
-Keep sash 1/2 closed.
-Work with contaminants 20 cm behind the hood face.
-Increase the face velocity.

*Use good work practices outlined in Appendix I when using any hood

Future Recommendations

1) Clean the plenums and duct work for each hood.
2) Maintain current maintenance work on the fans and motors.
3) Increase the face velocities in hoods 4,6,14, 125A and 163.
4) Decrease the face velocities in hoods 8, 149 and 158B.
5) Add a flap/sash to hood 125A.
6) Complete more sophisticated hood performance tests to verify the results from this test.
7) Test to see if there is re-entry of contaminant released in the roof of the North and South wings of the Rosenau Building.
8) Test to see if those contaminants exhausted from the Rosenau Building are re-entrained into the McGavran-Greenberg Building.
9) Measure levels of contaminants exhausted on the North and South wings to see if air filters are needed.

Precautions/Connected Hoods

The following list shows which hoods are affected by the use of other hoods. When all hoods which run off the same fan are in use, the face velocity for each of these hoods will decrease. Therefore, when a given hood is not in use, keep the sash closed.

Interconnected Hoods

4, 6, 14

149 and 158

9A, 9B, 8A and 8B

This information was attained through the use of blue prints and fan numbers on the hoods.

Conclusion

The overall assessment of the laboratory hoods in the basement and first floors of the Rosenau Building shows that most of the hoods are meeting basic guidelines specified by the ACGIH. If proper operating procedures are followed, 73% of the hoods meet or exceed face velocities recommended for their given condition and meet or exceed expectations for exposure to contaminants. But, this does not mean they provide adequate protection. Of the 73% meeting face velocity recommendations, 75% provide adequate protection for highly toxic chemicals to be handled in the hood. Special precautions such as working with the hood sash 1/2 closed must be enforced when using the other 25% of hoods for assured protection. A series of face velocity tests, SF_6 tests, smoke tube tests and TiCl4 tests along with general observations allowed for analysis of each hood. Their effectiveness and efficiency were analysed.

The problems found can be corrected through change in engineering, work practices or location. Engineering problems deal with increasing or decreasing face velocities, changing make-up air distributions, adding air foils or adding sash substitutes. Work practices which need improvement are working with materials behind the sash plane, keeping the hood bench clear and working with the hood sash partially if not 1/2 closed. Unfortunately, it is too late to change the location of the hoods, therefore, under applicable conditions, windows should not be opened and traffic should be minimized past the face of hoods.

Precaution should be taken by personnel operating the following hoods: 4,6,9A,125A,148 and 163. These hoods should only be used with the sash 1/2 closed and the use of highly toxic chemicals should be avoided until their current conditions are improved. Until then, the personnel using these hoods should follow the operation procedures outlined in Appendix I.

Acknowledgements

I would like to briefly thank those who made this project possible to complete. Rich Tracy for keeping me going when research wasn't going smoothly. Steve Bakalyar, whose time and patience devoted to helping calibrate the thermalanemometer and teaching the technicalities of the data logger saved precious time and unnecessary frustrations. Thanks to Eddie at Ivey's for donating a mannequin used in the SF_6 test. A special thanks to Mike Flynn. Without his guidance and knowledge, this project would not have been possible.

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Appendix A

The calibration data and regression curve for the thermalanemometer are in this section. Please refer to the ACGIH Industrial Ventilation Manual for information on setting up a wind tunned for calibration..

==

Calibration Curve
Thermal Anemometer
Rotating Vane Anemometer
February 18, 1990
Filename:Calcurve

==

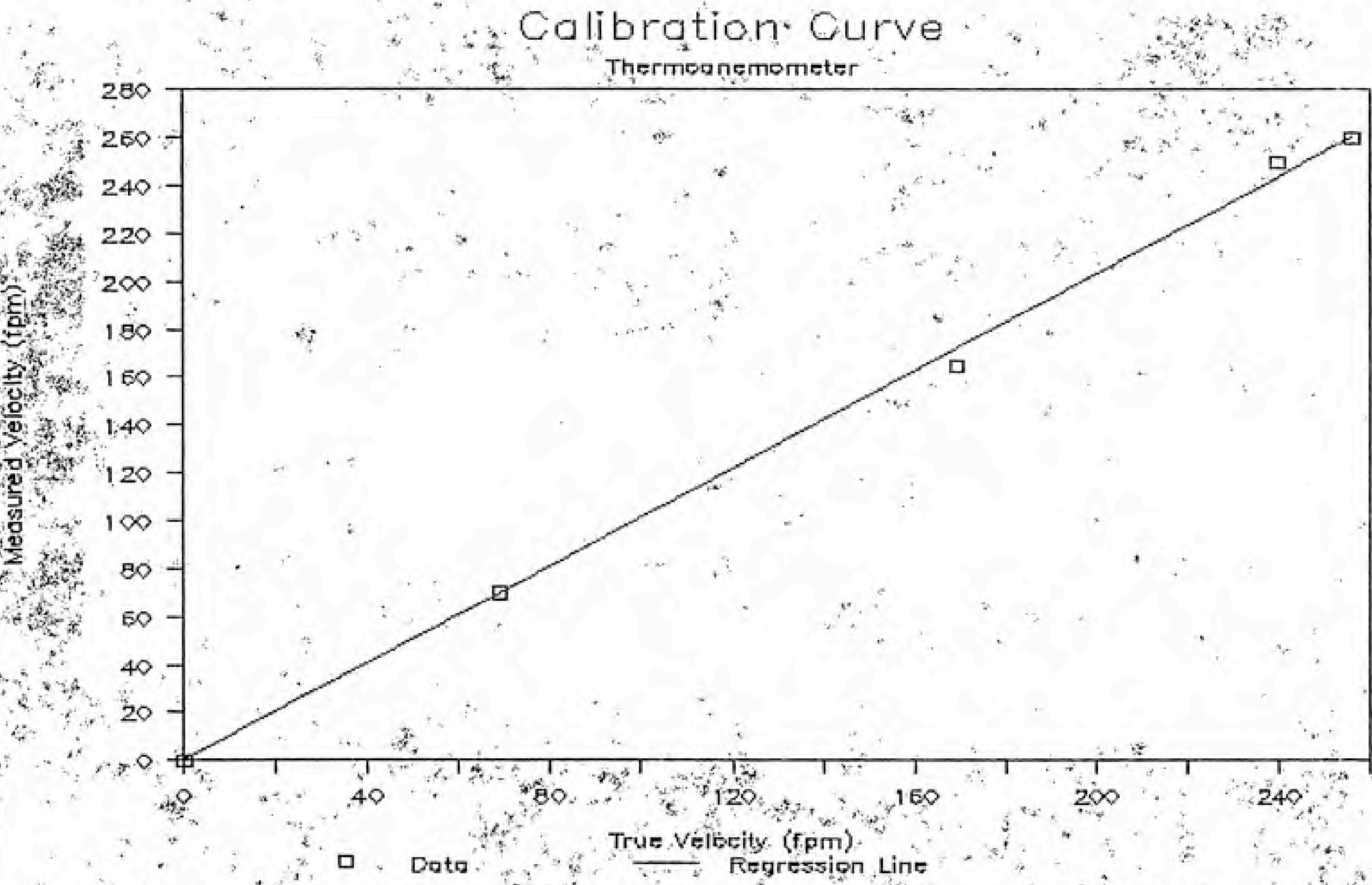
True Velocity	Thermoanemometer(fpm)
0	0
69	70
169	165
240	250
256	260

Regression Output:

Constant	0
Std Err of Y Est	4.535426
R Squared	0.998393
No. of Observations	5
Degrees of Freedom	4

X Coefficient(s)	1.018004
Std Err of Coef.	0.011466

0
70.24233
172.0428
244.3211
260.6092


Calibration Curve
Thermoanemometer
Measured Velocity (fpm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
0
40
80
120
160
200
240
True Velocity (fpm)
Data
Regression Line

Measured Value (fpm)	True Value (fpm)
0	0
5	4.911568
10	9.823136
15	14.73470
20	19.64627
25	24.55784
30	29.46940
35	34.38097
40	39.29254
45	44.20411
50	49.11568
55	54.02724
60	58.93881
65	63.85038
70	68.76195
75	73.67352
80	78.58508
85	83.49665
90	88.40822
95	93.31979
100	98.23136
105	103.1429
110	108.0544
115	112.9660
120	117.8776
125	122.7892
130	127.7007
135	132.6123
140	137.5239
145	142.4354
150	147.3470
155	152.2586
160	157.1701
165	162.0817
170	166.9933
175	171.9048
180	176.8164
185	181.7280
190	186.6395
195	191.5511
200	196.4627
205	201.3742

Measured Value (fpm)	True Value (fpm)
210	206.2858
215	211.1974
220	216.1089
225	221.0205
230	225.9321
235	230.8436
240	235.7552
245	240.6668
250	245.5784
255	250.4899
260	255.4015
265	260.3131
270	265.2246
275	270.1362
280	275.0478
285	279.9593

Appendix B

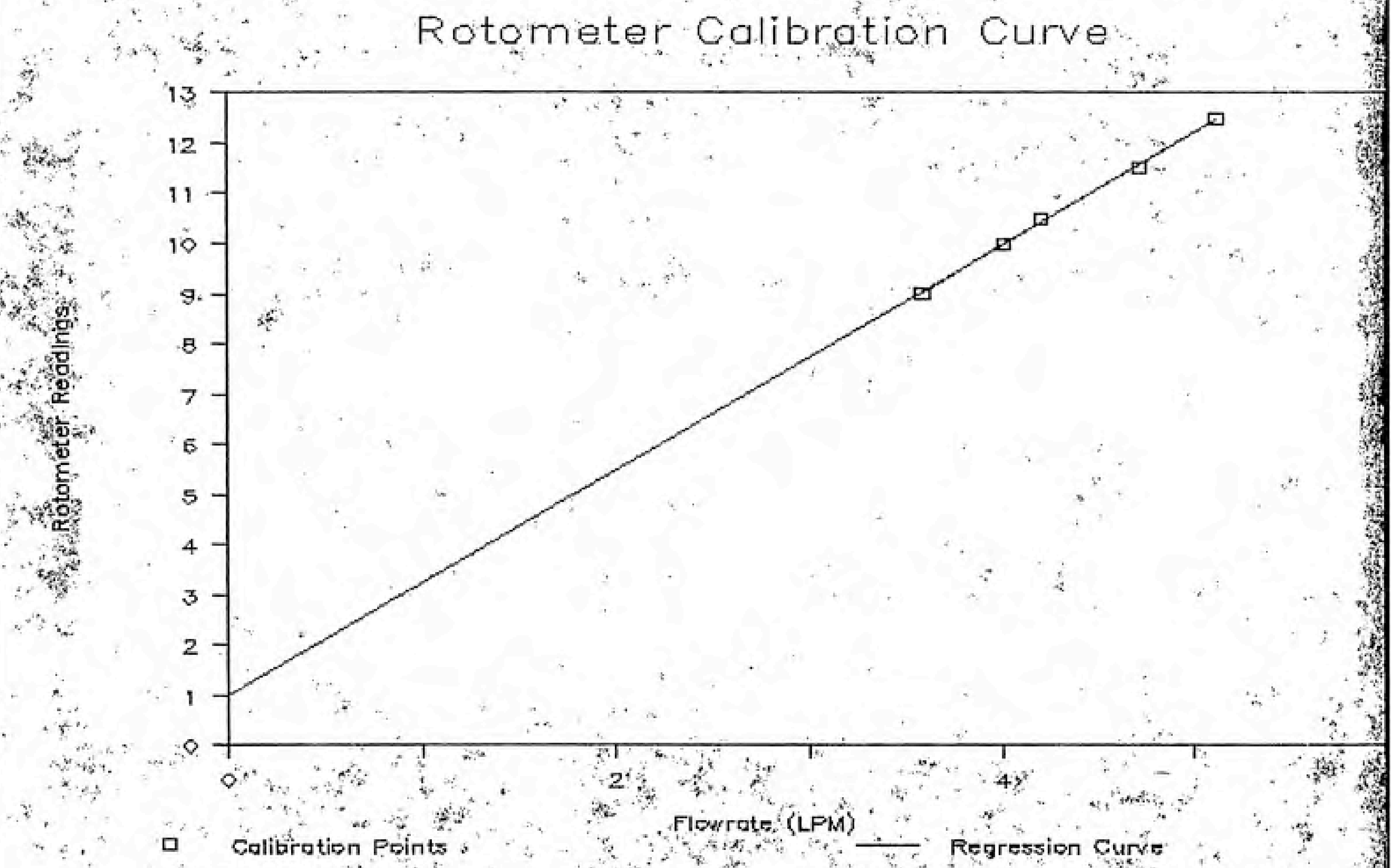
This section contains calibration data and the calibration curve for the rotometer. The rotometer was calibrated using a stop watch, soap, a 1 liter buret and a pump. The pump was connected to the buret to allow for the bubble to be sucked up the buret and timed with the stop watch. The pump flow was adjusted to various settings on the rotometer and a time measurement of the bubble moving up one liter was taken. A curve was formed using Time vs Flow Rate.

The pre-calibration measurements were the same as the post-calibration measurements, therefore, only one curve is shown. The post-calibration confirmed the flow rate was maintained at its original level. The calibration curve was calculated with a linear regression program from Lotus.

==
Rotometer Calibration Curve
April 17, 1990
==

LPM	ROTO	Regression Output:	
----	-----	Constant	0.984048
		Std Err of Y Est	0.065919
3.58	9	R Squared	0.998214
4	10	No. of Observations	5
4.2	10.5	Degrees of Freedom	3
4.71	11.5		
5.11	12.5	X Coefficient(s) 2.249062	
0		Std Err of Coef. 0.054921	

9.035693
9.980299
10.43011
11.57713
12.47675
0.984048



Rotometer Calibration Curve
Rotometer Readings
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
2
4
Flowrate (LPM)
Calibration Points
Regression Curve

Appendix C

This section contains the calibration data and regression curve for the Miran. Seven 10ul injections of 10% SF_6 were accumulated in the Miran. Three runs were recorded and averaged for the final regression curve. The chart recording for finding the correct wavelength is also included. The following settings were used on the Miran to obtain the proper wavelength setting for SF_6:

Ambient air was initially sampled on the scan mode with the chart recorder connected to the MIran. Increments of 0.5 were recorded. After this initial reading, 500ml of 10% SF_6 injected into the closed loop circuit of the Miran. Another strip chart was made after the injection. The wavelength was identified by comparing the two charts. 10.7 was identified as the correct wavelength for SF_6.

Miran Settings

Slit=0

Dial=%T

Mode=Scan

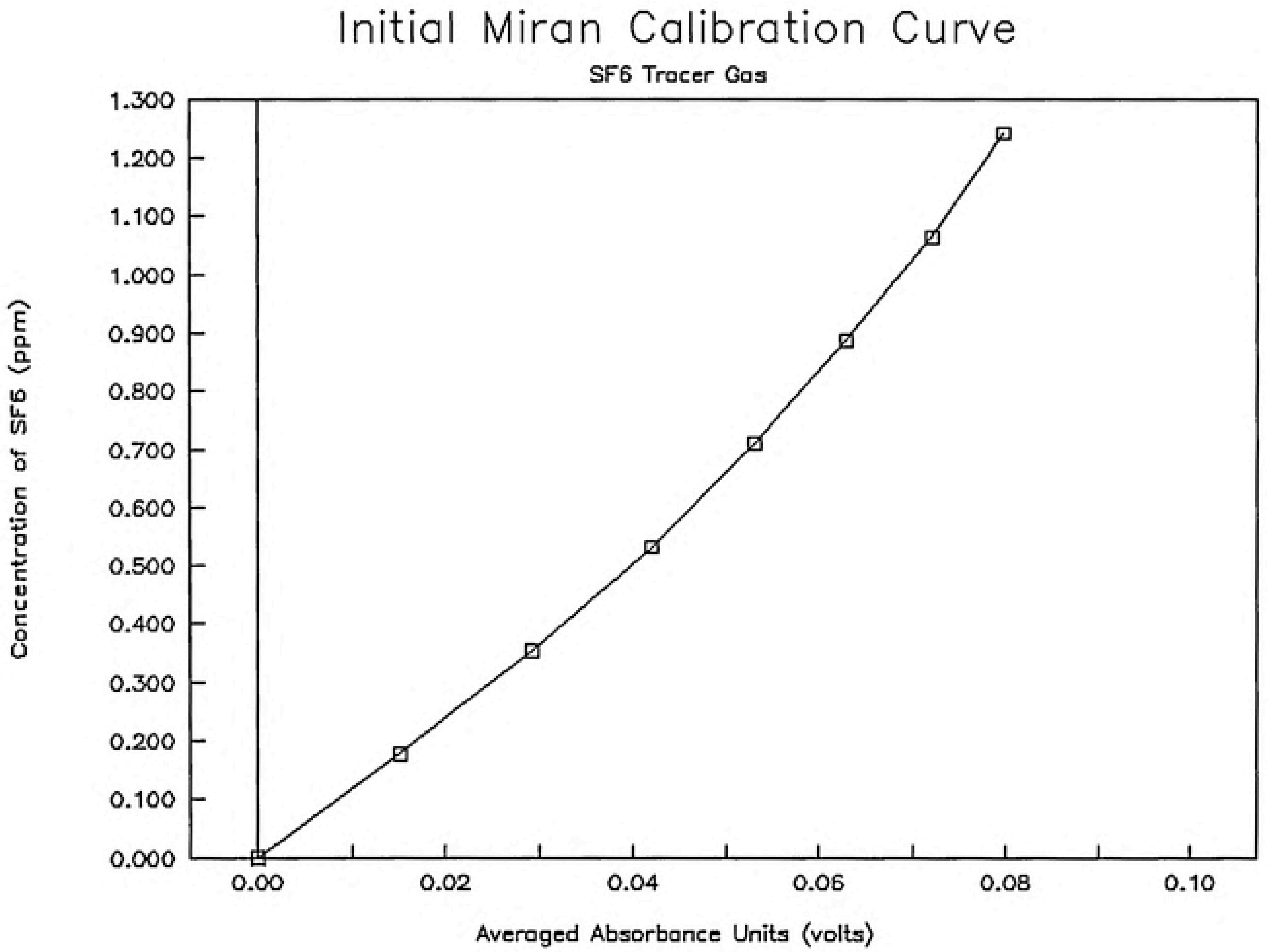
Initial Miran Calibration
Averaged Point Values
5/14/90

