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HEALTH DIVISION

MINIMUM ACCEPTABLE FACE VELOCITIES OF LABORATORY FUME HOODS AND GUIDELINES FOR THEIR CLASSIFICATION

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ABSTRACT

This report summarizes the data developed to support the requirement of a 100 LFM minimum face velocity requirement for laboratory fume hoods. Also included is a description of the Y-12 test hood as well as guidelines for a hood classification scheme.

INTRODUCTION

In February 1974, a joint study was undertaken by ORNL, ORGDP and Y-12 to determine the adequacy of laboratory (fume) hoods. The purpose of this report is to summarize the data which has been collected to define adequate face velocities for specific hood classifications.

In March 1974, recommended guidelines for the classification of laboratory hoods was issued by industrial hygiene representatives of the four UCC-ND plants (see Appendix A). It was recognized that utilization of any classification scheme would, in actual practice, be difficult to administer effectively. In addition, professional judgment would be required to review special situations and make exceptions to the established classifications.

To reconcile difficulties a multiple approach was taken. A test hood was purchased and installed in the Y-12 plant to determine adequacy of given flow rates for given concentrations of toxic chemicals. A complete description of this installation is given in Appendix B. In addition, breathing zone sampling was conducted for a significant number of actual operations involving a variety of toxic chemicals. Also, synthetic situations were employed using multiple concentration factors of TLV's for carbon monoxide and perchloroethylene. A complete description of each of these activities is presented.

DISCUSSION

I. Laboratory Test Hood (Y-12).

Data on three test chemicals are given in Table 1. Because of the generation method used, it was not possible to determine the precise concentration inside the hood. Concentrations generated inside the hood were therefore assigned a greater than or equal concentration.

From these data it is apparent that a flow rate of 100 LFM (with 40% sash opening) will prevent the concentration in the breathing zone from exceeding the TLV on carbon tetrachloride and perchloroethylene. It is also apparent that handling Freon 113 under most conditions would not present a problem.

In actual practice, professional judgment would be applied to situations involving carbon tetrachloride and a minimum flow rate of 125 LFM would probably be recommended. Regardless of the flow rate

on a given hood, breathing zone sampling would be required to insure the adequacy of the ventilation system in preventing exposure to materials as toxic as CCL_4, Beryllium, carcinogens, etc.

II. Breathing Zone Measurements

A. ORNL Data. The data in Table 2 represent workroom air samples taken in the breathing zone of workers during actual operations which were being performed in laboratory hoods. In all cases these results reflect "live" workroom conditions; that is, none were synthetic or mock-up to provide a sample. Concentrations of contaminants are in parts per million parts air by volume (ppm), with the exception of those for mercury and beryllium which, of course, are expressed in milligrams per cubic meter of air (mg/m^3). Threshold Limit Values (TLV's) are expressed in the same units. In the operations sampled none of the contaminants used exceeded or even approached the TLV concentrations. From these data, it seems reasonable to conclude that a face velocity of 100 LFM (with 40% sash opening) is adequate to control breathing zone concentrations of most contaminants used in ORNL laboratory hood operations.

B. Y-12 Data. As with the ORNL data (previous paragraph), data have been collected and summarized in Tables 3 and 4 for Y-12 operations. These data also were collected during actual operations and reflect the concentrations to which employees would have been exposed had respiratory protection not been used. Data in Table 3 summarizes the results of 221 breathing zone samples for beryllium and 381 breathing zone samples for uranium. Since the operations involve very small quantities of the materials, the potential for exposure is very low. The air flows versus concentrations detected suggest protection can be achieved with fairly low face velocities in operations of this type. However, operations of this type are subject to day-to-day changes. Hence, professional judgement would dictate 100 LFM as the minimum face velocity for these operations.

Data in Table 4 were secured during operations involving large quantities of beryllium powder of fairly small particle size. These breathing zone samples were secured on employees using respiratory

protection and clearly show that for these operations 134 and 124 LFM would not have been adequate to protect the employees from concentrations in excess of the TLV.

C. ORGDP Data. The data in Table 5 represent ORGDP air samples secured in the breathing zone of workers during actual operations being performed involving the contaminant identified. Except as indicated the face velocities were measured with the sash full open. Consequently, all face velocities would increase to $\geq$100 LFM with a 40% sash opening. Here again it is apparent that under the conditions of the tests, 100 LFM face velocity is adequate to prevent concentration approaching the TLV in the breathing zone.

III. Synthetic Situations for Breathing Zone Sampling

At ORNL as an alternative to performing breathing zone sampling on every employee potentially exposed to a toxic chemical, a system was devised using carbon monoxide as the test gas. Pure carbon monoxide gas was metered in at the air foil on a series of hoods in quantities sufficient to produce 10 TLV's of CO (500 ppm). The individual performing the test then went through a series of motions designed to simulate actual work movements. Breathing zone concentrations were determined during these activities. These tests were conducted on ∿350 laboratory hoods in the 4500 complex. Some 1000 to 1200 determinations were made during this investigation for carbon monoxide in the breathing zone.

The highest concentration detected was <5ppm or <10% TLV. (Note: 5 ppm is considered the lower limit of detection for the MSA carbon monoxide detector tube.) These data suggest that air flows of 100 LFM or greater (at a 40% sash opening) do, in fact, protect the employees from exposure to carbon monoxide in excess of the TLV.

Similar studies were conducted by Y-12 using perchloroethylene. Their data also showed that adequate protection is afforded the employee at face velocities of 100 LFM at a 40% sash opening.

CONCLUSIONS

1. Based on the data contained in this report the Industrial Hygienists at ORNL, Y-12, and ORGDP are of the opinion that 100 LFM at a 40% sash opening is the minimum acceptable face velocity for laboratory hoods. Additionally certain operations will require greater face velocities. Note: This recommended face velocity (100 LFM), in no way contradicts the results of the Paducah study (KY-L-714), i.e., a hood designed to 50 LFM with the sash full open would have a face velocity of at least 100 LFM with the sash at the 40% open point.
2. Professional judgement must be used in operations involving highly toxic chemicals, i.e., carcinogens, beryllium, etc.
3. Supportative data, i.e., breathing zone sampling, is necessary on chemicals assigned a toxic index of 3 or 4.
4. Because of the inherent problems of administering a hood classification system, the system should not be adopted formally but remain as Guidelines.

GENERAL COMMENTS

1. Laboratory hoods should be given a precise definition. For example: process ventilation in beryllium areas at Y-12 have been incorrectly characterized as laboratory hoods. Process ventilation installed to prevent exposure to any chemical or physical stress must be carefully designed and their adequacy evaluated.
2. It should be reiterated that operations particularly at ORNL and Y-12 are many and varied. Programs tend to change rapidly. Ventilation requirements may also change just as rapidly depending on the process and/or the likelihood of exposure to a chemical or physical stress.
3. Informal discussions were held with industrial hygienists of LASL and ANL. The Engineering Section, Industrial Hygiene Group (H-5) at LASL advised that as a "general rule of thumb" 100 LFM is the minimum face velocity permitted for handling toxic chemicals and 125 LFM is the minimum face velocity for radioactive materials.

They recognized that professional judgement was of considerable importance and was used in relation to highly toxic chemicals such as beryllium or carcinogens. In these cases 125 to 150 LFM would be recommended. Breathing zone samples would be performed only if considered necessary by the staff. Industrial hygiene at ANL advised they also use "rule of thumb" of 100 LFM for most chemicals and 135 LFM for radioactive materials. They recognize that some chemicals are handled in certain operations which require greater flow rates. They also use a generous amount of professional judgement.

