3M

3500/3520 Organic Vapor Monitor

Analysis Guide

December 1992

ANOTHER STEP TOWARDS BETTER OCCUPATIONAL HEALTH AND SAFETY

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3M Occupational Health & Environmental Safety Division
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3M
Organic Vapor Monitor
Analysis Guide

INTORDUCTION

The 1992 Analysis Guide contains 32 new compounds and updated capacity and recovery data. In addition, sampling rates on the following fifteen compounds were revised.

- S-Amyl Alcohol
- Butyl Acrylate
- 1-Chloro-1-nitropropane
- Dimethyl Foramide
- Furfuryl Alcohol
- S-Hexyl Acetate
- Methyl Bromide
- Methyl Cyclohexanol
- Phenyl Ether
- 1,1,1,2-Tetrachloro-2,2-difluoroethane
- 1,1,2-Trichloro-1,2,2-trifluoroethane
- Vinyl Bromide
- Vinylidene Chloride
- Vinyl Toluene
- Phenyl Glycidyl Ether

USE OF THE ANALYSIS GUIDE TABLES:

The Analysis Guide is designed for the customer involved in the analysis of the 3M 3500/3520 Organic Vapor Monitor by the gas chromatograph. The following tables summarize the 3M monitor sampling rate, capacity, recovery coefficient and calculation constants. The analysis guide provides the necessary information to calculate the time-weighted-average concentration in parts per million (ppm) or milligrams per cubic meter (mg/m^3).

A. Monitor Sample Information

- **Sampling Rate**

The (*) compounds in the Sampling Guide tables have been subjected to an extensive amount of laboratory work to verify the sampling rate. The sampling rates given for the remaining compounds in this table were determined from empirical relationships as outlined in a publication on Sampling Rate Validation. All sampling rates have an accuracy of ± 5%. The sampling rates are tabulated as either cubic centimeters/minute of micrograms/ppm-hour

Capacity

The capacity of the monitor for each individual compound is a function of molecular structure, vapor pressure, environmental conditions, etc. The capacity is stated in terms of weight (milligrams). For a single contaminant, if the analyst finds the weight collected by the monitor is greater than the defined capacity, then the validity of the sample should be questioned.

When sampling multiple contaminants, the combined weights of the contaminants collected should not exceed the defined value for the single contaminant with the lowest capacity.

- **Recovery Coefficients (Desorption Efficiency)**

The collected sample is removed from the activated carbon wafer for analysis by desorption with carbon disulfide (CS_2) or other suitable solvents. In order for the laboratory analyst to determine accurately the amount of contaminant collected by the adsorbent, it is necessary to know the efficiency of the desorption process. The recovery coefficient or desorption efficiency is determined by adding a known weight of contaminant onto the adsorbent and measuring the weight of contaminant in the desorbing solvent. The recovery coefficient is calculated by dividing the recovered weight by the known weight. **It is recommended that each analytical laboratory determine recovery coefficients according to the procedure outlined by the 3M laboratory contained in the Analysis Guide as "Recommended Procedure for Determination of Recovery Coefficients." Recovery coefficients determined by the 3M laboratory are tabulated in the following tables.**

B. Procedure to Calculate Contaminant Concentrations

The time-weighted-average concentration of the environment sampled can be calculated by knowing the length of the sampling period, the contaminant weight determined by gas chromatography, the recovery coefficient, and the calculation constant either A or B. The calculation constant A is used to calculate the concentration when expressed in units of milligrams per cubic meter (mg/m^3) and constant B when expressed in units of parts per million (ppm). The calculation constants A and B have been determined for every contaminant in the Analysis Guide by the following expressions:

$$A = \frac{1000}{\text{Sampling Rate}}$$

$$B = \frac{1000}{\text{Sampling Rate}} \times \frac{(24.45)}{(\text{Molecular Weight}}$$

The contaminant concentration can be calculated with the following information:

- **Sampling Information**

  Contaminant
  Length of Sampling Period (min.) **t**

  Contaminant Information from Tables in Analysis Guide

  Calculation Constant **A** or **B**

  Analytical Results

  Contaminant weight recovered **W** (Micrograms) corrected for blank
  Recovery Coefficient (**r**)

- **Temperature Effects**

  The following expressions calculate the time-weighted-average concentrations at a sampling temperature of 25°C (298°K) and pressure of 760 mm. When sampling at other environmental conditions, the expressions need to be corrected only for variations in temperature. The expressions can be multiplied by the following temperature correction factors (CF_T) for samples collected at temperatures other than 25°C (77°F).

