Odor Threshold Studies Performed with Gasoline and Gasoline Combined with MTBE, ETBE and TAME

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EXECUTIVE SUMMARY

The Clean Air Act Amendments of 1990 require that gasoline sold in areas of non-attainment for carbon monoxide or ozone contain specified amounts of fuel oxygenates. Fuel oxygenates include, methyl-tertiary-butyl ether (MTBE), ethyl-tertiary-butyl ether (ETBE), and tertiary-amyl-methyl ether (TAME). These oxygenated compounds increase the oxygen content of fuels, producing a more complete combustion, resulting in a reduction in carbon monoxide emissions. Oxygenated compounds such as MTBE have been previously added to gasoline to enhance octane ratings. More recently, larger amounts of oxygenates, MTBE, in particular, have been added to fuels to meet Clean Air Act Amendment requirements. This study examines the effect of oxygenate addition on the odor of gasoline blends.

Three blends of gasoline (summer, winter and a "composite") were evaluated for their odor detection and recognition thresholds in air. These gasolines were also combined with the gasoline oxygenates MTBE, ETBE or TAME to evaluate the effect of the oxygenates on the gasolines' odor detection and recognition thresholds. Additionally, commercial grade MTBE (97% pure, obtained from ARCO Chemical Co.) was evaluated for its odor detection and recognition thresholds in air and water as well as its taste threshold in water. The detection threshold is defined as the minimum concentration at which 50 percent of a given population can differentiate between a sample containing the odorant and a sample of odor free air. The recognition threshold value is defined as the minimum concentration at which 50 percent of a given population can recognize or identify the odorant. These evaluations were conducted at TRC Environmental Corporation's (TRC's) Odor Laboratory in Windsor, Connecticut.

The average detection and recognition threshold values for commercial grade MTBE were determined to be 0.053 and 0.125 parts-per-million (ppm), respectively. The average detection and recognition threshold values for this MTBE in water were determined to be 0.045 and 0.055 ppm, respectively. In general, compounds with odor thresholds below 1 ppm are considered highly odorous. The panelists descriptions of MTBE's odor included alcohol, chemical, ether and butane. Finally, the average taste detection threshold value for this oxygenate was determined to be 0.039 ppm. The panelists found the taste of MTBE to be highly objectionable.

The average detection and recognition threshold values for the headspace vapor of the three gasoline blends are as follows: summer blend - 0.576 and 0.802 ppm, respectively; winter blend - 0.479 and 1.121 ppm, respectively; and "composite" blend - 0.474 and 0.765 ppm, respectively. In general, the panelists described all three blends as smelling like gasoline.

The average detection and recognition threshold values for the headspace vapor of the gasoline-oxygenate mixtures are as follows: summer blend + 3% MTBE (97% purity) - 0.5 and 0.696 ppm, respectively; summer blend + 11% MTBE (97% purity) - 0.275 and 0.710 ppm, respectively; summer blend + 15% MTBE (97% purity) - 0.264 and 0.686 ppm, respectively; summer blend + 15% MTBE (99% purity) - 0.113 and 0.358 ppm, respectively. The odors associated with these mixtures included organic volatile, gasoline, ether, car exhaust, sweet gasoline and gasoline with ether. The summer blend of gasoline was also mixed with 15% ETBE (99% purity) and also with 15% TAME (94% purity). The average detection and recognition threshold values for these mixtures are 0.064 and 0.139 ppm (summer blend + ETBE) and 0.114 and 0.207 ppm (summer blend + TAME). The odors the panelists associated with these mixtures included ether, gasoline, chemical with gasoline, cleaning fluid and natural gas.

The winter and composite gasolines were each mixed with 15% MTBE (97% purity), respectively. The average detection and recognition threshold values for these mixtures were 0.219 and 0.398 ppm (winter blend + MTBE) and 0.085 and 0.185 ppm (composite blend + MTBE), respectively. The odor of the winter gasoline - MTBE mixture was associated with gasoline, chemical and ether by the panelists. The odor of the "composite" gasoline - MTBE mixture was associated with gasoline, gasoline with ether, and permanent marker by the panelists.

Section 1
INTRODUCTION

The Clean Air Act Amendments of 1990 require that gasoline sold in areas of non-attainment for carbon monoxide or ozone contain specified amounts of fuel oxygenates. Fuel oxygenates include, methyl-tertiary-butyl ether (MTBE), ethyl-tertiary-butyl ether (ETBE), and tertiary-amyl-methyl ether (TAME). These oxygenated compounds increase the oxygen content of fuels, producing a more complete combustion, resulting in a reduction in carbon monoxide emissions. Oxygenated compounds such as MTBE have been previously added to gasoline to enhance octane ratings. More recently, larger amounts of oxygenates, MTBE, in particular, have been added to fuels to meet Clean Air Act Amendment requirements. This study examines the effect of oxygenate addition on the odor of gasoline blends. A commercial blend of MTBE (97% purity, obtained from ARCO Chemical Co.) was also evaluated for its odor detection and recognition thresholds in air and water as well as its taste threshold in water. MTBE (99% purity) and ETBE (99% purity) were also supplied by ARCO Chemical Company. TAME (94% purity) was obtained by API from Aldrich Chemical Company and supplied to TRC through API's chemical repository, Experimental Pathology Laboratories, Inc. (Herndon, VA). The gasoline blends were furnished through Experimental Pathology Laboratories, Inc., Herndon, VA (summer blend - API Reference Fuel 91-01), and Sun Co., Inc., Marcus Hook, PA (winter blend and "composite" sample). The Reid Vapor Pressure (RVP) for the gasoline blends (in psi) are 8.5, for the summer blend; 12.3 for the winter blend; and 7.9 for the "composite sample".

Section 2
EXPERIMENTAL PROCEDURES

TASTE EVALUATION PROCEDURES

The taste threshold determinations met the criteria specified in *Review of Published Odor and Taste Threshold Values of Soluble Gasoline Components* (TRC, 1985). These criteria are summarized as follows:

1. Panel selection of at least six per group;
2. Panel selection based on taste sensitivity;
3. Panel calibration;
4. A "sip" and "spit" presentation method;
5. Room temperature solutions;
6. Purified water as a diluent;
7. Rinse between stimuli;
8. Consideration of threshold type;
9. Staircase presentation series;
10. Forced-choice procedure;
11. Repeated trials;
12. Concentration step increasing by a factor of two or three.

TRC performed the taste threshold testing following the procedure in Standard Method 2160B for the Examination of Water and Wastewater (APHA et al., 1992). The taste threshold value of MTBE was determined by comparing this oxygenate with water. Aliquots of the MTBE solutions used for the aqueous odor testing were also used for the taste tests. The samples were presented to the panelists in a series of increasing concentrations, and each sample was paired with a water reference. Each panelist was required to sip the sample via straw, hold it inside the mouth for a few seconds and discharge it without swallowing. The panelist then compared the sample of oxygenate with the reference sample and indicated whether or not a flavor or aftertaste could be detected.

ODOR EVALUATION PROCEDURES

These studies were conducted in TRC's Odor Laboratory in Windsor, Connecticut. The odor threshold determinations met the criteria specified in *Review of Published Odor and Taste Threshold Values of Soluble Gasoline Components* (TRC, 1985). These criteria are summarized as follows:

1. Panel selection of at least six per group;
2. Panel selection based on odor sensitivity;
3. Panel calibration;
4. Consideration of vapor modality (air and water);
5. Diluent in accord with compound;
6. Presentation mode that reduces ambient air intake;
7. Analytical measurement of odorant concentration;
8. Calibration of flow rate and face velocity (for olfactometers);
9. Consideration of threshold type (detection or recognition);
10. Ascending presentation series;
11. Repeated trials;
12. Forced-choice procedure;
13. Concentration step increasing by factor of two or three.

Threshold Determinations in Air Samples

Air samples of neat MTBE were produced by vaporizing a known volume of MTBE (0.6 μl) in a known volume of hydrocarbon-free air (0.400 ft^3) which was contained in a Tedlar® bag. The concentration in each sample bag was calculated according to the equation presented in Table 2-1 and expressed in parts-per-million (ppm). The average starting concentration of MTBE in the Tedlar® bag was calculated to be 11.16 ppm.

In contrast to the wholly vaporized MTBE samples, the headspace vapor samples from the summer, winter and "composite" gasolines as well as from the gasoline-oxygenate mixtures were generated by a mini-impinger system. Ten milliliters of gasoline or gasoline-oxygenate mixture were placed into a glass impinger. Carbon-filtered air was passed through an inlet tube over the headspace and the vapor was collected through an outlet tube into a Tedlar® bag. The resultant headspace vapor was diluted approximately 2000-fold prior to presentation to the odor panel. The

Table 2-1. TRC Solvent Bag Standard Preparation Data Form

TRC Project________________ Date________________

Location________________ Technician________________

Solvent Species________ Molecular Weight________ Density________

Dilution Gas________ Ambient Temperature________ Barometric Pressure________

Dry Gas Meter Calibration Factor (Y)________________

$$C\ ppm\ (V/V) = \frac{V_S(\mu L)\ D(g/L)\ \frac{mole}{MW(g)}\ \frac{24.04(L)}{mole}\ \frac{Tm(^{\circ}K)}{293}\ \frac{760}{Pm\ (mmHg)}}{V_d\ (ft^3)\ 28.32(L/ft^3)\ Y}$$

Bag No.	Volume of Injected Solvent (µL)	Tm (°F)	Tm (°K)	PDGM (in. H_2O)	Pm (in. Hg)	Volume of Dilution Gas (ft^3)	Solvent Concentration (ppm)

NOTE: P_m = pressure measured at the dry gas meter (PDGM) + barometric pressure.
Standard conditions are 68°F, 29.92 inches Hg.

concentration (in ppm) of total hydrocarbons in the Tedlar® bags containing the diluted gasoline headspace vapor was approximated by using an Organic Vapor Analyzer (OVA) (Foxboro 128). The OVA was calibrated against a gaseous mixture of 45% butane, 45% pentane and 10% hexane. The Tedlar® bag containing the diluted gasoline headspace vapor was then connected to the sampling port of the OVA and a reading obtained.

The readings for each sample were recorded on the appropriate ED_{50} evaluation forms (Appendices B and C). An API study of consumer gasoline vapor exposure during refueling demonstrated that approximately 80% of gasoline vapors are comprised of saturated C_4-C_6 compounds (Clayton Environmental Consultants, 1993).

The dilution-to-threshold (D/T) values used to calculate the threshold concentration levels were measured with a dynamic dilution triangle olfactometer (IITRI System, 1979 Model). The D/T value represents the ratio of the volume of odor-free air that must be added to the odorous sample to reach threshold. For example, a D/T of 100 means that 100 volumes of odor-free air must be added to one volume of odorous air to dilute it to threshold. The D/T ratio represents that dilution required for 50% of the panel to detect a difference between the odorous stimuli and the blank air.

On the triangle olfactometer, this is the point at which the panelist successively identifies the sniff port containing the odor. The olfactometer uses carbon-filtered air to make six simultaneous dilutions of the odorous air. A series of dilutions were presented in an ascending manner, each series representing approximately a three-fold concentration step. The dilution ratios, as determined by a soap film flow-meter, were approximately: 1/2411, 1/608, 1/175, 1/55, 1/24, 1/8. Each dilution level was presented by means of a cup containing three glass sniff ports. Two ports dispensed only carbon filtered air while the third dispensed the diluted odor. Flow rates from the sniffing ports were constant at 3 L/minute. Panelists chose which of the three ports differed from the other two, i.e., the odor. The olfactometer and its procedures meet the requirements of ASTM Standard Practice E 679 (ASTM, 1993a). A schematic illustration of the olfactometer is depicted in Figure 2-1. The D/T value was calculated by log dilution level versus probability plots. The probability of correct response at 50 percent was plotted against odorant concentration for a best fit (least squares) straight line function. This D/T determination method is recommended for use with the IITRI Olfactometer System, and is also recommended by ASTM Standard Practice E 679 (ASTM, 1993a).