4. These conclusions and comments in no way contradict the requirements of "General Design Criteria, Laboratory Buildings, ERDA Appendix 6301, Part II B (Approved November 20, 1972) which states: "An average air velocity of about 125 fpm across the face of each hood with the door opened to the full open operating position is recommended as a general rating. Higher or lower velocities may be justified under special circumstances depending upon the materials to be handled and their toxicity."

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TABLE 1

TEST HOOD DATA

	Hood Face Velocity (LFM)	Maximum Breathing Zone (ppm)	Average Breathing Zone (ppm)	% TLV	TLV (ppm)
Carbon tetrachloride					
Hood Conc. ≥100 ppm	150	4.6	4.6	46	10
≥100 ppm	125	4.6	4.6	46	
≥100 ppm	100	4.6	4.6	46	
≥100 ppm	75	60	15.2	152	
≥100 ppm	50	27	9.5	95	
Perchloroethylene					
Hood Conc. ≥1000 ppm	150	0.9	0.9	.9	100
≥1000 ppm	125	0.9	0.9	.9	
≥ 500 ppm	100	0.9	0.9	.9	
≥1000 ppm	100	1	0.9	.9	
≥ 500 ppm	75	13	3.4	3.4	
≥1000 ppm	75	110	25.6	25.6	
≥ 500 ppm	50	8	2.2	2.2	
Freon 113					
Hood Conc. ≥ 5,000 ppm	150	0.7	0.7	.07	1000
≥10,000 ppm	150	2	.86	.09	
≥ 5,000 ppm	125	0.7	0.7	.07	
≥10,000 ppm	125	30	4.4	.44	
≥ 1,000 ppm	100	15	4.2	.42	
≥ 2,000 ppm	100	100	17.9	1.8	
≥ 1,000 ppm	75	55	11.4	1.1	
≥ 1,000 ppm	50	210	43	4.3	

Note: These data are illustrated graphically in Figures 1 and 2.

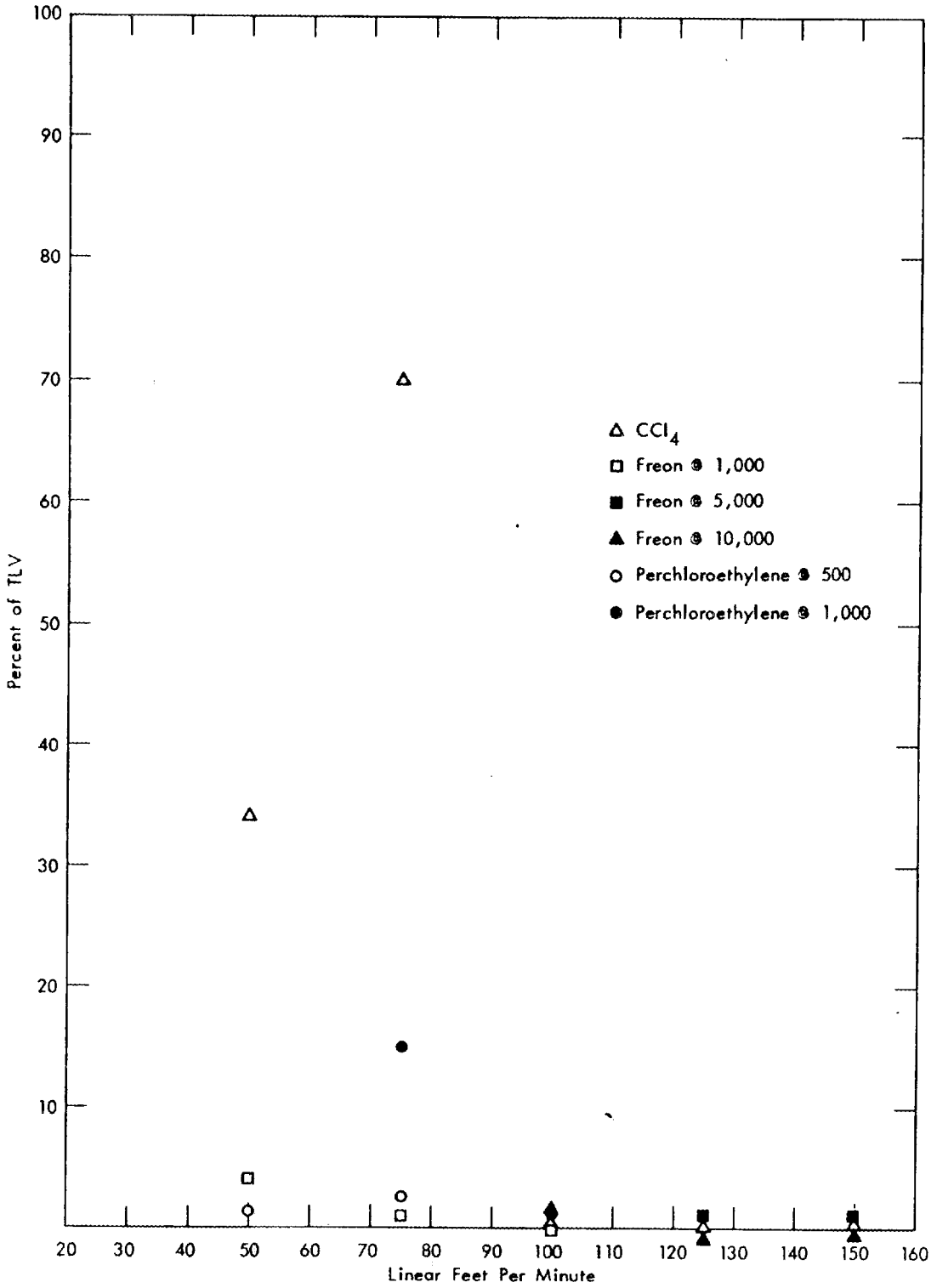

Figure 1. Summated Average Measured Concentrations.

