American Petroleum Institute

STEP Strategies for Today's Environmental Partnership

Petroleum Industry Data Characterizing Occupational Exposures to Methyl Tertiary Butyl Ether (MTBE) 1983–1993

Health and Environmental Sciences Department
Publication Number 4622
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One of the most significant long-term trends affecting the future vitality of the petroleum industry is the public's concerns about the environment. Recognizing this trend, API member companies have developed a positive, forward-looking strategy called STEP: Strategies for Today's Environmental Partnership. This program aims to address public concerns by improving our industry's environmental, health and safety performance; documenting performance improvements; and communicating them to the public. The foundation of STEP is the API Environmental Mission and Guiding Environmental Principles.

API ENVIRONMENTAL MISSION AND GUIDING ENVIRONMENTAL PRINCIPLES

The members of the American Petroleum Institute are dedicated to continuous efforts to improve the compatibility of our operations with the environment while economically developing energy resources and supplying high quality products and services to consumers. The members recognize the importance of efficiently meeting society's needs and our responsibility to work with the public, the government, and others to develop and to use natural resources in an environmentally sound manner while protecting the health and safety of our employees and the public. To meet these responsibilities, API members pledge to manage our businesses according to these principles:

- To recognize and to respond to community concerns about our raw materials, products and operations.
- To operate our plants and facilities, and to handle our raw materials and products in a manner that protects the environment, and the safety and health of our employees and the public.
- To make safety, health and environmental considerations a priority in our planning, and our development of new products and processes.
- To advise promptly, appropriate officials, employees, customers and the public of information on significant industry-related safety, health and environmental hazards, and to recommend protective measures.
- To counsel customers, transporters and others in the safe use, transportation and disposal of our raw materials, products and waste materials.
- To economically develop and produce natural resources and to conserve those resources by using energy efficiently.
- To extend knowledge by conducting or supporting research on the safety, health and environmental effects of our raw materials, products, processes and waste materials.
- To commit to reduce overall emission and waste generation.
- To work with others to resolve problems created by handling and disposal of hazardous substances from our operations.
- To participate with government and others in creating responsible laws, regulations and standards to safeguard the community, workplace and environment.
- To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport or dispose of similar raw materials, petroleum products and wastes.

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API PUBLICATION NUMBER 4622

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This report describes a survey designed to collect methyl tertiary butyl ether (MTBE) occupational exposure data. The survey was designed for the American Petroleum Institute (API) to assist the U.S. Environmental Protection Agency (EPA) in investigating the validity to health-related complaints following alleged exposures to MTBE. IT Air Quality Services (ITAQS) performed all work during this study under the direction of the Health and Environmental Sciences Department of API.

Ms. Inez vanArsdall of ITAQS and Mr. Doug Brinson developed the exposure data survey questionnaire under the direction of Dr. Will Ollison of API and Ms. Gail Levine of Summations, Inc. Data was submitted directly to ITAQS for aggregation and analysis (see questionnaire). Ms. Joan Abernethy of ITAQS conducted follow-up telephone calls to elicit the highest possible study response rate.

Mr. Ted Johnson, Mr. Darrell Hollowell, and Mr. Michael McCoy, Jr. of ITAQS prepared the final exposure database. Statistical analysis of the database was performed by Mr. McCoy and Mr. Johnson. Mr. McCoy was the project manager and technical director for the ITAQS effort. Mr. McCoy was also the principal author of the final project report. Mr. Johnson assisted in the preparation of the final project report and assisted in technical direction.

ABSTRACT

The compound methyl tertiary butyl ether (MTBE) is an oxygenate which is added to gasoline during the winter driving season to reduce carbon monoxide (CO) emissions from motor vehicles and is frequently used in reformulated gasoline. In 1992, the U.S. Environmental Protection Agency (EPA) began receiving anecdotal heath-related complaints following alleged exposures to MTBE. In early 1993, EPA began planning a series of clinical research studies to investigate the validity of these claims. As part of its response, the American Petroleum Institute (API) conducted a survey of API member companies to acquire data relating to occupational exposures to MTBE. This report describes the development and administration of this survey. It also provides a summary of the data obtained from the completed questionnaires.

The survey questionnaires were distributed to industrial hygienists at 17 API member companies who provided 1,833 MTBE concentration measurements associated with potential occupational exposures. The results were consistent with expectations. The highest exposure measurements were associated with process spills and upsets, whereas lower exposure measurements were associated with routine operations. Finally, exposures during activities associated with blending and distribution were lower than exposures during activities associated with transportation (barge, pipeline rail car) and refueling.

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Section 1
INTRODUCTION

The compound methyl tertiary butyl ether (MTBE) is routinely added to gasoline during the winter driving season to reduce carbon monoxide (CO) emissions from motor vehicles. In 1992, the U.S. Environmental Protection Agency (EPA) began receiving complaints concerning headaches, nausea, dizziness, and other symptoms allegedly following exposure to MTBE. In early 1993, EPA began planning a series of clinical research studies to investigate the validity of these claims. The American Petroleum Institute (API) conducted three surveys:

- The Exposure Survey: a survey of member companies to obtain exising data on measured workplace MTBE exposures.
- The State Complaint Survey: a survey of API state directors and the officers of allied oil and gas associations to obtain any health-related complaints linked to possible exposures to MTBE that they had obtained.
- Company Complaint Surveys: Two separate surveys of 18 member companies to obtain any health-related complaints linked to possible exposures to MTBE that they had received.

All four surveys were conducted by IT Air Quality Services (ITAQS).

This introduction provides a brief description of each of the three surveys. The remainder of this report provides a more detailed description of the Exposure Survey. The procedures and results of the other two surveys have been described together in API Publ. 4623 (ITAQS, 1995).

In the Company Complaint Survey, ITAQS administered a questionnaire to industrial hygienists at 18 API member companies. Each respondent was asked to document all complaints related to possible MTBE exposure which the company received

between January 1, 1988 and April 30, 1993 (the close of the 1992-93 oxygenate season). A subsequent follow-up survey, covering the 1993-94 oxygenate season, was also conducted. Questionnaire responses were limited to a description of each complaint; respondents were not asked to evaluate or verify the reported complaints.

The combined Company Complaint Surveys acquired data on 71 employee complaints and 13 customer complaints which listed a total of 191 individual symptoms. The surveys also acquired data on the complainant's gender, age, and type (employee or consumer); exposure location; probable MTBE source; and medical treatment received (if any). ITAQS developed a database listing all data acquired through the original and follow-up surveys, including a few complaints reported prior to the specified start date of January 1, 1988 (ITAQS, 1995).

In the State Complaint Survey, API administered a separate questionnaire requesting complaint data to 10 API state directors and to 11 state officers of allied oil and gas associations. Appendix C of the report by ITAQS (1995) provides an overview of this survey and a copy of the survey questionnaire. Two survey respondents indicated that their states did not have winter oxygenated fuels programs. Three respondents stated that no MTBE-related complaints had been received. The responses of the remaining questionnaire recipients are summarized in Appendix C of the report by ITAQS (1995).

In the Exposure Survey, ITAQS administered a survey questionnaire to industrial hygienists at 17 API member companies. The survey produced a database listing over 1,800 separate measurements. Each measurement was characterized by MTBE concentration, facility type and location, employee occupation, sample type (personnel or area), MTBE source, measurement location, exposure duration, and control equipment present. All data collected related to employee exposures. None of the data related to specific complaints collected through the two complaint surveys.

The remainder of this report provides a more detailed description of the Exposure Survey. It includes a copy of the survey questionnaire, discusses the selection of survey recipients, and describes the follow-up procedures used to increase response rate. The report concludes with a statistical analysis of the data acquired by the survey.

Section 2
METHODOLOGY

This section provides a description of the survey questionnaire used to collect data on MTBE exposures. It also discusses the selection of survey recipients and the follow-up procedures used to improve response rate. In addition, this section discusses the development of a unified database listing the collected exposure data in a common format appropriate for statistical analysis.

THE EXPOSURE DATA AND TELEPHONE FOLLOW-UP QUESTIONNAIRES

Two questionnaires were developed for the MTBE Exposure Survey: the exposure data questionnaire and the telephone follow-up questionnaire. Copies of these questionnaires are presented in Appendices A and B, respectively.

The exposure data questionnaire contained 13 questions and provided a table for entering data. This questionnaire requested that the respondent list all reported exposure events in which MTBE concentration was measured and provide supplementary data on them to be used in classifying exposures. The supplementary data items included facility type and location, employee occupation, sample type (personnel or area), MTBE source, measurement location, MTBE concentration, exposure duration, and presence and absence of control equipment. Respondents were asked to attach copies of the original data sets whenever possible.

The telephone follow-up questionnaire consisted of six questions to be included in follow-up telephone calls. These questions were designed to elicit general information about each contacted organization, their willingness to participate in the survey, and the availability of MTBE exposure data.

ADMINISTRATION OF QUESTIONNAIRES

During March and April of 1993, API contacted 17 member companies and identified an industrial hygienist at each company to receive the exposure data questionnaire. API transmitted a copy of the questionnaire and an explanatory cover letter to each industrial hygienist on May 4, 1993. Each recipient was asked to return the completed questionnaire and supplemental data sets to ITAQS by May 18, 1993, or as soon thereafter as possible, for aggregation and analysis. Company identity was kept confidential.

Between May 14 and 17, 1993, each of the recipients was contacted and interviewed using the telephone follow-up questionnaire presented in Appendix B. ITAQS made additional follow-up telephone calls on June 8, 9, and 24, 1993. By July 2, 1993, 15 of the 17 recipient companies had replied resulting in a survey response rate of approximately 88 percent. Of the 12 companies that provided data, 10 submitted both MTBE exposure data (in the form of completed questionnaires) and supplementary data sheets, one submitted a questionnaire, and one submitted supplementary data sheets. Three of the 15 responding companies indicated that no data were available. No additional data were received after July 2, 1993.

DEVELOPMENT OF EXPOSURE DATABASE

The exposure data collected during this study consisted of 11 completed questionnaire forms and 11 sets of supplementary data sheets collected from 12 companies. The data items and formats of the supplementary data sheets varied by respondent. To facilitate analysis of the data, ITAQS developed a common data format and processed the data from each company according to this format. The format consists of the 20 data items listed in Table 2-1.

Tables 3-1 through 3-13 in Section 3 present the categories defined to classify the responses associated with each data item listed in Table 2-1. Note that Item 20 (Sector Exposure Category) was developed as a means of combining information

Table 2-1. Data items in the common survey format .

Item	Data item	Question number	Item	Data item	Question number
1	Company name	Blinded	11	Year	7
2	Data set number	-	12	Duration	8
3	Facility type	1	13	Sampling method	9
4	State	2	14	Analytical method	10
5	Measurement location	3	15	Sensitivity/ detection limit	11
6	MTBE source (0-100%)	4	16	Control equipment present	12
7	Sample type	5	17	Other information	13
8	Subject type	6	18	Concentration value	14
9	Month	7	19	Concentration units	-
10	Day	7	20	Sector exposure category	-

associated with Items 3 (facility type), 6 (MTBE source), 8 (subject type), and 17 (other information). The following API task classifications were defined for this item:

1. MTBE manufacturing: This category includes all refinery and chemical plant manufacturing personnel handling neat MTBE. This category is subdivided into:
    - 101. Routine operations
    - 102. Routine maintenance/turnaround
    - 103. Spills, leaks, and process upsets
    - 104. Other

2. MTBE fuel blending, neat MTBE only: This category includes all personnel involved in the handling of neat (pure) MTBE during fuel blending activities.

3. MTBE fuel blending, fuel mixtures only: This category includes all personnel involved in the handling of gasoline-MTBE mixtures during fuel blending activities.

4. MTBE transportation, neat MTBE only: This category includes all personnel involved in the transport of neat MTBE, which includes barging, pipeline, trucking, and rail car personnel.

5. MTBE transportation, fuel mixtures only: This category includes all personnel involved in the transport of gasoline-MTBE mixtures, which includes barging, pipeline, and rail car personnel.

6. MTBE distribution, fuel mixtures only: This category includes all marketing terminal and trucking personnel involved in the handling of gasoline-MTBE mixtures.

7. MTBE refueling, fuel mixtures only: This category includes all service station and retail outlet personnel.

800. MTBE source measurements: This category includes mostly area samples that were taken near major sources. One example is a headspace measurement taken in a 5 gallon drum containing neat MTBE.

900. MTBE research-related activities: This category includes test burns and other experimental activities.

Each exposure listing acquired through the questionnaire consisted of a concentration value, a duration, and as many as 18 descriptive data items. Analysts transcribed the relevant information onto a hard copy form according to the common data format previously described. The resulting data sheets were then entered into a statistical software package located on a personal computer.

Quality assurance checks on the exposure database revealed that some values listed on the copies of data sheets were repeated. These duplicate values were removed from the final database. The codes assigned to all concentrations exceeding 100 ppm were checked for accuracy and internal consistency. All coding errors identified through this review were corrected. The final version of the exposure survey database contained 1,833 exposure estimates.

Section 3
DESCRIPTIVE STATISTICS

This section discusses the analysis of the exposure survey database. It provides detailed frequency distributions of individual variables for the complete database and for subsets of the data of particular interest. The section concludes with a discussion of selected groups of descriptive statistics.

FREQUENCY ANALYSES

The database contains one listing for each measured exposure concentration for a total of 1833 listings. Table 3-1 provides a frequency distribution of these listings by facility type. Approximately 45 percent of the exposure values relate to refineries. Bulk terminals accounted for 23 percent of the exposure values, while chemical plants and marine vessels accounted for 14 and 13 percent of the values, respectively. Each of the other facility types provided less than three percent of the exposure values.

Table 3-2 indicates the number of data listings associated with each State. Twenty-three States were represented. Approximately 23 percent of the exposure measurements were collected in California, while Texas contributed approximately 21 percent. Each of the other States listed in Table 3-2 accounted for less than 8 percent of the exposure values. No State was specified for approximately 14 percent of the exposure values. It should be noted that some of the measurements without State specifications were made aboard marine vessels.