Injection(ul)		Absorbance Units(volts)			Avg Abs.(volts)	Concentration
0		0	0	0	0	0
10	(10)	0.0151	0.0159	0.0141	0.015033	0.177304
10	(20)	0.0292	0.0302	0.0283	0.029233	0.354609
10	(30)	0.0418	0.0429	0.0411	0.041933	0.531913
10	(40)	0.0526	0.0535	0.0528	0.052966	0.709219
10	(50)	0.0633	0.063	0.0619	0.062733	0.886523
10	(60)	0.0724	0.0727	0.0705	0.071866	1.063829
10	(70)	0.0801	0.08	0.0787	0.0796	1.24113

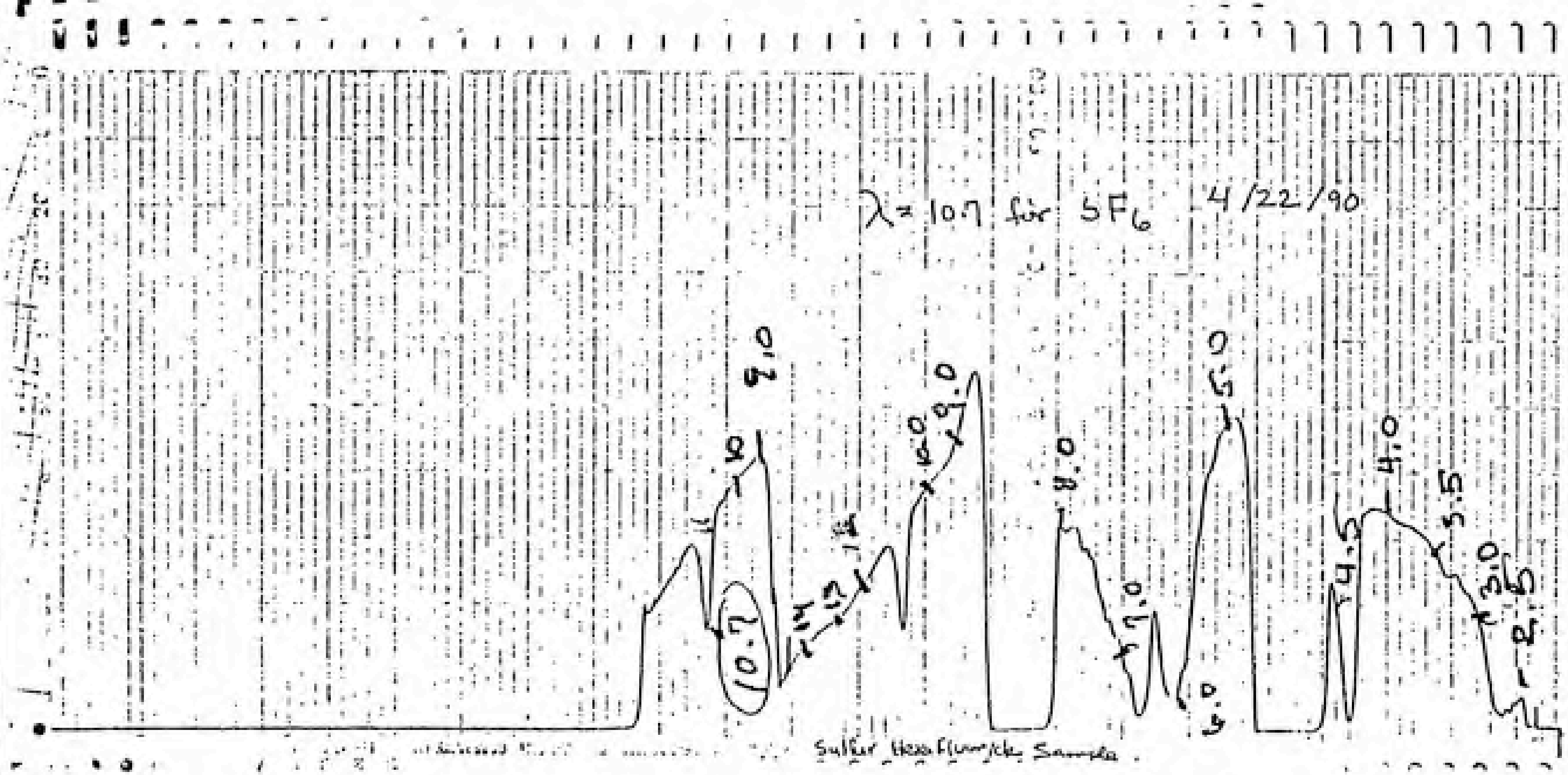
Regression Output:

Constant	0.006914
Std Err of Y Est	0.002772
R Squared	0.988103
No. of Observations	7
Degrees of Freedom	5
X Coefficient(s)	0.060227
Std Err of Coef.	0.002955

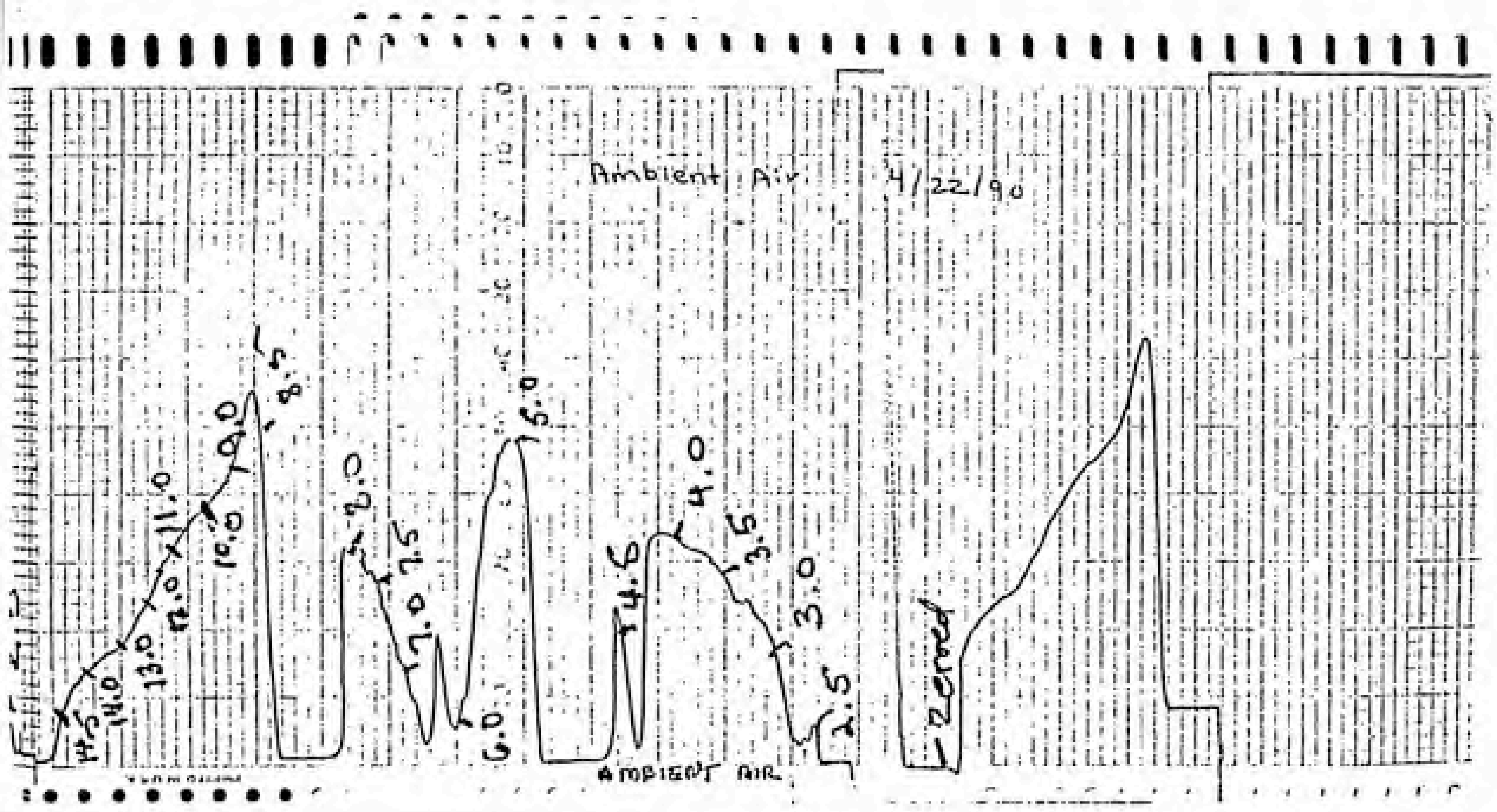
Absorbance Units(volts)	Regression Conc.ppm
0.01	0.051235
0.02	0.217272
0.03	0.383310
0.04	0.549348
0.05	0.715385
0.06	0.881423
0.07	1.047460
0.08	1.213498



Initial Miran Calibration Curve
SF6 Tracer Gas
Concentration of SF6 (ppm)
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.00
0.02
0.04
0.06
0.08
0.10
Averaged Absorbance Units (volts)



λ = 10.7 for SF6 4/22/90
Sulfur Hexafluoride Sample
10.7


Ambient Air 4/22/90
14.5
14.0
13.0
12.0
11.0
10.0
10.0
8.5
8.0
7.5
7.0
6.0
5.0
4.5
4.0
3.5
3.0
2.5
Zeroed
AMBIENT AIR

Appendix D

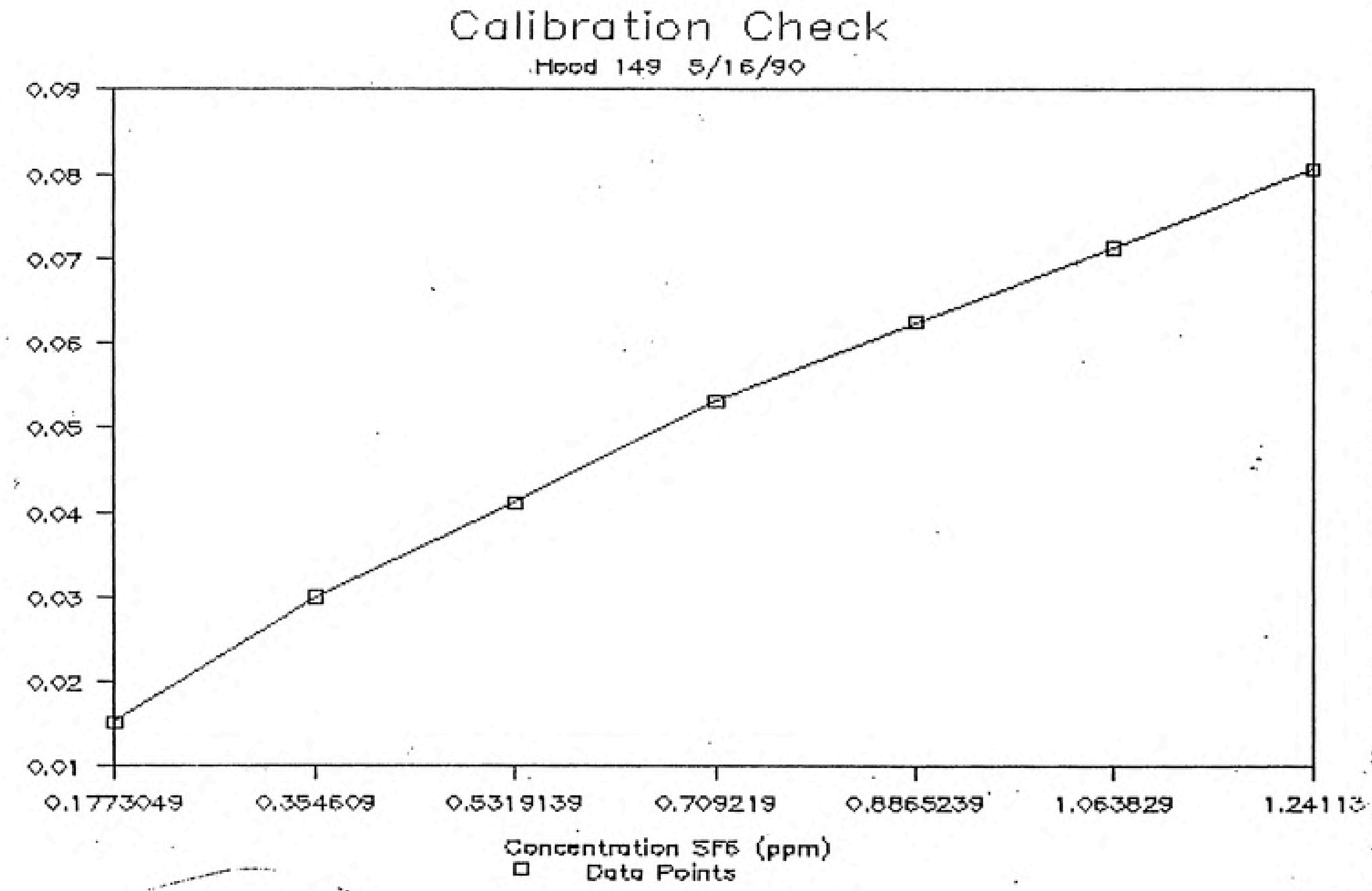
This section contains the data and curve collected during one check calibration run on the MIran completed throughout the testing period. Only one set of data was used to form the curve, not the average of three as used in the calibration curve for the MIran. The same method of sampling for calibration was used here as for the initial calibration of the Miran. A total of five check calibrations were completed during the evaluation of the hoods.

Miran Calibration Check 1
Averaged Point Values
5/14/90

Zero= 0.0865

Injection(ul)		Absorbance Units(volts)	Absorbance units(volts)-Zero	Concentration
10	(10)*	0.1018	0.0153	0.177304
10	(20)	0.1165	0.03	0.354609
10	(30)	0.1277	0.0412	0.531913
10	(40)	0.1397	0.0532	0.709219
10	(50)	0.149	0.0625	0.886523
10	(60)	0.1578	0.0713	1.063829
10	(70)	0.1671	0.0806	1.24113

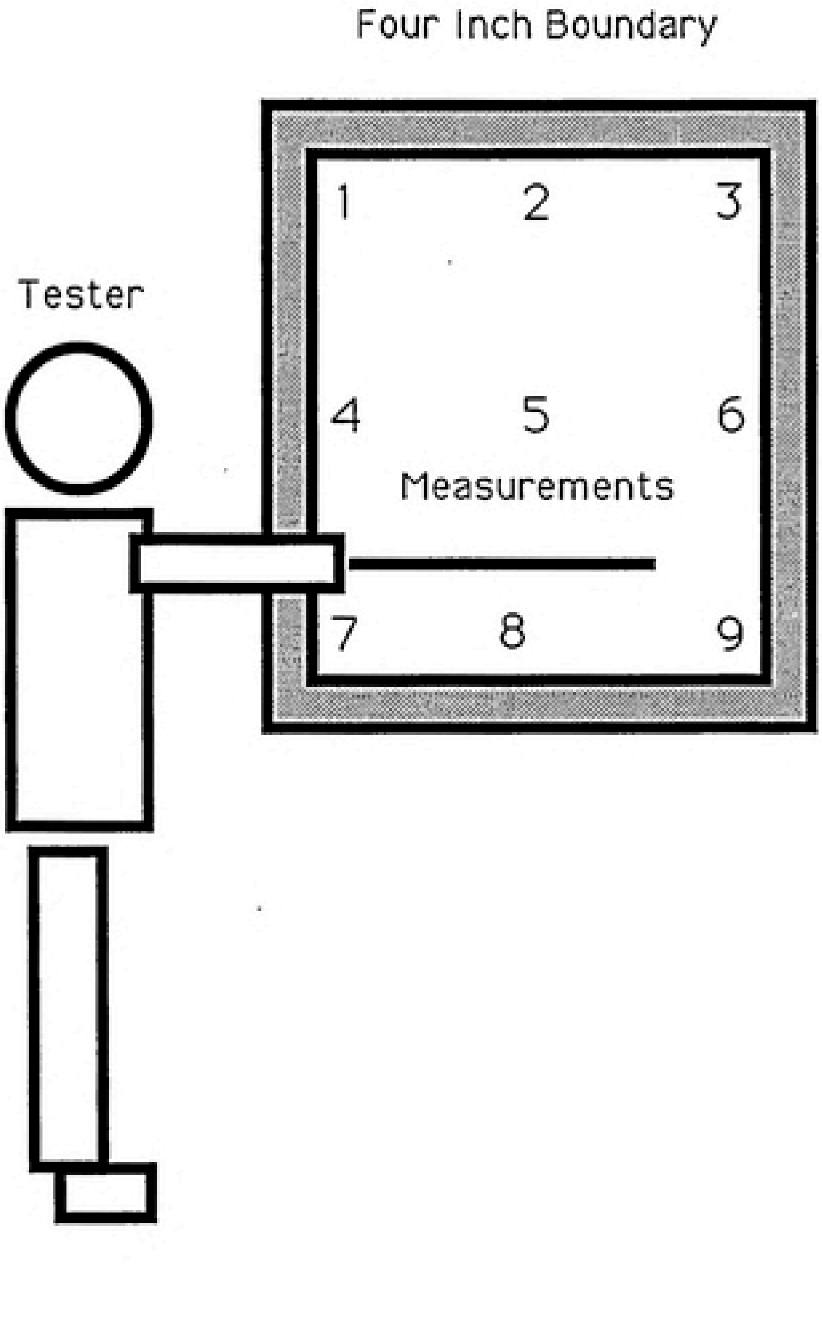
* Values within Parenthesis represent the cumulative volumes of SF_6.