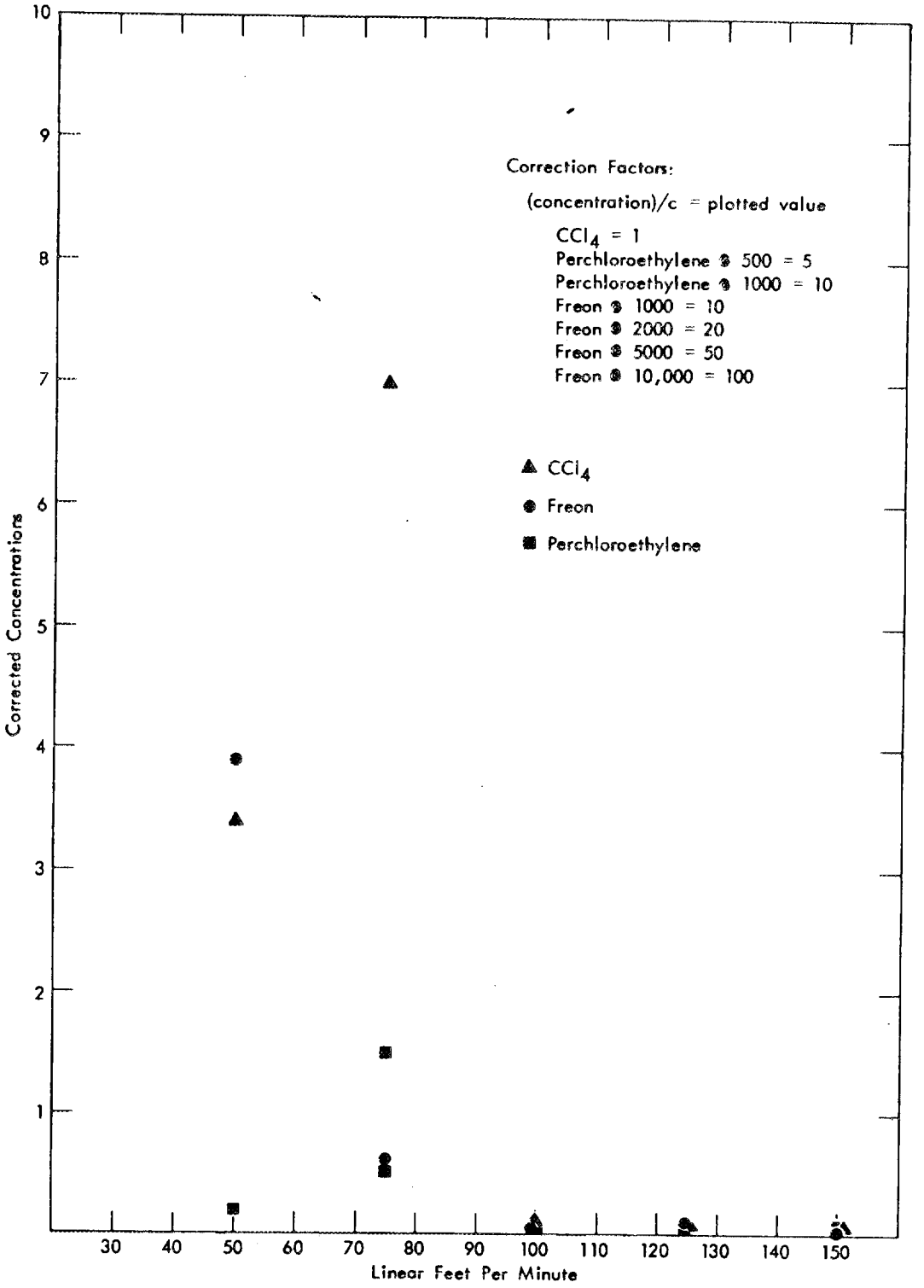

Figure 2. Summated Average Measured (Corrected) Concentrations.

TABLE 2

AIR SAMPLING DATA FOR OPERATIONS CONDUCTED IN HOODS AT ORNL

Date	Location	Contaminant	BZ Conc.*	TLV	Face Velocity (LFM)
2-21-73	4508 Rm. 139A	Benzene	<1	25	80
2-21-73	4508 Rm. 139A	Benzene	1	25	80
2-21-73	4508 Rm. 139A	Benzene	4.4	25	80
2-16-73	4508 Rm. 140	Benzene	2.8	25	
4-30-73	4500S	Dioxane	1.4	100	
4-30-73	4500S	Toluene	<1	100	
5-9-73	3502 Manipulator	Methyl Ethyl Ketone	90	200	170
5-9-73	3502 Manipulator Shop	Methyl Ethyl Ketone	40	200	170
5-29-73	4508 Rm. 139A	Benzene	7.5	25	110
6-5-73	4500S Rm. C-155	Toluene	<1	100	100
6-14-73	6010 Basement	Xylene	<1	100	140
11-28-73	3502 Manipulator Shop	Methyl Ethyl Ketone	<1	200	130
1-31-74	4500S Rm. E-159	Toluene	<10	100	90
2-15-74	4508 Rm. 139	Tetrabromoethane	≤.001	1	85
2-15-74	4508 Rm. 139	Methylene Iodide	≤.05	1	85
2-19-74	4500S Rm. F-63	Toluene	<10	100	70
2-19-74	4508 Rm. 139A	Benzene	<2.5	25	65
2-21-74	3502 Manipulator Shop	Methyl Ethyl Ketone	30.3	200	75
2-21-74	3502 Manipulator Shop	Methyl Ethyl Ketone	<20	200	75
2-25-74	4500S Rm. D-263	Tetrachloroethane	.31	5	140
2-26-74	4500N Rm. E-17	Carbon Tetrachloride	1.3	10	140
3-1-74	4500N Rm. E-17	Carbon Tetrachloride	<1	10	140
3-1-74	4500N Rm. E-17	Carbon Tetrachloride	3.0	10	140
4-3-74	2001 Rm. 201	Hydrofluoric Acid	.5	3	110
4-3-74	2001 Rm. 201	Hydrofluoric Acid	<.3	3	110
4-16-74	4500N Rm. A-13	Xylene	<10	100	130
4-16-74	4500N Rm. A-13	Dioxane	<10	100	130
4-16-74	3502 Manipulator Shop	Methyl Ethyl Ketone	<20	200	75

* Breathing Zone Concentration

TABLE 2 (Continued)

Date	Location	Contaminant	BZ Conc.*	TLV	Face Velocity (LFM)
4-16-74	3502 Manipulator Shop	Methyl Ethyl Ketone	<20	200	75
4-18-74	4500N Rm. B-1	Trichloroethylene	<10	100	120
4-22-74	4500S Rm. R-147	Mercury	< .005	.05	110
4-29-74	2001 Rm. 201	Hydrofluoric Acid	<0.3	3	110
5-17-74	3502 Manipulator Shop	Methyl Ethyl Ketone	<20	200	75
6-3-74	3502 Manipulator Shop	Methyl Ethyl Ketone	<20	200	75
6-4-74	3502 Manipulator Shop	Methyl Ethyl Ketone	<20	200	75
6-4-74	3502 Manipulator Shop	Xylene	<10	100	75
6-17-74	4508 Rm. 139A	Benzene	4.8	25	170
6-17-74	4508 Rm. 139A	Benzene	< 2.5	25	170
6-17-74	4508 Rm. 139A	Benzene	< 2.5	25	170
6-26-74	3047 Rm. 209	Toluene	<10	100	160
6-26-74	3047 Rm. 209	Toluene	<10	100	160
7-10-74	4508 Rm. 139A	Benzene	4.6	25	170
7-15-74	3502 Manipulator Shop	Methyl Ethyl Ketone	<20	200	75
8-8-74	4500S Rm. R-259	Beryllium	< 0.0002	0.002	170
8-16-74	4508 Rm. 139A	Benzene	< 2.5	25	160
8-28-74	4508 Rm. 139A	Benzene	< 2.5	25	160
8-29-74	4508 Rm. 139A	Benzene	< 2.5	25	160
9-5-74	4508 Rm. 139A	Benzene	< 1	25	160
9-6-74	3502 Manipulator Shop	Methyl Ethyl Ketone	4.5	200	75
9-6-74	3502 Manipulator Shop	Methyl Ethyl Ketone	6.1	200	75
9-5-74	4508 Rm. 139A	Benzene	2.1	25	160
9-5-74	4508 Rm. 139A	Benzene	2.5	25	160
9-5-74	4508 Rm. 139A	Benzene	< 1	25	160
9-5-74	4508 Rm. 139A	Benzene	2.8	25	160
9-17-74	4508 Rm. 139A	Benzene	1.3	25	160
9-17-74	4508 Rm. 139A	Benzene	2.7	25	160

* Breathing Zone Concentration

TABLE 3

AIR SAMPLING DATA FOR OPERATIONS CONDUCTED IN HOODS AT Y-12

Date	Location	Contaminant	BZ Conc.*	TLV	Face Velocity (LFM)
1-1-73 to 7-1-74	9995 Hood #63A	Beryllium	<0.1 (1)	2 μg/m³	144
1-1-73 to 7-1-74	9995 Hood #63D	Beryllium	<0.1 (2)	2 μg/m³	186
1-1-73 7-1-74	9995 Hood #64A	Beryllium	<0.1 (3)	2 μg/m³	100
1-1-73 7-1-74	9995 Hood #81A	Beryllium	<0.1 (4)	2 μg/m³	64
1-1-73 8-1-74	9995 Hood #53C	Uranium	<4 d/m/m³ (5)	35 d/m/m³	74
1-1-73 to 8-1-74	9995 Hood #54A	Uranium	<4 d/m/m³ (6)	35 d/m/m³	71

(1) Represents results of 56 samples.