Over 40 different workplace measurement locations were specified in the database (Table 3-3). Loading racks were the most frequently-occurring measurement

Table 3-1. Frequency distribution of facility type (FACTYPE).

Question No.	Response	Frequency	
		n	Percent
1	1: Chemical plant	263	14.3
	2: Refinery	825	45.0
	3: Bulk terminal	421	23.0
	4: Marine terminal	42	2.3
	5: Service station	32	1.7
	6: Research facility	4	0.2
	7: Marine vessel	246	13.4
	Missing	0	0
	Total	1833	100

Table 3-2. Frequency distribution of State (STATE).

Question No.	Response	Frequency	
		n	Percent
2	2: Alaska	15	0.8
	4: Arizona	71	3.9
	6: California	417	22.7
	8: Colorado	62	3.4
	10: Delaware	4	0.2
	17: Illinois	5	0.3
	18: Indiana	21	1.1
	22: Louisiana	136	7.4
	23: Maine	10	0.5
	24: Maryland	14	0.8
	30: Montana	4	0.2
	32: Nevada	16	0.9
	34: New Jersey	50	2.7
	35: New Mexico	17	0.9
	36: New York	22	1.2
	37: North Carolina	12	0.7
	40: Oklahoma	13	0.7
	42: Pennsylvania	118	6.4
	48: Texas	379	20.7
	49: Utah	49	2.7
	51: Virginia	31	1.7
	53: Washington	40	2.2
	56: Wyoming	5	0.3
	100: Canada	33	1.8
	101: AZ/NC	26	1.4
	Missing	263	14.3
	Total	1833	100.0

Table 3-3. Frequency distribution of measurement location (MEASLOC).

Question No.	Response	Frequency	
		n	Percent
3	1: Pump island[a]	54	2.9
	2: Facility perimeter	5	0.3
	3: Loading rack	257	14.0
	4: In vehicle	7	0.4
	5: Laboratory	179	9.8
	6: Refinery, unknown	163	8.9
	7: Terminal, unknown	87	4.7
	8: Tanker truck driver	51	2.8
	9: MTBE plant, unknown	119	6.5
	10: Garage	9	0.5
	11: Tank	203	11.1
	12: Vessel, deck	40	2.2
	13: Vessel, mast river	2	0.1
	14: Vessel, manifold	17	0.9
	15: Vessel, crew lounge	2	0.1
	16: Vessel, utility room	2	0.1
	17: Vessel, galley	2	0.1
	18: Vessel, engine room	8	0.4
	19: Engine room, blender	2	0.1
	20: Waste water separator	5	0.3
	21: MTBE unit	64	3.5
	22: Cat cracker	4	0.2
	23: Aromatics product unit	2	0.1
	24: Marine vessel, unknown	175	9.6
	25: Lab, blending, dock, or tank farm	14	0.8
	26: Marine dock	122	6.7
	27: Cooling tower	3	0.2
	28: MTBE pump	1	0.1
	29: Piping	8	0.4
	30: Control Room	6	0.3
	31: Operator shack	4	0.2
	32: Boiler area	3	0.2
	33: Sampling building/ MTBE sample tank	9	0.5
	34: Reactor area	32	1.7
	35: Turbine area	2	0.1
	36: Hydrogen area	1	0.1
	37: Compressor area	2	0.1

(continued)

Table 3-3 (Continued)

Question No.	Response	Frequency	
		n	Percent
	38: Central stores	1	0.1
	39: Machine shop	12	0.7
	40: Manifold	22	1.2
	41: Distillation room	8	0.4
	42: Vessel, bridge	3	0.2
	43: Pump house/pump station	12	0.7
	44: MTBE test burn area	8	0.4
	45: Chemical plant, unknown	79	4.3
	46: Vacuum truck	15	0.8
	47: Sump	4	0.2
	48: Filter area	2	0.1
	Missing	1	0.1
	Total	1833	100.0

[a]Includes pump islands at service stations, refineries, and bulk terminals.

location with 14 percent of the exposure values. Storage tanks were the second most common location with approximately 11 percent. Laboratory, marine vessel (unknown location), refinery (unknown location), marine dock, and MTBE plant (unknown location) contributed 9.8, 9.6, 8.9, 6.7, and 6.5 percent of the exposure values, respectively. Each of the other measurement locations accounted for less than 5 percent of the exposure values.

Table 3-4 lists the number of data listings associated with various MTBE sources. Approximately 43 percent of the listings were associated with the source category "gasoline mixed with MTBE in an unknown proportion". Approximately 30 percent of the values were associated with 100 percent (neat) MTBE. Each of the remaining exposure sources accounted for less than 6 percent of the exposure values.

The majority of the exposure measurements, approximately 73 percent, were personal samples (Table 3-5). Approximately 20 percent of the measurements were area samples. The remaining measurements, approximately 7 percent, were characterized as "personal and area samples" or as "sample type unknown".

Approximately 32 percent of the exposure values were associated with the subject type "operator" (Table 3-6). In approximately 24 percent of the cases, the subject type was missing or unknown (area samples have no subject type). Truck drivers and laboratory technicians accounted for approximately 11 and 9 percent of the exposure values, respectively. Each of the remaining subject types accounted for less than 6 percent of the database listings.

July and August were the most frequently-occurring months in the database, with approximately 18 and 14 percent of the exposure measurements, respectively (Table 3-7). The remaining responses are evenly distributed among the other 10 months. The years 1991 and 1992 account for the majority of the measurements with approximately 30 and 37 percent, respectively (Table 3-8). Approximately 17

Table 3-4. Frequency distribution of MTBE source (MTBESRC).

Question No.	Response	Frequency	
		n	Percent
4	2 percent MTBE	2	0.1
	4 percent MTBE	4	0.2
	5 percent MTBE	6	0.3
	6 percent MTBE	34	1.9
	8 percent MTBE	3	0.2
	10 percent MTBE	45	2.5
	11 percent MTBE	1	0.1
	12 percent MTBE	80	4.4
	15 percent MTBE	27	1.5
	75 percent MTBE	12	0.7
	100 percent MTBE	558	30.4
	-1: Mixed with gasoline, proportion unknown	790	43.1
	-3: Waste water	5	0.3
	-4: Unknown (mixed or neat)	102	5.6
	-5: Mixed in a plant stream	85	4.6
	Missing	79	4.3
	Total	1833	100.0

Table 3-5. Frequency distribution of sample type (SAMTYPE).

Question No.	Response	Frequency	
		n	Percent
5	1: Personal monitor	1333	72.7
	2: Area monitor	361	19.7
	3: Personal and area sample	68	3.7
	Missing	71	3.9
	Total	1833	100.0

Table 3-6. Frequency distribution of subject job type* (SUBTYPE).

Question No.	Response	Frequency	
		n	Percent
6	1: Customer	2	0.1
	50: Operator	588	32.1
	51: Lab technician	155	8.5
	52: Maintenance personnel	87	4.7
	53: Pipeline operator	15	0.8
	54: Truck driver	206	11.2
	55: Gauger-blender	26	1.4
	56: Helper	5	0.3
	57: Engineering assistant	2	0.1
	58: System analyst	3	0.2
	59: Technician	2	0.1
	60: Inspector	6	0.3
	61: Tankerman	48	2.6
	62: Machinist	10	0.5
	63: Pipefitter	15	0.8
	64: Foreman	22	1.2
	65: Mechanic	25	1.4
	66: Vessel worker	93	5.1
	67: Sampler	26	1.4
	68: Operator or contractor	14	0.8
	69: Electrician	11	0.6
	70: Welder	3	0.2
	71: Clerical	1	0.1
	72: Industrial hygiene technician	4	0.2
	73: Gas station attendant	22	1.2
	Missing	442	24.1
	Total	1833	100.0

* Job types were recategorized according to classifications discussed at 2-4.

Table 3-7. Frequency distribution of month (MONTH).

Question No.	Response	Frequency	
		n	Percent
7	1: January	119	6.5
	2: February	132	7.2
	3: March	121	6.6
	4: April	45	2.5
	5: May	99	5.4
	6: June	124	6.8
	7: July	324	17.7
	8: August	259	14.1
	9: September	106	5.8
	10: October	131	7.1
	11: November	136	7.4
	12: December	167	9.1
	Multiple	69	3.8
	Missing	1	0.1
	Total	1833	100.0

Table 3-8. Frequency distribution of year (YEAR).

Question No.	Response	Frequency	
		n	Percent
9	1982	5	0.3
	1987	11	0.6
	1988	2	0.1
	1989	114	6.2
	1990	307	16.8
	1991	542	29.6
	1992	682	37.2
	1993	137	7.5
	Multiple years	32	1.7
	Missing	1	0.1
	Total	1833	100.0

percent of the samples were collected during 1990. The years of 1989 and 1993 account for approximately 6 and 8 percent of the total exposure measurements, respectively. Each of the remaining years account for less than 2 percent of the measurements.

Table 3-9 presents the frequency distribution of measurement durations. A majority (1157 or 63 percent) of the exposure events were classifiable according to a specific duration range. Durations occur most frequently in the 1-to-15 minute range (12.2 percent) and in the 241-to-480 minute range (29.7 percent). Approximately 16.3 percent of the events were classified as "short-term exposure level" (STEL) with no stated time duration; similarly, 4.5 percent were classified as "time weighted averages" (TWA) with no stated duration. Duration was classified as missing for 4.7 percent of the events.

The majority of the concentration measurements, approximately 52 percent, were made using charcoal tubes (Table 3-10). Organic Vapor Monitors (OVM) were used to measure approximately 21 percent of concentration values. No sample method was indicated for approximately 19 percent of the samples. Each of the other sample methods is associated with 5.0 percent or less of the exposure measurements.

The most commonly used analytical method was Occupational Safety and Health Administration (OSHA) Method 7 (OSHA, 1990) as indicated by approximately 42 percent of the responses to Question 10 (Table 3-11). Approximately 30 percent of the responses failed to indicate an analytical method. The National Institute of Occupational Safety and Health (NIOSH) 1615 method (NIOSH, 1990) was used to collect 11.5 percent of the samples. Modified versions of the NIOSH method contributed an additional 6.2 percent of the measurements. Nine percent of the measurements were made using a Mobil in-house procedure (Mobil Oil Company, 1994), which is an adaptation of the NIOSH method designated as "P and CAM

Table 3-9. Frequency distribution of measurement duration (DURATION).

Question No.	Response	Frequency	
		n	Percent
8	-4: Time range specified covers two or more of the duration categories	145	7.9
	-3: Other (full shift, six full shifts, short term, and peak)	63	3.4
	-2: STEL[a]	300	16.3
	-1: TWA[b]	82	4.5
	1: 1 to 15 minutes	229	12.5
	2: 16 to 30 minutes	50	2.7
	3: 31 to 60 minutes	22	1.2
	4: 61 to 120 minutes	29	1.6
	5: 121 to 240 minutes	111	6.1
	6: 241 to 480 minutes	542	29.6
	7: Over 480 minutes	174	9.5
	Missing	86	4.7
	Total	1833	100.0

[a]STEL: short-term exposure level.
[b]TWA: time-weighted average.

Table 3-10. Frequency distribution of sample method (SAMMETH).

Question No.	Response	Frequency	
		n	Percent
9	1: charcoal tube	944	51.5
	2: SUMMA canister	0	0
	3: OVM[a]	378	20.6
	4: Sorbent tube	31	1.7
	5: Passive dosimeter	34	1.9
	6: Charcoal tube and OVM	91	5.0
	7: organic vapor badge	3	0.2
	Missing	352	19.2
	Total	1833	100.0

[a]OVM: organic vapor monitor.

Table 3-11. Frequency distribution of analytical method (ANALMETH).

Question No.	Response	Frequency	
		n	Percent
10	1: TO-14	0	0
	2: NIOSH P and CAM 127	34	1.9
	3: Modified NIOSH	113	6.2
	4,5,7: NIOSH 1615	211	11.5
	6: OSHA Method 7	767	41.8
	8: Modified MM-1233	166	9.1
	Missing	542	29.6
	Total	1833	100.0

127" (NIOSH, 1977). The remaining measurements were characterized as "NIOSH P and CAM 127" (1.9 percent).

Table 3-12 presents a frequency distribution for the responses to Question 12 (control equipment used). Control equipment information was not provided for approximately 65 percent of the exposure measurements. Respondents indicated "open system" for 7.6 percent of samples. Respirators or supplied air were indicated in approximately 6 percent of the responses. Respirators alone were indicated in 5 percent of the samples. The survey questionnaire did not clearly distinguish between non-use of respirators and non-reported or unknown use. As a consequence, we can not directly compare known use with known non-use; however, we calculated measurements with reported respirator use for comparison to those without reported use. Vapor recovery systems were used during approximately 4 percent of the samples. Each of the remaining types of control equipment accounted for less than 3 percent of the responses.

Question 13 requested other information pertinent to interpretation of the data. Table 3-13 presents a summary of the responses to this question. Approximately 61 percent of the samples were taken during routine activities. Activities involving the loading and unloading MTBE were indicated on approximately 24 percent of the responses. Approximately 11 percent of the samples were taken during turnaround and maintenance activities.

Table 3-14 lists the number of exposure values assigned to each of the 16 sector exposure categories. The most frequently assigned category was "transport of MTBE fuel mixtures" (21 percent). Blending of MTBE fuel mixtures was assigned to 17 percent of the responses. Distribution of MTBE fuel mixtures was assigned to approximately 16 percent of the samples. MTBE manufacturing-routine operations was assigned to approximately 14 percent of the survey responses. Transport of

neat MTBE and blending of neat MTBE were assigned to approximately 9 and 8 percent of the samples, respectively. Each of the remaining sector exposure categories were assigned to less than 5 percent of the total survey responses.

Table 3-12. Frequency distribution of control equipment (CONTINFO).