Composite scores were used to determine two types of thresholds, detection and recognition. The detection threshold value differs from the recognition threshold value in that, the detection threshold is the dilution at which a panelist is capable of determining that there is a difference between the sample and filtered air. The recognition threshold value is the dilution at which a panelist is capable of rating the intensity of the odor on the butanol scale. Both the odor thresholds of detection and recognition are expressed in parts-per-million. The thresholds were calculated by dividing the concentration (ppm) in the sample bag by the D/T ratio (dimensionless) as determined by odor panel evaluation. In addition, once panelists were able to rate the intensity of the odor on the butanol scale, they were asked to describe the odor associated with the sample.

The perceived odor intensity was measured with a dynamic dilution binary scale olfactometer arranged in a "lazy Susan" configuration (Figure 2-2). Supra-threshold levels of 1-butyl alcohol (Standard Reference ASTM E 544) were presented in two-fold concentration steps (the butanol scale) (ASTM, 1993b). Panelists compared the ports of the triangle olfactometer with the butanol and indicated the comparable level. The panelists were asked to rate the intensity of the odor on all subsequent dilutions after the odor was detected. The intensity of the odor was rated on a scale of 1 to 8 (as compared to port number 1 through 8). Ratings of 1 through 3 are considered weak odors, ratings of 4, 5 and 6 are considered moderate odors and ratings of 7 and 8 are strong odors.

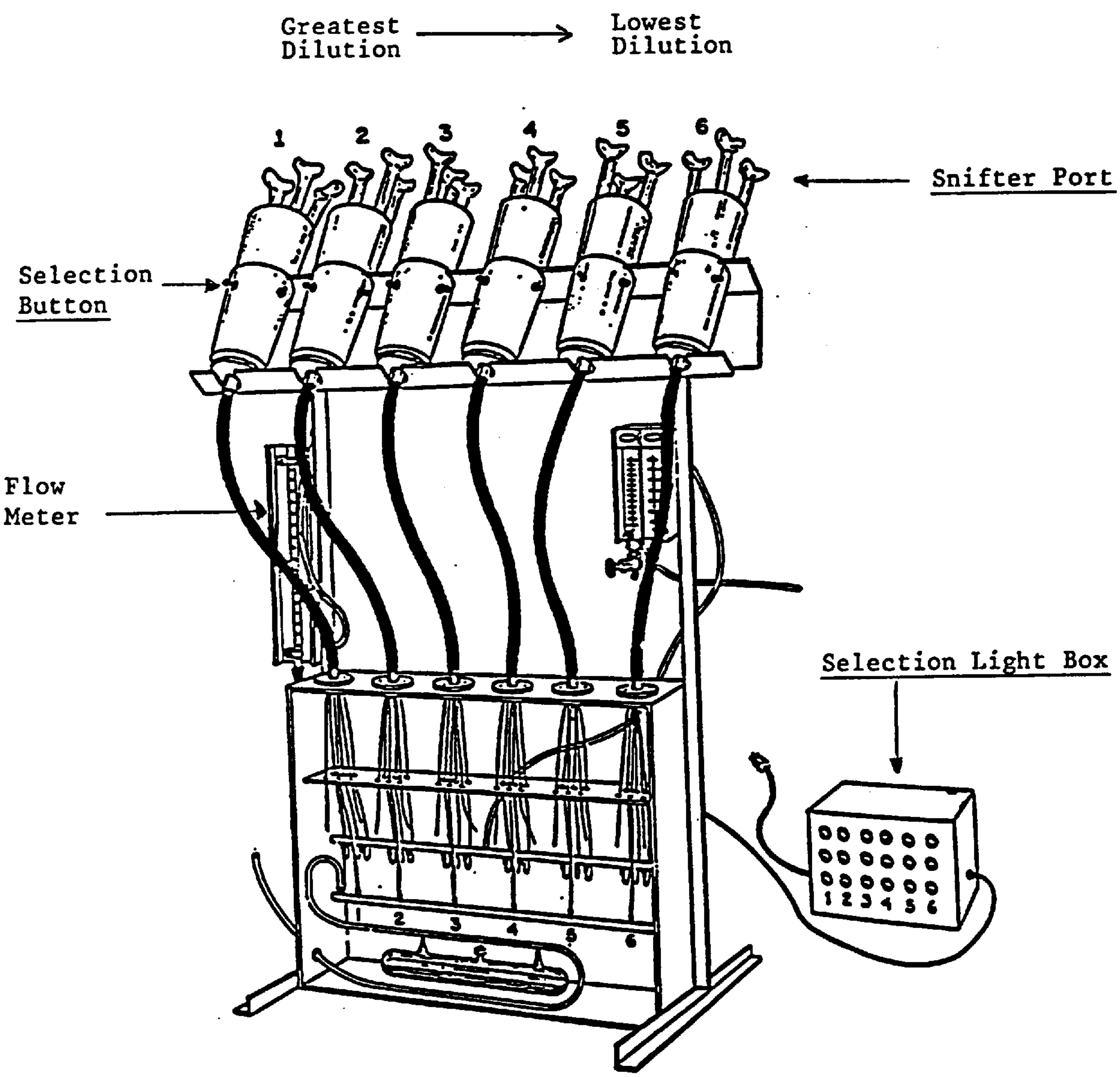

Figure 2-1. Dynamic Dilution Forced-Choice Triangle Olfactometer

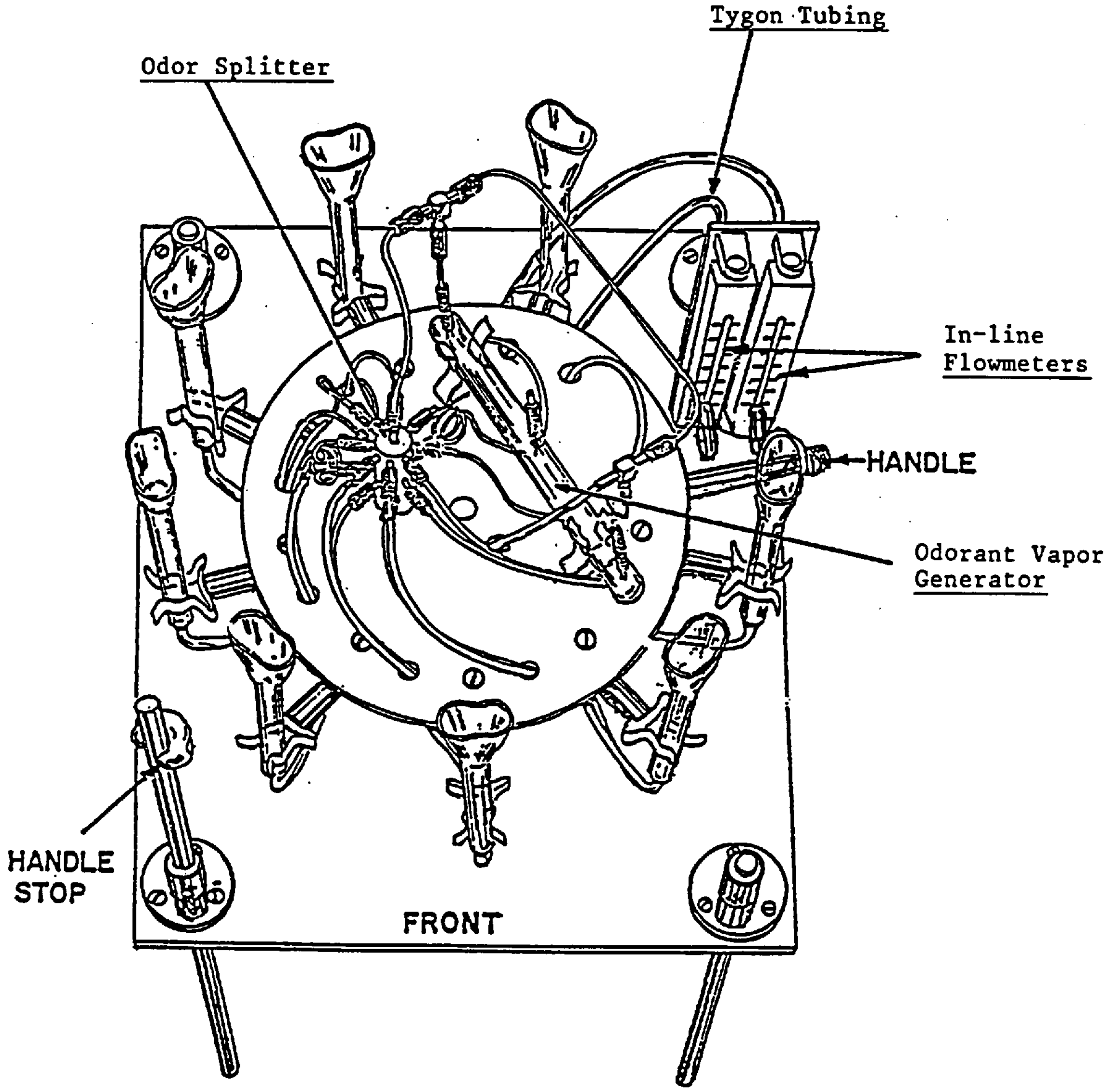

Figure 2-2. Butanol Olfactometer

Threshold Determinations in Aqueous Samples

TRC determined the odor thresholds of MTBE in its aqueous phase, following the Standard Method 2150 for the Examination of Water and Wastewater (APHA et al., 1992). A known concentration of MTBE was diluted with distilled water in a fixed ratio and evaluated organoleptically. Following Method 2150, aqueous samples (contained in flasks) with known concentrations of MTBE were presented to each panelist in ascending order from the weakest to the highest concentration. Based on the results of preliminary tests, a set of dilutions of MTBE was prepared. The nominal concentrations of the samples used in the aqueous odor testing were calculated to be 0.023 ppm, 0.046 ppm, 0.093 ppm, 0.185 ppm, 0.370 and 0.740 ppm MTBE. Each sample was presented to the panelist accompanied by two flasks that contained distilled water. The panelist sniffed the headspace of each flask and indicated which flask was different from the other two. The odor threshold is the dilution ratio at which the odor was just detected.

CALCULATION OF ODOR AND TASTE THRESHOLD VALUES

The odor and taste threshold values were calculated using a statistical-linear regression method. Tables 2-2 and 2-3 are used to calculate the threshold values. Table 2-2 is the ED_{50} Evaluation Form for the Dynamic Triangle Olfactometer. The Y-values of the linear regression are derived from the calibration data of the olfactometer. These Y-values are the log of the tolerance level concentration which is calculated by averaging adjacent dilution levels. Once each panelist has evaluated the sample, a frequency tally is taken which indicates the number of times the sample is first detected per concentration. An average rank for all panelists is then determined using the rank count number scale. The X-plotting value is determined using a conversion table (Table 2-3). The pairs of X and Y values are then used to

Table 2-2. ED_{50} Evaluation Form for the Dynamic Triangle Olfactometer

Sample: --

Evaluation Date: -------------- RESULT: Log ED_{50} = ED_{50} =

Cons. No.	Panelist	Dilution Level Number						
		1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		Panelist Indicated:						
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
Frequency Tally								
Average Rank								

X = Plotting Value								
Y = Log(Tolerance Level)								
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader ----------------------

Table 2-3. Table for Rank Conversion of Rank Data to X-Axis Plot Values

Average Rank	Number of Panelists				
	6	7	8	9	10
1.0	-1.07	-1.15	-1.22	-1.28	-1.33
1.5	-0.79	-0.89	-0.97	-1.04	-1.10
2.0	-0.57	-0.67	-0.77	-0.84	-0.91
2.5	-0.37	-0.49	-0.59	-0.67	-0.75
3.0	-0.18	-0.32	-0.43	-0.52	-0.60
3.5	0	-0.16	-0.28	-0.39	-0.47
4.0	+0.18	0	-0.14	-0.25	-0.35
4.5	+0.37	+0.16	0	-0.13	-0.23
5.0	+0.57	+0.32	+0.14	0	-0.11
5.5	+0.79	+0.49	+0.28	+0.13	0
6.0	+1.07	+0.67	+0.43	+0.25	+0.11
6.5		+0.89	+0.59	+0.39	+0.23
7.0		+1.15	+0.77	+0.52	+0.35
7.5			+0.97	+0.67	+0.47
8.0			+1.22	+0.84	+0.60
8.5				+1.04	+0.75
9.0				+1.28	+0.91
9.5					+1.10
10.0					+1.33

calculate the dilution-to-threshold (D/T) by a least squares method. The equation that is used is:

$$\text{Log D/T} = \bar{Y} - \{ \bar{X} \bullet [\{(XY) - N\,\bar{Y}\,\bar{X}\}/\{(X^2) - N\,(\bar{X})^2\}]\} \quad \text{(Equation 2-1)}$$

where:

- $\bar{Y}$ = mean value of all log (tolerance level) values actually used.
- $\bar{X}$ = mean value of plotting values.
- (XY) = sum of products of each X with corresponding Y.
- (X^2) = sum of squares of X values.
- N = number of plotting values.