Sampling (°C)	Temperature (°F)	Temperature Correction Factor (CF_T)
44	111	0.97
37	99	0.98
31	88	0.99
25	77	1.00
19	66	1.01
13	55	1.02
7	45	1.03
2	36	1.04
-3	27	1.05
-8	18	1.06

From the above table, every 10-11° above or below 77°F requires one percent correction to the calculated time-weighted-average concentration.

Calculation Procedures

A. #3500 Organic Vapor Monitor

The time-weighted-average concentration in milligrams per cubic meter of the contaminant in the environment sampled can be calculated from the following expression:

$$C(mg/m^3) = \frac{W\ (micrograms)}{r \times t\ (minutes)} \quad \mathbf{X\ A}$$

The time-weighted-average concentration in parts per million (ppm) of the contaminant can be calculated from the following expression:

$$C(ppm) = \frac{W\ (micrograms)}{r \times t\ (minutes)} \quad \mathbf{X\ B}$$

If the temperature correction is desired, the time weighted average concentration can be calculated by the following expression:

$$C(mg/m^3) = \frac{W\ (micrograms)}{r \times t\ (minutes)} \quad \mathbf{X\ A\ X\ CF}_T$$

$$C(ppm) = \frac{W\ (micrograms)}{r \times t\ (minutes)} \quad \mathbf{X\ B\ X\ CF}_T$$

Example Calculation

Contaminant	**Benzene**
Length of Sampling Period (t)	**420 minutes**
Temperature (T)	**75°F**
Calculation Constant **A**	**28.2**
or	
B	**8.83**
Contaminant Weight Recovered (W)	**27.2 micrograms**
Recovery Coefficient (r)	**1.02**

Using Calculation Constant **A**:

$$C(mg/m^3) = \frac{27.2}{(1.02)\quad(420)} \quad \mathbf{X\ 28.2}$$

$C = 1.79\ mg/m^3$

Using calculation Constant **B**:

$$C(ppm) = \frac{27.2}{(1.02)\quad(420)} \quad \mathbf{X\ 8.83}$$

$C = 0.56$ ppm

B. #3520 Organic Vapor Monitor with back-up section

Upon analysis of each adsorbent, the validity of the sample can be determined. But in order to assure a valid sample under all sampling conditions, the ratio of the contaminant weight (W_s) on the secondary adsorbent to the contaminant weight (W_P) on the primary adsorbent must meet the following criteria.

$$\frac{W_S}{W_P} \leq .50$$

W_P – weight collected on the primary adsorbent corrected for recovery and blank (micrograms)

W_S – weight collected on the secondary adsorbent corrected for recovery and blank (micrograms)

t – length of sampling period (minutes)

$$C\ mg/m3 = \frac{(W_P + 2.2\ W_S)\ X\ A}{t}$$

$$C\ ppm = \frac{(W_P + 2.2\ W_S)\ X\ B}{t}$$

A – calculation coefficient (mg/m^3)

B – calculation coefficient (ppm)

Recommended Procedure For Determination of Recovery Coefficients for 3M Organic Vapor Monitor #3500/3520

3M publishes the Recovery Coefficient for many of the organic vapors in the 3500 Compound Guide. However, we encourage the user to verify the recovery coefficients, since techniques and presence of multiple contaminants can affect recovery coefficients.

The recovery coefficient is determined by vapor-state spiking of monitors. This is accompanied by the following steps:

1) Remove plastic ring and white film from a monitor.

2) Place a 2.5 cm diameter filter paper on spacer plate.

3) The closure cap is snapped on the monitor.

4) Calculate the amount of material to be injected. The following formula will calculate the injection amount, in milligrams, that corresponds to the amount that would be collected by a monitor at sampling conditions chosen. By varying the chosen concentration levels and exposure times, a Recovery Coefficient curve can be generated.