Question No.	Response	Frequency	
		n	Percent
12	1: Open system	139	7.6
	2: Closed system	39	2.1
	3: Vapor recovery system in use	79	4.3
	4: Enhanced or forced ventilation in use	2	0.1
	5: Respirators or supplied air in use	112	6.1
	6: Closed system and vapor recovery system	34	1.9
	7: Respirators	91	5.0
	8: None	19	1.0
	9: Multiple (not defined)	8	0.4
	10: Closed system and respirators	3	0.2
	11: Open system and respirators	53	2.9
	12: Respirators and canopy hood recovery system	1	0.1
	13: Leak	4	0.2
	14: Open system and hood	8	0.4
	15: Open and vapor recovery system	18	1.0
	16: Open or closed system	15	0.8
	17: Open or closed system with vapor rec. system	23	1.3
	Missing	1185	64.6
	Total	1833	100.0

Table 3-13. Frequency distribution of other information (OTHERINF).

Question No.	Response	Frequency	
		n	Percent
13	1: Routine activities	1114	60.8
	2: Turnaround or maintenance activities	205	11.2
	3: Spill cleanup activities	8	0.4
	4: Process upset conditions	7	0.4
	5: Loading and unloading of MTBE	434	23.7
	6: Environmental work, installing wells	3	0.2
	7: Vapor vent overhead	5	0.3
	8: Tank operations and maintenance	9	0.5
	9: Leak	9	0.5
	10: Partial shutdown	10	0.5
	11: Process startup	6	0.3
	12: Test burn - MTBE	8	0.4
	13: Routine and turnaround/ maintenance	9	0.5
	Missing	6	0.3
	Total	1833	100.0

Table 3-14. Frequency distribution of Sector exposure categories (OLLICAT).

Question No.	Response	Frequency	
		n	Percent
-	2: MTBE blending - neat MTBE	146	8.0
	3: MTBE blending - fuel mixtures	313	17.1
	4: MTBE transport - neat MTBE	159	8.7
	5: MTBE transport - fuel mixtures	390	21.3
	6: MTBE distribution (fuel)	287	15.7
	7: MTBE refueling (fuel)	41	2.2
	8: MTBE fuel blending, transportation, or distribution (neat or mixed)	14	0.8
	9: MTBE transport (neat or mixed)	36	2.0
	10: MTBE blending (neat or mixed)	85	4.6
	11: Undefined	1	0.1
	101: MTBE manufacturing - routine operations	250	13.6
	102: MTBE manufacturing - routine maintenance/ turnaround	81	4.4
	103: MTBE manufacturing - spills, leaks, and upsets	6	0.3
	104: MTBE manufacturing - other	2	0.1
	800: Source	4	0.2
	900: Research	2	0.1
	Missing	15	0.8
	Total	1833	100.0

DESCRIPTIVE STATISTICS FOR MTBE CONCENTRATIONS

All Samples--personal and area

Table 3-15 presents descriptive statistics for MTBE concentrations for personal samples with and without reported respirator use and for area samples. The Table 3-15 database is smaller (1544) than that of Table 3-14 because some data that could be categorized by Sector could not identified as either personal or area samples. Four categories (MTBE manufacturing--other, MTBE manufacturing--spills, leaks and upsets, MTBE source, and MTBE research) contain insufficient data for meaningful evaluation. With respect to the remaining categories, MTBE transport (neat MTBE) has the largest geometric mean concentration, while MTBE manufacturing (routine operations) and MTBE blending (fuel mixtures) have the smallest geometric means. As expected, Sector exposure categories associated with neat MTBE have larger geometric means than similar categories associated with fuel mixtures. For example, the geometric mean for blending neat MTBE is 2.36 ppm; the geometric mean for blending fuel mixtures is 0.23 ppm. Transportation activities appear to produce higher exposures than blending operations: the geometric mean for transportation of neat MTBE (3.42 ppm) is larger than the geometric mean for blending neat MTBE (2.36 ppm). Refueling activities (Category 7) have a larger geometric mean than distribution activities (Category 6). The values are 1.99 ppm and 0.33 ppm, respectively. See page 2-4 for descriptions of API categories.

Area Samples

Table 3-16 presents statistics for MTBE concentrations obtained from area samples. Categories with too few values to be considered are MTBE manufacturing (routine maintenance/turnaround), MTBE manufacturing (spills, leaks, and upsets), MTBE manufacturing (other), MTBE distribution (fuel mixtures), MTBE refueling (fuel mixtures), source, and research. With respect to the remaining categories, MTBE blending (neat MTBE) has the largest geometric mean, while MTBE transportation (fuel mixtures) has the smallest geometric mean. As expected, exposure categories associated with neat MTBE have larger geometric means than similar categories with

MTBE fuel mixtures. Neat MTBE blending has a smaller geometric mean than neat MTBE transportation.

Personal Samples

Statistics for MTBE concentrations obtained from all personal samples, i.e., with and without reported respirator use, are presented in Table 3-17. Four categories, MTBE (spills, leaks, and upsets), MTBE (other), MTBE source, and MTBE research, have insufficient data for evaluation. With respect to the remaining categories, MTBE transportation (neat MTBE) has the largest geometric mean, while MTBE manufacturing (routine operations) has the smallest geometric mean. Consistent with previous tables, exposure categories associated with neat MTBE have larger geometric means than similar categories with MTBE fuel mixtures. MTBE blending (neat MTBE) has a smaller geometric mean that MTBE transportation (neat MTBE). MTBE distribution (fuel mixtures) has a lower geometric mean than activities associated with the refueling of vehicles (MTBE refueling/fuel mixtures).

PERSONAL SAMPLES WITHOUT REPORTED RESPIRATOR USE

Table 3-18 lists descriptive statistics for MTBE concentrations obtained from personal samples without reported respirator use. Categories with too few values to be considered are MTBE (spills, leaks, and upsets), MTBE (other), MTBE source, and MTBE research. With respect to the remaining categories, MTBE transportation (neat MTBE) has the largest geometric mean, while MTBE production (routine operations) has the smallest geometric mean. As expected, exposure categories associated with neat MTBE have larger geometric means than similar categories with MTBE fuel mixtures. MTBE blending (neat MTBE) has a smaller geometric mean than MTBE transportation (neat MTBE). MTBE distribution (fuel mixtures) has a smaller geometric mean than MTBE refueling (fuel mixtures).

Personal Samples with Reported Respirator Use

Statistics for MTBE concentrations obtained from personal samples where respirator use was reported are presented in Table 3-19. Seven categories -- MTBE (routine maintenance/turnaround), MTBE (spills, leaks, and upsets), MTBE (other), MTBE transportation (neat MTBE), MTBE refueling (fuel mixtures), MTBE source, and MTBE research -- were not evaluated because of insufficient data. With respect to the remaining categories, MTBE blending (neat MTBE) has the largest geometric mean, while MTBE production (routine operations) has the smallest geometric mean. Consistent with expectations, exposure categories containing neat MTBE have higher geometric means than similar categories with MTBE fuel mixtures.

DESCRIPTIVE STATISTICS ORGANIZED BY SECTOR AND SAMPLING DURATION

Analysts were able to determine the sample durations of 1,157 of the 1,833 exposure measurements. This subset of the exposure measurements was then classified according to four duration ranges or "exposure types":

Short-term (n = 273): duration < 30 minutes

Task-related (n = 344): 30 minutes < duration $\leq$ 6 hours

8-hour TWA (n = 433): 6 hours < duration $\leq$ 9 hours

Extended Shift (n = 107): duration > 9 hours

Note that the descriptive labels were applied somewhat loosely; for example, the 8-hour time-weighted average (TWA) designation was applied to exposures with sample durations between 6 and 9 hours.

Tables 3-20 through 3-28 provide descriptive statistics for duration-specific concentrations organized by exposure type. Each table provides statistics for one sector (e.g., MTBE manufacturing - routine operations). Three sectors are omitted

from the tables because of insufficient data (MTBE manufacturing - spills, leaks, and upsets; MTBE manufacturing - other; and MTBE source).

Several general patterns can be observed in the tables. Short-term exposures generally account for the largest number of measurements in each table; the smallest sample sizes are typically associated with task-related or extended-shift exposures. The largest median concentration listed in each table is generally associated with short-term exposures; eight-hour TWA exposures typically have the smallest median concentration. The results listed in each table under "distributional statistics" indicate that most of the frequency distributions are positively skewed with a large number of low concentrations and relatively few high concentrations.

Table 3-15. Descriptive statistics for MTBE concentrations for personal and area samples.

API exposure category	Number of values		Concentration, ppm				
	All	ND[a]	Minimum	Maximum	Median	GM[b]	GSD[c]
1:MTBE manufacturing							
Routine Operations	221	98	0.01	290.0	0.15	0.14	6.72
Routine maintenance/ turnaround	16	1	0.04	100.0	0.5	0.62	6.55
Spills, leaks, and upsets	4	1	0.34	200.0	100.00	28.72	19.60
Other	2	0	110.0	248.70	179.35	165.41	1.78
2:MTBE blending - neat MTBE	139	31	<0.01	98.93	1.80	2.36	6.31
3:MTBE blending - fuel mixtures	312	173	<0.01	140.0	0.16	0.23	8.83
4:MTBE transport - neat MTBE	131	11	0.03	1050.0	2.5	3.42	12.75
5:MTBE transport - fuel mixtures	385	136	<0.01	507.87	0.32	0.42	14.39
6:MTBE distribution (fuel)	287	66	<0.01	73.0	0.42	0.33	6.07
7:MTBE refueling (fuel)	41	2	<0.01	136.1	0.97	1.99	7.34
800:Source	4	0	100.0	9999.0[d]	700.0	757.94	7.24
900:Research	2	0	219.0	464.0	341.5	318.78	1.70

[a]Non-detects.
[b]Geometric mean.
[c]Geometric standard deviation (dimensionless).
[d]Measurement exceeded 9999.0 ppm (off scale).

Table 3-16. Descriptive statistics for MTBE concentrations for area samples.

API exposure category	Number of values		Concentration, ppm				
	All	ND[a]	Minimum	Maximum	Median	GM[b]	GSD[c]
1:MTBE manufacturing							
Routine Operations	83	32	0.01	132.9	0.09	0.13	7.43
Routine maintenance/ turnaround	1	0	100.0	100.0	100.0	100.0	-
Spills, leaks, and upsets	4	1	0.34	200.0	100.0	28.72	19.60
Other	0	-					
2:MTBE blending - neat MTBE	38	6	0.06	98.93	4.19	2.85	6.12
3:MTBE blending - fuel mixtures	19	9	0.04	21.0	0.2	0.57	8.36
4:MTBE transport - neat MTBE	24	2	0.05	220.0	0.44	0.48	7.17
5:MTBE transport - fuel mixtures	155	83	0.02	293.91	0.03	0.17	10.04
6:MTBE distribution (fuel)	4	3	0.02	1.0	0.06	0.08	6.36
7:MTBE refueling (fuel)	0	-					
800:Source	4	0	100.0	9999.0[d]	700.0	757.94	7.24
900:Research	0	-					

[a]Non-detects.
[b]Geometric mean.
[c]Geometric standard deviation (dimensionless).
[d]Measurement exceeded 9999.0 ppm (off scale).

Table 3-17. Descriptive statistics for MTBE concentrations for personal samples with and without reported respirator use.

API exposure category	Number of values		Concentration, ppm				
	All	ND[a]	Minimum	Maximum	Median	GM[b]	GSD[c]
1:MTBE manufacturing							
Routine Operations	138	66	0.01	290.0	0.17	0.14	6.35
Routine maintenance/ turnaround	15	1	0.04	7.19	0.5	0.44	3.85
Spills, leaks, and upsets	0	-					
Other	2	0	110.0	248.70	179.35	165.41	1.78
2:MTBE blending - neat MTBE	101	25	<0.01	97.0	1.80	2.20	6.41
3:MTBE blending - fuel mixtures	293	164	<0.01	140.0	0.15	0.22	8.78
4:MTBE transport - neat MTBE	107	9	0.03	1050.0	4.10	5.30	11.68
5:MTBE transport - fuel mixtures	230	53	<0.01	507.87	0.77	0.79	15.06
6:MTBE distribution (fuel)	283	63	<0.01	73.0	0.43	0.34	6.04
7:MTBE refueling (fuel)	41	2	<0.01	136.1	0.97	1.99	7.34
800:Source	0	-					
900:Research	2	0	219.0	464.0	341.5	318.78	1.70

[a]Non-detects.
[b]Geometric mean.
[c]Geometric standard deviation (dimensionless).

Table 3-18. Descriptive statistics for MTBE concentrations for personal samples without reported respirator use.

API exposure category	Number of values		Concentration, ppm				
	All	ND[a]	Minimum	Maximum	Median	GM[b]	GSD[c]
1:MTBE manufacturing							
Routine Operations	118	51	0.01	7.80	0.16	0.12	5.87
Routine maintenance/ turnaround	15	1	0.04	7.19	0.50	0.44	3.85
Spills, leaks, and upsets	0	-					
Other	1	0	248.70	248.70	248.70	248.70	-
2:MTBE blending - neat MTBE	75	16	<0.01	97.0	1.61	2.11	6.54
3:MTBE blending - fuel mixtures	251	152	<0.01	100.00	0.12	0.16	6.80
4:MTBE transport - neat MTBE	105	9	0.03	1050.0	3.82	5.10	11.64
5:MTBE transport - fuel mixtures	207	46	<0.01	507.87	0.75	0.79	15.20
6:MTBE distribution (fuel)	273	63	<0.01	14.0	0.43	0.33	5.88
7:MTBE refueling (fuel)	40	2	<0.01	136.1	0.97	1.8	6.89
800:Source	0	-					
900:Research	2	0	219.00	464.00	341.50	318.78	1.70

[a]Non-detects.
[b]Geometric mean.
[c]Geometric standard deviation (dimensionless).

Table 3-19. Descriptive statistics for MTBE concentrations for personal samples with reported respirator use.