This equation automatically calculates the best-fit straight line for the data and provides the log of the D/T. For example, Appendix A provides the olfactometer ED_{50} evaluation forms for the vaporized MTBE samples, in which the D/T values were calculated as just described. As seen in the first sheet (Sample A) the Y values (log tolerance level) to plot the detection threshold are 3.681, 3.083, 2.514, 1.992 and 0.732. A frequency tally of the initial odorant detection is made (circled samples on ED_{50} sheet). The frequency tallies (with respective average rank values in parentheses) are 1 (1), 1 (2), 3 (4), 1 (6) and 1 (7). The average rank values were then converted to the X values of -1.15, -0.67, 0, 0.67 and 1.15 respectively. Therefore the X,Y plotting values are -1.15, 3.681; -0.67, 3.083; 0, 2.514; 0.67, 1.992, and 1.15, 0.732. Using the least squares method, the D/T value is calculated to be 251. The concentration of MTBE in the bag (ppm) is divided by the D/T value to obtain the odor threshold value in ppm (0.043 ppm). The recognition threshold is calculated the same way except that the frequency tally is of the initial odorant recognition (first intensity ranking, designated on ED_{50} sheet by a number value in a square). The odor and taste threshold values in water are also determined in a similar manner.

PANEL

TRC Environmental Corporation maintains a pool of well-trained and experienced panelists from the Hartford, Connecticut area for olfactory evaluation at TRC's Olfactory Laboratory located in Windsor, Connecticut. For these odor and taste evaluation studies, the panel consisted of at least six individuals chosen to represent a normal distribution of olfactory sensitivity such as found in the general population. Prior to sample evaluation for odor thresholds, the panel was calibrated with a butanol intensity series.

Section 3
RESULTS AND CONCLUSIONS

TASTE EVALUATION RESULTS

MTBE (97%) was evaluated for its taste threshold in water (Table 3-1). The average taste detection threshold value for this oxygenate, in these studies, was 0.039 ppm. The panelists found the taste of MTBE (even at the lowest concentrations) to be highly objectionable.

Table 3-1. Taste Threshold Values for MTBE in Water (in ppm)

Oxygenate	Taste Threshold	Taste Characteristics[1]
97% MTBE	0.039 0.039	"nasty", bitter, rubbing alcohol, nauseating
avg	0.039	

[1] Combined odor characteristics from each sample within the group.

ODOR EVALUATION RESULTS

Results From the Evaluation of MTBE

The odor threshold values for MTBE in air and water are presented in Table 3-2. The

Table 3-2. Odor Threshold Values for MTBE in Air[1] and Water (in ppm)

Oxygenate	Odor Detection	Odor Recognition	Odor Character[2]
97% MTBE (air)	0.043 0.058 0.058	0.105 0.159 0.110	chemical, ether, sour, butane, alcohol, medicine, cleaning fluid
avg	0.053±0.005	0.125±0.017	
97% MTBE (water)	0.048 0.041	0.065 0.044	alcohol
avg	0.045	0.055	

[1] Mean ± Standard Error
[2] Combined odor characteristics from each sample within the group.

average detection and recognition threshold values for MTBE were 0.053 and 0.125 ppm, respectively. In addition, each panelist was asked to describe the odor associated with the sample. These odor descriptions included chemical, alcohol, ether and butane. The average odor detection and recognition threshold values for MTBE in water were 0.045 ppm and 0.055 ppm, respectively. In general, compounds that exhibit odor threshold values below 1 ppm, such as MTBE, are in general considered highly odorous. The average odor intensity ratings for MTBE in air and water are presented in Table 3-3. The average odor intensity rating for MTBE in air was 5.17 which indicates that this oxygenate has a moderate odor level at the concentration tested, while the odor intensity for MTBE in water was 2.86.

Table 3-3. Odor Intensity Values for MTBE in Air and Water

Oxygenate	Average Conc.(ppm)[1]	Average Odor Intensity[2]	Odor Intensity at 0 Dilution[3]	Slope of Odor Intensity
97% MTBE (air)	11.17	5.17	6.82	-0.42
97% MTBE (water)	0.74	2.86	3.94	-0.82

1 Average of the nominal starting concentrations of the samples.
2 Average odor intensity of the last dilution cup (8-fold dilution step).
3 Average odor intensity at 0 dilution, extrapolated value using linear regression (odor intensity vs. log dilution level).

The intensity values for each sample were extrapolated to a zero (0) dilution and the slope values of the odor intensity vs. concentration line were also calculated. Since odorant intensity increases as a function of concentration, these data indicate that the odor of MTBE in water is more intense compared with MTBE in air. The slope of the increase in the intensity of the odor of MTBE in water is also larger than the slope of MTBE in air, indicating a faster increase in intensity as the concentration is increased.

The D/T evaluation forms for the dynamic triangle olfactometer, which include the perceived odor characteristics of MTBE, as well as the aqueous MTBE odor and taste data sheets, are provided in Appendix A and present the responses of each panelist. The detection and recognition threshold values for each sample are calculated using this data as described in Section 2.

Results From the Evaluation of Gasoline

The threshold values and odor intensity ratings for the individual headspace samples of the three gasolines are presented in Tables 3-4 and 3-5, respectively. The average detection and recognition threshold values for the summer blend of gasoline were 0.576 and 0.802 ppm, respectively. The odor of the summer gasoline was associated primarily with gasoline and a chemical odor by the panelists. The average odor intensity rating of 2.26 for the summer

Table 3-4. Odor Detection and Recognition Thresholds[1] For Gasoline Headspace Vapor (in ppm)

Gasoline	Odor Detection	Odor Recognition	Odor Characteristics[2]
Summer Blend	0.444 0.571 0.714	0.741 0.833 0.833	gasoline, chemical, rubber, smokey, lemony, garbage
avg	0.576 ± 0.08	0.802 ± 0.03	
Winter Blend	0.530 0.430 0.476	1.330 1.080 0.952	gasoline, kerosene, chemical
avg	0.479 ± 0.03	1.121 ± 0.11	
Composite Sample	0.457 0.400 0.566	0.761 0.794 0.741	gasoline, organic solvent, rancid, alcohol, smokey
avg	0.474 ± 0.05	0.765 ± 0.02	

[1] Mean $\pm$ Standard Error
[2] Combined odor characteristics from each sample within the group.

Table 3-5. Odor Intensity Values for Gasoline Headspace Vapor Samples

Gasoline	Average Conc.(ppm)[1]	Average Odor Intensity[2]	Odor Intensity at 0 Dilution[3]	Slope of Odor Intensity
Summer Blend	20	2.26	3.98	-0.50
Winter Blend	26	2.03	3.04	-0.75
Composite	47	3.33	5.67	-0.39

[1] Average of the nominal starting concentrations of the samples.
[2] Average odor intensity of the last dilution cup (8-fold dilution step).
[3] Average odor intensity at 0 dilution, extrapolated value using linear regression (odor intensity vs. log dilution level).

blend of gasoline, at the highest concentration evaluated (2.27 ppm), indicates that this gasoline has a relatively weak odor. The average detection and recognition threshold values for the winter blend of gasoline were 0.479 and 1.12 ppm, respectively. The odor of the winter gasoline was associated with gasoline and kerosene by the panelists. The average odor intensity rating for this blend of gasoline, at the highest concentration evaluated (2.95 ppm) was rated at 2.03 which indicates that this blend of gasoline also has a weak odor. The average detection and recognition threshold values for the "composite" blend of gasoline are 0.474 and 0.765 ppm, respectively. The odor of the "composite" gasoline was primarily associated with gasoline and organic solvents by the panelists. The average odor intensity rating for this blend of gasoline was rated at 3.33 which indicates that this blend of gasoline has a weak odor at the highest concentration evaluated (5.43 ppm). The intensity values for each sample were also extrapolated to a zero (0) dilution and the slope values of the odor intensity vs. concentration line were also calculated. Since odorant intensity increases as a function of concentration, these data indicate that the odor intensities of the summer and winter blends of gasoline are similar, while the odor intensity of the composite sample is actually less intense than the two blends. The composite sample of gasoline also has a low slope value, indicating that the increase in intensity is smaller as concentration increases, compared with the summer and winter blends of gasoline.

The D/T evaluation forms for the dynamic triangle olfactometer, which include the perceived odor characteristics of the summer, winter and "composite" blends, are provided in Appendix B and present the responses of each panelist. The detection and recognition threshold values for each sample are calculated using this data as described in Section 2.

<u>Results From the Evaluation of the Gasoline and Oxygenate Mixtures</u>

The threshold values and odor intensity ratings for the headspace samples of the gasoline-oxygenate mixtures are presented in Tables 3-6 and 3-7, respectively. The summer blend of gasoline was evaluated in combination with the 99% pure MTBE (15% volume) and the 97% pure MTBE (3%, 11% and 15% volume). In general, the odor detection threshold decreased with increases in MTBE concentration. However, there was no difference between the summer blend of gasoline mixed with 11% MTBE (97% purity) or 15% MTBE (97% purity). The average detection and recognition threshold values for the summer blend of gasoline combined with 15% MTBE (99% purity) were 0.113 ppm and 0.358 ppm, respectively. The odors described by the panelists for this mixture included organic volatile, gasoline, ether and car exhaust. The average odor intensity score for this mixture is 4.59 (moderate odor) at the highest concentration tested (2.95 ppm). In comparison, the average detection and recognition threshold values for the summer blend of gasoline combined with MTBE were as follows:

- summer blend + 3% MTBE (97% purity) - 0.5 and 0.696 ppm, respectively.
- summer blend + 11% MTBE (97% purity) - 0.275 and 0.710 ppm, respectively.
- summer blend + 15% MTBE (97% purity) - 0.264 and 0.686 ppm, respectively.

Table 3-6. Odor Detection and Recognition Thresholds[1] For Gasoline-Oxygenate Headspace Vapor Samples (in ppm)

Gasoline	Odor Detection	Odor Recognition	Odor Characteristics[2]
Summer Blend + 15% MTBE (99%)	0.118 0.085 0.137	0.410 0.215 0.448	organic volatile, gasoline, ether, car exhaust, solvent, fragrance, adhesive
avg	0.113±0.015	0.358±0.070	
Summer Blend + 3% MTBE (97%)	0.531 0.400 0.568	0.800 0.537 0.750	gasoline, sweet, cleaning fluid, gasoline + ether
avg	0.500±0.05	0.696±0.080	
Summer Blend + 11% MTBE (97%)	0.341 0.248 0.237	0.938 0.619 0.574	gasoline, sweet, benzene, gasoline + ether
avg	0.275±0.03	0.710±0.110	
Summer Blend + 15% MTBE (97%)	0.305 0.279 0.207	0.865 0.596 0.596	gasoline, sweet, gasoline + ether, oily
avg	0.264±0.030	0.686±0.090	
Summer Blend + 15% ETBE (99%)	0.075 0.082 0.036	0.171 0.154 0.091	ether, gasoline, chemical with gasoline, natural gas, cleaner, alcohol
avg	0.064±0.010	0.139±0.020	
Summer Blend + 15% TAME (94%)	0.110 0.091 0.141	0.160 0.198 0.262	natural gas, gasoline, chemical, cleaning fluid, alcohol
avg	0.114±0.020	0.207±0.030	
Winter Blend + 15% MTBE (97%)	0.228 0.230 0.198	0.321 0.519 0.354	gasoline, chemical, ether, solvent, burning, plastic
avg	0.219±0.010	0.398±0.060	
Composite Sample + 15% MTBE (97%)	0.105 0.071 0.079	0.220 0.150 0.184	sweet gasoline, gasoline with ether, alcohol, permanent marker
avg	0.085±0.010	0.185±0.020	

[1] Mean ± Standard Error

[2] Combined odor characteristics from each sample within the group.