   $W = (K_o) \times (C) \times (t) \times (10^{-6}\ m^3/cm^3)$

Where:

W = Amount of liquid injection in milligrams
K_o = Sampling rate of monitor $cm^3/min.$
C = Average concentration in mg/m^3
t = Sampling time in minutes

For compounds that are solid at room temperature, prepare a solution in Carbon Disulfide such that no more than a 5 microliter injection is needed to spike the required number of milligrams of compound.

A suggested starting point would be assuming an average concentration of one P.E.L. (Permissible Exposure Limit) and an 8 hour exposure period, as long as the amount in milligrams does not exceed the recommended exposure limit of monitor.

5) Inject the known quantity of the organic material onto the filter paper through the center port.

6) The monitor is allowed to sit 16-24 hours to allow total transfer of the organic material from the filter paper to the sorbent before elution.

7) Remove filter paper from monitor.

8) Proceed with elution and determination of amount recovered by G.C. analysis. See #3500 Organic Vapor Monitor Instructions for Use.

For further assistance, call 3M Occupational Health and Environmental Safety Division Technical Service toll free on 1-800/243 4630, or write 3M Occupational Health and Environmental Safety Division, 3M Center, PO Box 33155, St. Paul, Minnesota 55144-1000.

Analysis Guide

	Sampling Rate (cc/min)	Capacity (mg)	Recovery Coefficient	Calculation Constant	
				A (mg/m^3)	B (ppm)
Acetone*	40.1 ± 0.9	3	0.87	24.9	10.51
Acetonitrile	48.2	0.1	0.82	20.8	12.37
Acrylonitrile	43.8	4	0.79	22.8	10.53
Allyl Alcohol	40.4	10	0.40	24.8	10.43
Allyl Chloride	35.1	1	0.73	28.5	9.05
i-Amyl Acetate	27.2	>25	–	36.8	6.90
n-Amyl Acetate*	26.0 ± 0.5	>25	0.94	38.6	7.26
s-Amyl Acetate	27.2	>25	–	36.8	6.91
i-Amyl Alcohol*	32.3 ± 0.4	>25	0.99 +	31.0	8.63
n-Amyl Alcohol (1-Pentanol)*	31.2 ± 0.4	>25	0.85 +	32.1	8.91
s-Amyl Alcohol (2-Pentanol)	31.2	>25	0.99 +	32.1	8.89
Benzene*	35.5 ± 0.6	13	1.02	28.2	8.83
Benzyl Chloride	27.2	>25	1.05	36.8	7.08
Bromoform	29.3	>25	1.05	34.1	3.30
1,3-Butadiene‡	42.8	0.4	–	23.4	10.53
i-Butyl Acetate*	31.0 ± 0.3	>25	–	32.3	6.80
n-Butyl Acetate	31.6	25	1.04	31.7	6.67
s-Butyl Acetate*	28.6 ± 0.4	>25	1.07	35.0	7.37
t-Butyl Acetate	29.4	25	1.05	34.0	7.17
Butyl Acrylate	27.3	>25	1.01	36.6	6.99
i-Butyl Alcohol*	35.9 ± 0.7	>25	1.02 +	27.9	9.20
n-Butyl Alcohol*	34.3 ± 0.7	>25	0.98 +	29.2	9.63
s-Butyl Alcohol	34.8	19	0.97 +	28.7	9.44
t-Butyl Alcohol	35.2	13	0.80	28.4	9.39
Butyl Cellosolve (2-Butoxyethanol)*	28.2 ± 0.6	>25	1.03+	35.5	7.35
Butyl Cellosolve Acetate (2-Butoxy ethyl Acetate)*	24.3 ± 1.0	>25	0.98	41.2	6.28
Butyl Glycidyl Ether (BGE)	27.0	>25	0.87	37.0	6.97
t-Butyl Methyl Ether (MTBE)*	32.9 ± 1.4	13	1.01	30.4	8.43
p-tert-Butyltoluene*	20.7 ± 0.4	>25	1.10	48.3	7.98
Camphor	21.4	>25	–	46.7	7.52
Carbon Disulfide	42.8	1	0.82++	23.4	7.52
Carbon Tetrabromide	26.6	–	–	37.6	2.77
Carbon Tetrachloride*	30.2 ± 0.4	>25	1.05	33.1	5.26
Cellosolve (2-Ethoxyethanol)*	32.4 ± 0.9	>25	0.95+	30.9	8.39
Cellosolve Acetate* (2-Ethoxyethyl Acetate)	26.6 ± 0.4	>25	1.03	37.6	6.96
Chlorobenzene*	29.3 ± 0.6	>25	1.00	34.1	7.38
Chlorobromomethane*	34.4 ± 0.9	10	1.00	29.1	5.51
Chloroform	33.5	7	0.98	29.9	6.13
1-Chloro-1-nitropropane	28.6	>25	–	35.0	6.92
Chloroprene (2-Chloro-1,3-butadiene)	32.2	5	–	31.1	8.53
o-Chlorostyrene	26.0	>25	0.80	38.5	6.77
o-Chlorotoluene	27.3	>25	–	36.6	7.05