API exposure category	Number of values		Concentration, ppm				
	All	ND[a]	Minimum	Maximum	Median	GM[b]	GSD[c]
1:MTBE manufacturing							
Routine Operations	20	15	0.06	290.0	0.20	0.42	7.27
Routine maintenance/ turnaround	0	-					
Spills, leaks, and upsets	0	-					
Other	1	0	110.0	110.0	110.0	110.0	-
2:MTBE blending - neat MTBE	26	9	0.22	72.12	3.80	2.45	6.24
3:MTBE blending - fuel mixtures	42	12	0.20	140.0	1.54	1.36	14.61
4:MTBE transport - neat MTBE	2	0	8.67	209.0	108.83	42.6	9.49
5:MTBE transport - fuel mixtures	23	7	0.20	52.0	0.78	0.78	14.61
6:MTBE distribution (fuel)	10	0	0.40	73.0	0.68	1.08	8.95
7:MTBE refueling (fuel)	1	0	69.3	69.3	69.3	69.3	-
800:Source	0	-					
900:Research	0	-					

[a]Non-detects.
[b]Geometric mean.
[c]Geometric standard deviation (dimensionless).

Table 3-20. Descriptive and distributional statistics by exposure type for MTBE manufacturing - routine operations.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	27	13[e]	0.16	7.80	1.00	0.68	3.52
Task	0	-					
8-hr TWA	76	38[f]	0.01	248.70	0.03	0.06	6.07
Ex Shift	2	0	0.16	0.17	0.17	0.16	1.04

Distributional statistics									
		Concentration range, ppm							
Exposure type	Number of values	ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	27	13[e]	0	14	0	0	0	0	0
Task	0								
8-hr TWA	76	38[f]	29	8	0	0	0	1	0
Ex Shift	2	0	2	0	0	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit: 0.16 to 1.00 ppm.
[f]Detection limit: 0.01 to 0.03 ppm.

Table 3-21. Descriptive and distributional statistics by exposure type for MTBE manufacturing - routine maintenance/turnaround.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	8	1[e]	0.50	7.19	0.90	1.12	2.55
Task	1	0	0.20	0.20	0.20	0.20	-
8-hr TWA	4	0	0.04	0.70	0.11	0.13	3.38
Ex Shift	2	0	0.16	0.20	0.18	0.18	1.17

Distributional statistics									
	Number of values	Concentration range, ppm							
Exposure type		ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	8	1[e]	3	4	0	0	0	0	0
Task	1	0	1	0	0	0	0	0	0
8-hr TWA	4	0	4	0	0	0	0	0	0
Ex Shift	2	0	2	0	0	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit: 0.05 ppm.

Table 3-22. Descriptive and distributional statistics by exposure type for MTBE blending - neat MTBE.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	35	1[e]	0.00	97.00	2.90	4.73	5.50
Task	13	1[f]	0.21	72.00	1.03	2.07	5.27
8-hr TWA	12	5[g]	0.04	87.97	2.24	1.73	9.86
Ex Shift	9	9[h]	0.23	0.34	0.30	0.30	1.12

Distributional statistics									
		Concentration range, ppm							
Exposure type	Number of values	ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	35	1[e]	5	18	5	6	0	0	0
Task	13	1[f]	4	6	1	1	0	0	0
8-hr TWA	12	5[g]	0	5	1	1	0	0	0
Ex Shift	9	9[h]	0	0	0	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit < 0.005 ppm.
[f]Detection limit: 0.21 ppm.
[g]Detection limit: 0.04 to 1.80 ppm.
[h]Detection limit: 0.23 to 0.34 ppm.

Table 3-23. Descriptive and distributional statistics by exposure type for MTBE blending - fuel mixtures.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	98	47[e]	0.02	100.00	0.30	0.42	9.03
Task	19	14[f]	0.03	1.98	0.05	0.12	3.94
8-hr TWA	112	78[g]	0.02	14.00	0.04	0.10	4.22
Ex Shift	22	13[h]	0.00	0.27	0.02	0.04	2.73

Distributional statistics									
		Concentration range, ppm							
Exposure type	Number of values	ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	98	47[e]	19	22	5	5	0	0	0
Task	19	14[f]	2	3	0	0	0	0	0
8-hr TWA	112	78[g]	24	8	2	0	0	0	0
Ex Shift	22	13[h]	9	0	0	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit: 0.02 to 0.23 ppm.
[f]Detection limit: 0.03 to 0.33 ppm.
[g]Detection limit: 0.02 to 0.20 ppm.
[h]Detection limit: <0.005 to 0.02 ppm.

Table 3-24. Descriptive and distributional statistics by exposure type for MTBE transport - neat MTBE.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	66	4[e]	0.30	1050.00	13.83	11.84	7.26
Task	27	4[f]	0.04	700.00	2.20	2.32	9.38
8-hr TWA	10	1[g]	0.03	711.90	0.18	0.30	19.17
Ex Shift	1	0	0.32	0.32	0.32	0.32	-

Distributional statistics									
	Number of values	Concentration range, ppm							
Exposure type		ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	66	4[e]	1	27	15	5	10	1	3
Task	27	4[f]	7	12	2	0	0	0	2
8-hr TWA	10	1[g]	8	0	0	0	0	0	1
Ex Shift	1	0	1	0	0	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit: 0.30 to 0.60 ppm.
[f]Detection limit: 0.04 to 0.36 ppm.
[g]Detection limit: 0.03 ppm.

Table 3-25. Descriptive and distributional statistics by exposure type for MTBE transport - fuel mixtures.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	64	4[e]	0.001	507.87	2.44	3.95	15.85
Task	92	28[f]	0.02	59.40	0.42	0.51	14.04
8-hr TWA	42	14[g]	0.01	26.24	0.14	0.16	5.12
Ex Shift	8	0	0.19	4.51	1.49	1.20	3.01

Distributional statistics									
		Concentration range, ppm							
Exposure type	Number of values	ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	64	4[e]	19	18	6	5	8	1	3
Task	92	28[f]	22	28	12	2	0	0	0
8-hr TWA	42	14[g]	22	5	1	0	0	0	0
Ex Shift	8	0	3	5	0	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit: 0.001 to 0.14 ppm.
[f]Detection limit: 0.02 to 0.04 ppm.
[g]Detection limit: 0.007 to 0.04 ppm.

Table 3-26. Descriptive and distributional statistics by exposure type for MTBE distribution - fuel mixtures.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	129	36[e]	0.00	14.00	0.75	0.46	7.20
Task	10	1[f]	0.26	4.05	0.98	1.00	2.41
8-hr TWA	87	25[g]	0.01	2.20	0.11	0.12	4.10
Ex Shift	47	1[h]	0.06	6.20	0.71	0.63	2.94

Distributional statistics									
	Number of values	Concentration range, ppm							
Exposure type		ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	129	36[e]	33	58	2	0	0	0	0
Task	10	1[f]	4	5	0	0	0	0	0
8-hr TWA	87	25[g]	57	5	0	0	0	0	0
Ex Shift	47	1[h]	31	15	0	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit: <0.005 to 0.08 ppm.
[f]Detection limit: 0.26 ppm.
[g]Detection limit: 0.01 to 0.05 ppm.
[h]Detection limit: 0.06 ppm.

Table 3-27. Descriptive and distributional statistics by exposure type for MTBE refueling - fuel mixtures.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	11	2[e]	0.16	136.10	2.80	4.70	11.52
Task	5	0	0.00	2.70	0.34	0.75	2.81
8-hr TWA	13	0	0.09	34.00	0.59	0.77	4.70
Ex Shift	11	0	0.00	17.20	1.10	2.85	4.47

Distributional statistics									
		Concentration range, ppm							
Exposure type	Number of values	ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	11	2[e]	1	4	0	3	1	0	0
Task	5	0	3	2	0	0	0	0	0
8-hr TWA	13	0	10	2	1	0	0	0	0
Ex Shift	11	0	5	4	2	0	0	0	0

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).
[e]Detection limit: 0.16 ppm.

Table 3-28. Descriptive and distributional statistics by exposure type for MTBE research.

Descriptive statistics							
	Number of values		Concentration, ppm				
Exposure type	All	ND[a]	Minimum[b]	Maximum	Median	GM[c]	GSD[d]
Short-Term	2	0	219.00	464.00	341.50	318.78	1.70
Task	0	-					
8-hr TWA	0	-					
Ex Shift	0	-					

Distributional statistics									
		Concentration range, ppm							
Exposure type	Number of values	ND	<1	1-10	11-40	41-100	101-200	201-300	>300
Short-Term	2	0	0	0	0	0	0	1	1
Task	0								
8-hr TWA	0								
Ex Shift	0								

[a]Non-detects.
[b]Minimum value is taken for non-detects and actual values.
[c]Geometric mean (ppm).
[d]Geometric standard deviation (dimensionless).

Section 4
SUMMARY AND CONCLUSIONS

The survey collected 1,833 individual MTBE concentration measurements representing a wide variety of occupational exposure situations. Analysts classified these measurements according to facility type, geographic location, work place location, and a variety of other descriptors. The following list identifies the most frequently occurring categories associated with each descriptor and indicates the percentage of measured values assigned to each category.

- facility type

  - refineries: 45 percent
  - bulk terminals: 23 percent
  - chemical plants: 14 percent
  - marine vessels: 13 percent

- geographic location

  - California: 23 percent
  - Texas: 21 percent

- work place location

  - loading racks: 14 percent
  - storage tanks: 11 percent

- MTBE source

  - gasoline (MTBE proportion unknown): 43 percent
  - neat MTBE: 30 percent

- sample type

  - personal: 73 percent
  - area: 20 percent

- subject type

  - operator: 32 percent
  - missing or unknown: 24 percent
  - truck drivers: 11 percent
  - laboratory technicians: 9 percent

- calendar month

  - July: 18 percent
  - August: 14 percent

- calendar year

  - 1992: 37 percent
  - 1991: 30 percent
  - 1990: 17 percent

- measurement duration

  - 241 to 480 minutes: 29.7 percent
  - short-term exposure level (STEL): 16.3 percent
  - 1 to 5 minutes: 12.2 percent
  - over 480 minutes: 11.0 percent

- sampling method

  - charcoal tubes: 52 percent
  - organic vapor monitors: 21 percent
  - unknown: 19 percent

- analytical method

  - OSHA Method 7: 42 percent
  - unknown: 30 percent
  - NIOSH Method 1615 and modifications: 17.7 percent

- control equipment in use

  - not specified*: 65 percent
  - open system: 8 percent
  - respirator or supplied air: 6 percent

*Survey instrument did not distinguish between samples without control equipment/respirators and where equipment presence was unknown, so data are combined in Table 3-18.

- sector

  - transport of MTBE fuel mixtures: 21 percent
  - blending of MTBE fuel mixtures: 17 percent
  - distribution of MTBE fuel mixtures: 16 percent
  - MTBE manufacturing - routine operations: 14 percent

Analysts calculated descriptive statistics for the MTBE concentrations according to sector, sample type (personal versus area), and (with and without) reported respirator use. Based on sectors with sufficient data for analysis, the statistics for area and personal samples combined indicate that MTBE manufacturing (spills, leaks, and upsets) had the largest geometric mean, while MTBE manufacturing (routine operations) and MTBE blending (fuel mixtures) had the smallest geometric means. As expected, sector exposure categories associated with neat MTBE had larger geometric means than similar categories associated with fuel mixtures. For example, the geometric mean for handling neat MTBE during blending was 2.36 ppm; the geometric mean for blending fuel mixtures was 0.23 ppm. Transportation activities appear to produce higher mean exposures than blending operations: the geometric mean for transportation of neat MTBE (3.42 ppm) was larger than the geometric mean for handling neat MTBE during blending (2.36 ppm). Refueling activities had a larger geometric mean (1.99 ppm) than distribution activities (0.33 ppm).

Researchers focussed the remaining analysis on the MTBE measurements obtained from personal samplers carried by subjects without reported respirator use (use unknown or not affirmatively indicated in questionnaire response). Within that population, based on sectors with sufficient data for analysis, the sector with the largest geometric mean was transportation of neat MTBE (5.1 ppm). MTBE manufacturing - routine operations had the smallest geometric mean (0.12 ppm). As expected, exposure categories associated with neat MTBE had larger geometric means than similar categories associated with MTBE fuel mixtures. For example, the geometric means for MTBE blending were 2.11 ppm for neat MTBE and 0.16 ppm for fuel mixtures. The geometric mean for MTBE refueling (1.8 ppm) was larger than the geometric mean for distribution (0.33 ppm).

Analysts were able to determine sample durations for 1,157 of the 1,833 exposure measurements. These measurements were classified according to four duration ranges: short-term (less than 30 minutes), task-related (30 minutes to 6 hours), "8-hour" TWA (6+ hours to 9 hours), and extended shift (greater than 9 hours).

An analysis of MTBE measurements by duration range and sector revealed several general patterns. Short-term exposures generally accounted for the largest number of measurements associated with each sector. The smallest sample sizes were typically associated with task-related or extended shift exposures. The largest median MTBE concentration calculated for each sector was associated with short-term exposures; eight-hour TWA exposures typically had the smallest median concentrations. Eighty-nine percent of the MTBE concentrations were below 10 ppm; three percent exceeded 100 ppm. The MTBE concentrations exceeding 100 ppm were primarily associated with the transport of MTBE (neat and fuel mixtures) and tended to occur during short-term exposures.

Section 5

REFERENCES

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APPENDIX A

EXPOSURE DATA QUESTIONNAIRE

API Survey #1: Exposure Measurements

Attention: Inez vanArsdall,
ITAQS (919) 493-3661

Respondent:_____
Company_____
Tel. #:_____

Attachment A: Questionnaire for Each Exposure Data Set

We are interested in the following descriptive elements for each data set that you may have. Please fill out this form to the extent possible for each data set. If possible, please attach copies of the data sets themselves in answer to question 14. If data sets are related (taken over various times in the same place) please note they are related to data sets #_____.