(2) Represents results of 57 samples.

(3) Represents results of 55 samples.

(4) Represents results of 53 samples.

(5) Represents results of 190 samples.

(6) Represents results of 191 samples.

* Breathing Zone Concentration

TABLE 4

AIR SAMPLING DATA FOR OPERATIONS CONDUCTED IN HOODS AT Y-12

Date	Location	Contaminant	BZ Conc.*	TLV	Face Velocity (LFM)
10-23-70	9201-5, 3rd Floor Hood #61	Beryllium	9.3 $\mu g/m^3$	2 $\mu g/m^3$	134
10-26-70	9201-5, 3rd Floor Hood #61	Beryllium	3.3 $\mu g/m^3$	2 $\mu g/m^3$	134
11-1-70	9201-5, 3rd Floor Hood #61	Beryllium	10.6 $\mu g/m^3$	2 $\mu g/m^3$	134
11-4-70	9201-5, 3rd Floor Hood #61	Beryllium	2.9 $\mu g/m^3$	2 $\mu g/m^3$	134
11-6-70	9201-5, 3rd Floor Hood #61	Beryllium	2.2 $\mu g/m^3$	2 $\mu g/m^3$	134
11-9-70	9201-5, 3rd Floor Hood #61	Beryllium	5.2 $\mu g/m^3$	2 $\mu g/m^3$	134
11-10-70	9201-5, 3rd Floor Hood #61	Beryllium	8.8 $\mu g/m^3$	2 $\mu g/m^3$	134
11-11-70	9201-5, 3rd Floor Hood #61	Beryllium	2.0 $\mu g/m^3$	2 $\mu g/m^3$	134
11-13-70	9201-5, 3rd Floor Hood #61	Beryllium	6.4 $\mu g/m^3$	2 $\mu g/m^3$	134
2-1-70	9201-5, 3rd Floor Hood #61	Beryllium	0.1 $\mu g/m^3$	2 $\mu g/m^3$	134
10-22-70	9201-5, Hood #62	Beryllium	0.1 $\mu g/m^3$	2 $\mu g/m^3$	124
10-23-70	9201-5, Hood #62	Beryllium	1.7 $\mu g/m^3$	2 $\mu g/m^3$	124
10-26-70	9201-5, Hood #62	Beryllium	3.3 $\mu g/m^3$	2 $\mu g/m^3$	124
11-1-70	9201-5, Hood #62	Beryllium	2.0 $\mu g/m^3$	2 $\mu g/m^3$	124
11-4-70	9201-5, Hood #62	Beryllium	2.0 $\mu g/m^3$	2 $\mu g/m^3$	124
11-6-70	9201-5, Hood #62	Beryllium	0.5 $\mu g/m^3$	2 $\mu g/m^3$	124
11-9-70	9201-5, Hood #62	Beryllium	2.2 $\mu g/m^3$	2 $\mu g/m^3$	124
11-11-70	9201-5, Hood #62	Beryllium	16.7 $\mu g/m^3$	2 $\mu g/m^3$	124
11-10-70	9201-5, Hood #62	Beryllium	8.7 $\mu g/m^3$	2 $\mu g/m^3$	124
11-13-70	9201-5, Hood #62	Beryllium	0.4 $\mu g/m^3$	2 $\mu g/m^3$	124
8-1-73	9201-5, 2nd Floor Hood #22	Beryllium	0.68 $\mu g/m^3$	2 $\mu g/m^3$	124
8-1-73	9201-5, 2nd Floor Hood #20	Beryllium	0.28 $\mu g/m^3$	2 $\mu g/m^3$	124

TABLE 4 (Continued)

Date	Location	Contaminant	BZ Conc. *	TLV	Face Velocity (LFM)
8-1-73	9201-5, 2nd Floor Hood #20	Beryllium	0.66 $\mu g/m^3$	2 $\mu g/m^3$	124
8-2-73	9201-5, 2nd Floor Hood #22	Beryllium	0.47 $\mu g/m^3$	2 $\mu g/m^3$	124
8-2-73	9201-5, 2nd Floor Hood #19	Beryllium	0.33 $\mu g/m^3$	2 $\mu g/m^3$	124
8-2-73	9201-5, 2nd Floor Hood #19	Beryllium	0.31 $\mu g/m^3$	2 $\mu g/m^3$	124

* Breathing Zone Concentration

TABLE 5

AIR SAMPLING DATA FOR OPERATIONS CONDUCTED IN HOODS AT K-25

Date	Location	Contaminant	BZ Conc.*	TLV	Face Velocity (LFM)
10-1-74	K-1004-A-19-248069	Trichloroethane	<50 ppm	350	70
10-1-74	K-1004-A-18-259019	Nitrous Fumes	0 ppm	5	85
10-1-74	K-1004-A-19-259020	Ammonium Hydroxide	0 ppm	25	85
10-1-74	K-1004-A-19-259021	Hydrogen Chloride	0 ppm	5	110
10-8-74	K-1004-L-23-248533	Acetone	<100 ppm	1000	50
10-8-74	K-1004-L-9-248535	Acetone	<100 ppm	1000	95
10-8-74	K-1004-L-9-248534	Acetone	<100 ppm	1000	110
10-8-74	K-1004-L-6-24857	Acetone	<100 ppm	1000	80
10-8-74	K-1006-B-102-249674	Benzene	0 ppm	10	40
10-8-74	K-1006-C-101-249726	Hydrogen Chloride	0 ppm	5	90
10-8-74	K-1006-C-108-249688	Acetone	<100 ppm	1000	125
10-8-74	K-1006-C-104-249723	Hydrogen Floride	0 ppm	3	85
10-8-74	K-1006-C-108-249715	Hydrogen Chloride	0 ppm	5	90
10-31-74	K-1004-D-17-187105	Trichloroethane	<50 ppm	350	50
10-31-74	K-1004-D-31-187195	Hydrogen Floride	0 ppm	3	110
10-2-74	K-1004-B-150-248092	Acetone	<100 ppm	1000	125
10-1-74	K-1004-B-108-255561	Hydrogen Chloride	0 ppm	5	95
10-1-74	K-1004-B-108-255562	Hydrogen Chloride	0 ppm	5	120
10-1-74	K-1004-B-108-255559	Hydrogen Chloride	0 ppm	5	65
10-1-74	K-1004-B-108-255560	Hydrogen Chloride	0 ppm	5	100
9-27-74	K-1004-B-118-255573	Hydrogen Chloride	0 ppm	5	85
9-27-74	K-1004-B-114-248008	Hydrogen Floride	0 ppm	3	50
9-27-74	K-1004-B-103-248018	Hydrogen Floride	0 ppm	3	65
9-27-74	K-1004-B-103-246780	Hydrogen Chloride	0 ppm	5	205
10-31-74	K-1004-D-28-248088	Hydrogen Chloride	0 ppm	5	40
10-3-74	K-1101-Lab-248547	Hydrogen Chloride	0 ppm	5	75
10-3-74	K-1413-Lab-258400	Hydrogen Chloride	0 ppm	5	65
10-3-74	K-1420-Lab-258525	Hydrogen Chloride	0 ppm	5	40
10-3-74	K-1010-A-253390	Perchloroethylene	0 ppm	100	30
10-3-74	K-1231-104	Hydrogen Chloride	0 ppm	5	75
9-30-74	K-1004-C-210-258858	Trichloroethane	<100 ppm	350	60
9-30-74	K-1004-C-212-258857	Hydrogen Floride	0 ppm	3	55
9-30-74	K-1004-C-219-256053	Hydrogen Floride	0 ppm	5	85
9-30-74	K-1004-C-220-256051	Hydrogen Chloride	0 ppm	5	100
9-30-74	K-1004-C-215-255237	Hydrogen Floride	0 ppm	3	120
9-30-74	K-1004-C-215-255237	Hydrogen Chloride	0 ppm	5	120
9-30-74	K-1004-C-215-255237	Nitrous Fumes	0 ppm	5	120
9-30-74	K-1004-C-215-255237	Acetone	<100 ppm	1000	120