Table 3-7. Odor Intensity Values for Gasoline-Oxygenate Headspace Vapor Samples

Gasoline	Average Conc.(ppm)[1]	Average Odor Intensity[2]	Odor Intensity at 0 Dilution[3]	Slope of Odor Intensity
Summer Blend + 15% MTBE (99%)	26	4.59	6.28	-0.46
Summer Blend + 3% MTBE (97%)	21	3.05	5.45	-0.37
Summer Blend + 11% MTBE (97%)	28	2.95	5.02	-0.42
Summer Blend + 15% MTBE (97%)	31	3.07	5.15	-0.41
Summer Blend + 15% ETBE (99%)	30	3.92	5.23	-0.59
Summer Blend + 15% TAME (94%)	26	3.50	5.14	-0.51
Winter Blend + 15% MTBE (97%)	27	4.05	5.43	-0.47
Composite Sample + 15% MTBE (97%)	57	4.60	6.33	-0.49

[1] Average of the nominal starting concentrations of the samples.
[2] Average odor intensity of the last dilution cup (8-fold dilution step).
[3] Average odor intensity at 0 dilution, extrapolated value using linear regression (odor intensity vs. log dilution level).

The odors that were described for these mixtures included organic volatile, gasoline, ether, car exhaust, sweet gasoline and gasoline with ether. The average odor intensity ratings for these mixtures ranged from 2.9 to 4.6 (weak to moderate odors) at concentrations ranging from 2.4 ppm to 3.5 ppm. The intensity ratings were proportional to the recognition thresholds, the higher the recognition threshold concentration (and therefore the weaker the odor), the lower the intensity rating, the lower the recognition threshold concentration (and therefore the stronger the odor), the higher the intensity rating (see Table 3-5 for individual descriptions and intensities).

The summer blend of gasoline was also mixed with 15% ETBE (99% purity) and also with 15% TAME (94% purity). The average detection and recognition threshold values for these mixtures are 0.064 and 0.139 ppm (summer blend + ETBE) and 0.114 and 0.207 ppm (summer blend + TAME). The odors the panelists associated with these mixtures included ether, gasoline, chemical with gasoline, cleaning fluid and natural gas. The odor intensity ratings for these mixtures were 3.92 (ETBE mixture) at 3.4 ppm and 3.5 (TAME mixture) at 2.95 ppm. The intensity values for each sample were also extrapolated to a zero (0) dilution and the slope values of the odor intensity vs. concentration line were also calculated. Since odorant intensity increases as a function of concentration, the data indicates that the summer blend + 15% MTBE (99%) has the most intense odor. The odor of the summer blend of gasoline combined with MTBE, ETBE or TAME was more intense than the odor of the summer blend of gasoline alone.

The winter and composite gasolines were each mixed with 15% MTBE (97% purity) and the average detection and recognition threshold values for these mixtures are 0.219 and 0.398 ppm (winter blend + MTBE) and 0.085 and 0.185 ppm (composite blend + MTBE). The odor of the winter gasoline - MTBE mixture was associated with gasoline, chemical and ether by the panelists. The average odor intensity rating for this mixture was rated at 4.05 which indicates that this blend of gasoline also has a moderate odor. The odor of the "composite" gasoline - MTBE mixture was associated with gasoline, gasoline with ether, and permanent marker by the panelists. The average odor intensity rating for this mixture was rated at 4.60 which indicates that this blend of gasoline has a moderate odor. The odor intensity of the winter blend of gasoline combined with MTBE was similar to the intensities of the summer blend combined with MTBE, ETBE or TAME. Consistent with the composite gasoline alone, the composite gasoline with 15% MTBE added exhibited the lowest odor intensity when the starting concentration was taken into consideration.

The D/T evaluation forms for the dynamic triangle olfactometer, which include the perceived odor characteristics of the summer, winter and "composite" blends, are provided in Appendix C and present the responses of each panelist. The detection and recognition threshold values for each sample are calculated using this data as described in Section 2.

CONCLUSIONS

MTBE, ETBE and TAME are powerful odorants that are capable of significantly reducing the odor thresholds of gasoline. The commercial grade of MTBE has an odor detection threshold of 0.053 ppm in air and 0.045 ppm when in water. The reduction in the odor threshold of gasoline after the addition of MTBE is dependant on the amount of MTBE added. There was no reduction in the odor threshold of the summer blend of gasoline after the addition of 3% (by volume) of commercial grade of MTBE when compared to the gasoline alone. However, the addition of 11% and 15% commercial grade MTBE to summer gasoline, resulted in an average 53% reduction (52% and 54%, respectively) in the odor threshold of the summer gasoline blend alone. There was an 80% decrease in the detection threshold of the summer blend when 15% MTBE (99% purity) was added.

The odor thresholds of the three gasolines were similar, ranging from 0.474 ppm to 0.576 ppm. The addition of commercial grade MTBE (15%) to the three gasoline blends resulted in reductions in the odor detection thresholds ranging from 54% to 82%. The most significant reduction was seen with the addition of MTBE to the composite gasoline sample. The reason for this large reduction is unknown.

Finally, a comparison of the summer blend of gasoline combined with MTBE, ETBE or TAME yielded results consistent with the odor detection thresholds of the oxygenates themselves. Previous investigations have shown ETBE to be the most odorous oxygenate (TRC, 1993a), followed by TAME (TRC, 1993b) then MTBE. The addition of ETBE or TAME to the summer blend produced an 89% and 80% decrease, respectively, in the odor threshold of the summer blend alone. The order of the odor detection thresholds (from lowest to highest) is: summer blend + ETBE (0.064 ppm) < summer blend + TAME (0.114 ppm) < summer blend + commercial grade MTBE (0.264 ppm).

It is evident from the data therefore, that the addition of 11% to 15% (by volume) MTBE, as well as 15% (by volume) TAME or ETBE to gasoline results in a significant reduction in the odor detection and recognition thresholds of gasoline. This decrease in the odor threshold was also associated with an increase in the odor intensity of the oxygenated gasoline.

REFERENCES

TRC Environmental Consultants, Inc. 1985. *Review of Published Odor and Taste Threshold Values of Soluble Gasoline Components.* API Publication No. 4419. American Petroleum Institute, Washington, D.C.

Clayton Environmental Consultants. 1993. *Gasoline Vapor Exposure Assessment at Service Stations.* API Publication No. 4553. American Petroleum Institute, Washington, D.C.

ASTM (American Society for Testing and Materials), 1993a. ASTM E 679, Standard Practice for Determination of Odor and Taste Thresholds By a Forced-Choice Ascending Concentration Series Method of Limits. *ASTM Book of Standards.* v. 15.07, Philadelphia, PA.

ASTM (American Society for Testing and Materials), 1993b. ASTM E 544, Standard Practices for Referencing Suprathreshold Odor Intensity. *ASTM Book of Standards.* v. 15.07, Philadelphia, PA.

APHA, AWW, WEF, 1992. In A.E. Greenberg, L.S. Clesceri and A.D. Eaton, eds. *Standard Methods for the Examination of Water and Wastewater, 18th ed.* American Public Health Association (APHA), Washington, D.C.

TRC Environmental Corporation, 1993a. *Final Report to ARCO Chemical Company on the Odor and Taste Threshold Studies Performed with Methyl Tertiary-Butyl Ether (MTBE) and Ethyl Tertiary-Butyl Ether (ETBE).* TRC Project No. 13442-M31, ARCO Chemical Co., Newtown Square, PA.

TRC Environmental Corporation, 1993b. *Odor and Taste Threshold Studies Performed With Tertiary-Amyl Methyl Ether (TAME).* API Project No. 08200-0300-SA13, American Petroleum Institute, Washington, D.C.

APPENDIX A

MTBE DATA SHEETS

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: MTBE - A 10.9 PPM
2.01 103

Evaluation Date: 6/10 **RESULT:** Log ED_{50} = 2.40 ED_{50} = 251

Detection = 0.0434 ppm
Recognition = 0.105 ppm
intensity $\bar{x}$ = 5.14

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		Panelist Indicated:						
1	Joan	BN	TD	B2	B3.5	T4	C5	medicine
2	Ann	BN	TN	BN	Bd	TH	C5	turpentine
3	Jill	BN	CN	BN	TN	TN	C5	chemical
4	Dick	BN	CN	Bd	BN	T1	C3	volatile, cleaning fluid
5	Mary	BN	TN	Bd	BB	T5	C7	rotten onions
6	Ruth	BN	TN	Bd	BB	T6	C8	lemony, sour
7	Karen	Td	TD	B2	B3	T4	C5	chemical
8								
9								
10	Frequency Tally recognition		2		3	1	1	
Frequency Tally		1	1	3	1		1	
Average Rank		1	2	4	6		7	
recognition values			1.5		4	6	7	

	<1	1	2	3	4	5	6	"7"
X = Plotting Value	-1.15	-.67	0	.67		1.15		
Recognition values		-.89		0	.67	1.15		
Y = Log(Tolerance Level)	3.681	3.083	2.514	1.992	1.158	.732		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:
~~1~~
~~2~~
~~3~~
~~4~~
~~5~~
~~6~~
~~7~~
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader K. Ulehan

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: MTBE – B 11.3 ppm

1.85 71

Evaluation Date: 6/10 **RESULT:** Log ED_{50} = 2.30 ED_{50} = 199

D=.058 ppm

R=.159 ppm

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Joan	BN	Td	B1.5	B2.5	T4	C5	medicine, gasoline
2	Ann	BN	TN	TN	CN	TN	C6	rubbing alcohol
3	Jill	CN	BN	TN	BN	TN	C3	medicine
4	Dick	BN	CN	BN	Bd	TN	C3	gasoline
5	Mary	BN	CN	Bd	BN	T6	C7	rotten onions
6	Ruth	CN	Td	BN	B5	T6	C7	lemony, sour
7	Karen	TN	Td	BN	B3	T4	C6	
8								
9								
10	Frequency Tally Recognition			3	1	2	1	
	Frequency Tally		3	1	1	1	1	

Average Rank 2 4 5 6 7

Recognition values 2 4 5.5 7

X = Plotting Value -.67 0 .32 .67 1.15

Recognition values -.67 0 .49 1.15

Y = Log(Tolerance Level) 3.083 2.514 1.992 1.158 .732

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count: 1 2 3 ~~4~~ 5 6 7 8 9 10

Plot Y versus X
X at Y=0 is Log ED

Panel Leader K. Volkane

ED$_{50}$ Evaluation Form for Dynamic Triangle Olfactometer

Sample: MTBE - C 11.3 ppm
2.01 103

Evaluation Date: 6/10 **RESULT:** Log ED$_{50}$ = 2.27 ED$_{50}$ = 187.03

D = .058 ppm
R = .110 ppm

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Jean	BN	CN	B 1.5	B2.5	T4	C4.5	chemicals
2	Ann	TN	CN	CN	TN	CN	C 4	chemical
3	Jill	CN	BN	BN	TN	Td	C3	[illegible]
4	Dick	BN	CN	TN	Bd	T 2	C 3	butane
5	Mary	TN	Td	BN	B3	T5	C7	garbage rotten onions
6	Ruth	BN	TN	B 1	B6	T1	C8	witch hazel - rubbing alcohol
7	Homer	CN	T 1	B2	B3	T5	C6	ether
8								
9								
10	Frequency Tally Recognition		1	3		1	2	
	Frequency Tally		2	2	1	1	1	
	Average Rank		1.5	3.5	5	6	7	
	Recognition values		1	3		5	6.5	
	X = Plotting Value	-.89	-.16	.32	.67	1.15		
	Recognition values	-1.15	-.32		.32	.89		
	Y = Log(Tolerance Level)	3.083	2.514	1.992	1.555	1.158		
	Log(Dilution Factor)							

Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count: 1 2 3 4 5 6 7 8 9 10

Plot Y versus X
Y at X=0 is Log ED

Panel Leader R. [illegible]

AQUEOUS MTBE ODOR THRESHOLD STUDY DATA SHEET[1]