Calibration Check
Hood 149 5/16/90
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.1773049
0.354609
0.5319139
0.709219
0.8865239
1.063829
1.24113
Concentration SF6 (ppm)
Data Points

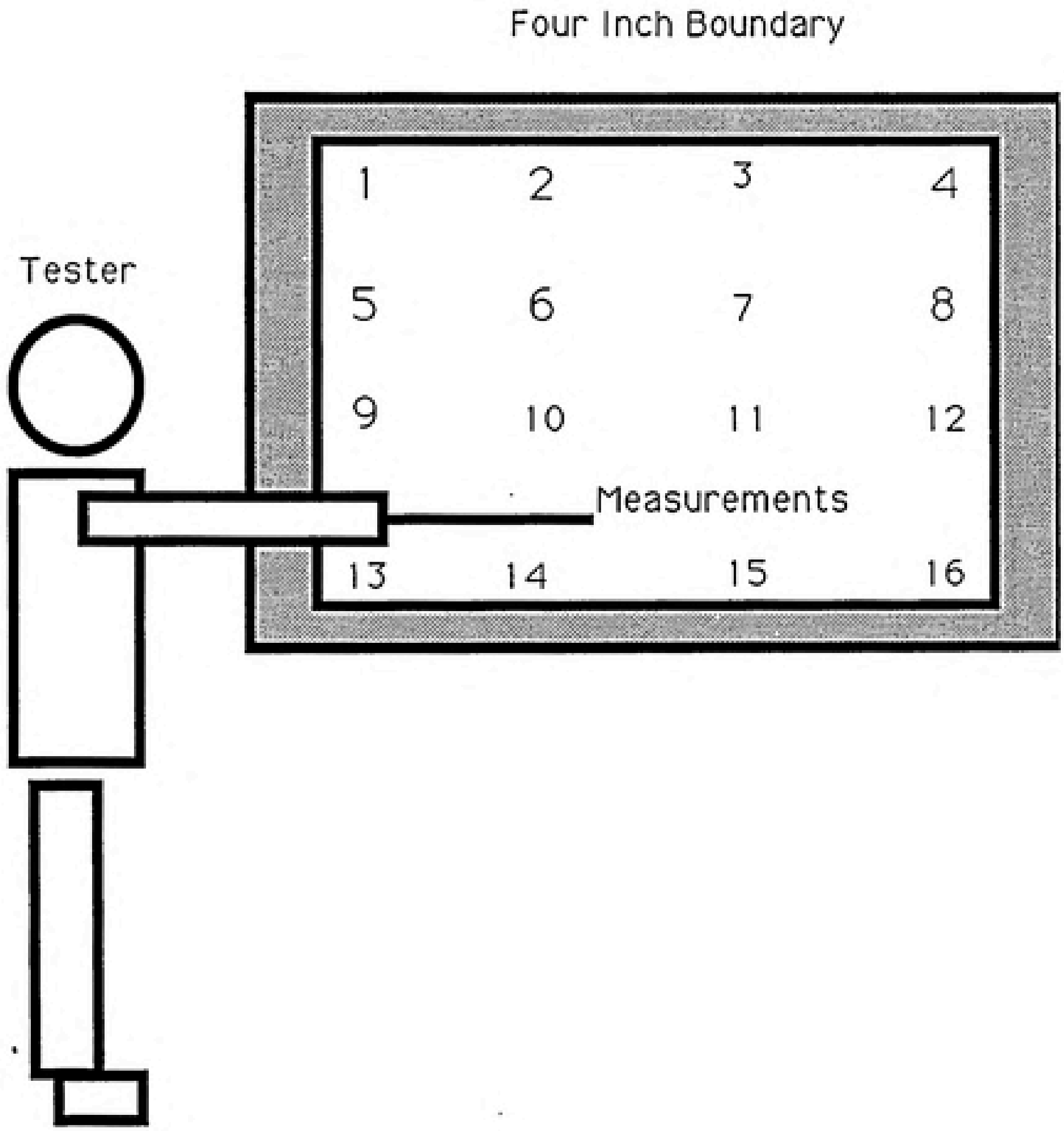
Appendix E

The results of the face velocity tests are in this section. They are in order of hood number. Figures of how the nine-point and sixteen-point face velocity measurements were collected are also included in this section.

Nine Point Face Velocity Test



Sixteen Point Face Velocity Test



Appendix F

This section contains the results of the SF_6 test organized according to hood number. The voltage readings collected from the data logger were averaged and multiplied by 20 to attain the final exposure levels(ppm). The raw data was multiplied by this value to represent results from an 8 lpm flow rate and from the use of 100% SF_6. The final calculated result is a "worst case" example of possible exposure at the given location. The actual flow rate used was 4 lpm and the concentration of gas was 10% SF6.

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

4 Data Set 1

40.00	10.00	70.00	65.00	30.00
25.00	20.00	50.00	40.00	10.00
10.00	30.00	60.00	35.00	10.00
15.00	45.00	35.00	15.00	10.00
60.00	60.00	10.00	15.00	15.00

Average FPM
31.40

Data Set 2

35.00	10.00	70.00	45.00	35.00
25.00	30.00	50.00	10.00	20.00
10.00	20.00	20.00	10.00	30.00
15.00	40.00	30.00	20.00	20.00
60.00	50.00	20.00	25.00	15.00

Average FPM
28.60

Data Set 3

35.00	10.00	45.00	50.00	30.00
25.00	30.00	55.00	50.00	30.00
10.00	40.00	50.00	30.00	30.00
10.00	40.00	65.00	15.00	15.00
35.00	45.00	25.00	10.00	20.00

Total Avg 30.67

31.40
28.60
32.00

Average FPM
32.00

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

6

Data Set 1

35.00	10.00	15.00	40.00	15.00
40.00	15.00	30.00	25.00	15.00
40.00	15.00	20.00	20.00	15.00
20.00	15.00	30.00	15.00	25.00

Average FPM
22.75

Data Set 2

40.00	15.00	15.00	30.00	15.00
40.00	15.00	30.00	25.00	15.00
40.00	15.00	25.00	20.00	15.00
20.00	20.00	25.00	15.00	30.00

Average FPM
23.25

Data Set 3

35.00	15.00	10.00	25.00	15.00
40.00	15.00	30.00	25.00	20.00
40.00	15.00	25.00	20.00	15.00
20.00	20.00	25.00	15.00	20.00

Total Avg 22.75

22.75
23.25
22.25

Average FPM
22.25

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

Room #

7

Data Set 1

110.00	85.00	75.00	105.00
80.00	70.00	70.00	65.00
70.00	70.00	60.00	50.00
75.00	70.00	10.00	60.00

Average FPM
70.31

Data Set 2

100.00	85.00	80.00	110.00
80.00	75.00	70.00	70.00
75.00	70.00	55.00	60.00
70.00	85.00	10.00	55.00

Average FPM
71.88

Data Set 3

105.00	85.00	75.00	105.00
80.00	70.00	70.00	65.00
70.00	70.00	55.00	55.00
100.00	80.00	10.00	60.00

Total Avg 71.46

70.31
71.88
72.19

Average FPM
72.19

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

8

Data Set 1

195.00	165.00	160.00	185.00
175.00	135.00	100.00	160.00
180.00	140.00	25.00	110.00
155.00	155.00	50.00	115.00

Average FPM

137.81

Data Set 2

195.00	140.00	180.00	180.00
180.00	140.00	160.00	160.00
170.00	140.00	20.00	115.00
165.00	160.00	35.00	120.00

Average FPM

141.25

Data Set 3

180.00	150.00	180.00	180.00
170.00	140.00	155.00	150.00
165.00	145.00	15.00	140.00
150.00	160.00	20.00	125.00

Total Avg 139.37

137.81
141.25
139.06

Average FPM

139.06

===

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

===

Room #

8A

Data Set 1

65.00	120.00	110.00
85.00	85.00	115.00
80.00	100.00	110.00

Average FPM: 96.67

Data Set 2

65.00	120.00	115.00
85.00	80.00	115.00
80.00	100.00	115.00

Average FPM: 97.22

Data Set 3

65.00	120.00	115.00
85.00	80.00	115.00
80.00	100.00	115.00

Average FPM: 97.22

Total Avg 97.04

96.67
97.22
97.22

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

Room #: 8B

Data Set 1

120.00	110.00	100.00
110.00	90.00	95.00
100.00	100.00	105.00

Average FPM: 103.33

Data Set 2

120.00	115.00	105.00
110.00	90.00	95.00
100.00	100.00	105.00

Average FPM: 104.44

Data Set 3

120.00	115.00	105.00
110.00	90.00	95.00
100.00	110.00	105.00

Average FPM: 105.56

Total Avg 104.44

103.33
104.44
105.56

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

Room #

9A

Data Set 1

120.00	100.00	100.00	95.00
110.00	95.00	90.00	115.00
90.00	60.00	60.00	75.00
110.00	80.00	15.00	70.00

Average FPM
86.56

Data Set 2

125.00	115.00	120.00	110.00
110.00	100.00	90.00	110.00
115.00	80.00	20.00	80.00

Average FPM
92.81

Data Set 3

120.00	100.00	100.00	120.00
105.00	100.00	85.00	100.00
100.00	60.00	55.00	75.00
110.00	80.00	20.00	75.00

Total Avg 89.06

86.56
92.81
87.81

Average FPM
87.81

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #: 9B

Data Set 1

90.00	95.00	120.00	120.00
75.00	80.00	75.00	110.00
60.00	75.00	100.00	80.00
10.00	40.00	65.00	75.00

Average FPM: 79.38

Data Set 2

100.00	95.00	130.00	130.00
75.00	95.00	80.00	100.00
65.00	50.00	95.00	80.00
15.00	50.00	40.00	100.00

Average FPM: 81.25

Data Set 3

100.00	110.00	120.00	125.00
75.00	80.00	85.00	100.00
65.00	65.00	90.00	90.00
10.00	40.00	35.00	85.00

Average FPM: 79.69

Total Avg 80.11

Total Avg
79.38
81.25
79.69

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

12

Data Set 1

140.00	130.00	110.00
115.00	80.00	120.00
25.00	100.00	60.00

Average FPM: 97.78

Data Set 2

135.00	135.00	110.00
120.00	95.00	110.00
25.00	95.00	70.00

Average FPM: 99.44

Data Set 3

140.00	130.00	140.00
120.00	90.00	110.00
25.00	100.00	70.00

Total Avg 100.00

Average FPM: 102.78

Total Avg
97.78
99.44
102.78

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

===

Room #
------
14 Data Set 1

5.00	25.00	15.00	25.00
5.00	5.00	15.00	25.00
5.00	15.00	10.00	10.00
25.00	15.00	15.00	30.00

Average FPM

15.31

Data Set 2

5.00	20.00	10.00	15.00
5.00	15.00	10.00	20.00
5.00	25.00	25.00	15.00
20.00	20.00	15.00	10.00

Average FPM

14.69

Data Set 3

5.00	5.00	10.00	15.00
5.00	5.00	15.00	20.00
5.00	25.00	25.00	20.00
5.00	25.00	15.00	15.00

Total Avg 14.48

15.31
14.69
13.44

Average FPM

13.44

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

123

Data Set 1

30.00	115.00	115.00	105.00
25.00	110.00	110.00	110.00
40.00	105.00	5.00	30.00
80.00	65.00	5.00	15.00

Average FPM

66.56

Data Set 2

45.00	110.00	110.00	110.00
20.00	110.00	125.00	110.00
40.00	85.00	5.00	65.00
85.00	55.00	5.00	10.00

Average FPM

68.13

Data Set 3

45.00	105.00	105.00	110.00
25.00	95.00	115.00	100.00
65.00	95.00	5.00	65.00
90.00	80.00	5.00	15.00

Total Avg 68.23

66.56
68.13
70.00

Average FPM

70.00

****

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

****

Room #: 125 hood A

Data Set 1

100.00	105.00	65.00	40.00
100.00	70.00	40.00	45.00
45.00	45.00	30.00	20.00
5.00	5.00	15.00	5.00

Average FPM: 29.87

Data Set 2

100.00	90.00	80.00	80.00
100.00	75.00	45.00	15.00
60.00	45.00	30.00	20.00
5.00	5.00	20.00	5.00

Average FPM: 48.44

Data Set 3

120.00	85.00	75.00	80.00
100.00	60.00	35.00	20.00
50.00	35.00	25.00	20.00
5.00	10.00	10.00	5.00

Average FPM: 45.94

Total Avg 41.12

28.97
48.44
45.94

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

Room #	Data Set 1			
125 hood B	130.00	120.00	105.00	110.00
	15.00	125.00	110.00	95.00
				Average FPM: 101.25

Data Set 2

130.00	120.00	105.00	110.00
15.00	130.00	115.00	100.00
			Average FPM: 103.13

Data Set 3

130.00	120.00	115.00	120.00
15.00	135.00	105.00	95.00

Total Avg 102.92 — Average FPM: 104.38

Total Avg
101.25
103.13
104.38

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

Room #	
129	**Data Set 1**

140.00	130.00	150.00
100.00	95.00	110.00
15.00	5.00	60.00

Average FPM: 89.44

Data Set 2

150.00	150.00	140.00
100.00	90.00	110.00
15.00	5.00	65.00

Average FPM: 91.67

Data Set 3

145.00	130.00	140.00
100.00	95.00	110.00
15.00	5.00	40.00

Total Avg 89.26

Average FPM: 86.67

Total Avg
89.44
91.67
86.67

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

148

Data Set 1

55.00	80.00	75.00	80.00
30.00	45.00	65.00	80.00
25.00	45.00	75.00	20.00
25.00	5.00	70.00	45.00

Average FPM: 51.25

Data Set 2

55.00	70.00	80.00	90.00
40.00	40.00	80.00	80.00
50.00	50.00	70.00	30.00
25.00	5.00	60.00	35.00

Average FPM: 53.75

Data Set 3

75.00	75.00	85.00	90.00
50.00	40.00	70.00	80.00
55.00	55.00	70.00	65.00
30.00	15.00	65.00	20.00

Total Avg 54.58

Total Avg
51.25
53.75
58.75

Average FPM: 58.75

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #	Data Set 1			
149				
left side	280.00	320.00	340.00	
	220.00	230.00	300.00	
	280.00	180.00	270.00	
				Average FPM
				268.89
	Data Set 2			
	300.00	320.00	350.00	
	210.00	210.00	310.00	
	220.00	190.00	250.00	
				Average FPM
				262.22
	Data Set 3			
	310.00	310.00	360.00	
	300.00	210.00	310.00	
	270.00	200.00	270.00	
	Total Avg	271.11		Average FPM
	268.89			282.22
	262.22			
	282.22			

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

149
right side

Data Set 1

340.00	300.00	300.00
310.00	230.00	290.00
240.00	250.00	250.00

Average FPM
278.89

Data Set 2

340.00	310.00	330.00
320.00	250.00	290.00
200.00	250.00	260.00

Average FPM
283.33

Data Set 3

340.00	300.00	330.00
310.00	250.00	280.00
190.00	250.00	280.00

Total Avg 281.11

Average FPM
281.11

Total Avg
278.89
283.33
281.11

****

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

****

****

Room #

158A

Data Set 1

130.00	80.00	95.00
90.00	55.00	35.00
80.00	30.00	25.00

Average FPM

68.89

Data Set 2

120.00	80.00	80.00
90.00	50.00	40.00
75.00	35.00	15.00

Average FPM

65.00

Data Set 3

125.00	100.00	110.00
90.00	50.00	40.00
75.00	30.00	15.00

Average FPM

70.56

Total Avg 68.15

68.89
65.00
70.56

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

Room #	Data Set 1			
1588				
Left side	260.00	240.00	210.00	
	220.00	220.00	180.00	
	10.00	10.00	10.00	
				Average FPM
				151.11

Data Set 2			
260.00	240.00	210.00	
220.00	210.00	175.00	
10.00	10.00	10.00	
			Average FPM
			149.44

Data Set 3			
260.00	240.00	210.00	
220.00	210.00	180.00	
10.00	10.00	10.00	
Total Avg	150.18		Average FPM
151.11			150.00
149.44			
150.00			