Descriptive Elements for Data Set # _____

1) Type of facility

___ chemical plant
___ refinery
___ bulk terminal
___ marine terminal
___ service station
___ other/describe_____

2) Facility Location

___ State

3) Description of Location Where Measurements Taken

___ pump island
___ facility perimeter
___ loading rack
___ in vehicle
___ process unit/describe_____
___ other/describe_____

4) MTBE Source

___ neat MTBE
___ in gasoline_____%
___ other/describe_____

5) Sample Type

___ personal monitor

___ area monitor
___ other/describe_____

6) Subject Type if Personal Monitor

___ customer/describe_____
_____

___ employee/describe job_____
_____
_____

7) Sampling Date(s)_____

8) Sample Duration (TWA?)_____

9) MTBE Sampling Method

___ mg charcoal tube
___ mg _____ tube
___ SUMMA canister
___ other/describe_____

10) MTBE Analytical Method

___ NIOSH #_____
___ modified NIOSH/describe____
_____
_____
___ TO-14
___ other/describe_____

11) Analytical Method Sensitivity (LOD)_____

12) Emission or Exposure Control Information Relevant to Data Set

___ open system
___ closed system
___ vapor recovery system in use
___ enhanced or forced ventilation in use
___ respirators or supplied air in use
___ other/describe_____

13) Other Information Pertinent to Interpretation of the Data Set

___ routine activities
___ turnaround or maintenance activities
___ spill cleanup activities
___ process upset condition
___ other/describe_____

14) Measured MTBE levels (ppb or ppm): (If you have repeated sampling under similar conditions over a period of time, please note that a particular data set "is related to data set _____". Hard copy data sets may be attached. Please number multiple data sets).

_____	_____	_____	_____	____
_____	_____	_____	_____	____
_____	_____	_____	_____	____
_____	_____	_____	_____	____

APPENDIX B

FOLLOW-UP TELEPHONE QUESTIONS

API MTBE Exposure Survey
Attention: Inez vanArsdall
(919) 493-3661

Attachment B: Telephone Followup

An ITAQS representative will contact you by telephone several days after you have received this letter and attachments to ask you the following questions:

1. **Does your company manufacture MTBE, blend MTBE, or distribute gasoline containing MTBE?**

2. **Have you conducted any measurements of airborne concentrations of MTBE?**

3. **Are you willing to share this information with ITAQS as an API contractor on a confidential basis? Are you the proper person to contact concerning this type of data (if not, who should we contact)?**

4. **Can you provide the descriptive elements for the requested data? If not, could you provide a narrative description characterizing each data set?**

5. **Will you supply the underlying data sets as hard copy, microfilm, or in machine readable form?**

6. **Could you identify, assemble and transmit the requested information to ITAQS by May 18, 1993? If not, by what date?**

APPENDIX C

PRESENTATION OF PRELIMINARY MTBE EXPOSURE FINDINGS
EPA CONFERENCE ON MTBE AND OTHER OXYGENATES
A RESEARCH UPDATE

JULY 26-28, 1993
FALLS CHURCH, VA

APPENDIX C-2

Preliminary findings from the exposure survey were presented at the July 26-28, 1993 EPA Conference on MTBE and Other Oxygenates: A Research Update. The following pages constitute the presentation summary and projection transparencies provided for inclusion in the conference proceedings. These materials contain additional information and are appended to this report for the convenience of the reader. Note that the preliminary data presented in this appendix may differ in some instances from that contained in the final report. For example, duplicate values discovered on the original data sheets, and discussed at page 2-5 of the report, are included in this preliminary presentation but were removed from analyses presented in the final report. As in the final report, the preliminary analyses focus on personal sample measurements without reported respirator use; even though respirator status may have been unknown in some cases. See discussion page 3-13 regarding Table 3-12.

American Petroleum Institute
Occupational Exposures - MTBE

Jack Hinton, Dr.PH, CIH
July 27, 1993

There are five basic steps involved in bringing Methyl, Tertiary Butyl Ether (MTBE) to market.

Manufacturing - MTBE production at both chemical plant and petroleum refinery facilities;

Blending - introduction of MTBE into motor gasolines which includes handling of both neat MTBE and blended MTBE fuels;

Transportation - movement of MTBE or MTBE blended fuels via barge, tanker, railcar, truck or pipeline to points of distribution;

Distribution - storage and movement of MTBE blended fuels from distribution terminals to the service station; and

Service Station - storage and dispensing of MTBE blended fuels to the motoring public.

The American Petroleum Institute initiated a survey to collect and aggregate member company occupational exposure data for MTBE. The data collected are typical of industry operations, reflective of all the steps listed above, and span an eleven year time period (May 1982 to March 1993). Further, the data are representative of all the major users and manufacturers of MTBE, with 92% of the data gathered since 1990, 50% of the data collected in the oxyfuel winter months and 45% of the data gathered during the 1992/1993 oxyfuel season.

A total of 2038 exposure measurements were received and were distributed as follows:

18% area samples;

7% engineering source samples;

12% personal samples where employees wore respiratory protection; and

63% personal samples where no respiratory protection was worn.

The presentation is based on the data set of 63% personal samples where respiratory protection was not worn, because it is felt to be most representative of potential employee exposure to MTBE.

This data set represents at least the following number of employees per exposure grouping:

Operation	Number of Workers	Number of Exposure Measurements
Manufacturing	881	365
Blending	1800	523
Transportation	1489	641
Distribution	7705	305
Service Station	37,753	41
Other	not determined	8
Total	**49,628**	**1,883**

The data are felt to be representative of exposure groupings with the exception of the service station category. However, the 37,753 employees in the service station category are felt to be an over statement of the actual number of employees with potential for job activity-related exposure to MTBE. The majority of the 37,753 employees would be store clerks who are responsible for the collection of payment for gasoline sales and operation of the "food mart" portion of the station. Only a small fraction of this number would be employees whose job description included the requirement to dispense fuel and service and/or repair vehicles. The 41 service station exposure measurements are felt to be less representative than the other exposure measurement categories listed, but not as "out of line" as the comparison of 41 measurements to 37,753 workers implies.

The data are further aggregated for each operation category (manufacturing, blending, transportation, distribution, service station) by sample duration (short-term - less than 30 minutes; Task/Activity - between 30 minutes and 6 hours; time-weighted-average TWA workshift - between 6 hours and 9 hours; and extended workshift - greater than 9 hours) and source of MTBE (neat or fuel mixture).

The American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Limit (WEEL) was used to assess exposure exceedances for task/activity, TWA workshift and extended workshifts. Since no comparable short-term exposure limit exists, the Excursion Limit convention was borrowed from the American Conference of Governmental Industrial Hygienists (ACGIH). This "rule of thumb" convention uses a 3-fold multiplication of the 8-hour exposure limit value to determine an acceptable short-term exposure. It is emphasized that this presentation advocates neither the need nor the establishment of a short-term value equal to the 300 ppm value used here (3 x 100 ppm AIHA - WEEL = 300 ppm excursion limit). The value of 300 ppm is simply used as a convention to sort and present short-term data.

Personal exposures in the manufacturing category are less than[1] 10 ppm for all sample types for both routine and maintenance operations. A single exposure of 249 ppm was reported for a "bottle-washing" activity in a quality control lab. A review of information associated with this value indicates this to be an atypical exposure as the automated bottle-wash equipment is usually controlled with exhaust ventilation, and other samples included in this data set, which are representative of this activity, are below the 10 ppm limit reported above.

Personal exposures in the blending category are less than 100 ppm for all sample types for both neat and fuel mixture operations, with the data predominantly being less than 10 ppm.

Personal exposures in the transportation category are generally less than 50 ppm for short-term activities associated with mixed fuel and generally less than 200 ppm for short-term activities associated with neat MTBE. Short-term exposures for both neat and fuel mixtures can exceed 300 ppm, the highest value being 1050 ppm, and are generally reflective of barge loading, sampling and gauging activities or vacuum hosing associated with "pigging" (cleaning) operations in pipelines. Activity/Workshift exposures for neat MTBE activities are generally less than 10 ppm, with occasional exposures ranging up to 711 ppm where barge loading, sampling, gauging, or pigging operations occurred during the shift. Activity/Workshift exposures for mixed fuel activities are generally below 10 ppm with no exposures seen above the 100 ppm WEEL.

Personal exposures in the distribution category are generally less than 10 ppm for short-term operations and generally less than 1 ppm for activity/workshift timeframes.

Personal exposures in the service station category are generally less than 100 ppm for short-term activities and are limited to vehicle or dispensing pump repair. Activity/Workshift exposures are generally less than 10 ppm. Monitored exposures for this category are generally representative of full-service activities associated with dispensing fuel and garage repairs. Some samples are reflective of weights and measure inspection activities and fuel dispensing pump repair.

From these data, personal occupational exposures to MTBE are generally well within the AIHA 100 ppm WEEL, and range as follows:

26%	below the Limit of Detection;
34%	between the Limit of Detection and 1.0 ppm;
36%	between 1.0 ppm and 100 ppm; and
4%	in excess of 100 ppm.

[1]The term "less than" is used for values below a stated concentration (e.g., - 10ppm) and should not be confused with values below an analytical limit of detection which are expressed as "below the Limit of Detection".

Short-term exposures to MTBE are generally well within an excursion value of three times the 100 ppm AIHA WEEL (300 ppm excursion limit), and range follows:

19% below the Limit of Detection;
20% between the Limit of Detection and 1.0 ppm;
59% between 1.0 ppm and 300 ppm; and
2% in excess of 300 ppm.

The data demonstrate that exposures in excess of 100 ppm TWA or 300 ppm short-term occur infrequently and are generally limited to specific non-routine or extraordinary tasks. Once determined, respiratory protection or other ventilation techniques are used to control exposures in these situations.

A relative index based on geometric means (G.M.) of short-term and activity/workshift TWA concentrations can be constructed to rank order exposure potential. From this data set the ranked order of exposure potential would be as follows:

	MTBE (PPM)	
Operation	G.M. Short-Term	G.M. TWA
Transporting Neat MTBE	11.0	0.24
Blending Neat MTBE	5.1	0.58
Service Station	4.7	0.77
Transporting MTBE/Fuel Mix	3.3	0.13
Manufacturing-Maintenance	1.0	0.14
Distributing	0.85	0.13
Manufacturing-Routine	0.84	0.06
Blending MTBE/Fuel Mix	0.58	0.10

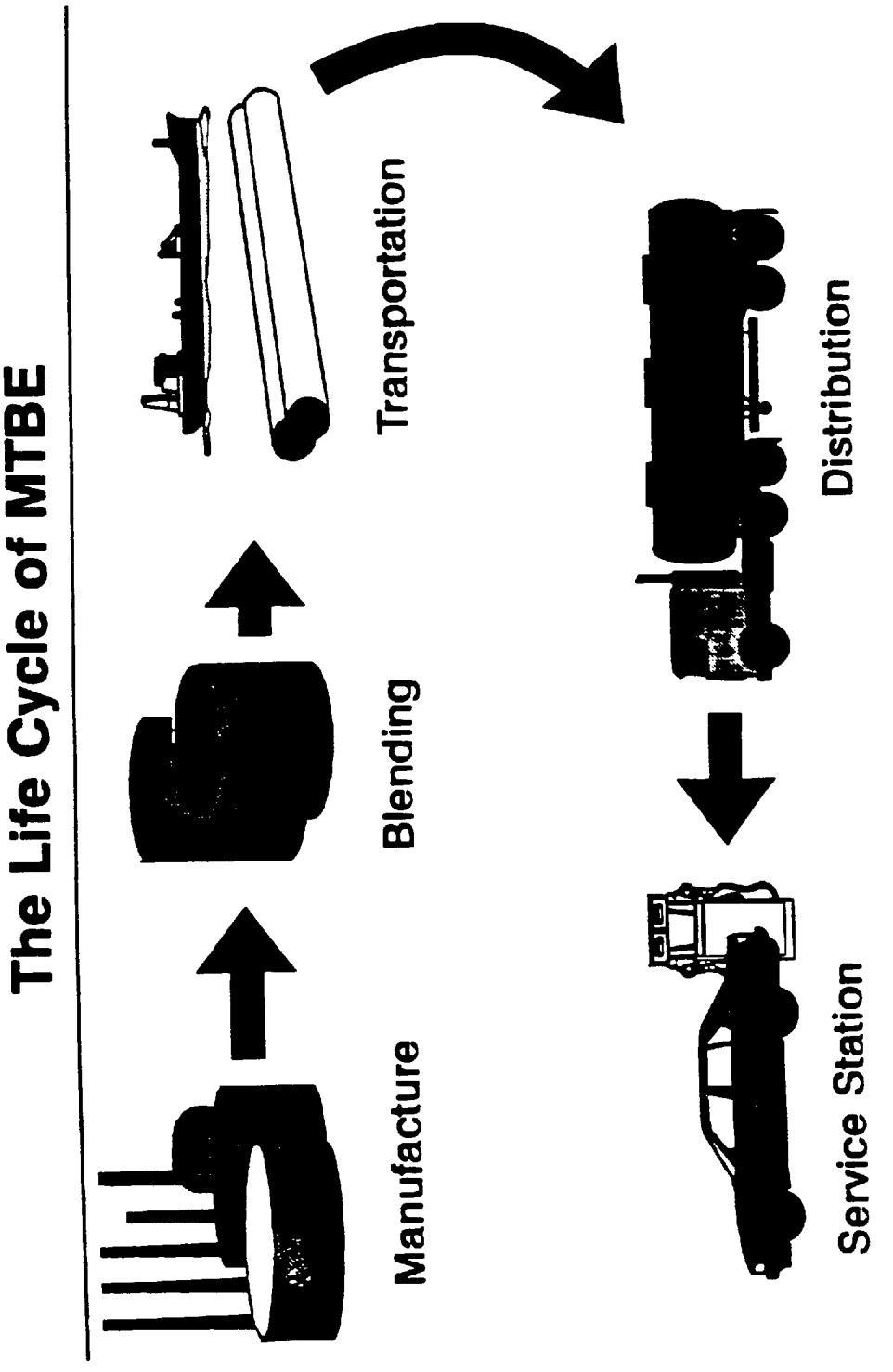
A:\JACK.ABS Disk 3

American Petroleum Institute
Occupational Exposures - MTBE

Jack Hinton, Dr PH, CIH
July 27, 1993

Occupational Exposures - MTBE

- Aggregated member company MTBE exposure data
- Timeframe: May, 1982 to March, 1993
- 16 companies responded
  (All major users and manufacturers of MTBE)



Occupational Exposures - MTBE

Data Variables:

Facility type
State
Measurement locations
MTBE source
Sample type
Job type
Month, Year
Sampling/analytical method
Control information
Operating conditions
MTBE concentrations

Occupational Exposures - MTBE

Operation	# Workers	# Exposure Measurements
Manufacturing	881	365
Blending	1800	523
Transportation	1489	641
Distribution	7705	305
Service Station	37753	41
Other	not determined	8
Total	49628	1883

Occupational Exposures - MTBE

Data distributions: 2038 exposure measurements

18% Area samples

7% Source samples

63% Personal samples w/o resp. protection

12% Personal protection w/resp. protection

100%

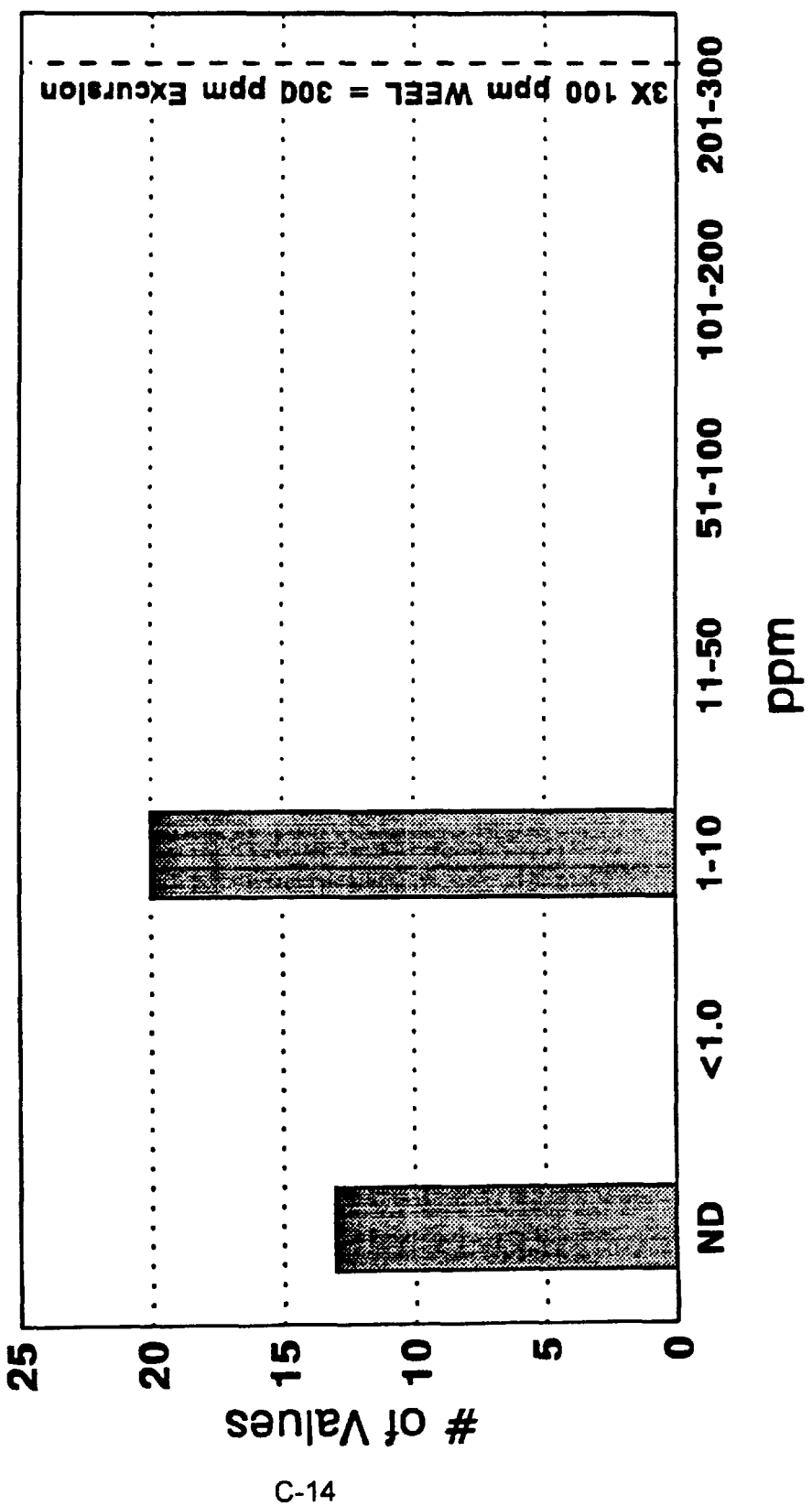
Occupational Exposure - MTBE
Manufacturing - Personal Samples

Operation	Exposure Type	# Values All	# Values ND	Concentration, ppm Min.	Max.	Median	G.M.	G.S.D.
Routine	Short-term	33	13	0.016	7.8	1.0	0.84	3.5
	Task	0	-	-	-	-	-	-
	8-hr TWA	82	38	0.01	249	0.03	0.06	6.0
	Ex Shift	2	0	0.16	0.17	-	-	-
Maintenance/ Turnaround	Short-term	14	1	0.50	7.2	0.70	1.0	2.6
	Task	1	0	0.20	-	-	-	-
	8-hr TWA	12	0	0.04	0.7	0.14	0.14	2.3
	Ex Shift	2	0	0.16	0.2	-	-	-

Occupational Exposures - MTBE

Manufacturing - Personal Samples

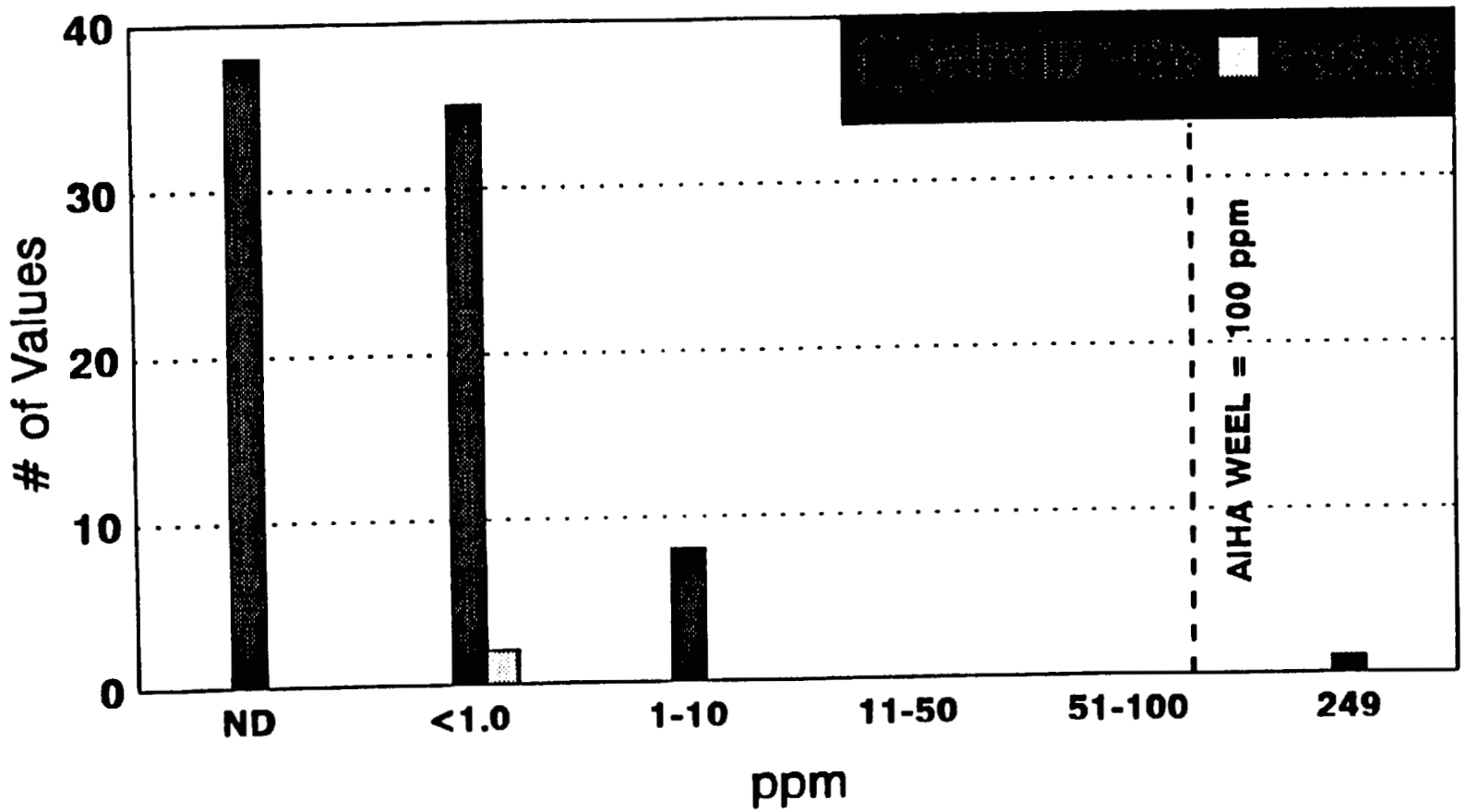
Routine Operations - Short-term



Occupational Exposures - MTBE

Manufacturing - Personal Samples

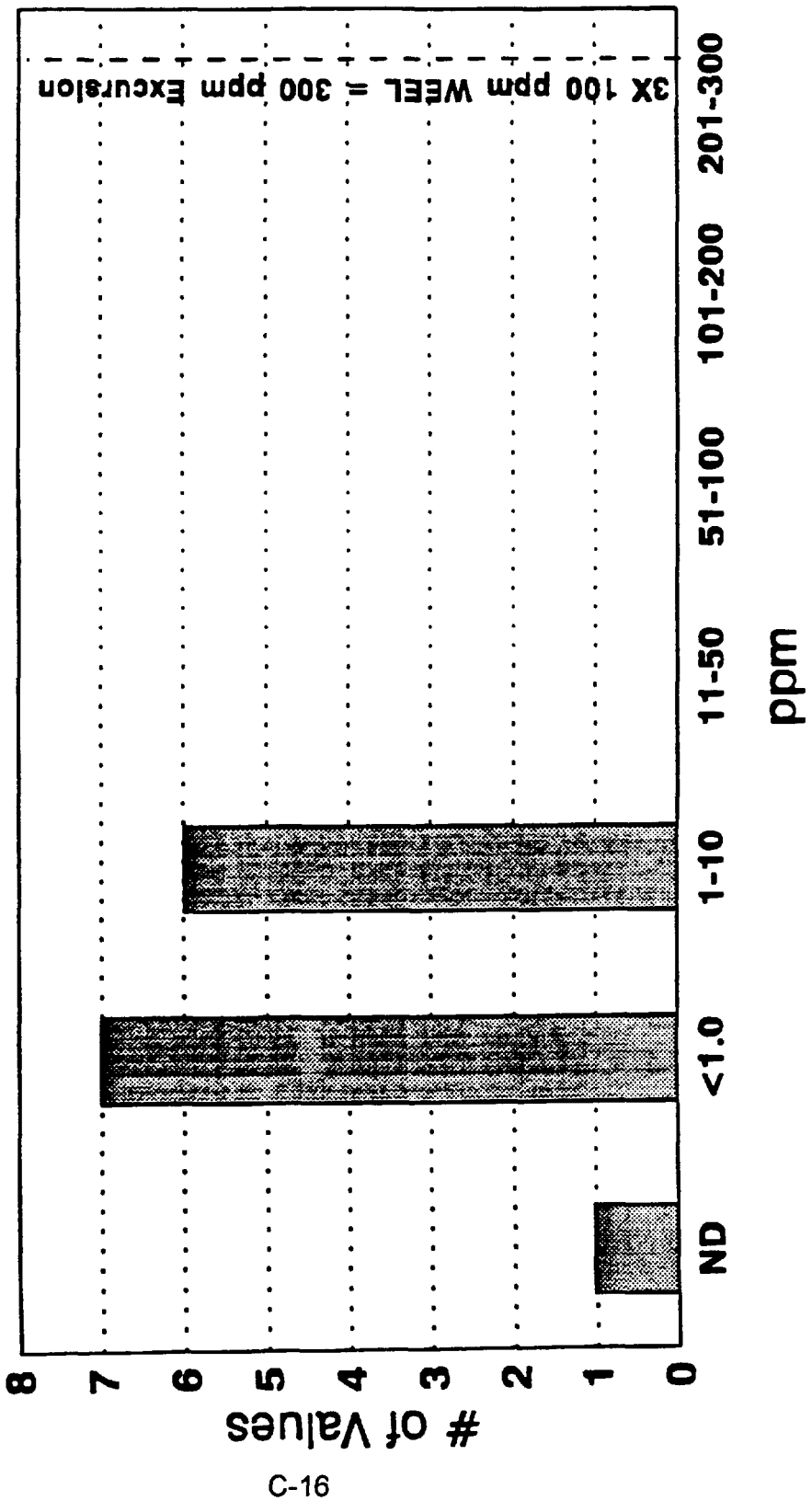
Routine Operations - Activity/Workshift Exposure