Round 1
Starting concentration = 0.740 ppm

Panelist	A (0.023 ppm)	B (0.046 ppm)	C (0.093 ppm)	C (0.185 ppm)	A (0.370 ppm)	B (0.740 ppm)	Odor Characteristics
Nolya C.	C n	B 2	C 4	C 5	A 5	B 5	medicine, alcohol
Alma D.	B n	A n	C n	C n	A n	B 1	alcohol
Terry A.	C d	A n	C n	C n	A d	B 2	ether, sweet
Don P.	A n	A n	C 2	C 3	A 4	B 4	hospital, medicine
Mary S.	C d	B 1	C 2	C 2	A 3	B 3	rubbing alcohol
Florence T.	A n	B n	C d	C 1	A 2	B 3	medicine
Irene C.	C n	B n	C n	C d	A 1	B 2	rubbing alcohol
Frequency Tally (detection)		2	2	1	1	1	
Frequency Tally (recognition)		2	1	1	1	2	

Results[2]: D/T detection = 15.35 (0.048 ppm)
D/T recognition = 11.38 (0.065 ppm)

Round 2
Starting concentration = 0.740 ppm

Panelist	A (0.023 ppm)	B (0.046 ppm)	C (0.093 ppm)	C (0.185 ppm)	A (0.370 ppm)	B (0.740 ppm)	Odor Characteristics
Nolya C.	A n	C n	C 2	C 3	A 3	B 4	medicine, ether
Alma D.	A n	B 1	C 2	C 3	A 3.5	B 2	hospital
Terry A.	B d	A n	C d	C 1	A 2	B 2.5	sweet, alcohol
Don P.	A n	A n	C 2	C 2	A 2	B 3	alcohol
Mary S.	B d	C d	C 1	C 2	A 2.5	B 3	hospital
Florence T.	C d	A n	B n	A n	A 3	B 3.5	medicine
Irene C.	B n	C n	A n	C 1	A 1.5	B 2	rubbing alcohol
Frequency Tally (detection)		1	4	1	1		
Frequency Tally (recognition)		1	3	2	1		

Results[2]: D/T detection = 17.95 (0.041 ppm)
D/T recognition = 16.82 (0.044 ppm)

[1]Panelists had the option of choosing 1 of 3 flasks per dilution group. The letter of the correct flask (A, B, or C) for each dilution heads the column. Each panelist then rated the chosen flask, where:
- n = nothing
- d = different from other two flasks, but cannot rank on butanol scale
- 1-5 = butanol scale ranking (8 highest possible ranking)

[2]The detection threshold was determined by a linear regression method

= detection

= recognition

MTBE-TASTE THRESHOLD STUDY DATA SHEET[1]

Round 1
Starting concentration = 0.740 ppm

Panelist	1 (0.023 ppm)	2 (0.046 ppm)	3 (Blank)	4 (0.093 ppm)	5 (0.185 ppm)	6 (0.370 ppm)	7 (Blank)	8 (0.740 ppm)	Taste Characteristics
Nolya C.	-	+	-	+	+	+	-	+	bitter, nasty
Alma D.	-	+	-	+	+	+	-	+	
Terry A.	-	-	-	-	-	+	-	+	nauseating
Don P.	-	-	-	-	-	+	-	+	
Mary S.	-	+	-	+	+	+	-	+	rubbing alcohol
Florence T.	-	-	-	-	-	+	-	+	
Irene C.	-	+	-	+	+	+	-	+	
Frequency Tally (detection)		4				3			

Result[2]: D/T detection = 19 (0.039 ppm)

Round 2
Starting concentration = 0.740 ppm

Panelist	1 (0.023 ppm)	2 (0.046 ppm)	3 (Blank)	4 (0.093 ppm)	5 (0.185 ppm)	6 (0.370 ppm)	7 (Blank)	8 (0.740 ppm)	Taste Characteristics
Nolya C.	+	+	-	+	+	+	-	+	nasty
Alma D.	-	+	-	+	+	+	-	+	
Terry A.	-	-	-	-	-	+	-	+	rubbing alcohol
Don P.	-	-	-	-	-	+	-	+	
Mary S.	-	+	-	+	+	+	-	+	bitter
Florence T.	-	-	-	-	-	+	-	+	
Irene C.	-	+	-	+	+	+	-	+	bitter
Frequency Tally (detection)	1	3				3			

Result[2]: D/T detection = 19 (0.039 ppm)

[1]Panelists compared each test sample with a water reference and rated them either "-" (not different from water) or "+" (different from water).

[2]The detection threshold was calculated using a linear regression method

= detection

APPENDIX B

GASOLINE HEADSPACE VAPOR DATA SHEETS

20 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Bag A - Summer

recognition 1.44 27

Evaluation Date: 6/16 **RESULT:** Log ED_{50} = 1.65 ED_{50} = 45

detection: 0.444 ppm

recognition: 0.741 ppm

X intensity = 2.64

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Joan	TN	TN	B1	B2	T3	C3.5	gasoline
2	Nolya	BN	TN	CN	CN	Td	C3	rubber
3	Alma	TN	TN	BN	BN	CN	C2	rotting garbage
4	Mary	TN	TN	CN	BN	T2	C3	gasoline
5	Terry	TN	TN	Cd	Bd	T1	C1.5	gasoline
6	Ruth	CN	BN	CN	CN	TN	C4.5	gas
7	Betsy	BN	TN	BN	TN	Td	C1	gasoline
8								
9								
10	Frequency Tally recognition			1		2	4	
Frequency Tally				1	1	3	2	
Average Rank				1	2	4	6.5	
recognition values				1		2.5	5.5	
X = Plotting Value				-1.15	-.67	0	.89	
recognition values				-1.15		-.49	.49	
Y = Log(Tolerance Level)				2.514	1.992	1.555	1.158	

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader K Vatarus

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

20 ppm

Sample: Bag B - Summer

recognition 1.38 24

Evaluation Date: 6/16 RESULT: Log ED_{50} = 1.55 ED_{50} = 35

detection = 0.571 ppm
recognition = 0.833 ppm
x̄ intensity = 1.86

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Joan	BN	BN	Bd	BT1	T2	C3	gasoline
2	Nolya	BN	BN	CN	TN	T1	C1	smoke
3	Alma	TN	TN	BN	TN	CN	CT	chemical
4	Mary	BN	BN	T1	BN	T2	C3	gasoline
5	Terry	TN	BN	CN	BN	CN	CT	burnt chemical
6	Ruth	BN	BN	CN	BN	TN	C3	lemon
7	Betsy	BN	Bd	CN	CN	T1	C1	gasoline
8								
9								
10	Frequency Tally recognition				1	2	4	
Frequency Tally				1		3	3	
Average Rank				1		3	6	

recognition value: 1 2.5 5.5

X = Plotting Value: -1.15 -.32 .67

recognition value: -1.15 -.49 .49

Y = Log(Tolerance Level): 2.514 1.492 1.555 1.158

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader K. Vitone

.20 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Bag C. Summer

recognition 1.38 24

Evaluation Date: 6/16 **RESULT:** Log ED_{50} = 1.45 ED_{50} = 28

detection: 0.714 ppm
recognition: 0.533 ppm
$\bar{x}$ intensity = 2.29

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Joan	TN	BN	BN	BI	T2	C3	gasoline
2	Nolya	BN	TN	CN	CN	CN	C2	rubber
3	Alma	BN	TN	BN	BN	CN	C1.5	chemical
4	Mary	BN	TN	BN	CN	T1	C2.5	gasoline
5	Terry	BN	BN	CN	CN	T1	C1	gas
6	Ruth	BN	BN	CN	Td	CN	C5	smokey
7	Betsy	BN	BN	BN	TN	Td	C1	gasoline
8								
9								
10	Frequency Tally recognition				1	2	4	
Frequency Tally					1	3	3	
Average Rank					1	3	6	
recognition values					1	2.5	5.5	
X = Plotting Value					-1.15	-.32	.67	
recognition values					-1.15	-.49	.49	
Y = Log(Tolerance Level)					1.992	1.555	1.158	
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X

Panel Leader K. V[illegible]

32 ppm

ED$_{50}$ Evaluation Form for Dynamic Triangle Olfactometer

Sample: Winter Bag D

recognition 1.38 24

Evaluation Date: 6/16 **RESULT: Log ED$_{50}$ =** 1.78 **ED$_{50}$ =** 60

0.53 ppm detection
1.33 ppm recognition
$\bar{x}$ intensity = 2.0

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		Panelist Indicated:						
1	Joan	BN	TN	Bd	B[1]	T2	C3	
2	Nelya	CN	BN	CN	BN	Td	C[3]	
3	Alma	TN	TN	BN	BN	TN	T[1]	
4	Mary	TN	BN	CN	Bd	T[1]	C2	
5	Terry	CN	TN	CN	TN	Td	C[1]	
6	Ruth	BN	BN	TN	CN	Td	C[3]	
7	Betsy	TN	TN	CN	Bd	T[1]	C1	
8								
9								
10	Frequency tally recognition				1	2	4	
Frequency Tally				1	2	3	1	
Average Rank				1	2.5	5	7	
recognition values					1	2.5	5.5	
X = Plotting Value				-1.15	-.49	.32	1.15	
recognition values					-1.15	-.49	.49	
Y = Log(Tolerance Level)				2.514	1.992	1.555	1.158	
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X

Panel Leader K. Patterson

26 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: E - Winter

recognition 1.38 24

Evaluation Date: 6/16 **RESULT:** Log ED_{50} = 1.78 ED_{50} = 60

0.43 ppm detection
1.08 ppm recognition
$\bar{x}$ intensity = 2.0

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Dilution Level Number						
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Jon	BN	TN	Bd	B$\boxed{T}$	T_2	C_3	gasoline
2	Nolyn	BN	CN	CN	BN	Td	C$\boxed{B}$	gasoline
3	Alma	TN	TN	BN	BN	TN	C$\boxed{T}$	kerosene
4	Mary	TN	BN	CN	Bd	T$\boxed{T}$	C_2	gasoline
5	Terry	TN	CN	CN	TN	Td	C$\boxed{T}$	gasoline
6	Ruth	BN	BN	TN	CN	Td	C$\boxed{B}$	chemical
7	Betsy	TN	TN	CN	Bd	T$\boxed{T}$	C_1	gasoline
8								
9								
10	Frequency Tally recognition				1	2	4	
Frequency Tally				1	2	3	1	
Average Rank				1	2.5	5	7	
recognition values					1	2.5	5.5	

	<1	1	2	3	4	5	6	"7"
X = Plotting Value			-1.15	-.49	.32	1.15		
recognition values				-1.15	-.49	.49		
Y = Log(Tolerance Level)			2.514	1.992	1.555	1.158		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X

Panel Leader: Kim M T[illegible]

20 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: F – Winter

recognition 1.32 21

Evaluation Date: 6/16 **RESULT:** Log ED_{50} = 1.62 ED_{50} = 42

0.476 ppm: detection
0.952 ppm: recognition
$\bar{X}$ intensity: 2.10

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Dilution Level Number						
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Joan	BN	Td	B0	B2	T3	C4	gasoline
2	Nolya	BN	BN	CN	BN	Td	C3	gasoline
3	Alma	CN	TN	BN	TN	CN	C1	gasoline
4	Mary S.	BN	BN	CN	Bd	T1	C1.5	gasoline
5	Terry	TN	BN	CN	TN	Td	C1	gasoline
6	Ruth	BN	BN	CN	CN	BN	C3	gasoline
7	Betsy	BN	TN	CN	BN	CN	C2	gasoline
8								
9								
10	Frequency Tally recognition			1		1	5	
Frequency Tally			1		1	2	3	
Average Rank			1		2	3.5	6	
recognition values				1		2	5	
X = Plotting Value			-1.15		-.67	-.16	.67	
recognition values				-1.15		-.67	.32	
Y = Log(Tolerance Level)			3.083	2.514	1.992	1.555	1.158	
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED

Panel Leader K. Richards

48 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Composite #1

1.80

Evaluation Date: 7/14 **RESULT:** Log ED_{50} = 2.02 ED_{50} = 105 63

detection: 0.457 ppm
recognition: 0.761 ppm
$\bar{x}$ intensity = 3.71

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Diane	C2	BN	TN	BE1	T2	C3	smoky
2	Joan	CN	CN	BN	B2	T3	C5	gasoline
3	Nolua	CN	TN	CN	B2	T	C2	gas
4	Tina	BN	TN	B2	B2	T	C2	gasoline
5	Ruth	CN	TN	CN	BN	TB	C5	gasoline
6	Joyce	BN	CN	BN	TN	T	C5	organic solvent
7	Karen	CN	BN	CN	B	T3	C4	gas
8								
9								
10	Frequency Tally recognition			1	2	4		
Frequency Tally				2	3	2		
Average Rank				1.5	4	6.5		
recognition values				1	2.5	5.5		
X = Plotting Value				-.89	0	.89		
recognition values				-1.15	-.49	.49		
Y = Log(Tolerance Level)				2.514	1.992	1.555		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader R. Vehana

50 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Composite #2

1.80

Evaluation Date: 7/14 **RESULT:** Log ED_{50} = 2.09 ED_{50} = 125 63

detection : 0.400 ppm
recognition : 0.794 ppm
$\bar{x}$ intensity = 3.57

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Diane	TN	Cd	Bd	BIII	T1.5	C2	rancid, sour
2	Joan	CN	TN	BII	B2	T3.5	C4.5	gasoline
3	Nelya	CN	TN	CN	Bd	TII	C3	gasoline
4	Tina	BN	TN	Bd	BII	T2	C2.5	gasoline
5	Ruth	CN	TN	CN	BN	T4	C5	gasoline
6	Joyce	BN	CN	TN	TN	T4	C5	asphalt
7	Karen	CN	BN	CN	Bd	TII	C3	gasoline
8								
9								
10	Frequency Tally recognition			1	2	4		
	Frequency Tally			3	2	2		
	Average Rank			2	4.5	6.5		
	recognition values			1	2.5	5.5		
	X = Plotting Value			-.67	.16	.89		
	recognition values			-1.15	-.49	.49		
	Y = Log(Tolerance Level)			2.514	1.992	1.555		

Log (Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count: 1 2 3 4 5 6 7 8 9 10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader K. [illegible]

43 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Composite #3

1.76

Evaluation Date: 7/14 **RESULT:** Log ED_{50} = 1.88 ED_{50} = 76 58

detection = 0.506 ppm
recognition = 0.741 ppm
$\bar{X}$ intensity = 3.71

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Diane	BN	B1	TN	B1	T1.5	C2	rancid
2	Joan	CN	Td	CN	B1.5	T2	C3	gasoline
3	[illegible]	CN	TN	CN	Bd	T2	C3	'gassy' alcohol
4	Tina	BN	TN	BII	B2	T2	C3	gasoline
5	[illegible]	CN	BN	CN	BN	Td	CII	gasoline
6	[illegible]	BN	CN	BN	TN	CN	CI	gasoline
7	Kim	CN	TN	CN	B1	T2	C3	gasoline
8								
9								
10	Frequency Tally Recognition			1	3	1	2	
Frequency Tally				1	4	1	1	
Average Rank				1	3.5	6	7	
Recognition Values				1	3	5	6.5	
X = Plotting Value				-1.15	-.14	.67	1.15	
Recognition values				-1.15	-.32	.32	.89	
Y = Log(Tolerance Level)				2.514	1.792	1.555	1.58	

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader [illegible signature]

APPENDIX C

GASOLINE-OXYGENATE HEADSPACE VAPOR DATA SHEETS

26 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: – MTBE (ARCO) – 99% BAG #A
– Summer Blend recognition 1.80 63

Evaluation Date: 6-1-93 **RESULT:** Log ED_{50} = 2.34 ED_{50} = 220

detection : 0.118 ppm
recognition : 0.41 ppm
Intensity = 4.21

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Dick	C_N	T_N	B_N	B_d	$T_{[2]}$	C_3	solvent chemical
2	Alma	B_N	T_d	B_D	$B_{[1]}$	T_2	C_3	chemical and gasoline
3	Ruth	B_N	C_N	B_D	$B_{[5]}$	$T_?$	C_8	ether
4	Joyce	B_N	C_N	B_N	B_d	$T_{[1]}$	C_4	deodorant fragrance
5	Jen	C_N	C_N	T_N	$B_{[1]}$	T_4	C_5	gas
6	Jill	C_N	T_N	C_N	B_D	$T_{[1]}$	$C_{1.5}$	GAS
7	Joan	B_N	$T_{[1]}$	B_2	B_3	$T_{1.5}$	C_5	chemical/gas
8								
9								
10	Frequency Tally recognition		1		3	3		
Frequency Tally			2	1	4			
Average Rank			1.5	3	5.5			
recognition values			1		3	6		
X = Plotting Value			-.84	-.32	.49			
recognition values			-1.15		-.32	.67		

	<1	1	2	3	4	5	6	"7"
Y = Log(Tolerance Level)	3.681	3.083	2.514	1.992	1.158	.732		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X

Panel Leader T. Cull [illegible]

60 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: MTBE-ARCO-9990 Bag #B
Summer Blend recognition 2.08 121

Evaluation Date: 6-18-93 **RESULT:** Log ED_{50} = 2.48 ED_{50} = 305

detection: 0.085 ppm
recognition: 0.215 ppm
$\bar{X}$ intensity = 5.0

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Dick	BN	TN	BN	B1	T1	C4	solvent/gasoline
2	Alma	CN	TN	CN	B1	T2	C3	Kerosene/Gas
3	Ruth	BN	BN	Bd	B3	T6	C8	Gasoline
4	Joyce	CN	TN	Bd	B4	T3	C4	Perfume
5	Jenn	CN	BN	B3	B5	T5	C8	Gasoline
6	Jill	CN	TN	BN	Bd	T1	C3	Fragrance
7	John	Td	T1	B2	B3	T4.5	C5	Gas/chemical
8								
9								
10	Frequency Tally recognition		1	1	4	1		
Frequency Tally		1		3	3			
Average Rank		1		3	6			
recognition values			1	2	4.5	7		
X = Plotting Value		-1.15		-.32	.67			
recognition values			-1.15	-.67	.16	1.15		
Y = Log(Tolerance Level)		3.681	3.083	2.514	1.992	1.158		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X

Panel Leader [signature]

26 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: - MTBE - ARCO - 99% → BAG C
- SUMMER 91 AS blend recognition 1.76 58

Evaluation Date: 6-15-93 **RESULT:** Log ED_{50} = 2.28 ED_{50} = 190

detection: 0.137 ppm
recognition: 0.448 ppm
Intensity: 4.57

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Dice	BN	TN	BN	B1	T2	C3	Gas/ether organic volatile odor
2	Alma	BN	TN	Bd	B1	T2	C3	chemical odor
3	Ruth	BN	TN	B3	B5	T7	C8	ether gasoline
4	Joyce	B	CN	BN	Bd	T4	C5	Detergent
5	Jen	CN	TN	BN	Bd	T5	C7	car odor exhaust
6	Jill	BN	TN	CN	Bd	T1½	C1	adhesive
7	Joan	BN	Td	B1	B2	T3.5	C5	chemical
8								
9								
10	Frequency Tally recognition			2	3	2		
Frequency Tally			1	2	4			
Average Rank			1	2.5	5.5			
recognition values				1.5	4	5.5		
X = Plotting Value			-1.15	-.49	.49			
recognition values				-.89	0	.49		
Y = Log(Tolerance Level)			3.083	2.514	1.492	1.158		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X

Panel Leader [illegible signature]

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: 3% MTBE - summer (20ppm) #1
recognition 1.45

Evaluation Date: 6/17 **RESULT:** Log ED_{50} = 1.67 ED_{50} = 47 25

detection = .531 ppm
recognition = 0.50 ppm
$\bar{X}$ intensity = 2.71

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Ann	BN	BN	CN	BN	Td	C1	gasoline
2	Irene	CN	TN	CN	BN	Td	C2	gasoline
3	Florence	CN	BN	CN	CN	Td	C4	gasoline
4	Tiny	TN	BN	CN	Bd	T2	C3	gasoline w/sickening sweet odor
5	Don	TN	CN	CN	B1	T3	C4	gasoline w/ sweet odor
6	Mary	BN	TN	TN	CN	T1	C3	gasoline
7	Bill	BN	TN	CN	BN	T1	C2	gasoline
8								
9								
10	Frequency Tally recognition				1	3	3	
Frequency Tally					2	5		

	<1	1	2	3	4	5	6	"7"
Average Rank					1.5	5		
recognition values					1	3	6	
X = Plotting Value				-.89	.32			
recognition values				1.15	-.32	.67		
Y = Log (Tolerance Level)				1.992	1.555	1.158		
Log (Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED

Panel Leader K. Vikrane

21 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: 390 MTBE ... Summer #3

1.45 28

Evaluation Date: 6/17 **RESULT:** Log ED_{50} = 1.57 ED_{50} = 37

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"	
		Correct Choice Would Be: (t = top, c = center, b = bottom)							Detection = 0.508 ppm recognition = 0.75 ppm X mkas.4 = 3.28
		Panelist Indicated:							
1	Ann	BN	CN	BN	TN	CN	CB	natural gas	
2	Irene	CN	TN	TN	CN	Td	CB	gasoline w/ sweet smell	
3	Florence	CN	TN	CN	Bd	TB	C5	gasoline w/ sweet smell	
4	Terry	BN	TN	CN	BN	T1	C3	gasoline, pungent, sickening	
5	Don	TN	CN	CN	TN	T2	C4	gasoline	
6	Mary	CN	Bd	CN	BN	T1	C2	gasoline w/ nutty smell	
7	Jill	BN	CN	CN	TN	T2	C3	gasoline, not offensive	
8									
9						5	2		
10	Frequency Tally recognition				1	5	1		
Frequency Tally									
Average Rank recognition values					1	4 3	7 6.5		
X = Plotting Value recognition values				-1.15	0 -.32	1.15 .89			
Y = Log(Tolerance Level)				1.992	1.555	1.158			
Log(Dilution Factor)									
Dilution Level No.	<1	1	2	3	4	5	6	"7"	

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader K. Vetrano

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: 390 MTBE - Summer (22ppm) #2

1.61 41

Evaluation Date: 6/17 **RESULT:** Log ED_{50} = 1.74 ED_{50} = 55

Detection = 0.40 ppm
recognition = 0.531 ppm
$\bar{x}$ intensity = 2.71

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)							
	Panelist Indicated:							
1	Ann	CN	CN	TN	Bd	TII	C2	gasoline
2	Irene	CN	BN	TN	CN	TIII	C3	gasoline cleaning fluid
3	Florence	CN	BN	TN	Bd	TII	C5	gasoline
4	Terry	BN	CN	BN	TN	TIII	C3	pleasant, sweet gasoline
5	Don	TN	TN	CN	BIII	T3	C3	gasoline
6	Mary	BN	BN	CN	TN	TIII	C3	gasoline
7	Jill	CN	CN	TN	CN	T1.5	C3	gasoline w/sweet odor
8								
9								
10	Frequency Tally recognition				1	6		
Frequency Tally					3	4		
Average Rank					2	5.5		
recognition values					1	4.5		
X = Plotting Value					-.67	.49		
recognition values					-1.15	.16		
Y = Log(Tolerance Level)					1.992	1.555		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1 2 3 4 5 6 7 8 9 10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader [signature]

30 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: 1190 MTBE + Summer Gasoline #1

recognition 1.50 32

Evaluation Date: 6/17 **RESULT:** Log ED_{50} = 1.94 ED_{50} = 88

detection: 0.341 ppm
recognition: 0.938 ppm
Intensity: 2.71

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Dilution Level Number						
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Ann	CN	CN	Bd	BT1	T2	C3	gasoline
2	Irene	CN	BN	CN	BN	Td	C2	gasoline
3	Flounce	CN	BN	CN	BN	Td	C4	gasoline w/ sweetness
4	Terry	BN	TN	CN	Bd	T1	C3	Sweet gasoline
5	Don	TN	CN	BN	B1	T2	C3	gasoline, sweet
6	Mary	BN	TN	Bd	Bd	T1	C3	gasoline not unpleasant
7	Jill	BN	TN	CN	BN	Td	C1	gasoline sweet
8								
9	Frequency Tally							
10	recognition				2	2	3	
Frequency Tally				2	2	3		
Average Rank				1.5	3.5	6		
recognition values					1.5	3.5	6	
X = Plotting Value				-.89	-.16	.67		
recognition values					-.89	-.16	.67	
Y = Log(Tolerance Level)			2.514	1.992	1.555	1.158		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