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

1588 Center

Data Set 1

185.00	160.00	155.00	160.00
170.00	130.00	125.00	150.00

Average FPM: 154.38

Data Set 2

190.00	175.00	155.00	165.00
170.00	135.00	130.00	150.00

Average FPM: 158.75

Data Set 3

175.00	170.00	155.00	165.00
185.00	135.00	125.00	150.00

Average FPM: 157.50

Total Avg 156.88

154.38
158.75
157.50

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

158 Right Side

Data Set 1

200.00	170.00	170.00
190.00	135.00	135.00
200.00	140.00	140.00

Average FPM: 164.44

Data Set 2

190.00	175.00	160.00
185.00	145.00	135.00
190.00	150.00	150.00

Average FPM: 164.44

Data Set 3

195.00	175.00	170.00
180.00	145.00	150.00
190.00	150.00	160.00

Total Avg 165.74

Average FPM: 168.33

Total Avg

164.44
164.44
168.33

==

Data Collection
February 26, 1990 through March 19, 1990
Hood Face Velocities
measured with a thermoanemometer

==

Room #

163

Data Set 1

70.00	65.00	70.00	70.00
65.00	55.00	55.00	60.00
65.00	50.00	50.00	55.00
75.00	55.00	60.00	65.00

Average FPM

68.75

Data Set 2

65.00	65.00	70.00	70.00
55.00	55.00	55.00	60.00
60.00	55.00	55.00	60.00
75.00	50.00	60.00	65.00

Average FPM

60.94

Data Set 3

70.00	65.00	75.00	75.00
55.00	50.00	55.00	60.00
60.00	50.00	55.00	55.00
75.00	45.00	60.00	65.00

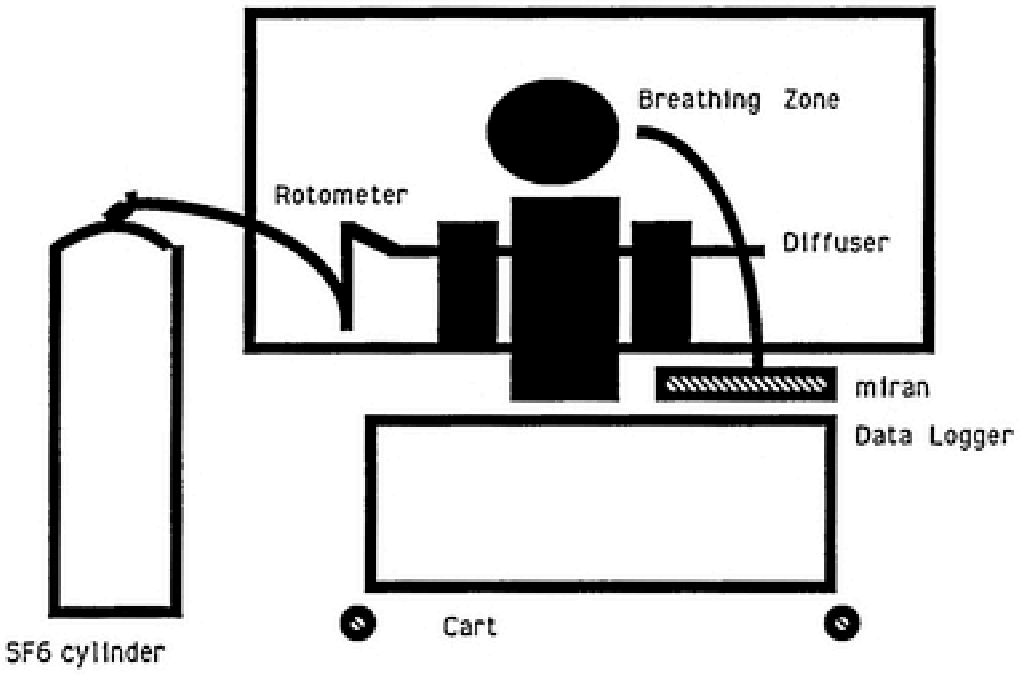
Total Avg 63.44

68.75
60.94
60.63

Average FPM

60.63

Sulfur Hexafluoride Leak Test Set-Up



==
Hood 4
SF6 Leak Detection Data
5/24/90
==

Zero/Background Level= 0.0034

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.017	0.272	4.401420
2	0.018	0.292	4.733495
3	0.0198	0.328	5.331231
4	0.0211	0.354	5.762928
5	0.0227	0.386	6.294249
6	0.0239	0.41	6.692739
7	0.0256	0.444	7.257267
8	0.027	0.472	7.722172
9	0.0273	0.478	7.821795
10	0.0303	0.538	8.818020
	Averaged Results=	0.3974	6.483532

Hood Performance Rating= 8 AU 6.48

==
Hood 6
SF6 Leak Detection Data
5/22/90
==

Zero/Background Level= 0.0408

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.043	0.044	0.615763
2	0.0426	0.036	0.482932
3	0.0414	0.012	0.084442
4	0.0419	0.022	0.250480
5	0.041	0.004	-0.04838
6	0.0418	0.02	0.217272
7	0.0415	0.014	0.117650
8	0.0407	-0.002	-0.14800
9	0.0409	0.002	-0.08159
10	0.0417	0.018	0.184065
	Averaged Results=	0.017	0.167461

Hood Performance Rating= 8 AU 0.167

==
Hood 7
SF6 Leak Detection Data
5/22/90
==

Zero/Background Level= -0.0305

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0311	-0.012	-0.31404
2	-0.0312	-0.014	-0.34725
3	-0.0309	-0.008	-0.24763
4	-0.0313	-0.016	-0.38046
5	-0.0312	-0.014	-0.34725
6	-0.0316	-0.022	-0.48008
7	-0.0309	-0.008	-0.24763
8	-0.0307	-0.004	-0.18121
9	-0.0309	-0.008	-0.24763
10	-0.0307	-0.004	-0.18121
	Averaged Results=	-0.011	-0.29744

Hood Performance Rating= 8 AU -0.30

==
Hood 8
SF6 Leak Detection Data
5/22/90
==

Zero/Background Level= 0.0179

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0236	0.114	1.778026
2	0.0253	0.148	2.342554
3	0.0254	0.15	2.375761
4	0.0273	0.188	3.006704
5	0.0284	0.21	3.371987
6	0.0304	0.25	4.036137
7	0.0295	0.232	3.737270
8	0.0308	0.258	4.168967
9	0.0321	0.284	4.600665
10	0.0321	0.284	4.600665
	Averaged Results=	0.2118	3.401874

Hood Performance Rating= 8 AU 3.40

==

Hood 8 A
SF6 Leak Detection Data
5/25/90

==

Zero/Background Level= 0.0034

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0037	0.006	-0.01517
2	0.004	0.012	0.084442
3	0.0046	0.024	0.283687
4	0.0045	0.022	0.250480
5	0.0051	0.034	0.449725
6	0.0063	0.058	0.848215
7	0.0079	0.09	1.379536
8	0.0072	0.076	1.147083
9	0.0073	0.078	1.180290
10	0.0071	0.074	1.113875
	Averaged Results=	0.0474	0.672215

Hood Performance Rating= 8 AU 0.67

==

Hood 8 B
SF6 Leak Detection Data
5/25/90

==

Zero/Background Level= -0.0023

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0022	0.002	-0.08159
2	-0.0015	0.016	0.150857
3	-0.0012	0.022	0.250480
4	-0.0007	0.032	0.416517
5	0	0.046	0.648970
6	0.0001	0.048	0.682178
7	-0.001	0.026	0.316895
8	-0.0002	0.042	0.582555
9	0.001	0.066	0.981045
10	0.0007	0.06	0.881423
	Averaged Results=	0.036	0.482932

Hood Performance Rating= 8 AU 0.48

==
Hood 9 A
SF6 Leak Detection Data
5/25/90
==

Zero/Background Level= 0.0478

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.066	0.364	5.928966
2	0.0682	0.408	6.659532
3	0.0695	0.434	7.091229
4	0.0698	0.44	7.190852
5	0.0691	0.426	6.958399
6	0.0707	0.458	7.489720
7	0.0707	0.458	7.489720
8	0.071	0.464	7.589342
9	0.07	0.444	7.257267
10	0.0695	0.434	7.091229
	Averaged Results=	0.433	7.074626

Hood Performance Rating= 8 AU 7.07

==
Hood 9 B
SF6 Leak Detection Data
5/25/90
==

Zero/Background Level= -0.0138

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0107	0.062	0.914630
2	-0.0115	0.046	0.648970
3	-0.0116	0.044	0.615763
4	-0.0114	0.048	0.682178
5	-0.0136	0.004	-0.04838
6	-0.0142	-0.008	-0.24763
7	-0.0149	-0.022	-0.48008
8	-0.0166	-0.056	-1.04461
9	-0.0157	-0.038	-0.74574
10	-0.0149	-0.022	-0.48008
	Averaged Results=	0.0058	-0.01850

Hood Performance Rating= 8 AU -0.018

==
Hood 12
SF6 Leak Detection Data
5/22/90
==

Zero/Background Level= -0.0305

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0277	0.056	0.815008
2	-0.029	0.03	0.383310
3	-0.028	0.05	0.715385
4	-0.0284	0.042	0.582555
5	-0.0294	0.022	0.250480
6	-0.0288	0.034	0.449725
7	-0.0286	0.038	0.516140
8	-0.0285	0.04	0.549348
9	-0.0284	0.042	0.582555
10	-0.0285	0.04	0.549348
	Averaged Results=	0.0394	0.539385

Hood Performance Rating= 8 AU 0.54

==
Hood 14
SF6 Leak Detection Data
5/22/90
==

Zero/Background Level= 0.0425

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0434	0.018	0.184065
2	0.0432	0.014	0.117650
3	0.0436	0.022	0.250480
4	0.044	0.03	0.383310
5	0.0432	0.014	0.117650
6	0.0429	0.008	0.018027
7	0.0431	0.012	0.084442
8	0.0437	0.024	0.283687
9	0.0446	0.042	0.582555
10	0.0447	0.044	0.615763
	Averaged Results=	0.0228	0.263763

Hood Performance Rating= 8 AU 0.26

Hood 123
SF6 Leak Detection Data
5/19/90

Zero/Background Level= 0.003

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0012	-0.0018	-0.14468
2	0.0016	-0.0014	-0.13804
3	0.0022	-0.0008	-0.12808
4	0.0015	-0.0015	-0.13970
5	0.0018	-0.0012	-0.13472
6	0.0015	-0.0015	-0.13970
7	0.0018	-0.0012	-0.13472
8	0.0019	-0.0011	-0.13306
9	0.0008	-0.0022	-0.15133
10	0.0017	-0.0013	-0.13638
	Average Results=	-0.0014	-0.13804

Hood Performance Rating= 8 AU -0.13804

Hood 125A
SF6 Leak Detection Data
5/19/90

Zero/Background Level= -0.0105

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0091	0.392	6.393871
2	0.0082	0.374	6.095004
3	0.0088	0.386	6.294249
4	0.0109	0.428	6.991607
5	0.0123	0.456	7.456512
6	0.0101	0.412	6.725947
7	0.0074	0.358	5.829344
8	0.0065	0.34	5.530476
9	0.0064	0.338	5.497268
10	0.0077	0.364	5.928966
	Averaged Results=	0.3848	6.274324

Hood Performance Rating= 8 Au 6.27

Hood 125B
SF6 Leak Detection Data
5/19/90

Zero/Background Level= 0.0072

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0075	0.006	-0.01517
2	0.009	0.036	0.482932
3	0.0088	0.032	0.416517
4	0.0085	0.026	0.316895
5	0.0088	0.032	0.416517
6	0.0082	0.02	0.217272
7	0.0078	0.012	0.084442
8	0.0073	0.002	-0.08159
9	0.0062	-0.02	-0.44687
10	0.0051	-0.042	-0.81216
	Averaged Results=	0.0104	0.057876

Hood Performance Rating= 8 AU .058

Hood 129
SF6 Leak Detection Data
5/25/90

Zero/Background Level= 0.0465

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0465	0	-0.11480
2	0.0462	-0.006	-0.21442
3	0.0462	-0.006	-0.21442
4	0.0461	-0.008	-0.24763
5	0.0464	-0.002	-0.14800
6	0.0467	0.004	-0.04838
7	0.0468	0.006	-0.01517
8	0.0464	-0.002	-0.14800
9	0.0464	-0.002	-0.14800
10	0.0462	-0.006	-0.21442
	Averaged Results=	-0.0022	-0.15133

Hood Performance Rating= 8 AU -0.15

Hood 148
SF6 Leak Detection Data
5/25/90

Zero/Background Level= 0.046

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0465	0.01	0.051235
2	0.0466	0.012	0.084442
3	0.0462	0.004	-0.04838
4	0.0457	-0.006	-0.21442
5	0.0464	0.008	0.018027
6	0.0468	0.016	0.150857
7	0.0468	0.016	0.150857
8	0.0469	0.018	0.184065
9	0.047	0.02	0.217272
10	0.0469	0.018	0.184065
	Averaged Results=	0.0116	0.077801

Hood Performance Rating= 8 AU .077801

Hood 149 Left Side
SF6 Leak Detection Data
5/16/90

Zero/Background Level= 0.0854

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0849	-0.0005	-0.12310
2	0.0847	-0.0007	-0.12642
3	0.0847	-0.0007	-0.12642
4	0.0846	-0.0008	-0.12808
5	0.0845	-0.0009	-0.12974
6	0.0846	-0.0008	-0.12808
7	0.0849	-0.0005	-0.12310
8	0.0845	-0.0009	-0.12974
9	0.0848	-0.0006	-0.12476
10	0.0849	-0.0005	-0.12310
	Averaged Results=	-0.00069	-0.12625

Hood Performance Rating= 8 AU -0.12625

==
Hood 149 Right Side
SF6 Leak Detection Data
5/14/90
==

Zero/Background Level=.08725

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.0881	0.017	0.167461
2	0.0873	0.001	-0.09819
3	0.0872	-0.001	-0.13140
4	0.0877	0.009	0.034631
5	0.0876	0.007	0.001423
6	0.0877	0.009	0.034631
7	0.0878	0.011	0.067838
8	0.0878	0.011	0.067838
9	0.0861	-0.023	-0.49668
10	0.0857	-0.031	-0.62951
	Average Results=	0.001	-0.09819

Hood Performance Rating= 8 AU -0.09819

==
Hood 158A
SF6 Leak Detection Data
5/18/90
==

Zero/Background Level= -0.0265

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0237	0.056	0.815008
2	-0.0232	0.066	0.981045
3	-0.0222	0.086	1.313121
4	-0.0232	0.066	0.981045
5	-0.0234	0.062	0.914630
6	-0.0226	0.078	1.180290
7	-0.0208	0.114	1.778026
8	-0.0205	0.12	1.877648
9	-0.0204	0.122	1.910856
10	-0.019	0.15	2.375761
	Averaged Results=	0.092	1.412743

Hood Performance Rating= 8 AU 1.41

==

Hood 158 Left Side
SF6 Leak Detection Data
5/17/90

==

Zero/Background Level= -0.0288

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0288	0	-0.11480
2	-0.0292	-0.008	-0.24763
3	-0.0289	-0.002	-0.14800
4	-0.0287	0.002	-0.08159
5	-0.0292	-0.008	-0.24763
6	-0.0294	-0.012	-0.31404
7	-0.0291	-0.006	-0.21442
8	-0.0291	-0.006	-0.21442
9	-0.0292	-0.008	-0.24763
10	-0.0291	-0.006	-0.21442
	Averaged Results=	-0.0054	-0.20446

Hood Performance Rating= 8 AU -0.20446

==

Hood 158BCenter
SF6 Leak Detection Data
5/17/90

==

Zero/Background Level= -0.029

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0337	-0.0047	-0.19284
2	-0.0347	-0.0057	-0.20944
3	-0.0344	-0.0054	-0.20446
4	-0.0327	-0.0037	-0.17623
5	-0.0336	-0.0046	-0.19117
6	-0.031	-0.002	-0.14800
7	-0.0291	-0.0001	-0.11646
8	-0.0281	0.0009	-0.09985
9	-0.0299	-0.0009	-0.12974
10	-0.03	-0.001	-0.13140
	Averaged Results=	-0.00272	-0.15996

Hood Performance Rating= 8 AU -0.15996

Hood 158BRight
SF6 Leak Detection Data
5/17/90

Zero/Background Level= -0.0258

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	-0.0267	-0.018	-0.41367
2	-0.0275	-0.034	-0.67933
3	-0.0233	0.05	0.715385
4	-0.0219	0.078	1.180290
5	-0.0222	0.072	1.080668
6	-0.0219	0.078	1.180290
7	-0.0207	0.102	1.578781
8	-0.0201	0.114	1.778026
9	-0.0195	0.126	1.977271
10	-0.0217	0.082	1.246705
	Averaged Results=	0.065	0.964442

Hood Performance Rating= 8 AU 0.96

Hood 163 Left Side
SF6 Leak Detection Data
5/16/90

Zero/Background Level= 0.03345

Time(minutes)	Data(volts)	Data-Zero	Concentration(ppm)
1	0.035	0.031	0.399914
2	0.0357	0.045	0.632366
3	0.0368	0.067	0.997649
4	0.0369	0.069	1.030857
5	0.038	0.091	1.396139
6	0.039	0.111	1.728215
7	0.0393	0.117	1.827837
8	0.04	0.131	2.060290
9	0.0407	0.145	2.292742
10	0.042	0.171	2.724440
	Averaged Results=	0.0978	1.509045