APPENDIX A

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UCND - Safety and Envionmental
Protection
9704-2, Y-12

March 25, 1974

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LABORATORY HOODS
CLASSIFICATION GUIDELINES

On December 4, 1973, J. F. Morehead (Y-12), H. F. Higdon (ORGDP) and I met to discuss problems of hood classifications. Although Turok (PGDP) was not in attendance he has reviewed the "Classification Guidelines" and is in agreement with us. We suggest that the attached Guidelines be used when or if we are required to classify hoods in terms of the toxic materials being handled. This system will, we believe, result in the least confusion. As experienced is gained we may need to make changes in the TLV ranges for each class.

I would hope that these guidelines would not end "being carved in stone." For example, if it could be demonstrated under actual use conditions that the TLV were not exceeded, a Class II hood could be used for any given material.

N. E. Bolton
ORNL, Industrial Hygiene Department

NEB:rcw

Attachments

LABORATORY HOODS

Classification Guidelines

Selection Requirements

For purposes of selection of the class hood required the following definitions shall be used:

Toxicity

High - Gases and vapors having a TLV of $\leq$10 ppm.
Dusts, fumes and mists having a TLV of <0.1 mg/M^3.

Moderate - Gases and vapors having a TLV of >10 to 200 ppm.
Dusts, fumes and mists having a TLV of 0.1 to 0.5 mg/M^3.

Low - Gases and vapors having a TLV of >200 ppm.
Dusts, fumes and mists having a TLV of >0.5 mg/M^3.

Note: The Industrial Hygiene Department shall be contacted in the event that operations involve chemicals with either a C or skin denotation. The proper hood classification required for chemicals in these categories will be determined on the basis of professional judgement.

Alternate Selection Requirements

If TLV's are not established, the following data may be used to determine hood classification requirements.

Hood Classification Requirements	Toxic Index	LD_{50} Single Oral Dose Rats mg/Kg	LC_{50} 4 hr. Inhalation ppm	LD_{50} Skin mg/Kg	Approximate TLV Range
I	1	501-15,000	1,001-100,000	350-22,600	>200 ppm or >0.5 mg/M^3
	2	50.1-500	101-1,000	44-349	
II	3	1.1-50	11-100	5.1-43	≥10 - <200 ppm or ≥0.1 - <0.5 mg/M^3
111	4	≤1	<10	≤5	<10 ppm or <0.1 mg/M^3

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Classification

Hoods for general laboratory usage shall be classified in the following categories:

Class 1 - For handling a) non-toxic or low toxicity materials or b) higher toxic materials in sealed containers and/or closed systems.

Class 2 - For handling of moderately toxic materials.

Class 3 - For handling of highly toxic materials.

Airflow Requirements

Laboratory hoods, when operating with the sash set at the Normal Operating Opening shall have face velocities as follows:

Class 1 - Design airflow shall be 60 ft/min.
Minimum airflow shall be 50 ft/min.

Class 2 - Design airflow shall be 100 ft/min.
Minimum airflow shall be 80 ft/min.

Class 3 - Design airflow shall be 150 ft/min.
Minimum airflow shall be 125 ft/min.

Hood Identification

All Class I Hoods shall bear the following label:

CLASS I

Air flow requirements: Minimum 50 ft/min., design 60 ft/min. for chemicals in the following category:

Gases and vapors having a TLV of $\geq$200 ppm.
Dusts, fumes, and mists having a TLV of $\geq$0.5 mg/M^3.

For information: Call Industrial Hygiene Department.

All Class II Hoods shall bear the following label:

CLASS II

Air flow requirements: Minimum 80 ft/min., design 100 ft/min. for chemicals in the following category:

Gases and vapors having a TLV of $\geq$10 to <200 ppm
Dusts, fumes, and mists having a TLV of $\geq$0.1 to <0.5 mg/M^3.

For information: Call Industrial Hygiene Department.

All Class III Hoods shall bear the following label:

CLASS III

Air flow requirements: Minimum 125 ft./min., design 150 ft/min., for chemicals in the following category:

Gases and vapors having a TLV of <10 ppm.
Dusts, fumes, and mists having a TLV of <0.1 mg/M^3.

For information: Call Industrial Hygiene Department.

APPENDIX B

DESCRIPTION OF THE Y-12 LABORATORY TEST HOOD

DESCRIPTION OF THE Y-12 LABORATORY TEST HOOD

I. TESTING SET-UP

The Y-12 Test Hood (NII, Model H-804) is located in the northwest corner of Room 43, Building 9766. A counterbalanced, vertical sash is installed on the hood which can be easily moved up and down to vary the hood opening or close it off entirely. In order to simulate the actual conditions in hoods throughout the plant, several items were kept within the hood during testing. In the back right corner was a 14 oz. can of cleanser, a 1 liter flask, and the Scott-Davis Halide Meter (11" x 7" x 7"). In the back left corner was a 1 quart bottle, a 2 quart bottle, and a 1 gallon metal safe can. These are mentioned because any item within a hood in some way affects the airflow. A picture of the hood model with diagrams of unrestricted airflow is shown in Figure 1.

II. TEST GASES

Three materials were chosen to be tested:

Carbon Tetrachloride (CCL_4)

TLV - 10 ppm or 65 mg/m^3

Boiling Point - 170^0F.

Vapor Density (air = 1) - 5.32

Lower Detection Limit = 4.6 ppm or 30 mg/m^3

Perchloroethylene (C_2Cl_4)

TLV - 100 ppm/670 mg/m^3

Boiling Point - 248^0F.