ˈot Y versus X

Panel Leader K. Vihane

26 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: 11% MTBE r Gasoline #2

recognition 1.63 42

Evaluation Date: 6/17 **RESULT:** Log ED_{50} = 2.02 ED_{50} = 105

detection: 0.248 ppm
recognition: 0.619 ppm
Intensity: 3.4

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		Panelist Indicated:						
1	Ann	BN	BN	CN	Bd	TB	Cy	ether gasoline
2	~~Hattie~~ Irene	CN	TN	CN	CN	Td	CB	gasoline
3	Florence	CN	TN	CN	Bd	TI	C5	gasoline
4	Tiny	BN	TN	BN	Bd	TI	C2	gasoline ether, sickening sweet
5	Don	TN	CN	BN	BI	T2	C3	gasoline, sweet
6	Mary	BN	Bd	Bd	BI	T2	C3	gasoline, tolerable
7	Sil	BN	TN	CN	Bd	TI	C2	gasoline, sweet
8								
9								
10	Frequency Tally recognition				2	4	1	
Frequency Tally				1	5	1		
Average Rank				1	4	7		
recognition values					1.5	4.5	7	
X = Plotting Value			-1.15	0	1.15			
recognition values				-.89	.16	1.15		
Y = Log(Tolerance Level)			2.514	1.992	1.555	1.158		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED

Panel Leader K. Vichan

27 ppM

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: #7 1190 MTBE r Summer Gasoline
recognition 1.67 47

Evaluation Date: 6/17 **RESULT:** Log ED_{50} = 2.06 ED_{50} = 114

detection: 0.237 ppm
recognition: 0.574 ppm
intensity = 3.00

Cons. No.	Panelist	1	2	3	4	5	6	"7"	
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C		
	Panelist Indicated:								
1	Ann	TN	BN	Bd	Bd	T1	C3		gasoline, sweet
2	Irene	CN	TN	BN	Bd	T2	C2		benzene
3	Florence	CN	BN	CN	Bd	T2	C5		sweet gasoline
4	Terry	TN	TN	CN	Bd	T1	C2		gasoline, nauseating, sweetness
5	Don	CN	BN	TN	B1	T2	C3		gasoline, sweetness
6	Mary	BN	TN	CN	Bd	T2	C3		gasoline pleasant, sweet
7	Jill	BN	TN	CN	B1	T2	C3		gasoline.
8									
9	Frequency Tally								
10	recognition				2	5			
Frequency Tally				1	6				
Average Rank				1	4.5				
recognition values					1.5	5			

X = Plotting Value: −1.15 .16
recognition values: −.89 .37

Y = Log(Tolerance Level): 2.514 1.992 1.555

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X

Panel Leader K. V[illegible]

32 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: 1590 MTBE + Gasoline II 1.
recognition 1.57 37

Evaluation Date: 6/17 **RESULT: Log ED_{50} =** 2.02 **ED_{50} =** 105

detection: 0.305 ppm
recognition: 0.865
$\bar{x}$ intensity = 3.070

Cons. No.	Panelist	1	2	3	4	5	6	"7"	
		Correct Choice Would Be: (t = top, c = center, b = bottom)							
		Panelist Indicated:							
1	Ann	CN	CN	CN	CN	Td	C4	gasoline + ethy	
2	Irene	BN	TN	CN	Bd	T1	C2	oily	
3	Florence	CN	TN	CN	Bd	T3	C5	gasoline	
4	Terry	CN	TN	CN	Bd	T1	C2	gasoline + sweet	
5	Don	TN	CN	Bd	B1	T2	C4	gasoline, sweetness	
6	Mary	TN	TN	CN	Bd	T2	C3	gasoline	
7	Jill	CN	BN	TN	Bd	T1	C1.5	gasoline	
8									
9	Frequency Tally								
10	recognition				1	5	1		
Frequency Tally				1	5	1			
Average Rank				1	4	7			
recognition values					1	4	7		
X = Plotting Value			-1.15	0	1.15				
recognition values				-1.15	0	1.15			
Y = Log(Tolerance Level)			2.514	1.992	1.555	1.158			
Log(Dilution Factor)	<1	1	2	3	4	5	6	"7"	
Dilution Level No.	<1	1	2	3	4	5	6	"7"	

For Rank Count:

1
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Plot Y versus X
Y at X=0 is Log ED

Panel Leader K. [illegible]

34 ppm

ED$_{50}$ Evaluation Form for Dynamic Triangle Olfactometer

Sample: 15% MTBE + Gasoline #2

1.76 57

Evaluation Date: 6/17 **RESULT:** Log ED$_{50}$ = 2.09 ED$_{50}$ = 122

detection: 0.279 ppm
recognition = 0.596 ppm
$\bar{X}$ intensity = 2.570

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		Panelist Indicated:						
1	Ann	BN	CN	TN	CN	Td	CF4	rubbing alcohol
2	Irene	CN	BN	Bd	B1	T2	C2	gasoline
3	Florence	CN	TN	CN	Bd	T1	C3	gasoline
4	Terry	BN	TN	CN	B1	T1	C3	gasoline, sweet, intolerable
5	Don	TN	CN	Bd	B2	T3	C4	gasoline, sweet
6	Mary	CN	TN	CN	B1	T1	C3	gasoline/something else unpleasant
7	Jill	BN	TN	TN	Bd	T2	C1	gasoline
8								
9								
10	Frequency Tally recognition				4	2	1	
Frequency Tally				2	4	1		
Average Rank				1.5	4.5	7		
recognition values					2.5	5.5	7	
X = Plotting Value				-.89	.16	1.15		
recognition values					-.49	.49	1.15	
Y = Log(Tolerance Level)				2.514	1.992	1.555	1.158	
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
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Plot Y versus X
Y at X=0 is Log ED$_{50}$

Panel Leader K. Hoffman

28 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: 1590 MTBE T Summer Gas # 3

recognition 1.67 47

Evaluation Date: 6/17 **RESULT:** Log ED_{50} = 2.13 ED_{50} = 135

detection: 0.207 ppm
recognition: 0.596 ppm
$\bar{x}$ intensity: 3.57

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Ann	CN	BN	TN	Bd	TII	C5	gasoline
2	June	BN	TN	CN	Bd	TII	C3	gasoline, oily
3	Florence	CN	TN	Bd	[illegible]	T3	C5	gasoline + mostly sweet
4	Terry	CN	TN	CN	Bd	TII	C4	gasoline, intolerable sweetness
5	Don	TN	CN	Bd	BII	T2	C4	gasoline, sweet
6	Mary	BN	TN	BN	Bd	TII	C2	gasoline, Tolerable
7	Jill	BN	TN	BN	Bd	TII	C2	gasoline
8								
9								
10	Frequency Tally recognition				2	5		
Frequency Tally				2	5			
Average Rank				1.5	5			
recognition values					1.5	5		
X = Plotting Value				-.89	.32			
recognition values					-.89	.32		
Y = Log(Tolerance Level)				2.514	1.992	1.555		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

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Plot Y versus X

Panel Leader K. Helhane

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Summer + (15%) TBE #1 31 ppm
recognition 2.25

Evaluation Date: 6/21 **RESULT:** Log ED_{50} = 2.62 ED_{50} = 415 181

detection = 0.075 ppm
recognition = 0.171 ppm
$\bar{x}$ intensity = 3.85

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Ann	BN	Td	B[1]	B2	T4	C5	alcohol, ethyl
2	Florence	BN	TN	Bd	B[2]	T3	C3	sweet cleaner
3	Alma	BN	BN	Bd	B[1]	T2	C3	chemical
4	Don	BN	Td	B[1]	B2	T2	C3	alcohol chemical
5	Mary	BN	TN	CN	Bd	T[1]	C2	5 gasoline + chemical smell
6	Jill	BN	TN	BN	B[2]	T3	C4	cleaning fluid
7	Joan	TN	T[1]	B3	B4.5	T5.5	C6.5	
8								
9								
10	Frequency tally recognition	.	1	2	3	1		
Frequency Tally			3	2	2			

	<1	1	2	3	4	5	6	"7"
Average Rank			2	4.5	6.5			
recognition value			1	2.5	5	7		
X = Plotting Value			-.67	.16	.89			
recognition value			-1.15	-.49	.32	1.15		
Y = Log(Tolerance Level)			3.083	2.514	1.992	1.555		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
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Plot Y versus X
Y at X=0 is Log ED

Panel Leader K. Vickers

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Summer +(15%)ETBE #2 30 ppm

recognition 2.28

Evaluation Date: 6/21 **RESULT: Log ED_{50} =** 2.57 **ED_{50} =** 367 194

detection = 0.082 ppm
recognition = 0.154 ppm
$\bar{x}$ intensity: 3.71

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"	
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C		
	Panelist Indicated:								
1	Ann	TN	CN	BN	TN	TB1	C4	ether alcohol - gasoline	
2	Florence	BN	TN	CN	Bd	TT1	C4	cleanser	
3	Alma	TN	Td	B1	B2	T3	C4	chemical + gas	
4	Don	TN	Td	B1	B2	T2	C1	chemical alcohol	
5	Mary	BN	TN	Bd	B1	T2	C3	gasoline sunset	
6	Jill	BN	TN	CN	Bd	T1	C4	natural gas	
7	Joan	Td	T1.5	B2.5	B4	T5	C6	gasoline + chemical	
8									
9									
10	Frequency Tally recognition		1	2	1	3			
Frequency Tally		1	2	1	2	1			
Average Rank		1	2.5	4	5.5	7			
recognition values			1	2.5	4	6			
X = Plotting Value		-1.15	-.49	0	.49	1.15			
recognition values			-1.15	.49	0	.67			
Y = Log(Tolerance Level)		3.681	3.083	2.514	1.992	1.555			
Log(Dilution Factor)									
Dilution Level No.	<1	1	2	3	4	5	6	"7"	

For Rank Count:

1
2
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Plot Y versus X
Y at X=0 is Log ED

Panel Leader K. Vetrano

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Summer +(15%)ETBE #3 30 ppm

recognition 2.52 328

Evaluation Date: 6/21 **RESULT:** Log ED_{50} = 2.92 ED_{50} = 836

detection = 0.036 ppm
recognition = .041 ppm
$\bar{X}$ intensity = 4.21

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		Panelist Indicated:						
1	Ann	T_N	C_N	B_d	B_1	T_2	C_4	ether
2	Florence	C_N	B_N	B_d	B_3	T_3	C_5	cleanser
3	Alma	B_N	T_1	$B_{1.5}$	B_2	T_3	$C_{3.5}$	chemical w/ gasoline
4	Don	T_N	T_d	B_1	B_2	T_2	C_3	chemical alcohol
5	Mary	B_N	T_N	B_d	B_2	$T_{2.5}$	C_3	gasoline w/something else
6	Jill	B_N	T_d	B_2	B_3	$T_{3.5}$	C_4	natural gas
7	Joan	T_1	T_2	$B_{3.5}$	$B_{4.5}$	T_6	C_7	gasoline or something else
8								
9								
10	Frequency tally recognition	1	1	2	3			
Frequency Tally		1	3	3				
Average Rank		1	3	6				
recognition values		1	2	3.5	6			
X = Plotting Value		-1.15	-.32	.67				
recognition values		-1.15	-.67	-.16	.67			
Y = Log(Tolerance Level)		3.681	3.083	2.51	1.992			

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
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Plot Y versus X
Y at Y=0 is Log ED

Panel Leader K. Vihan

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Summer + Tame #1 (1550) 26 ppm .
recognition 2.21 162