Occupational Exposures - MTBE

Manufacturing - Personal Exposures

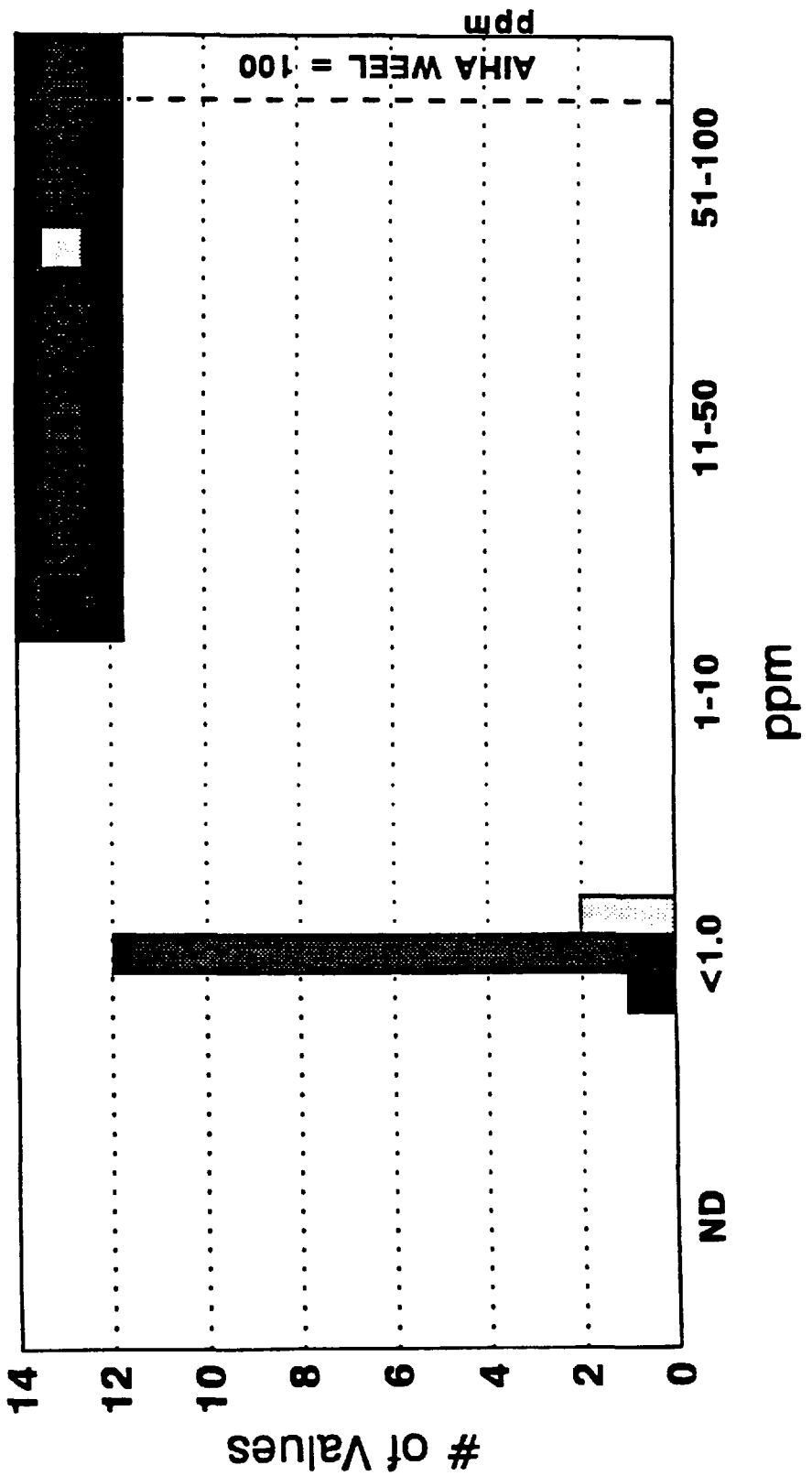
Maintenance/Turnaround - Short-term Exposures



Occupational Exposures - MTBE

Manufacturing - Personal Samples

Maintenance/Turnaround - Activity/Workshift Exposure



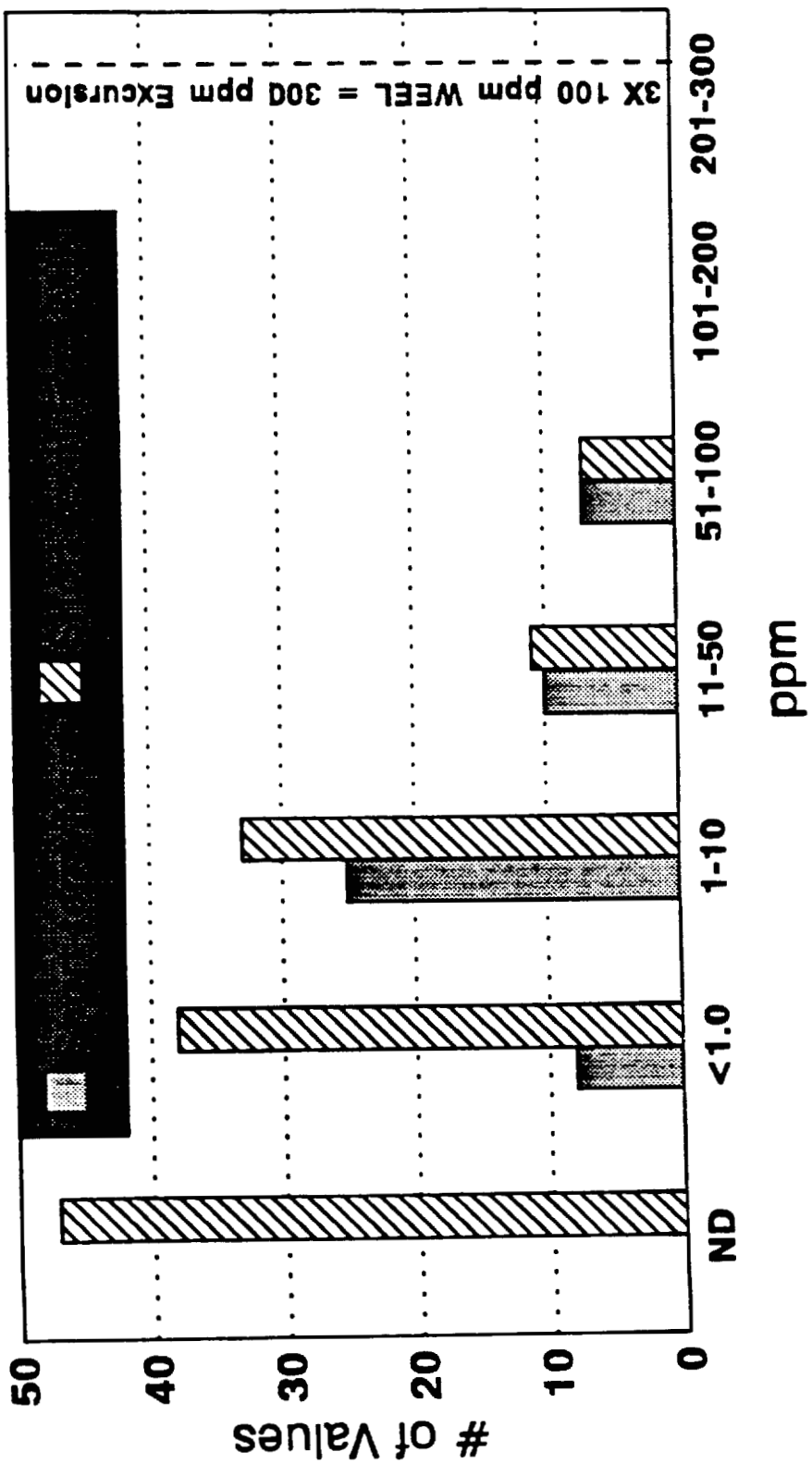
Occupational Exposure - MTBE
Blending - Personal Samples

Operation	Exposure Type	# Values All	# Values ND	Concentration, ppm Min.	Concentration, ppm Max.	Concentration, ppm Median	Concentration, ppm G. M.	Concentration, ppm G.S.D.
Neat	Short-term	50	1	0.01	97	2.3	5.1	5.6
	Task	13	1	0.21	72	1.0	2.1	5.3
	8-hr TWA	13	5	0.04	88	2.6	1.9	9.2
	Ex Shift	9	9	0.23	0.34	0.3	0.3	1.1
Fuel Mix	Short-term	136	47	0.02	100	0.4	0.58	9.4
	Task	19	14	0.03	2	0.05	0.12	3.9
	8-hr TWA	122	78	0.02	14	0.05	0.10	4.1
	Ex Shift	22	13	0.01	0.27	0.02	0.04	2.7