Vapor Density (air = 1) - 5.67

Lower Detection Limit = 0.9 ppm or 6.03 mg/m^3

Freon 113, Trichlorotrifluorethane (CCl_2F-$CClF_2$)

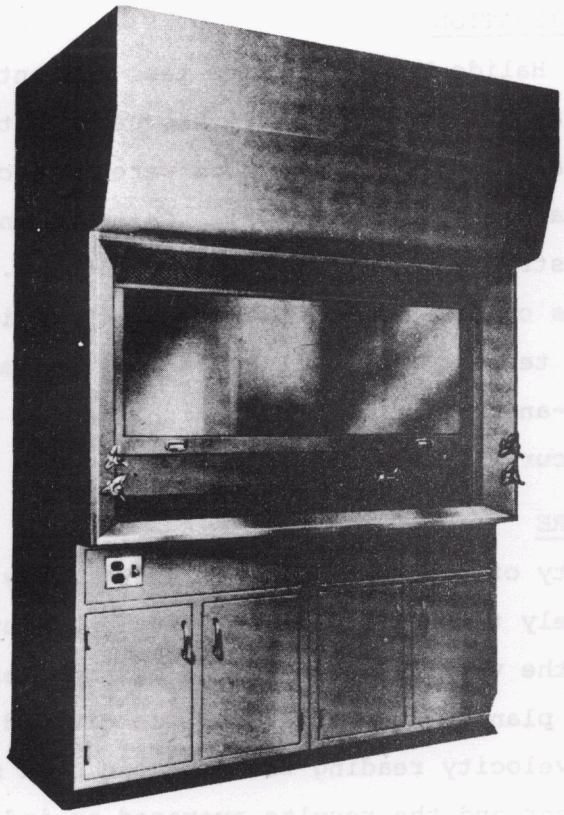
TLV - 1,000 ppm/7,600 mg/m^3

Boiling Point - 117^0F.

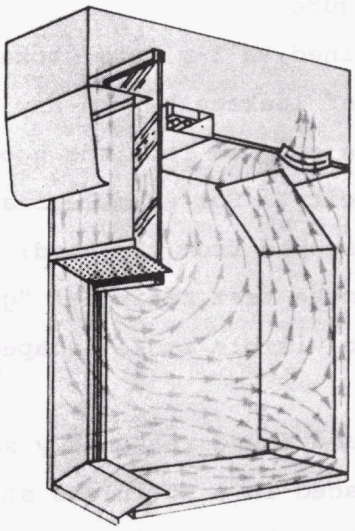
Vapor Density (air = 1) - 6.46

Lower Detection Limit = 0.7 ppm or 5.32 mg/m^3

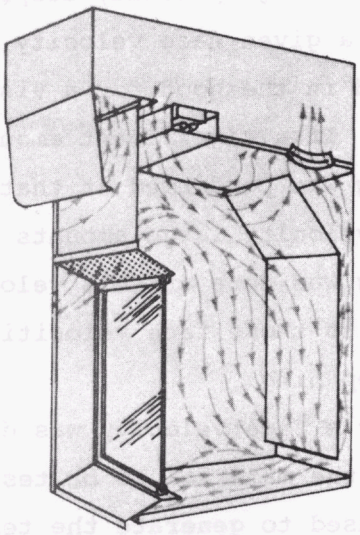
These gases were picked primarily because of the range of TLV's represented, and the availability of instrumentation.



H-804 V.I.P. HOOD



SASH IN OPEN POSITION



SASH IN CLOSED POSITION

Figure 1. Fume Hood-V.I.P. Series H-800.

Note: Specific Design Data and Operating Characteristics of this Fume Hood are given on page 66 of Catalog of Laboratory Furniture, Inc. (Copyright 1973).

III. INSTRUMENT CALIBRATION

The Scott-Davis Halide Meter, used to test concentrations inside the hood and the Miran Infrared Gas Analyzer, used to test breathing zone concentrations at the face of the hood were both calibrated at the Y-12 Plant Laboratory (Building 9995). Calibration curves were provided for both instruments for the three test gases. The Alnor Thermo-anemometer was calibrated by Y-12 electrical maintenance and a curve provided. The technique used is given in Attachment 1. Later, another Alnor Thermo-anemometer was used which read in actual feet per minute making a curve unnecessary.

IV. TESTING PROCEDURE

The face velocity of the test hood was adjusted by means of a damper to approximately the desired measurement. Measurements were normally taken with the vertical sash at its maximum height (face opening= 29 2/3" x 61"). The plane of the hood face was divided into 8 equally spaced sections. A velocity reading was taken in each section with an Alnor Thermo-anemometer and the results averaged as indicated in Table 1. Table 2 illustrates the effect of the sash position on face velocity. This effect is graphically displayed in Figure 2.

Once a given face velocity was determined, a 3-minute smoke bomb was placed in the hood for a visual check of leakage before any testing was done. If a significant amount of smoke escaped from the hood opening, no testing was performed at that face velocity. For example: at 25 fpm face velocity large amounts of smoke escaped from the hood; therefore, no testing was done at this velocity. A smoke test rating of "good" was given to those face velocities where no visible smoke escaped from the hood opening.

After a face velocity was determined and found reasonably safe, an amount of the material to be tested was placed in a stainless steel electric fry pan, used to generate the tested vaports. All testing was done with the fry pan in 2 positions -- in the middle of the hood and in the extreme left of the hood-- both positions were 4 inches from the lower edge of the hood face. At the extreme right inside the hood was a sink which precluded testing in that position.

TABLE 1

THERMO-ANEMOMETER READINGS FOR TESTED FACE VELOCITIES

150 Feet Per Minute	165[1]	155	165	175
	160	145	155	150
Indicated Average - 159				
Meter Indicated 164 = Actual 150				
Actual Average - 146				
	145	155	135	140
	130	130	130	140
Indicated Average - 138				
Meter Indicated 164 = Actual 125				
Actual Average - 123				
(Change in Thermo-Anenometers - Meter Indicated Now Equals Readings)				
100 Feet Per Minute	100	95	105	110
	95	90	100	110
Average - 101				
75 Feet Per Minute	75	70	75	80
	85	75	75	70
Average - 76				
50 Feet Per Minute	50	50	50	50
	55	45	50	45
Average - 49				
25 Feet Per Minute	25	20	25	25
	30	25	20	25
Average - 25				