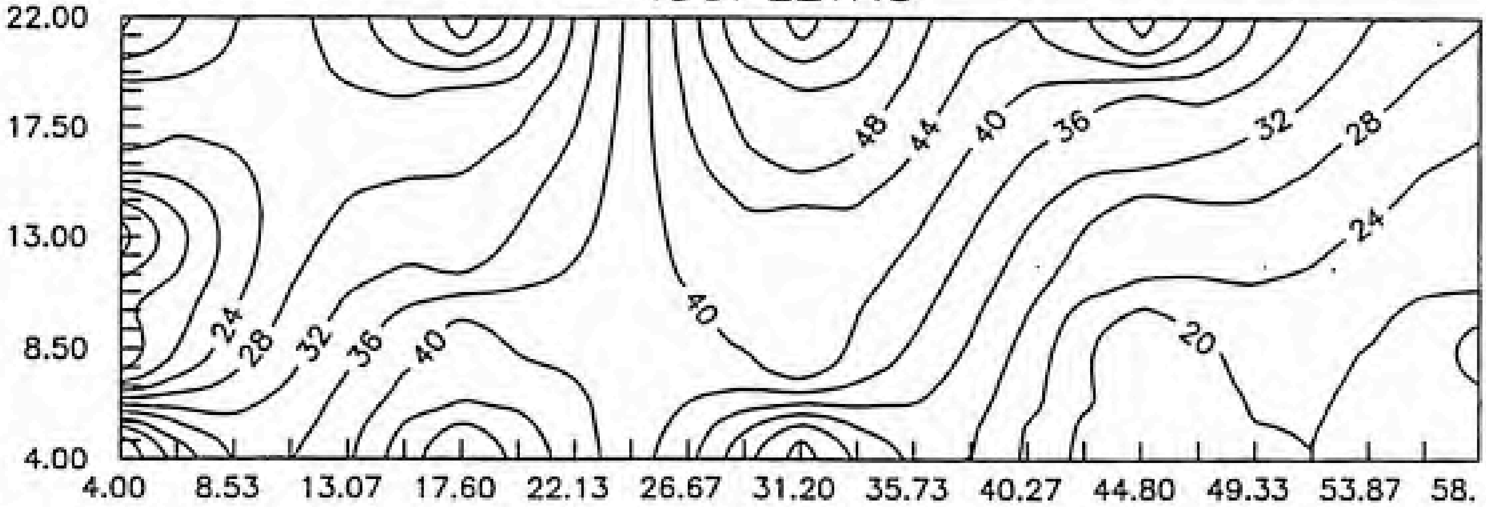
Hood Performance Rating= 8 AU 1.51

Appendix G

This section contains the isopleth graphs depicting the velocity contours at the hood face. The average of the three measurements taken at each of the points designated at the hood face were used to create these graphs. The Surfer Program takes the measurements of the hood and the exact location of the face velocity measurements taken across the hood face. The program then plots out the dimensions of the hood frame and forms the contour lines within this outline. The lines represent varying levels of face velocity which the program automatically charts. The program calculates the air flow velocities and connects equal values to form lines at increments of 4. The numbers on the contour lines show the speed of air at that given point, in fpm.