Evaluation Date: 6/21 **RESULT:** Log ED_{50} = 2.37 ED_{50} = 235

detection = 0.11 ppm
recognition = 0.16 ppm
$\bar{x}$ intensity = 3.29

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Ann	CN	BN	TN	Bd	TD	C3	alcohol
2	Florence	CN	TN	Bd	BT1	T2	C3	cleaning fluid
3	Alma	BN	TN	Bd	BT1	T2	C3	chemical kerosene
4	Don	TN	Cd	Bd	B2	T3	C3.5	alcohol base
5	Mary S.	BN	CN	BN	BT1	T2	C2.5	gasoline
6	Jill	BN	TN	CN	BT1	T2	C3	cleaning fluid
7	Joan	BN	TT1	B2	B3	T4	C5	chemical
8								
9								
10	Frequency Tally recogn. hits		1		5	1		
Frequency Tally			1	3	3			
Average Rank			1	3	6			
recognition values			1		4	7		
X = Plotting Value			-1.15	-.32	.67			
recognition values			-1.15		0	1.15		
Y = Log(Tolerance Level)		3.053	2.514	1.992	1.555			
Log(Dilution Factor)								

Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

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Plot Y versus X
Y at X=0 is Log ED

Panel Leader K. Vetrano

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Summer Hisii TLAME #2 26 ppm
recognition 2.11

Evaluation Date: 6/21 **RESULT:** Log ED_{50} = 2.45 ED_{50} = 285 131

detection = 0.09 ppm
recognition 0.198 ppm
$\bar{x}$ intensity = 3.72

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Ann	CN	CN	Bd	B1	T2	C3	gas, alcohol
2	Florence	TN	BN	CN	Bd	T1	C4	liquid cleaning fluid
3	Alma	TN	TN	B1	B1.5	T2	C3	gasoline - chemical
4	Don	TN	CN	Bd	B1	T2	C3	strong alcohol base
5	Mary	TN	TN	Td	Bd	T2	C3	gasoline
6	Jill	BN	TN	Bd	B2	T4	C5	gasoline, cleaning fluid
7	John	BN	T1	B2	B3	T4	C5	gasoline
8								
9								
10	Frequency Tally recognition		1	1	3	2		
Frequency Tally			1	4	2			
Average Rank			1	3.5	6.5			
recognition values			1	2	4	6.5		
X = Plotting Value			-1.15	-.16	.89			
recognition values			-1.15	-.67	0	.89		
Y = Log(Tolerance Level)			3.083	2.514	1.992	1.555		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
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Plot Y versus X

Panel Leader K. Vetrano

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: Summer + TAME (15%) #3 27 ppm
recognition 2.01 103

Evaluation Date: 6/21 **RESULT:** Log ED_{50} = 2.28 ED_{50} = 191

detection = .141 ppm
recognition = 0.262 ppm
$\bar{x}$ intensity = 3.50

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Ann	CN	Td	CN	Bz	T3	C4	natural gas
2	Florelle	CN	BN	CN	Bd	T1	C3	cleaner
3	Alma	BN	Td	B1	Bz	T2.5	C3	chemical
4	Don	BN	CN	BN	BF	T2	C3	alcohol base
5	Mary	BN	CN	CN	Bd	T1	C	gasoline
6	Jill	BN	TN	CN	Bd	T3	C4	cleaning fluid
7	Joan	TN	T1	Bz	B3	T4.5	C5.5	gasoline
8								
9								
10	Frequency tally recognition		1	1	2	3		
Frequency Tally			2		5			
Average Rank			1.5		5			
recognition values			1	2	3.5	6		
X = Plotting Value			-.89		.32			
recognition values			-1.15	-.67	-.16	.67		
Y = Log(Tolerance Level)			3.083	2.514	1.992	1.555		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
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Plot Y versus X

Panel Leader: K. Vetrano

29 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: B - MTBE - 97%
- WINTER GAS 1.91 82

Evaluation Date: 6-18-93 **RESULT:** Log ED_{50} = 2.16 ED_{50} = 146

detection: 0.198 ppm
recognition: 0.354 ppm
Intensity: ~~3.15~~ 4.14

Cons. No.	Panelist	Dilution Level Number 1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Dick	BN	TN	BN	Bd	TIII	C2	weak solvent, 50% odor
2	Alma	BN	Td	Bd	BIII	T2	C3	chemical
3	Ruth	CN	Td	CN	BIII	T6	C8	gasoline
4	Joyce	BN	CN	BN	BN	TN	CIII	perfume
5	Jen	BN	BN	BN	Bd	TIII	C2	burning
6	Jill	CN	TN	CN	TN	TIII	C2	ether
7	John	TN	TIII	B2	B3	TH	C1	chemical
8								
9								
10	Frequency Tally recognition		1		2	3	1	
Frequency Tally			2		3	1	1	

Average Rank			1.5		4	6	7	
recognition values			1		2.5	5	7	
X = Plotting Value		-.89		0	.67	1.15		
recognition values		-1.15		-.49	.32	1.15		
Y = Log(Tolerance Level)		3.083		1.992	1.555	1.158		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
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9
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Plot Y versus X

Panel Leader

27 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: R – MTBE – 9750
– WINTER GAS recognition 1.72 52

Evaluation Date: 6-18-93 **RESULT:** Log ED_{50} = 2.07 ED_{50} = 117

detection: 0.230 ppm
recognition: 0.519 ppm
$\bar{X}$ intensity: ~~3.43~~ 4

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Dick	CN	TN	BN	B1	CN	C3	GAS
2	Alma	CN	Td	B11	B1	T2	C3	Liquid Rubber
3	Ruth	CN	TN	Bd	B5	T7	C8	CHEM...
4	Joyce	BN	CN	CN	TN	TN	BN	—
5	Jen	CN	TN	BN	Bd	T1	C3	GASolin..
6	Jill	CN	TN	Bd	A11	T2	C3	GAS
7	Joan	Td	CN	B1	B2	T3	C4	GAS Citrus
8								
9								
10	Frequency Tally recognition			1	3	1	1	
Frequency Tally			1	3	1		1	
Average Rank			1	3	5		6	
recognition values				1	3	5	6	
X = Plotting Value			-1.15	-.32	.32		.67	
recognition values				-1.15	-.32	.32	.67	
Y = Log(Tolerance Level)		3.083	2.514	1.992	1.555	1.158		
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:
1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED

Panel Leader [signature]

26 ppm

ED_{50} Evaluation Form for Dynamic Triangle Olfactometer

Sample: E - NITBE - 9750
— WINTER GAS recognition 1.91 81

Evaluation Date: 6-18-93 **RESULT:** Log ED_{50} = 2.06 ED_{50} = 114

detection: 0.228 ppm
recognition: 0.321 ppm
$\bar{X}$ intensity = ~~4.4~~ 4.00

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Dilution Level Number						
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Dice	BN	TN	BN	BT1	T1	C4	GAS
2	Alma	BN	TN	CN	BT1	T1.5	C2	Chemical
3	Ruth	CN	TN	Bd	BT5	T7	C8	ETHER GASOLINE
4	Joyce	BN	CN	CN	BN	CN	CN	—
5	Jen	BN	TN	Bd	BT1	T2	C3	GAS
6	Jill	BN	CN	CN	Cd	T5	C2	GAS
7	John	Td	Bd	BT1	B2	T3.5	C5	Chemical
8								
9								
10	Frequency Tally recognition			1	4	1		
Frequency Tally				3	2	1		
Average Rank				2	4.5	6		
recognition values				1	3.5	6		
X = Plotting Value				-.67	+.16	.67		
recognition values				-1.15	-.16	.67		
Y = Log(Tolerance Level)				2.514	1.992	1.555		

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED

Panel Leader [signature]

55 ppm

ED$_{50}$ Evaluation Form for Dynamic Triangle Olfactometer

Sample: Composite + MTBE #1

2.39

Evaluation Date: 7/14 **RESULT:** Log ED$_{50}$ = 2.72 ED$_{50}$ = 522 (250)

detection: 0.105 ppm
recognition: 0.22 ppm
$\bar{x}$ intensity = 4.43

Cons. No.	Panelist	1	2	3	4	5	6	"7"
		Correct Choice Would Be: (t = top, c = center, b = bottom)						
		T	T	B	B	T	C	
		Panelist Indicated:						
1	Diane	BN	T.4	B2	B2	T3	C9.5	sweet
2	Juan	TN	Td	B1.5	B2.5	T4	C5.5	chemical
3	Nolya	BN	CN	CN	B1	T11	C3	alcohol
4	Tina	BN	Td	B11	B1.5	T2	C2	gas
5	Ruth	CN	BN	Bd	B11	T4	C6	gasoline
6	Joyce	CN	CN	BN	B3	T4	C6	solvent
7	Karen	CN	T3	B2	B3	T4	C5	gasoline/ether
8								
9								
10	Frequency Tally Recognition		2	2	2	1		
Frequency Tally			4	1	2			
Average Rank			2.5	5	6.5			
recognition value			1.5	3.5	5.5	7		

X = Plotting Value		-.49	.32	.89				
recognition value		-.89	-.16	.49	1.15			
Y = Log(Tolerance Level)		3.083	2.514	1.992	1.555			
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED$_{50}$

Panel Leader K. Vitrano

62 ppm

ED50 Evaluation Form for Dynamic Triangle Olfactometer

Sample: Composite + MTBE #2

2.62

Evaluation Date: 7/14 RESULT: Log ED_{50} = 2.94 ED_{50} = 872 415

dilution: 0.071 ppm
recognition: 0.150 ppm
X intensity = 4.79

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Diane	CN	TII	B2	B3.5	T4	C4	unpleasant
2	Joan	Td	TII	B2.5	B3.5	T4	C4.5	chemicals; gasoline
3	Melissa	CN	TN	CN	BII	T2	C3	grading rub alcohol
4	Tina	Td	TII	B2	B2	T3.5	C5	permanent marker
5	Ruth	CN	TN	BII	B6	T7	C8	lemony witch hazel
6	Joyce	BN	CN	Bd	BII	T5	C5	cleaning product
7	Karen	BN	Td	BI	B2	T3	C4	gasoline
8								
9								
10	Frequency Tally Recognition		3	2	2			
Frequency Tally		2	2	2	1			
Average Rank		1.5	3.5	5.5	7			
recognition value			2	4.5	6.5			
X = Plotting Value		-.89	-.16	.49	1.15			
recognition value			-.67	.16	.89			
Y = Log(Tolerance Level)		3.681	3.083	2.514	1.992			

Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED_{50}

Panel Leader K. [illegible]

5.3 ppm

ED$_{50}$ Evaluation Form for Dynamic Triangle Olfactometer

Sample: Composite + MTBE #3
2.46

Evaluation Date: 7/14 **RESULT:** Log ED$_{50}$ = 2.86 ED$_{50}$ = 718 (288)

detection: 0.07 ppm
recognition: 0.184 ppm
X intensity = 4.57

Cons. No.	Panelist	1	2	3	4	5	6	"7"
	Correct Choice Would Be: (t = top, c = center, b = bottom)	T	T	B	B	T	C	
	Panelist Indicated:							
1	Diane	Td	TT	B1.5	B2	T2.5	C3	alcohol
2	Jean	Td	TT	B2	B2.5	T3.5	C4	chemicals w/ gasoline
3	[illegible]	CN	TN	CN	BT	T2	C3	alcohol sweet
4	Tina	CN	Td	BT	B1	T2	C4	permanent marker
5	[illegible]	CN	TN	BT	B7	T8	C8	gasoline
6	Joyce	BN	CN	BN	Bd	[illegible]	C6	"fantastik"
7	Kevin	CN	Td	BT	B2	T3	C4	gas
8								
9								
10	Frequency Tally recognition		2	3	1	1		
	Frequency Tally	2	2	1	2			
	Average Rank	1.5	3.5	5	6.5			
	recognition values		1.5	4	6	7		

	<1	1	2	3	4	5	6	"7"
X = Plotting Value	-.89	-.16	.32	.89				
recognition values		-.89	0	.67	1.15			
Y = Log(Tolerance Level)	3.681	3.083	2.514	1.992	1.555			
Log(Dilution Factor)								
Dilution Level No.	<1	1	2	3	4	5	6	"7"

For Rank Count:

1
2
3
4
5
6
7
8
9
10

Plot Y versus X
Y at X=0 is Log ED$_{50}$

Panel Leader K. [illegible]

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