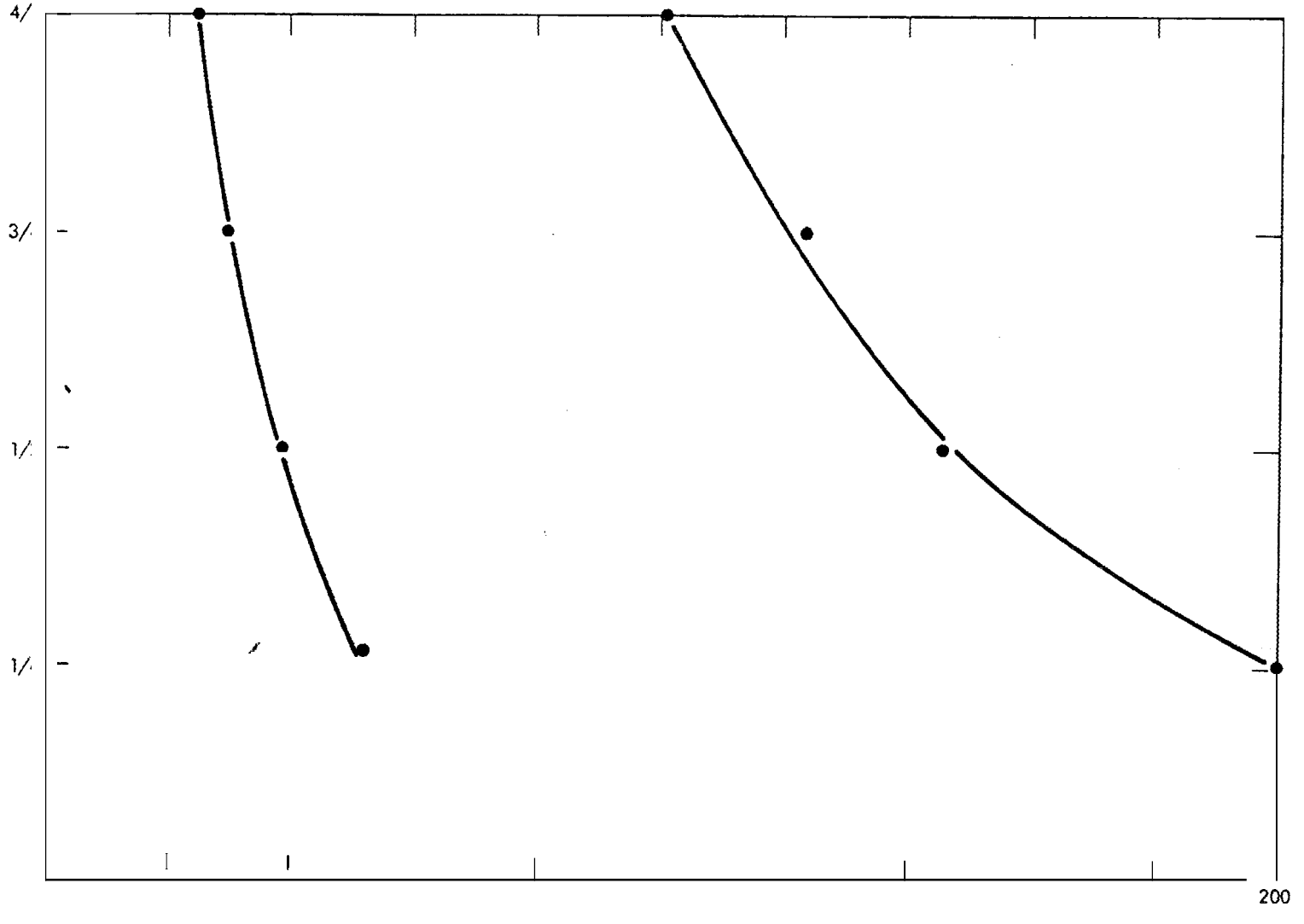
[1]The values given are in feet per minute (fpm).

TABLE 2

THERMO-ANEMOMETER READINGS FOR CHANGES IN HEIGHT OF VERTICAL SASH

100 Feet Per Minute					
	Fully Open Sash	100[1]	95	105	110
		95	90	100	110
	Average - 101				
	3/4 Open Sash	120	115	125	135
	Average - 124				
	1/2 Open Sash	145	140	150	150
	Average - 146				
	1/4 Open Sash	220	195	210	210
	Average - 209				
25 Feet Per Minute					
	Fully Open Sash	25	20	25	30
		30	25	20	25
	Average - 25				
	3/4 Open Sash	30	25	30	30
	Average - 30				
	1/2 Open Sash	40	35	40	40
	Average - 39				
	1/4 Open Sash	50	50	55	55
	Average - 52				

[1]The values given are in feet per minute (fpm).


4/
3/
1/
1/
200

The inside concentrations were tested 4 inches above the fry pan with a Scott-Davis Halide Meter. Because of turbulence inside the hood, concentrations fluctuated; therefore, meter readings were kept at or slightly above the level necessary for a given concentration.

Once a given concentration was establised, 8 readings were taken using the same grid pattern as face velocity readings with a Miran Infrared Gas Analyzer. The top sections corresponded approximately to the breathing zone of one standing at the hood, the bottom sections of one sitting on a high laboratory stool or chair. For each tested material at each inside concentration, 3 tests were made--with the fry pan on the extreme left, in the middle, and in the middle with a 7 inch diameter hot plate turned to its highest setting directly behind it.

Tests were to be made at 1, 2, 5, and 10 times the threshold limit of the 3 tested vapors. However, if no leakage was detected at the highest concentration further tests were considered unnecessary. In marginal situations a respirator was worn by the operator to prevent his being exposed to the test chemical.

Attachment 1

K-GD-826

CALIBRATION OF LOW VELOCITY ANEMOMETERS

Several low velocity anemometers were calibrated for environmental and safety personnel at the ORGDP and GAT in a low velocity wind tunnel built specifically for this purpose at the K-1303 Model Test Facility. Calibration was accomplished by video taping helium-filled soap bubbles as they passed a scale in the test section and calculating velocity by viewing the video tape frame by frame to determine the distance a bubble traveled in a specified time interval.

INSTRUMENTATION

The setup used in this calibration procedure is shown in Figure 1. The apparatus includes video equipment, a bubble generator, and a low velocity wind tunnel. The video equipment* consists of a high-speed camera, strobe light, recorder, and monitor. The camera takes 60 frames per second and is equipped with a zoom lens. The recorded tape may be played back at actual speed, half-speed, or one frame at a time. The bubble generating equipment at the left side of figure 1 forms helium-filled neutrally buoyant bubbles of controlled size from 1/16 inch to 1/4 inch diameter. Initially the wind tunnel was a 30-inch by 30-inch duct with a flared inlet and an outlet section converging to the permanent test stand piping. Observation of the flow in this tunnel revealed the presence of large vortices. A honeycomb section 18 inches long and with 2-inch cells was then then added upstream of the test section in conjunction with screens and succeeded in producing an acceptable flow pattern.

PROCEDURE

The calibration velocity was determined by measuring the distance which a bubble traveled in a specified time interval. A scale was attached inside the test section, and bubbles, introduced through a cell of the honeycomb section, passed about 6 inches in front of the scale. The bubbles passing the scale were video taped with the high-speed camera. The tape of these bubbles was replayed one frame at a time, and individual bubbles which appeared to be flowing parallel to the scale were traced. The distance through which a bubble traveled in a given number of frames, i.e., a specified, accurate time interval, determined its velocity. The average velocity of 20 bubbles was used as the calibration velocity. Only the bubbles which appeared to travel in a straight line were selected for velocity measurements. The variation of velocities among the individual bubbles was apparent in the turbulence relative intensity (T_u).

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* "Videostrobe" Model 800 system.