\+ Methylene Chloride as the solvent

‡ See Technical Data Bulletin 63

++ Acetonitrile as the Solvent

Analysis Guide

	Sampling Rate (cc/min)	Capacity (mg)	Recovery Coefficient	Calculation Constant	
				A (mg/m^3)	B (ppm)
Cumene*	24.5 ± 0.9	>25	0.96	40.8	8.32
Cyclohexane*	32.4 ± 0.7	22	1.07	30.9	8.98
Cyclohexanol*	29.5 ± 0.3	>25	1.0 +	33.9	8.27
Cyclohexanone*	28.9 ± 0.3	>25	0.97	34.6	8.63
Cyclohexene*	32.3 ± 0.4	22	1.02	31.0	9.23
Cyclopentadiene	39.5	–	–	25.3	9.36
Cyclopentane	36.2	–	–	27.6	9.63
n-Decane*	23.1 ± 0.5	>25	1.04	43.3	7.44
Diacetone Alcohol*	28.2 ± 0.4	>25	1.04 +	35.5	7.47
o-Dichlorobenzene*	27.8 ± 0.6	>25	0.95	36.0	5.98
p-Dichlorobenzene*	27.8 ± 0.6	>25	0.95	36.0	5.98
1,1-Dichloroethane	33.2	4	–	30.1	7.44
1,2-Dichloroethylene*	35.2 ± 0.5	1	0.99	28.4	7.16
Dichloroethyl Ether	26.1	>25	–	38.3	6.55
1,1-Dichloro-1-nitroethane	28.5	>25	–	35.1	5.96
1,1-Dichloro-2,2,2-trifluoroethane (HCFC-123)*	30.9 ± 2.6	14	0.99	32.4	5.17
Dicyclopentadiene	23.6	–	–	42.4	7.84
Diethyl Ketone	32.7	–	–	30.6	8.68
Diisobutyl Ketone*	24.6 ± 0.8	>25	1.07	40.7	7.00
Dimethylacetamide	32.0	–	0.89 +	31.3	8.77
Dimethyl Formamide	35.5	>25	0.74 +	28.2	9.42
p-Dioxane	34.5	>25	0.80	29.0	8.05
Dipropylene Glycol Methyl Ether	25.3	>25	–	39.5	6.53
Dipropyl Ketone	27.8	–	–	36.0	7.70
Divinyl Benzene	23.3	–	–	42.9	8.06
n-Dodecane*	21.5 ± 0.9	>25	1.04	46.5	6.68
Enflurane (2-Chloro-1,1,2-trifluoroethyl difluoromethyl ether)	28.3	4	0.81	35.3	4.68
Epichlorohydrin (1-Chloro-2,3-epoxypropane)	29.6	>25	0.95	33.8	8.88
Ethyl Acetate*	34.5 ± 0.6	10	1.01	29.0	8.05
Ethyl Acrylate	32.2	19	0.96	31.1	7.59
Ethyl Alcohol	51.2	12	0.44	19.5	10.38
Ethyl Benzene	27.3	>25	0.92	36.6	8.45
Ethyl Bromide*	36.4 ± 0.3	1	1.03	27.5	6.16
Ethyl Butyl Ketone (3-Heptanone)	28.0	>25	–	35.7	7.66
Ethylene Chlorohydrin (2-Chloroethanol)	33.9	>25	–	29.5	8.90
Ethylene Dibromide (1,2-Dibromoethane)*	29.6 ± 0.4	>25	1.04	33.8	4.39
Ethylene Dichloride (1,2-Dichloroethane)*	33.2 ± 0.7	18	1.02	30.1	7.44
Ethyl Ether	36.8	7	1.02	27.2	8.98
Ethyl Formate	38.8	1	–	25.8	8.52
Ethyl Mercaptan	41.1	–	–	24.3	9.57
Furfural	34.3	>25	0.71 +	29.2	7.42
Furfuryl Alcohol	30.6	>25	0.76 +	32.7	8.14
Gasoline*	30.5 ± 1.3	–	1.05	32.8	7.49
Glycidol (2,3-Epoxy-1-propanol)	37.1	>25	–	27.0	8.91