HOOD FOUR

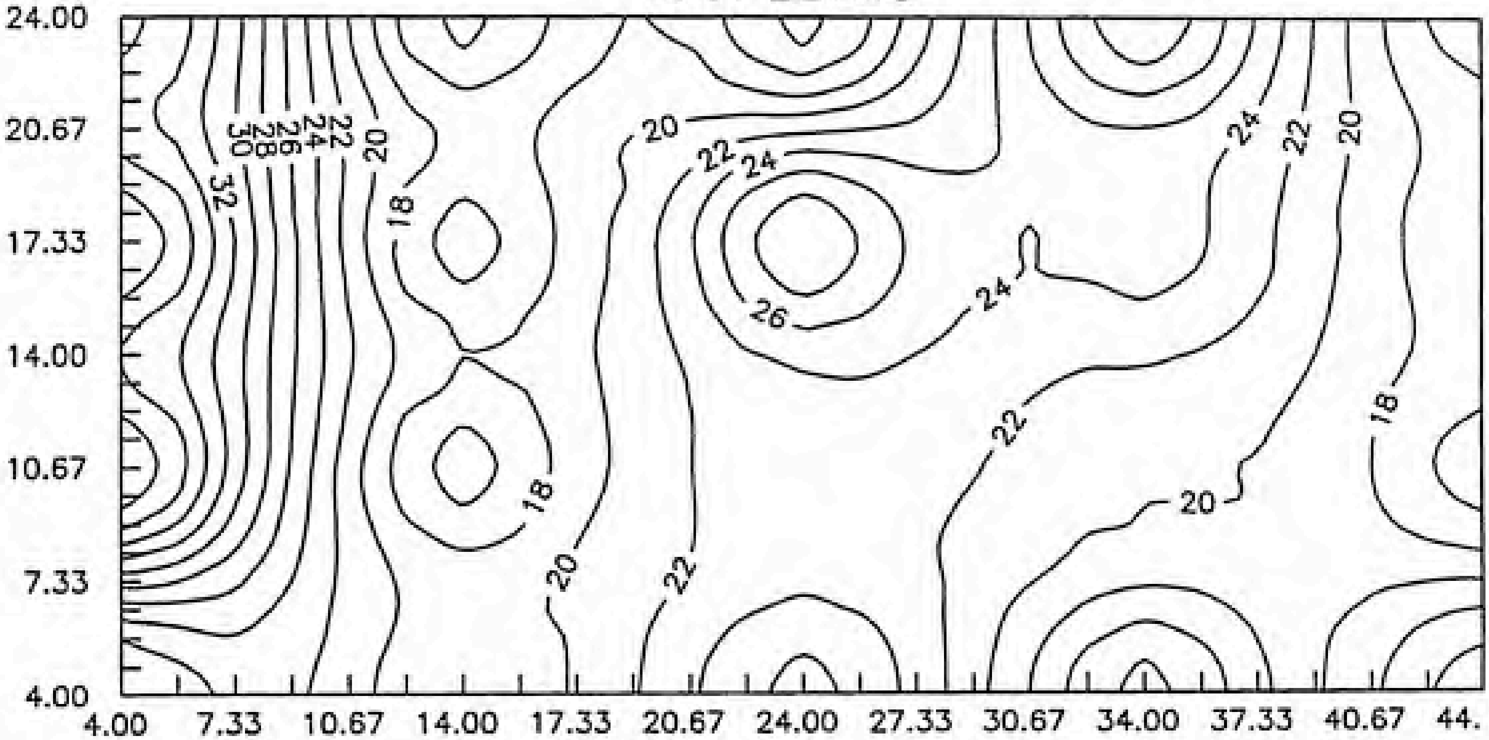
ISOPLETHS



SCALE 1 inch = 7.771 data units

HOOD SIX

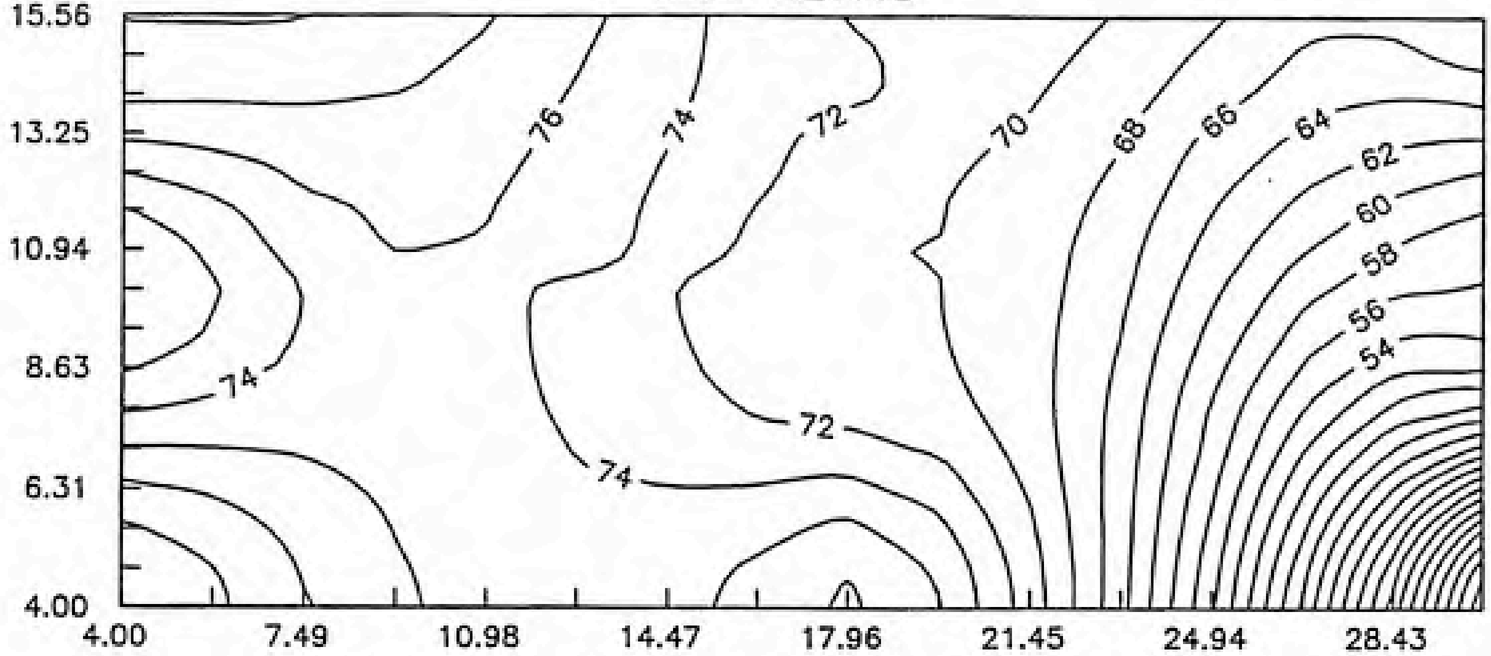
ISOPLETHS



SCALE 1 inch = 5.714 data units

HOOD SEVEN

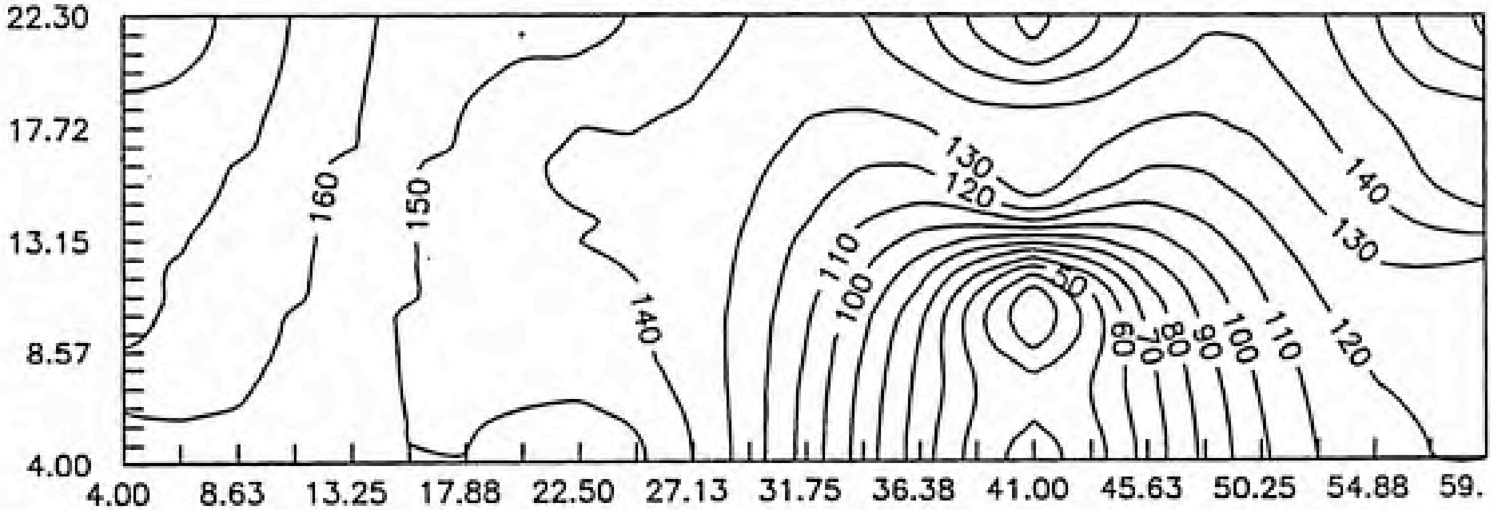
ISOPLETHS



SCALE 1 inch = 3.739 data units

HOOD EIGHT

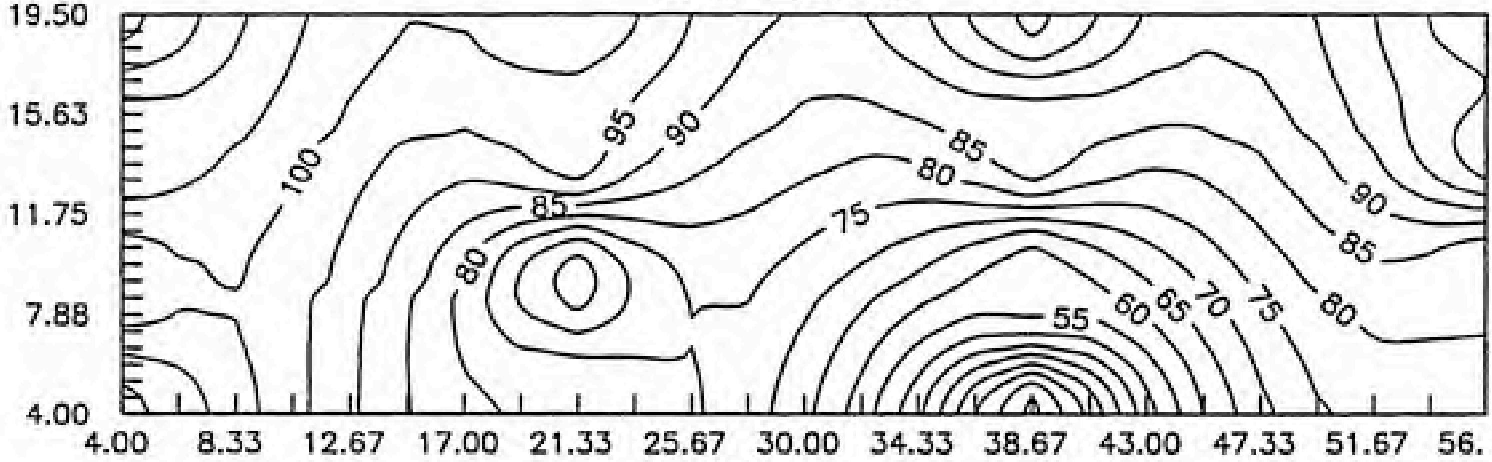
ISOPLETHS



SCALE 1 inch = 7.929 data units

HOOD NINE A

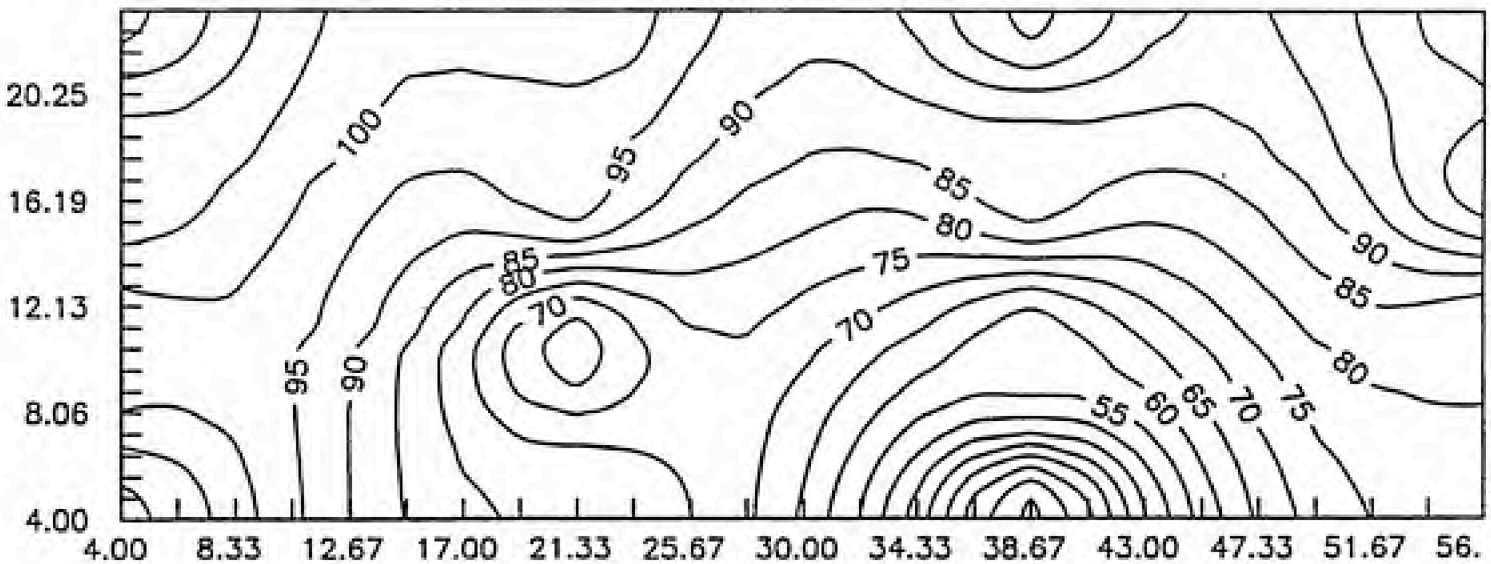
ISOPLETHS



SCALE 1 inch = 7.429 data units

HOOD NINE B

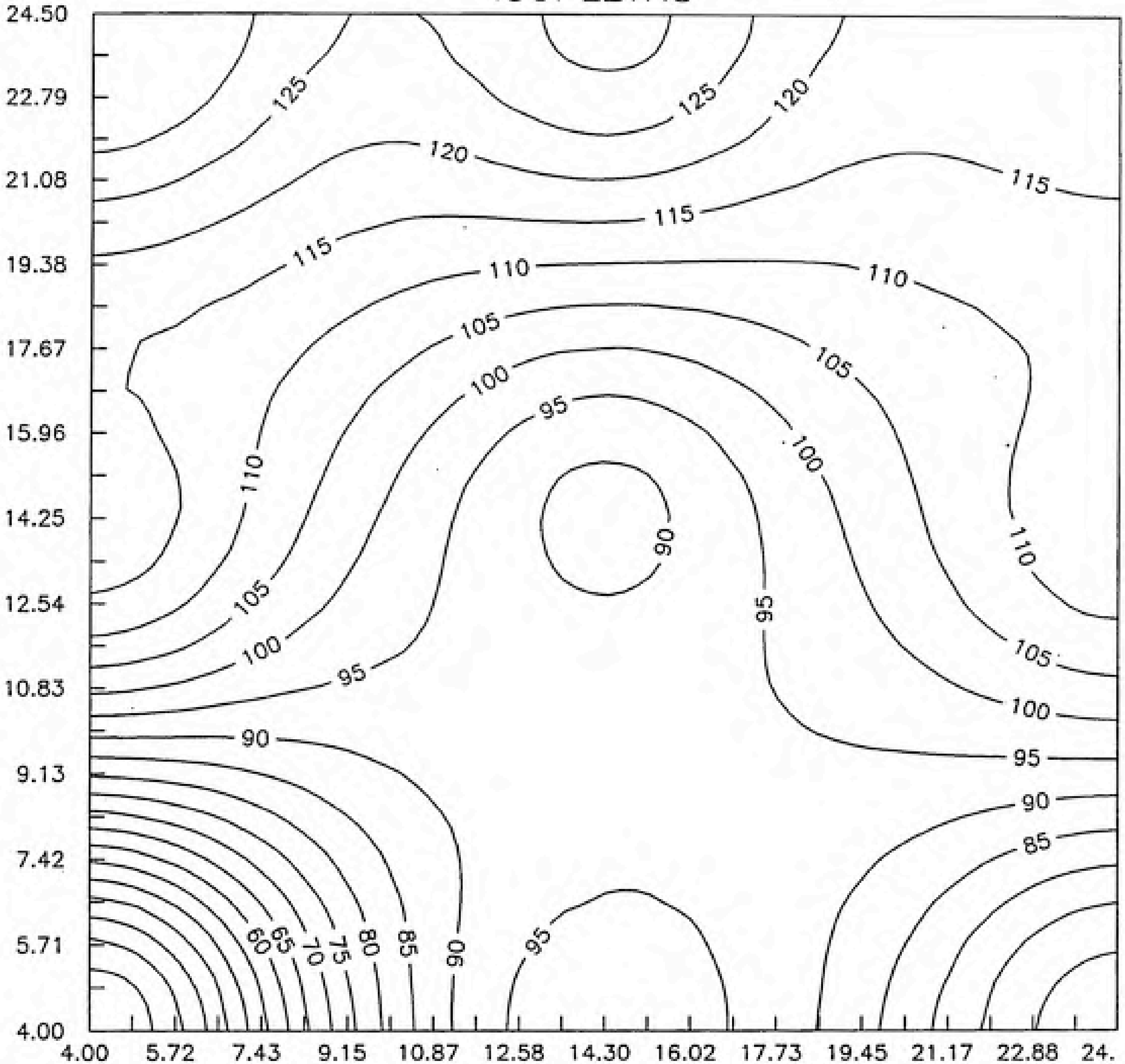
ISOPLETHS



SCALE 1 inch = 7.429 data units

HOOD 12

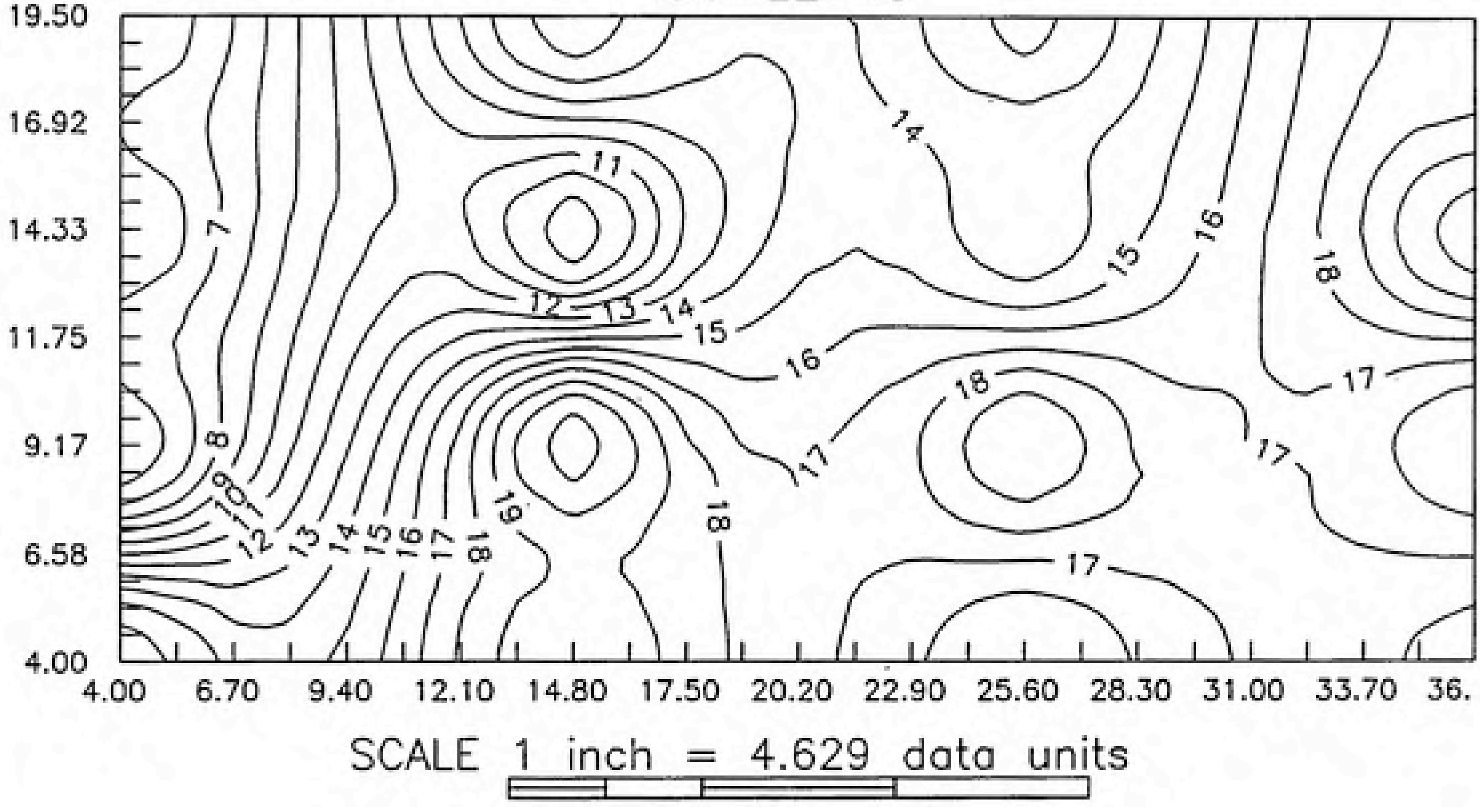
ISOPLETHS



SCALE 1 inch = 2.943 data units

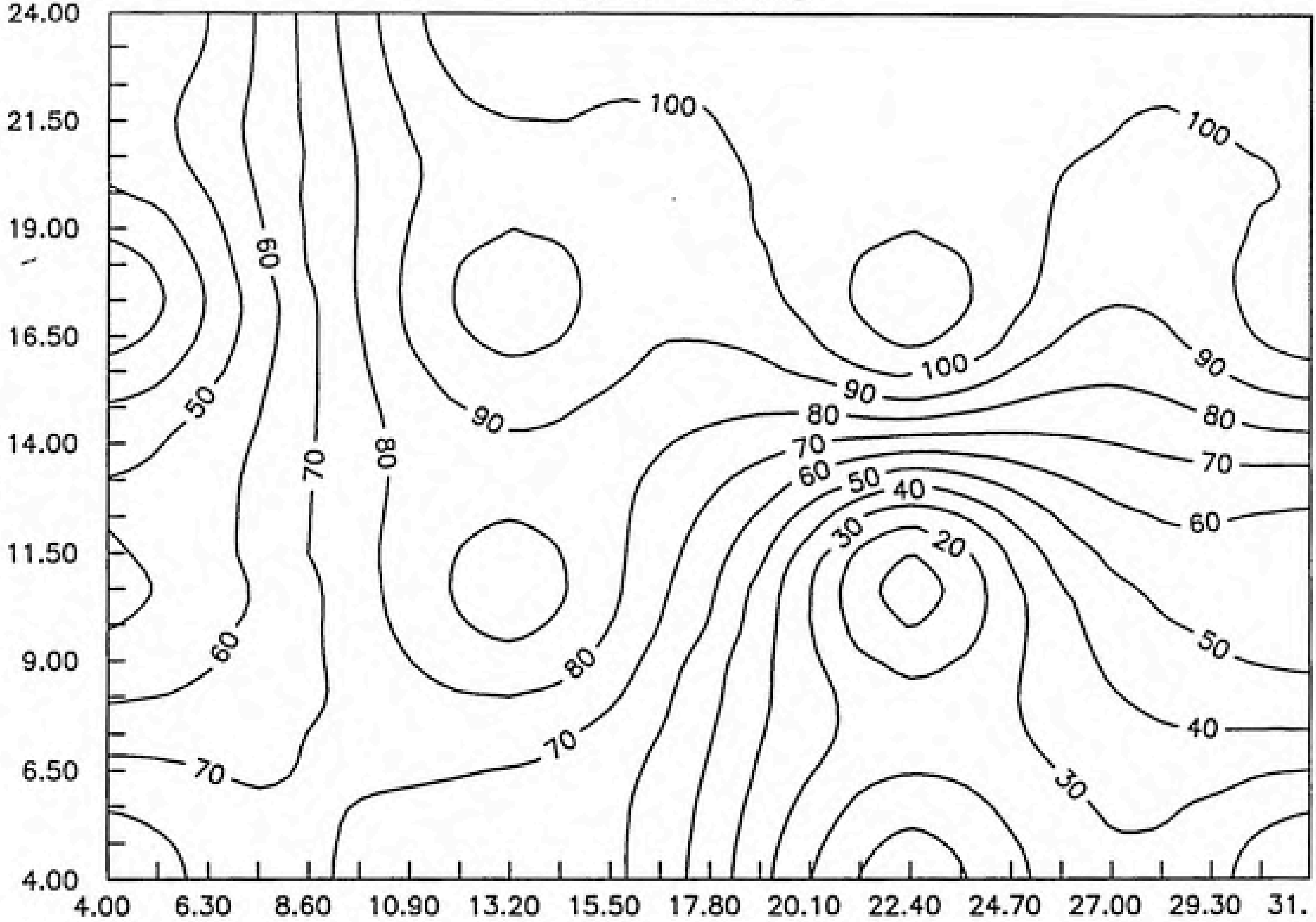
HOOD 14

ISOPLETHS



HOOD 123

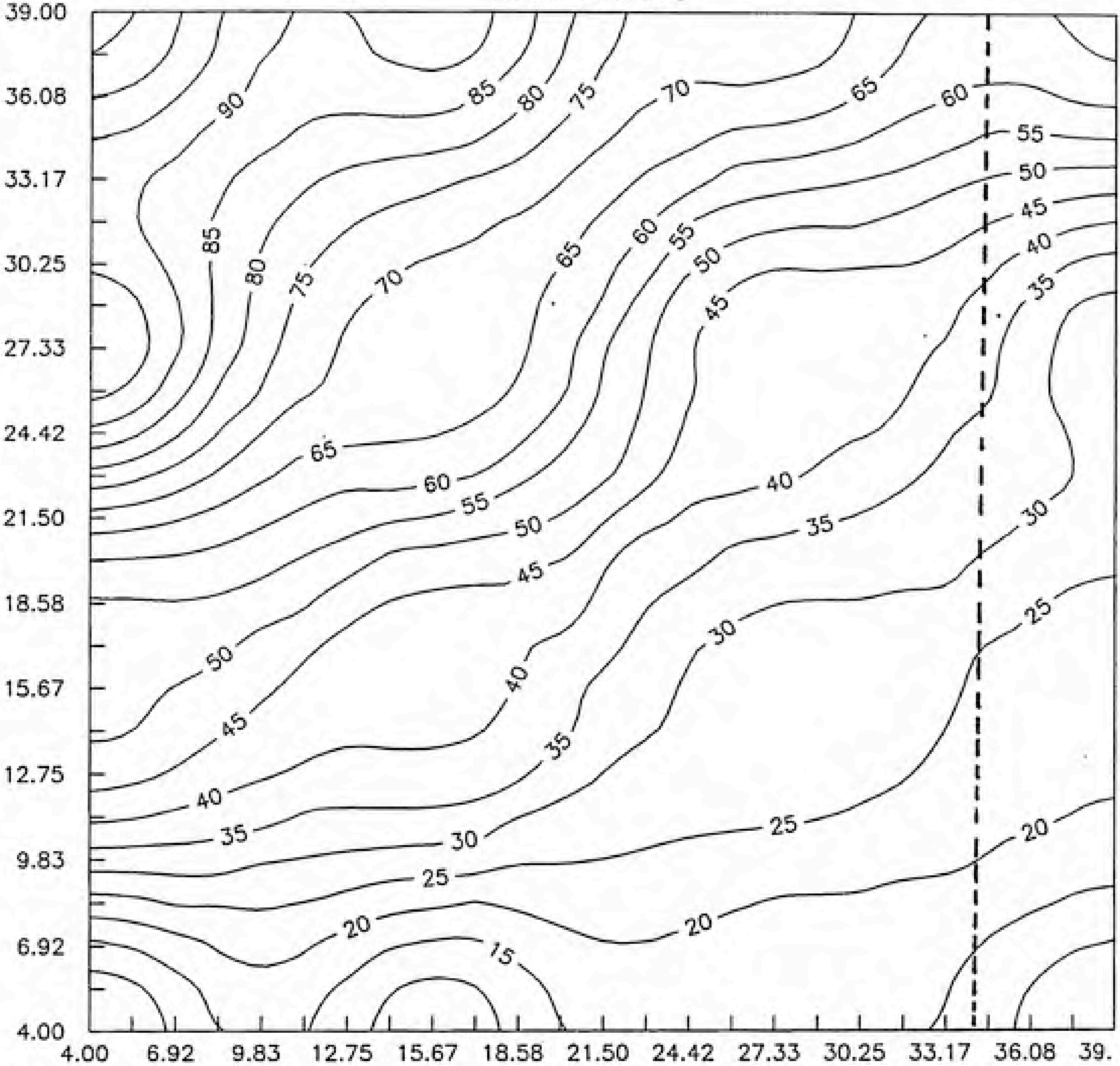
ISOPLETHS



SCALE 1 inch = 3.943 data units

HOOD 125A

ISOPLETHS

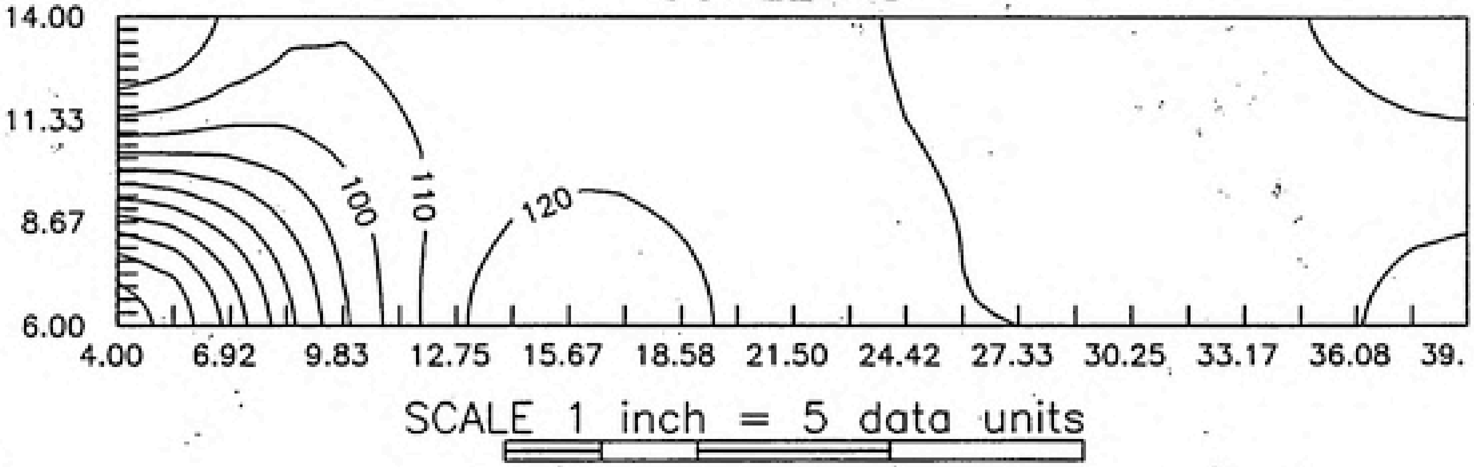


SCALE 1 inch = 5 data units

---- Values to the right of the dased line are negative. The air is flowing out of the hood, not into the hood.