PHOTO NO. 73-1021

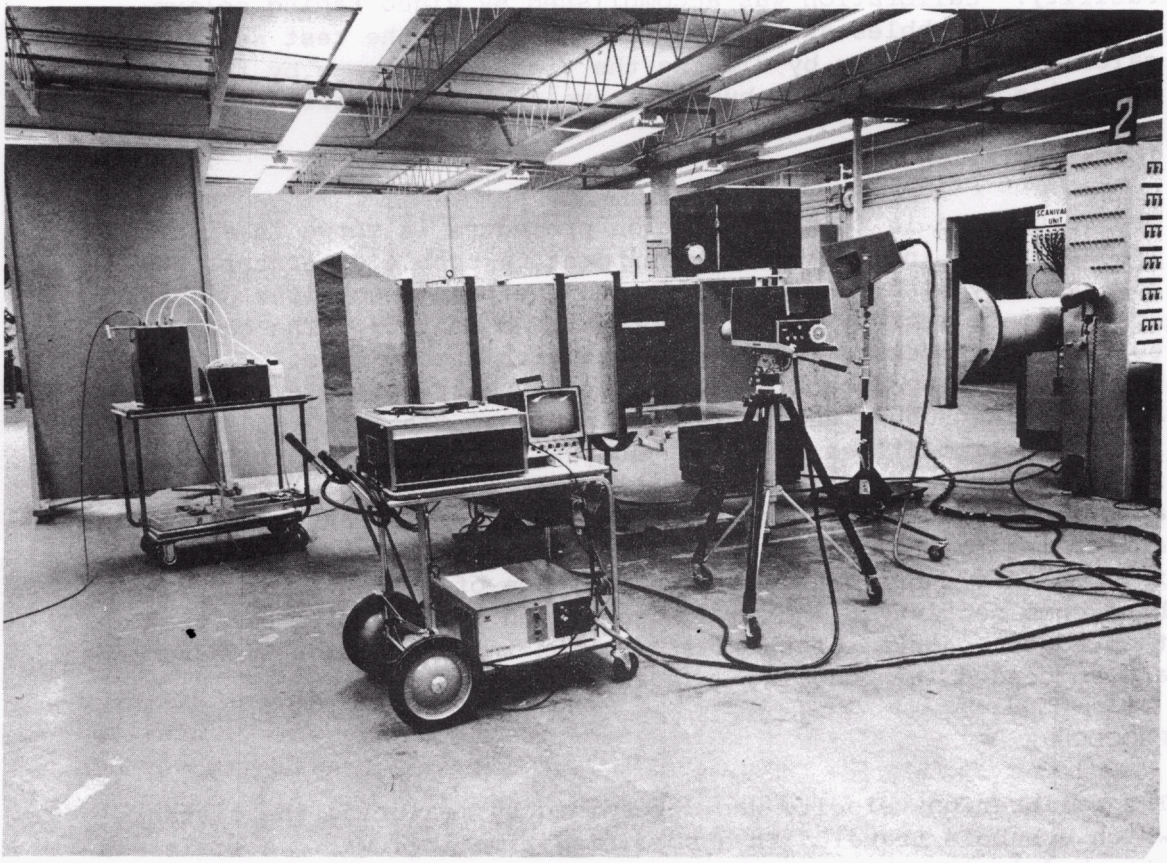

Figure 1. Anemometer Calibration Set-Up.

$$T_u = \frac{1}{V_B}\left[\sum_{i=1}^{n} (V_B - V_i)^2/n\right]^{1/2}$$

where n is the number of bubbles used in the calculation;
V_i is the individual bubble velocity; and
V_B is the average bubble velocity.

RESULTS

Four consecutive samplings of 20 bubbles showed a mean velocity variation of 2% and a turbulence intensity variation of 1%. The setup shown in Figure 1 is suitable for velocities from 50 to 800 fpm. For velocities less than 50 fpm, the turbulence introduced by the bubble generator probe is detectable. The velocity is limited to 800 fpm by the speed of the camera and the length of the scale.

The instrument to be calibrated was placed inside the test section at the same height as the scale and about 6 inches in front of it. The types of anemometers are shown in Figure 2. The Alnor type 3002 Velometer, the Anemothern 2135, and the Total-Vector anemometer did not function properly and could not be calibrated. The sensitivity of the Fluidic anemometer was so great that proper adjustment could not be maintained in the test section, and, therefore, it could not be calibrated. The remaining Alnor Velometer appeared to function reasonably well, but since no operating instructions were available, this instrument may have been improperly used. The two Taylor anemometers, the Alnor Thermo-anemometer, and the Anemothern 2448 functioned properly and were calibrated. The Flow Corporation anemometer was employed mainly to provide a turbulence check.

This low velocity calibration procedure provides an accurate and fairly inexpensive method for anemometer calibration. The system will be maintained for periodic application.

PHOTO NO. 73-938

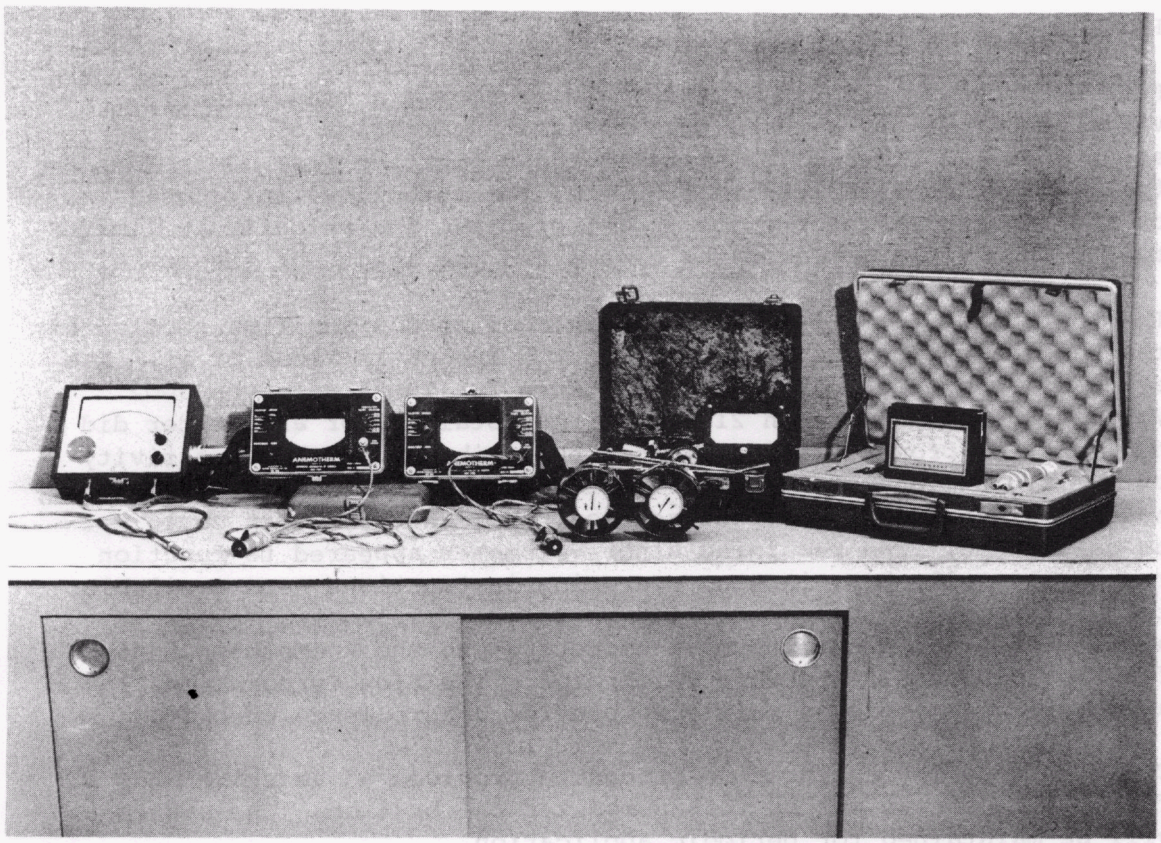

Figure 2. Low Velocity Anemometers.

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