+ Methylene Chloride as the solvent

Analysis Guide

	Sampling Rate (cc/min)	Capacity (mg)	Recovery Coefficient	Calculation Constant	
				A (mg/m^3)	B (ppm)
Halothane (2-Bromo-2-Chloro-1,1,1-trifluoroethane)	30.2	4	–	33.1	4.10
n-Heptane*	28.9 ± 0.7	>25	1.08	34.6	8.46
Hexachlorobutadiene	22.9	–	–	43.7	4.09
Hexachlorocyclopentadiene	22.1	–	–	45.2	4.06
Hexachloroethane	26.7	>25	–	37.5	3.86
n-Hexane*	32.0 ± 0.7	18	1.05	31.3	8.88
Hexane Isomers*	32.0 ± 0.7	18	1.05	31.3	8.87
s-Hexyl Acetate	25.2	>25	–	39.7	6.73
Isoflurane (Forane)	28.3	–	–	35.3	4.68
Isooctyl Alcohol	25.1	–	–	39.8	7.48
Isophorone*	21.7 ± 0.7	>25	0.75	46.1	8.16
Isopropoxyethanol	29.5	–	–	33.9	7.96
Isopropyl Acetate	31.7	15	1.05 +	31.5	7.56
Isopropyl Alcohol	39.4	6	0.61	25.4	10.34
Isopropyl Ether	31.2	10	–	32.1	7.67
Isopropyl Glycidyl Ether	29.1	>25	–	34.4	7.24
Mesitylene (Trimethyl Benzene)*	26.3 ± 0.7	>25	1.06	38.0	7.75
Mesityl Oxide*	31.2 ± 1.2	>25	0.85	32.1	8.00
Methyl Acetate*	37.0 ± 0.6	2	1.00	27.0	8.93
Methyl Acrylate	35.8	11	0.94	27.9	7.94
Methylal (Dimethoxymethane)	37.9	5	0.92	26.4	8.49
Methyl Amyl Ketone (2-Heptanone)	27.9	>25	–	35.8	7.69
Methyl Bromide	40.9	0.5	–	24.4	6.30
Methyl Butyl Ketone (2-Hexanone)*	29.7 ± 0.7	>25	1.00	33.7	8.23
Methyl Cellosolve (2-Methoxyethanol)*	36.3 ± 0.4	>25	0.83 +	27.5	8.86
Methyl Cellosolve Acetate (2-Methoxyethyl Acetate)*	29.0 ± 0.5	>25	1.00	34.5	7.14
Methyl Cyclohexane*	28.9 ± 0.4	>25	1.05	34.6	8.63
Methyl Cyclohexanol	25.3	>25	–	39.5	8.46
Methylene Chloride (Dichloromethane)*‡	37.9 ± 0.3	3	0.90	26.4	7.59
Methyl Ethyl Ketone (2–Butanone)*	36.3 ± 0.9	12	0.92	27.5	9.35
Methyl Formate	45.0	0.2	0.93 +	22.2	9.06
5-Methyl-3-heptanone (Ethyl Amyl Ketone)	26.4	>25	–	37.9	7.24
Methyl Iodide	36.7	0.2	–	27.3	4.69
Methyl Isoamyl Ketone	28.0	>25	–	35.7	7.66
Methyl Isobutyl Carbinol (Methyl Amyl Alcohol)	29.2	>25	–	34.2	8.21
Methyl Isobutyl Ketone (Hexone)*	30.0 ± 0.4	>25	1.06	33.3	8.15
Methyl Isopropyl Ketone	32.8	–	–	30.5	8.65
Methyl Methacrylate	31.8	24	1.05	31.5	7.69
1-Methyl-2-pyrrolidinone	28.8	–	0.43	34.7	8.56
alpha-Methyl Styrene*	25.0 ± 0.5	>25	1.01	40.0	8.29
Morpholine	33.1	–	–	30.2	8.48