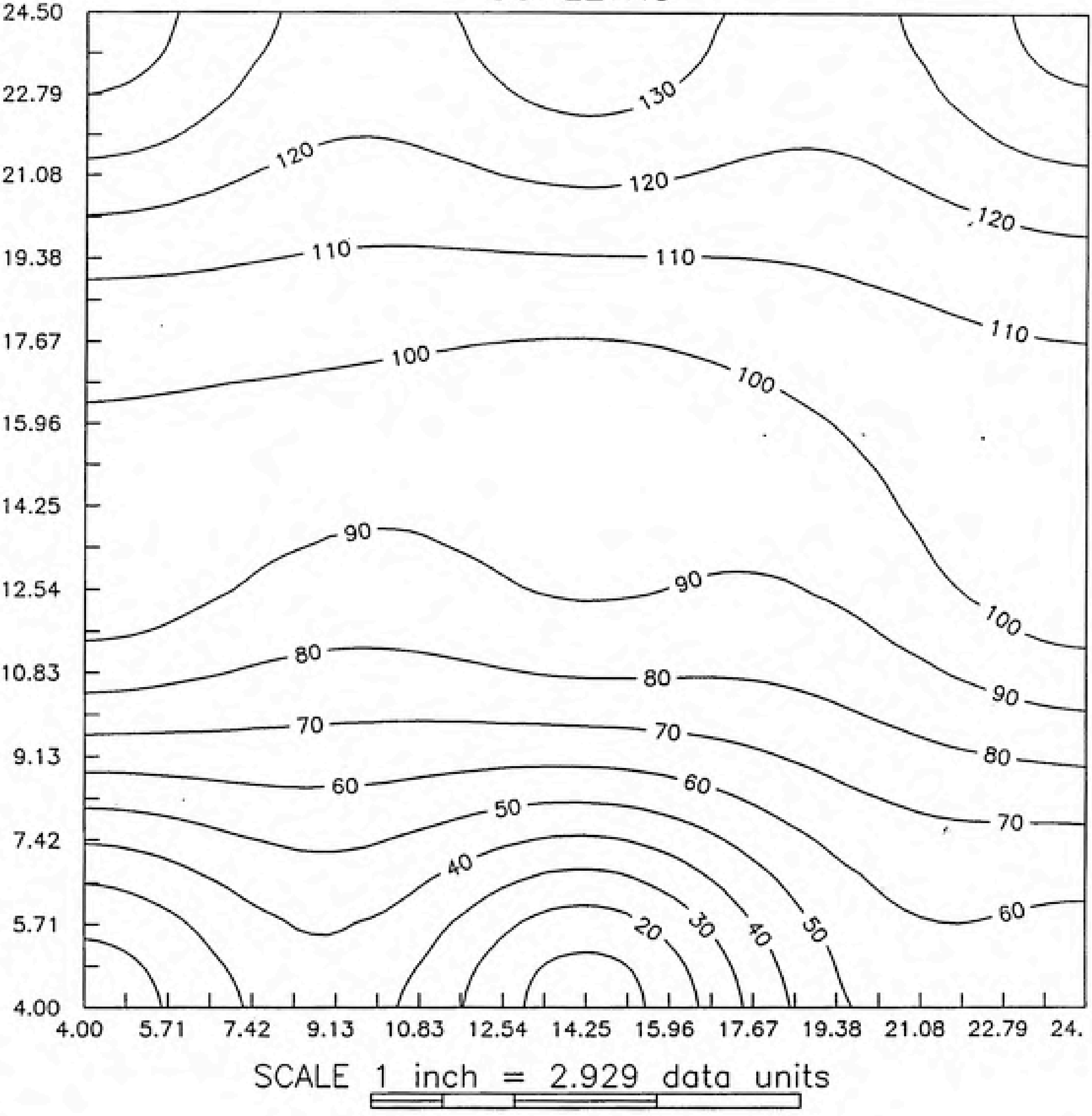
HOOD 125B

ISOPLETHS



HOOD 129

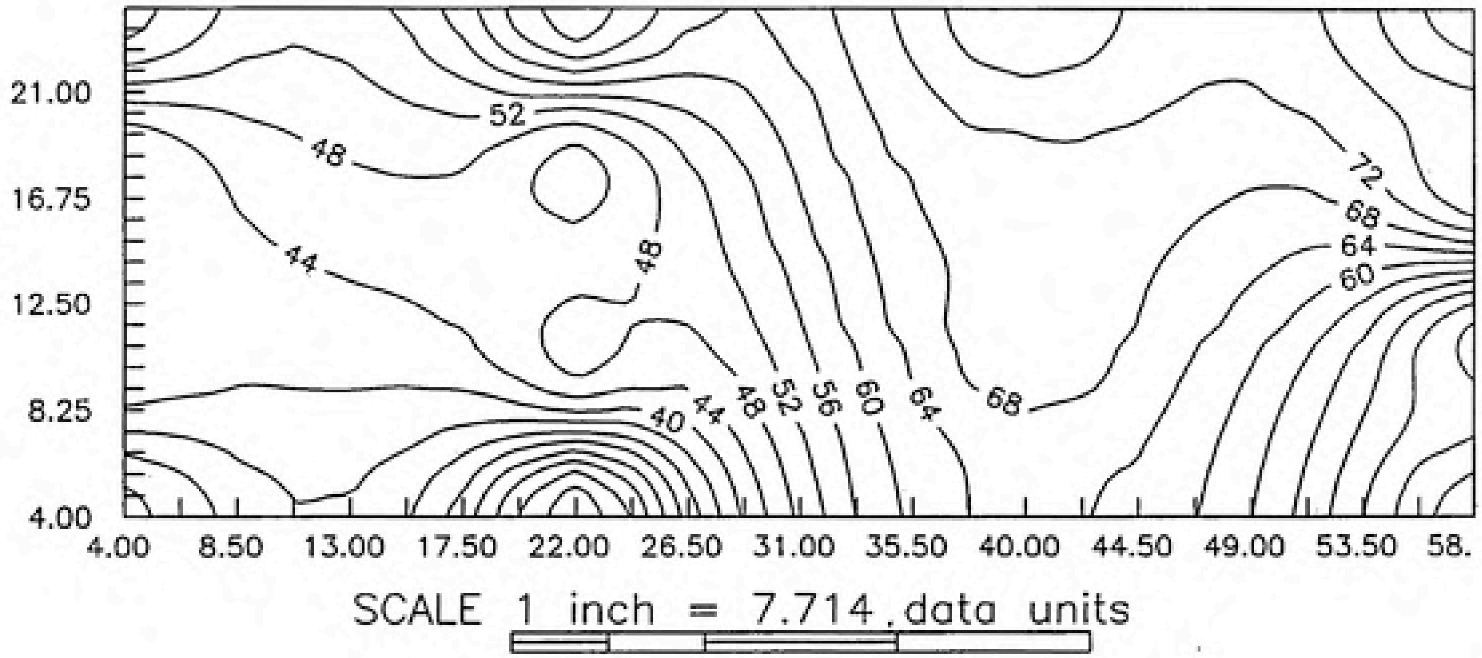
ISOPLETHS



SCALE 1 inch = 2.929 data units

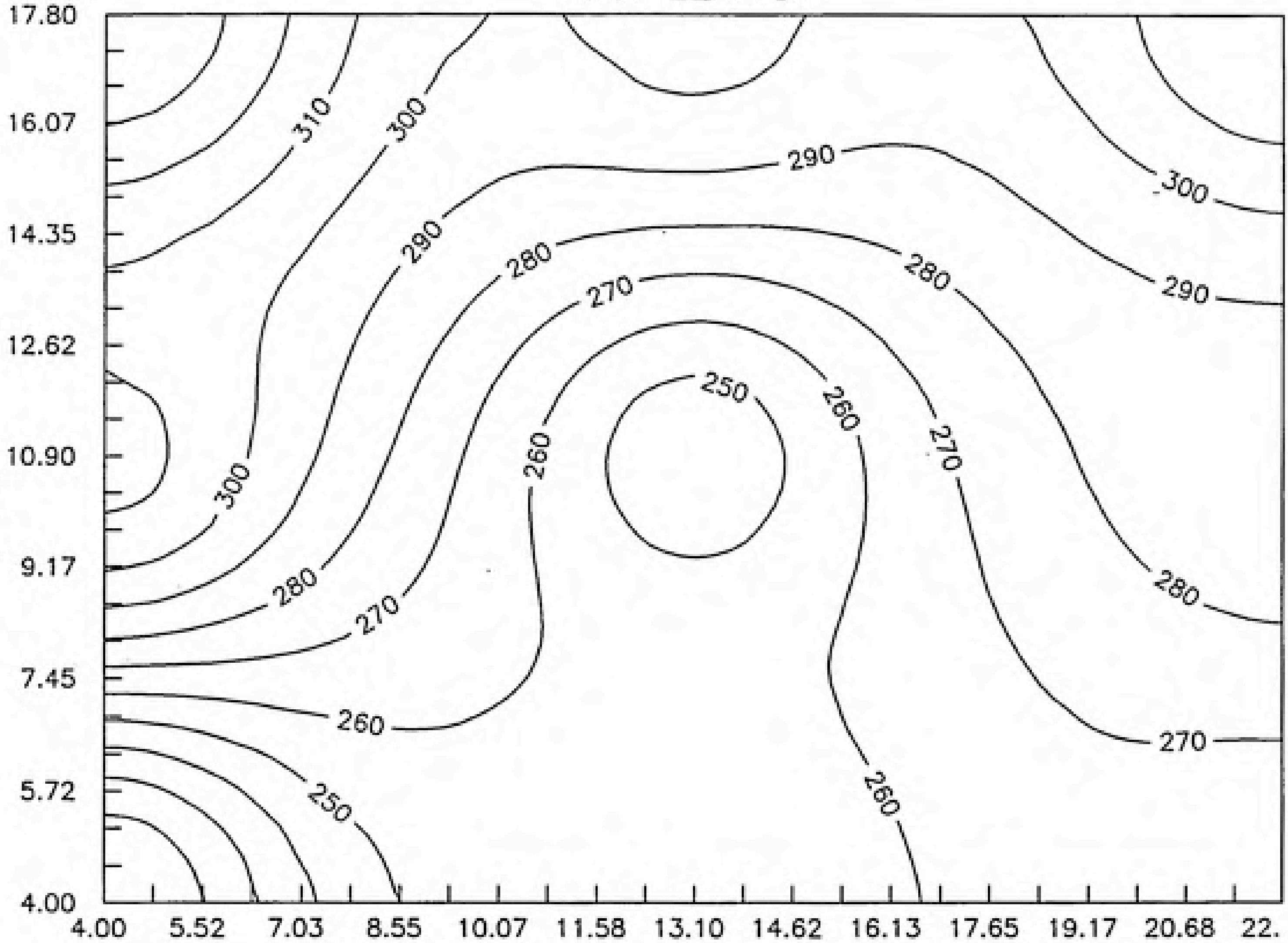
HOOD 148

ISOPLETHS



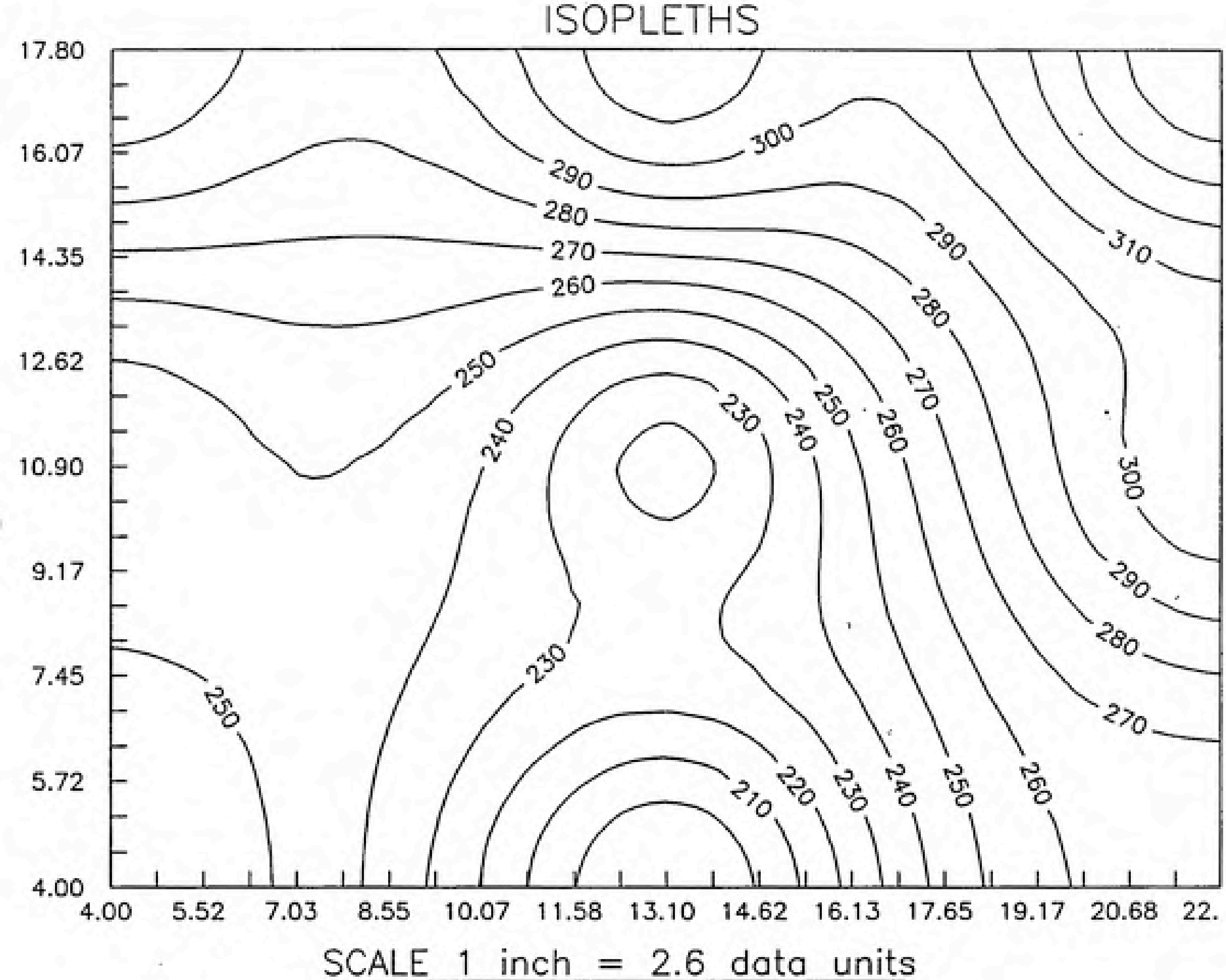
HOOD 149 RIGHT

ISOPLETHS



SCALE 1 inch = 2.6 data units

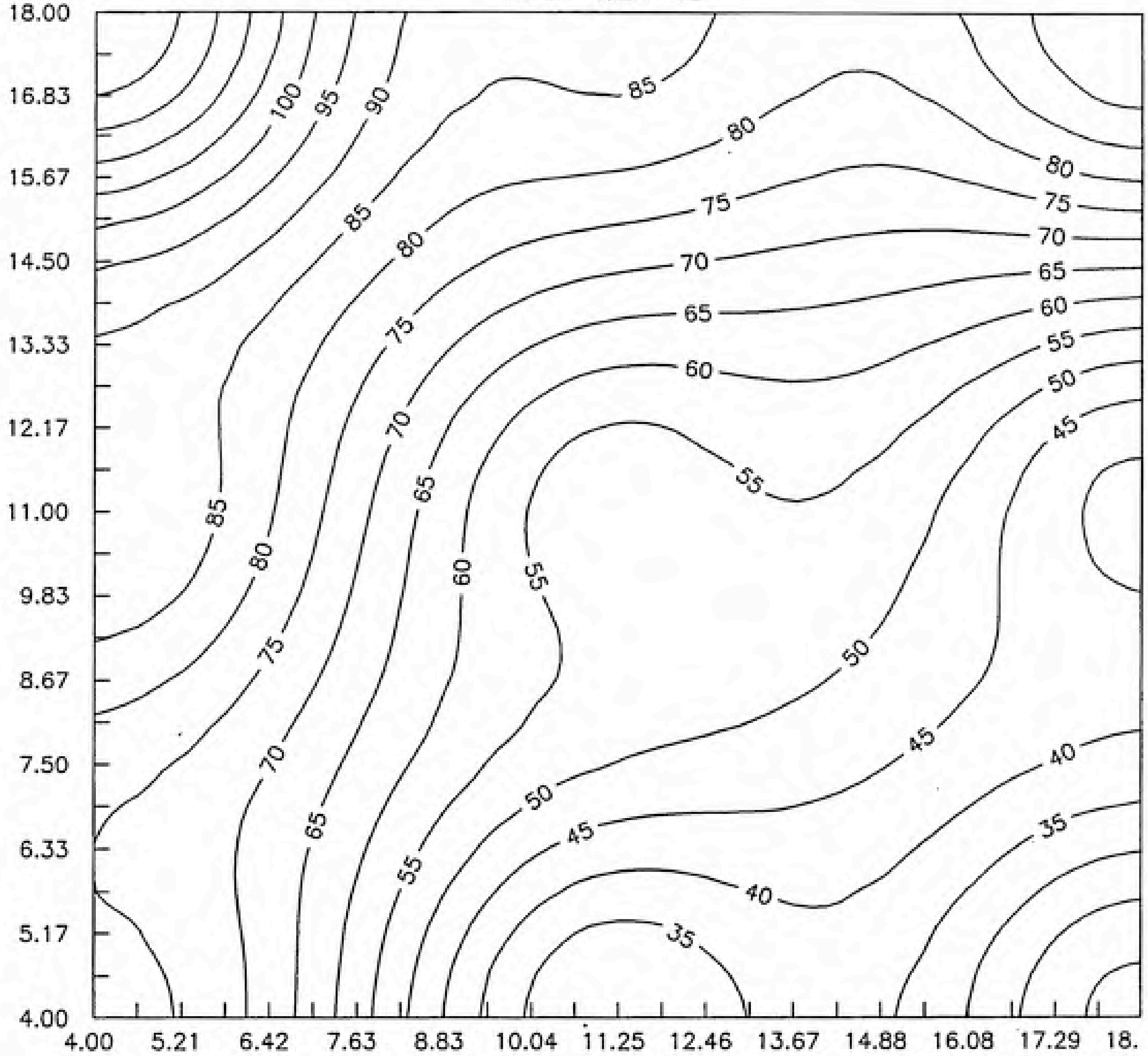
HOOD 149 LEFT



SCALE 1 inch = 2.6 data units

HOOD 158 A

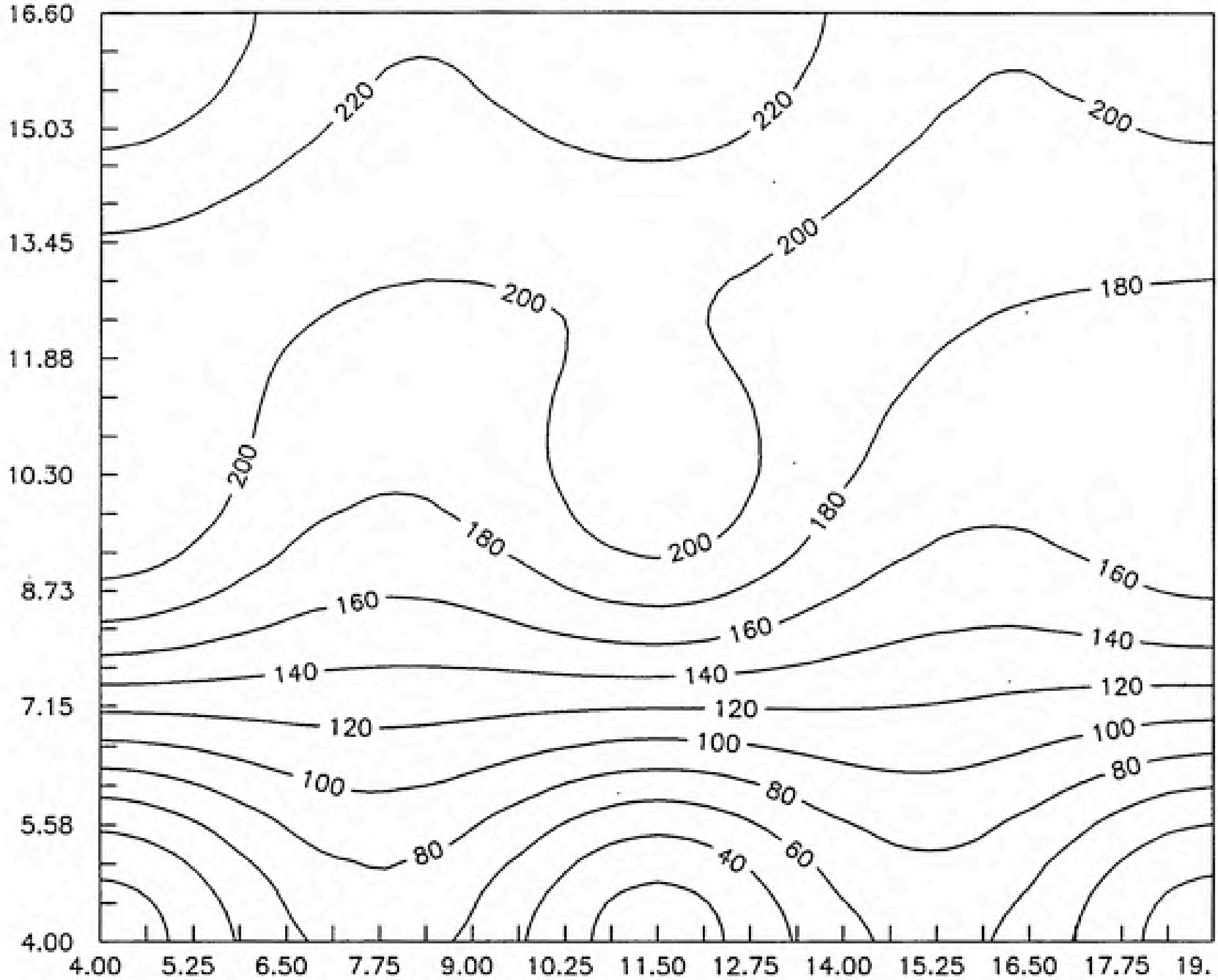
ISOPLETHS



SCALE 1 inch = 2.071 data units

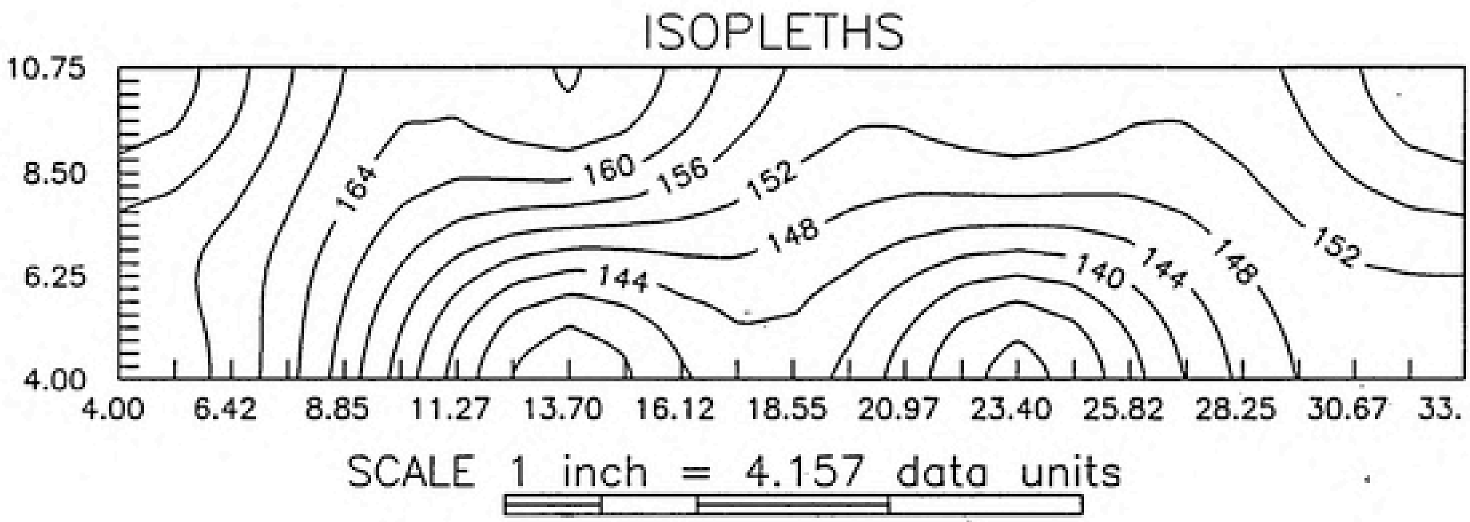
HOOD 158 B LEFT

ISOPLETHS



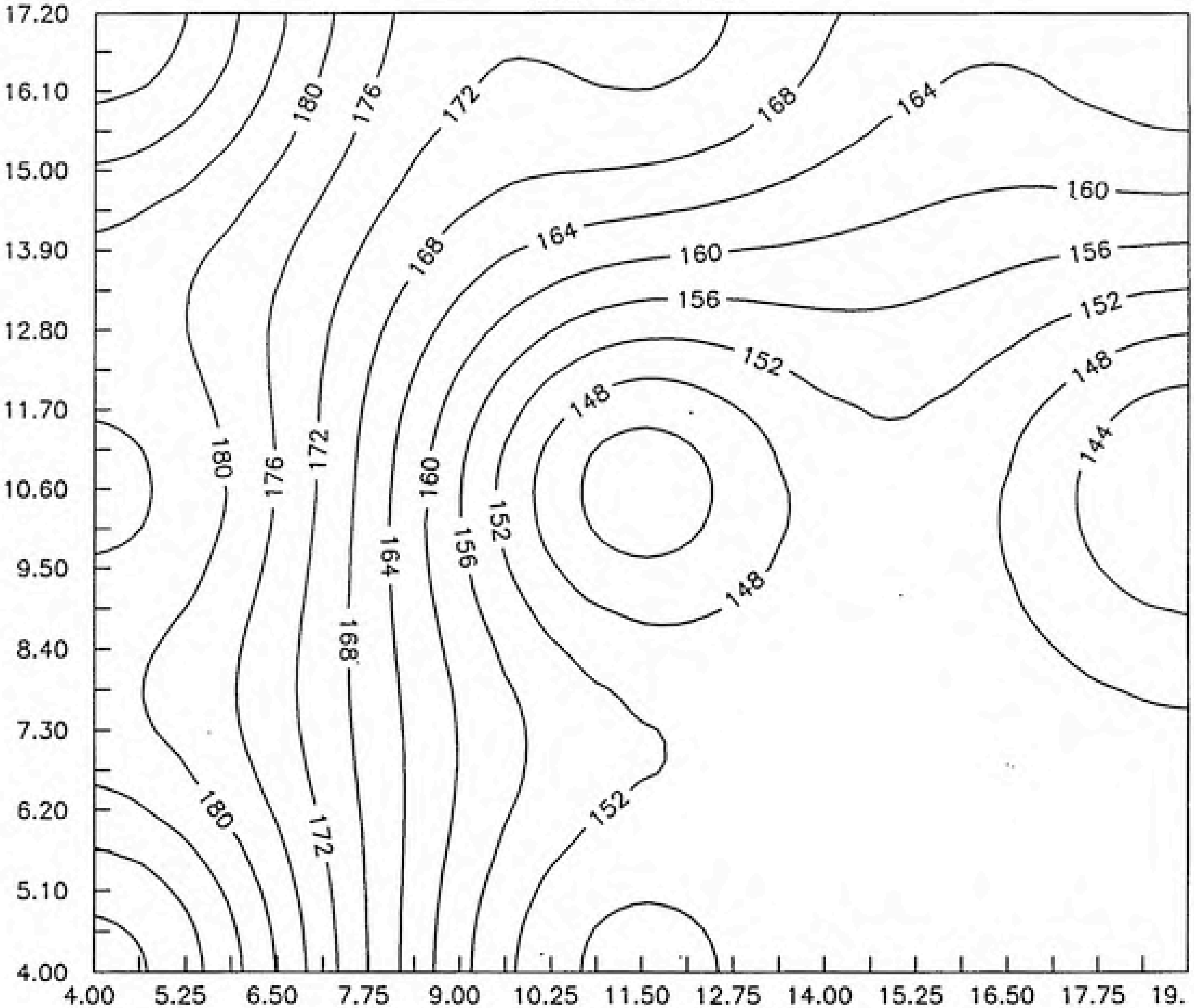
SCALE 1 inch = 2.143 data units

HOOD 158 B CENTER



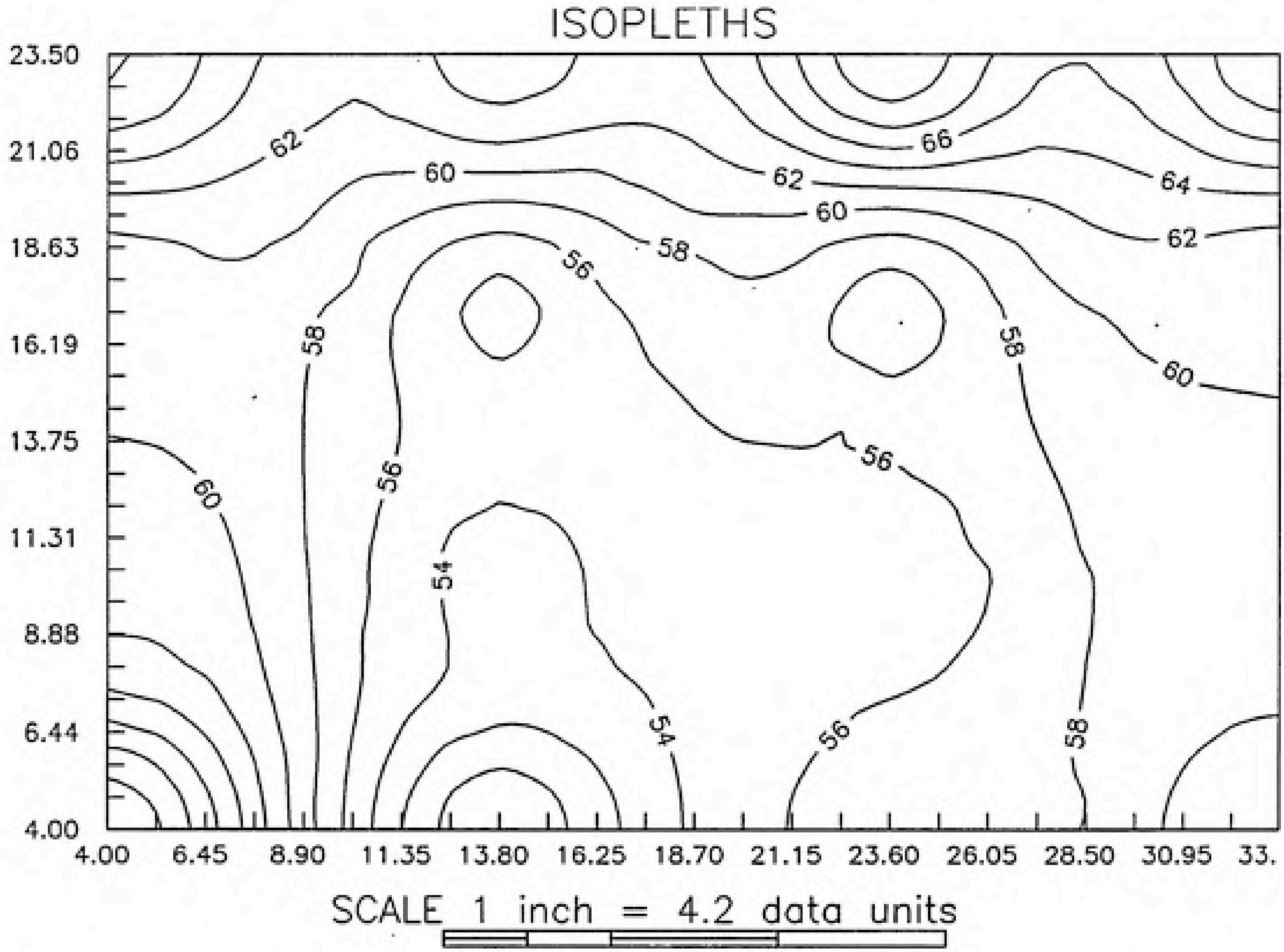
HOOD 158 B RIGHT

ISOPLETHS



SCALE 1 inch = 2.143 data units

HOOD 163


ISOPLETHS
23.50
21.06
18.63
16.19
13.75
11.31
8.88
6.44
4.00
4.00
6.45
8.90
11.35
13.80
16.25
18.70
21.15
23.60
26.05
28.50
30.95
33.
62
60
66
62
64
60
62
58
56
58
58
60
56
60
56
54
54
56
58
SCALE 1 inch = 4.2 data units

Appendix H

This section contains a list of good work practices which should be followed by all hood operators.

Guidelines for Good Work Practices

1. Keep the hood sash closed when hood is not in use.
2. Work with the hood sash partially or 1/2 closed.
3. Handle contaminants as far back in the hood as practical.
4. Do not generate contaminants outside of the hood face.
5. Do not lean into the hood.
6. Avoid sharp movements of arms in and out of the hood.
7. Do not walk quickly past the hood face.
8. Do not adjust dampers on make-up air units to velocities above those of the hood face.
9. Do not open windows located next to hoods.
10. Do not handle highly toxic or flammable materials in hoods with inadequate performance ratings.
11. Do not use the hood bench as a storage area.
12. Do not block the rear slots with bottles, boxes etc..
13. Keep objects at least 6 inches behind the hood face.

Following the above guidelines will help improve hood operation and will increase the hood operators level of protection.