+ Methylene Chloride as the solvent

‡ See Technical Data Bulletin 71

Analysis Guide

	Sampling Rate (cc/min)	Capacity (mg)	Recovery Coefficient	Calculation Constant	
				A (mg/m^3)	B (ppm)
Naptha(VM&P)*	33.2±0.7	20	1.04	30.1	7.36
Napthalene	24.6	>25	–	40.7	7.76
n-Nonane*	24.6±0.6	>25	1.09	40.7	7.75
n-Octane*	26.6±0.6	>25	1.08	37.6	8.06
n-Pentane*	35.3±0.9	7	1.02	28.3	9.62
2,4-Pentanedione	31.7	–	0.85	31.5	7.70
2-Pentanone (Methyl Propyl Ketone)*	33±0.5	23	1.03	30.3	8.62
Perchloroethylene*	28.3±0.5	>25	1.05	35.3	5.20
Phenyl Ether	20.3	>25	0.93	49.3	7.08
Phenyl Glycidyl Ether	22.2	>25	–	45.0	7.33
n-Propyl Acetate*	30.1±0.5	21	1.01	33.3	7.96
n-Propyl Alcohol*	39.7±0.7	25	0.93 +	25.2	10.26
Propylene Dichloride (1,2-Dichloropropane)*	30.6±0.4	25	1.04	32.7	7.07
Propylene Glycol Monomethyl Ether (PGME)*	32.4±2.1	>25	0.92+	30.9	8.37
Propylene Glycol Monomethyl Ether Acetate (PGMEA)*	25.2±1.1	>25	0.99	39.7	7.34
Propylene Oxide*	37.7±2.5	–	1.00	26.5	11.17
n-Propyl Nitrate	33.3	>25	1.05+	30.0	6.99
Resorcinol	25.8	–	–	38.8	8.61
Stoddard Solvent	24.3	>25	0.82	41.2	6.99
Styrene*	26.8±0.8	>25	0.94	37.3	8.77
1,1,1,2-Tetrachloro-2,2-difluoroethane	27.5	5	–	36.4	4.36
1,1,2,2-Tetrachloro-1,2-difluoroethane	28.2	5	–	35.5	4.25
1,1,2,2-Tetrachloroethane	28.4	>25	0.89	35.2	5.12
Tetrahydrofuran	37.2	8	1.09	26.8	9.13
Toluene*	31.4±0.6	25	1.05	31.8	8.46
1,1,1-Trichloroethane (Methyl Chloroform)*	30.9±0.3	20	1.03	32.4	5.95
1,1,2-Trichloroethane*	29.7±0.6	>25	1.02	33.7	6.19
Trichloroethylene*	31.1±0.2	20	1.00	32.2	6.00
1,2,3-Trichloropropane	27.4	>25	–	36.5	6.07
1,1,2-Trichloro-1,2,2-trifluoroethane	29.1	18	1.11	34.4	4.48
Vinyl Acetate	35.8	17	1.02	27.9	7.94
Vinyl Bromide	37.0	0.3	–	27.0	6.18
Vinyl Chloride*	40.8±0.5	0.04	1.02	24.4	9.56
4-Vinyl-1-cyclohexene*	27.9±1.8	–	1.13	35.8	8.10
Vinylidene Chloride	35.1	0.5	–	28.5	7.19
Vinyl Toluene	25.1	>25	–	39.8	8.24
Xylene*	27.3±0.5	>25	1.07	36.6	8.44

+ Methylene Chloride as the solvent

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