Occupational Exposures - MTBE

Blending - Personal Samples

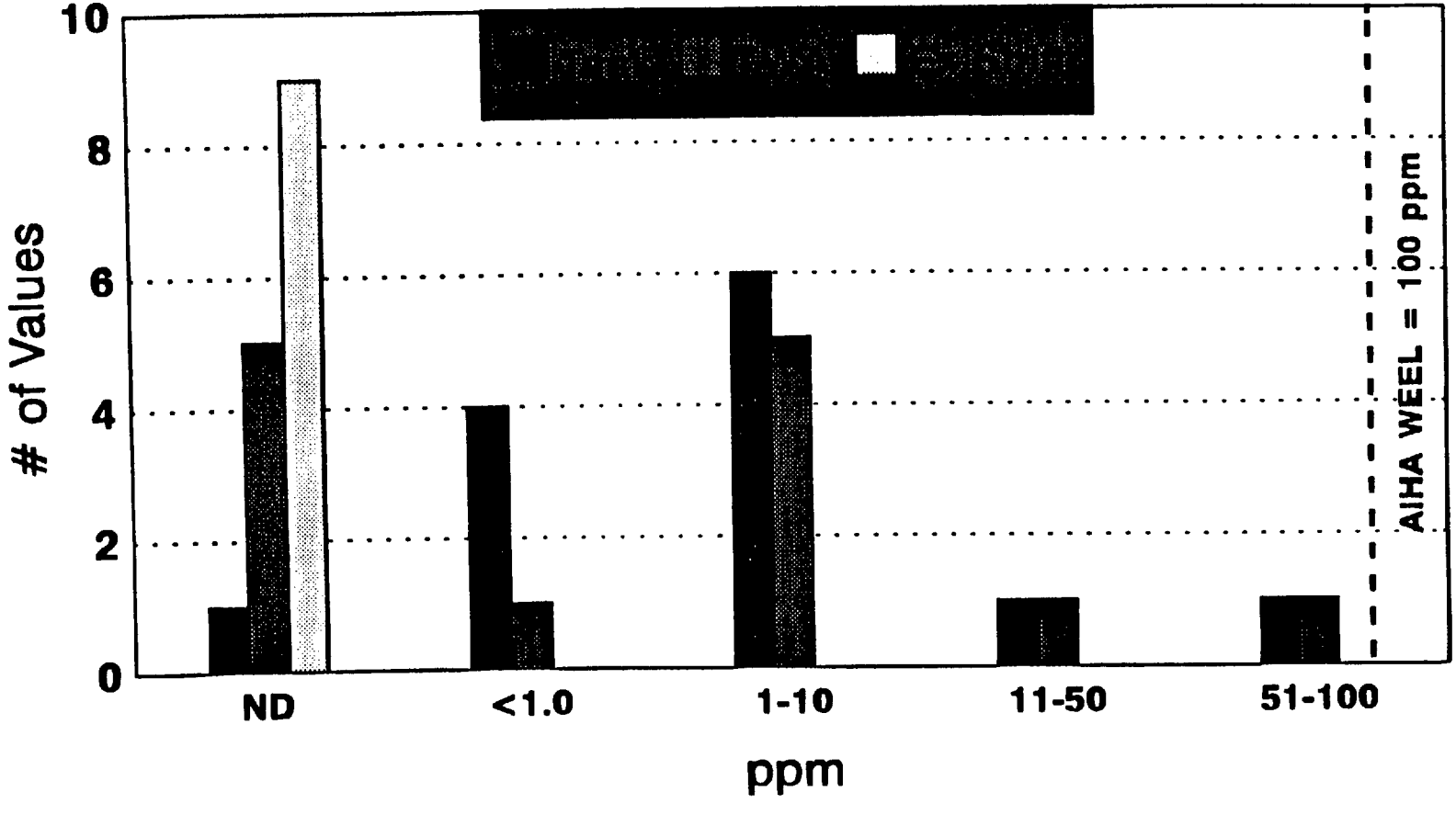
Short-term Exposure Data



Occupational Exposures - MTBE

Blending - Personal Samples

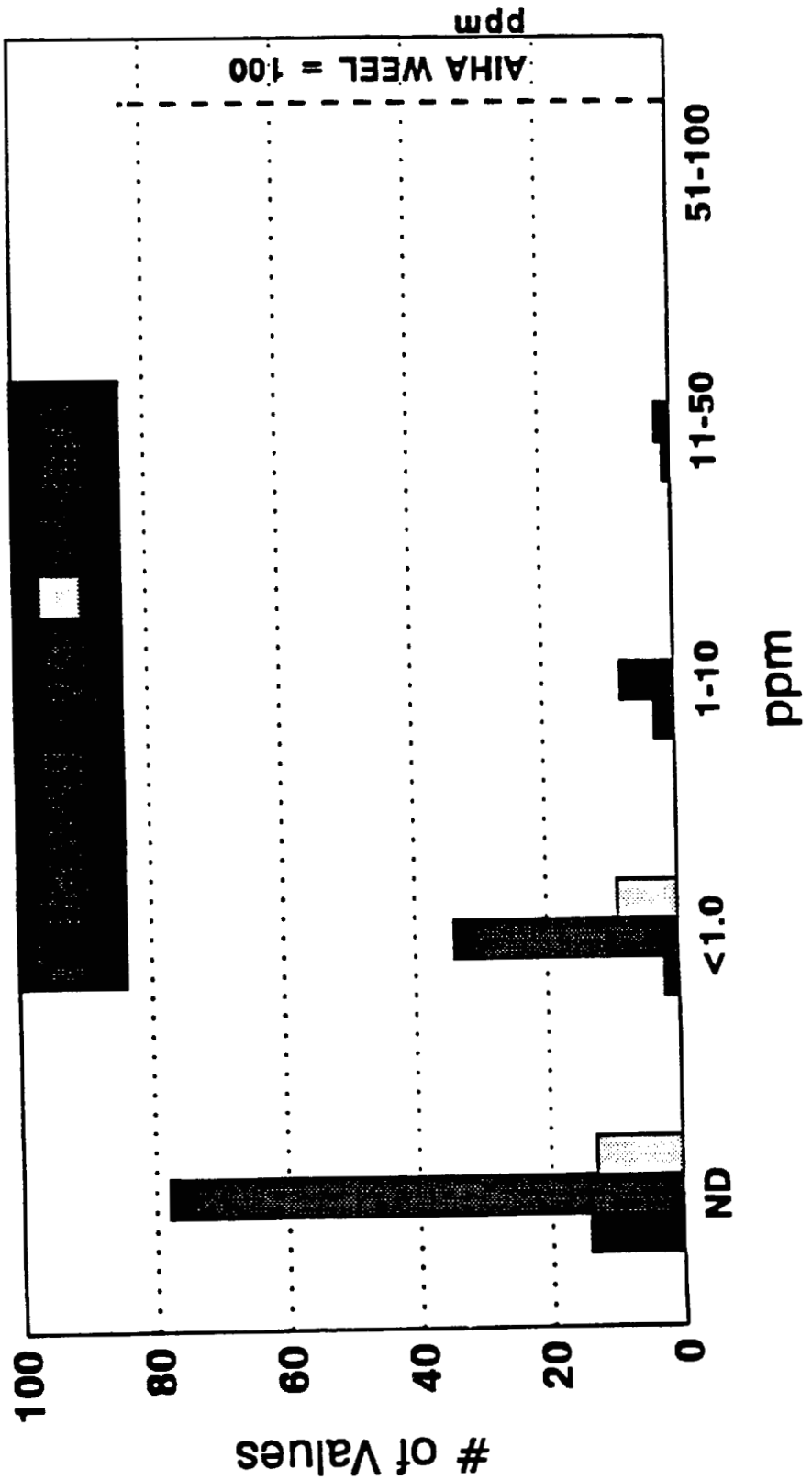
Neat - Activity/Workshift Exposure



Occupational Exposures - MTBE

Blending - Personal Samples

Mixed Fuel - Activity/Workshift Exposure



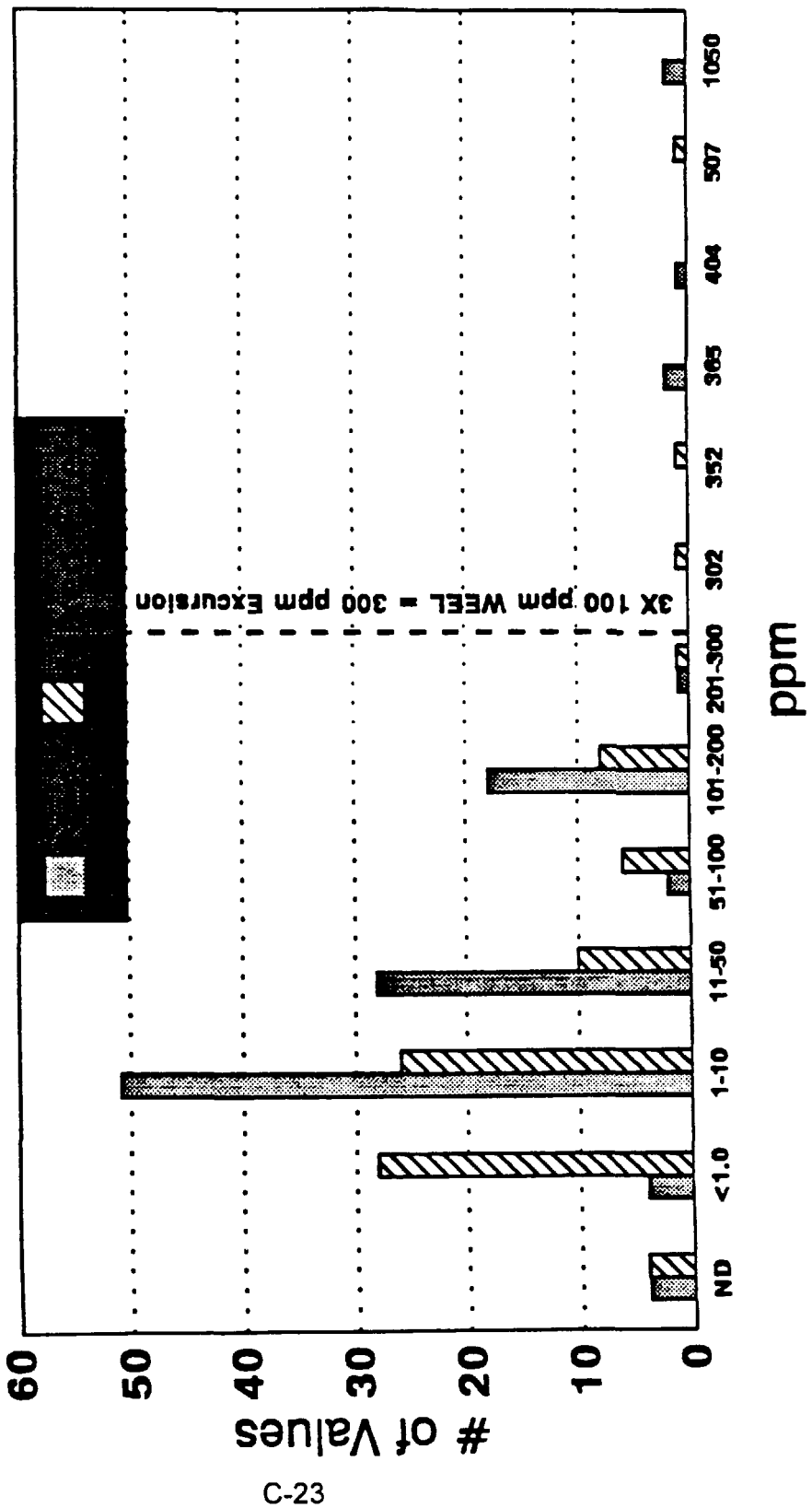
Occupational Exposure - MTBE
Transport - Personal Samples

Operation	Exposure Type	# Values All	# Values ND	Concentration, ppm Min.	Max.	Median	G. M.	G. S.D.
Neat	Short-term	114	4	0.3	1050	9.7	11	7.3
	Task	27	4	0.04	700	2.2	2.3	9.4
	8-TWA	17	1	0.02	712	0.21	0.24	10.6
	Ex Shift	1	0	0.32	-	-	-	-
Fuel Mix	Short-term	86	4	0.01	508	2	3.3	13.2
	Task	92	28	0.02	59	0.42	0.51	14.0
	8-TWA	59	14	0.01	26	0.12	0.13	6.3
	Ex Shift	8	0	0.19	4.5	1.5	1.2	3.0

Occupational Exposures - MTBE

Transport - Personal Samples

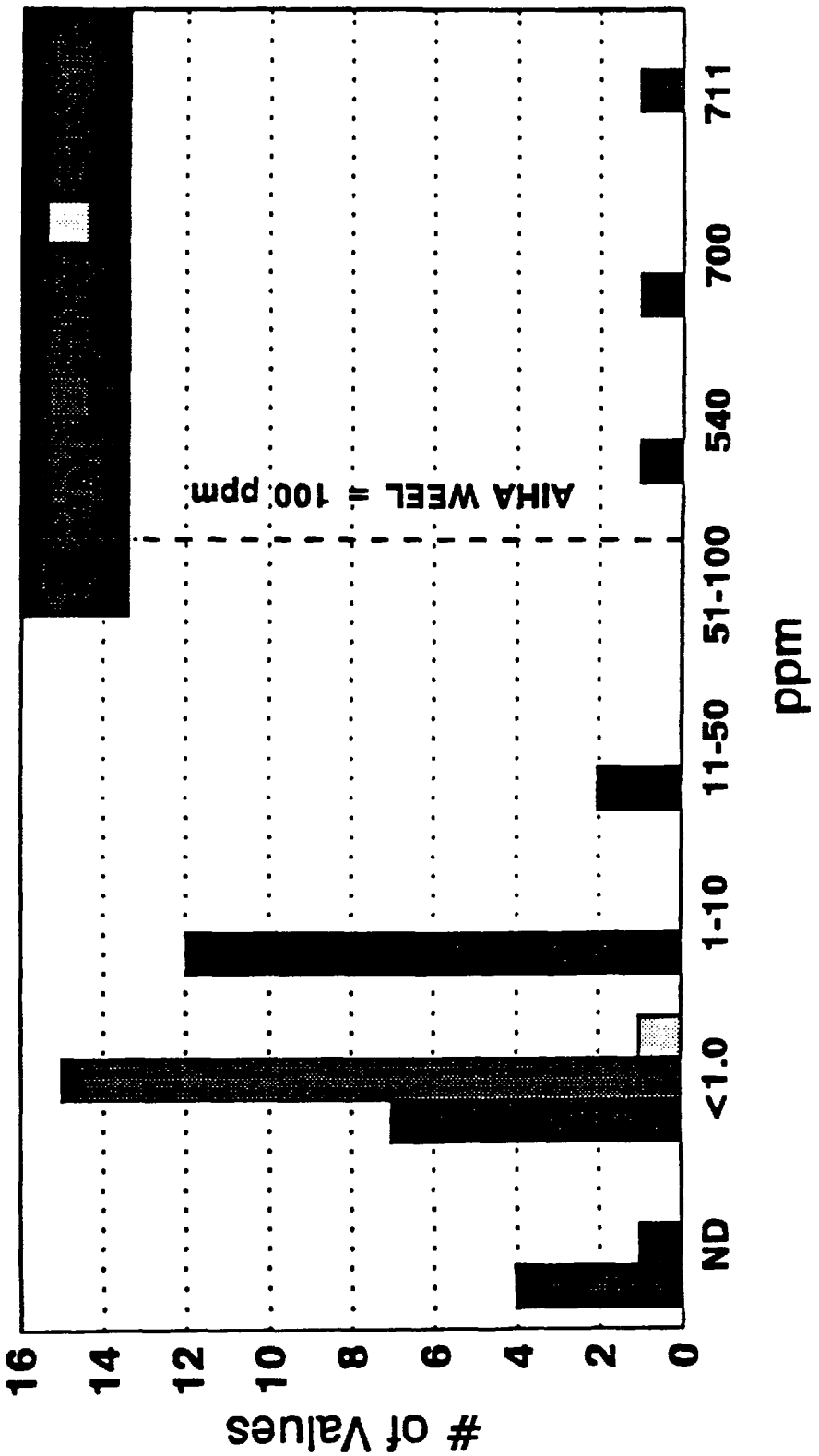
Short-term Exposure Data



Occupational Exposures - MTBE

Transport- Personal Samples

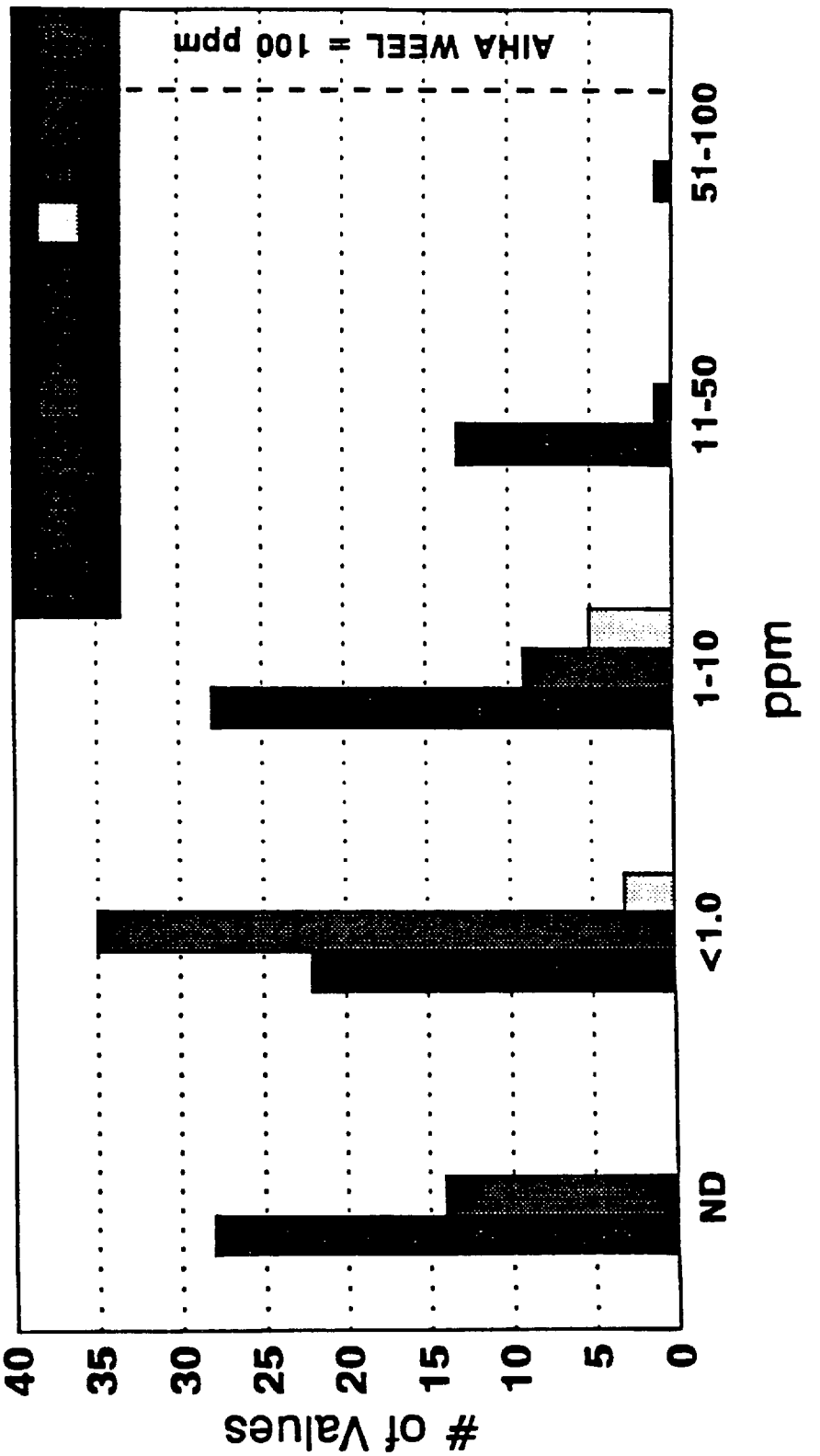
Neat - Activity/Workshift Exposures



Occupational Exposures - MTBE

Transport- Personal Samples

Mixed Fuel - Activity/Workshift Exposures



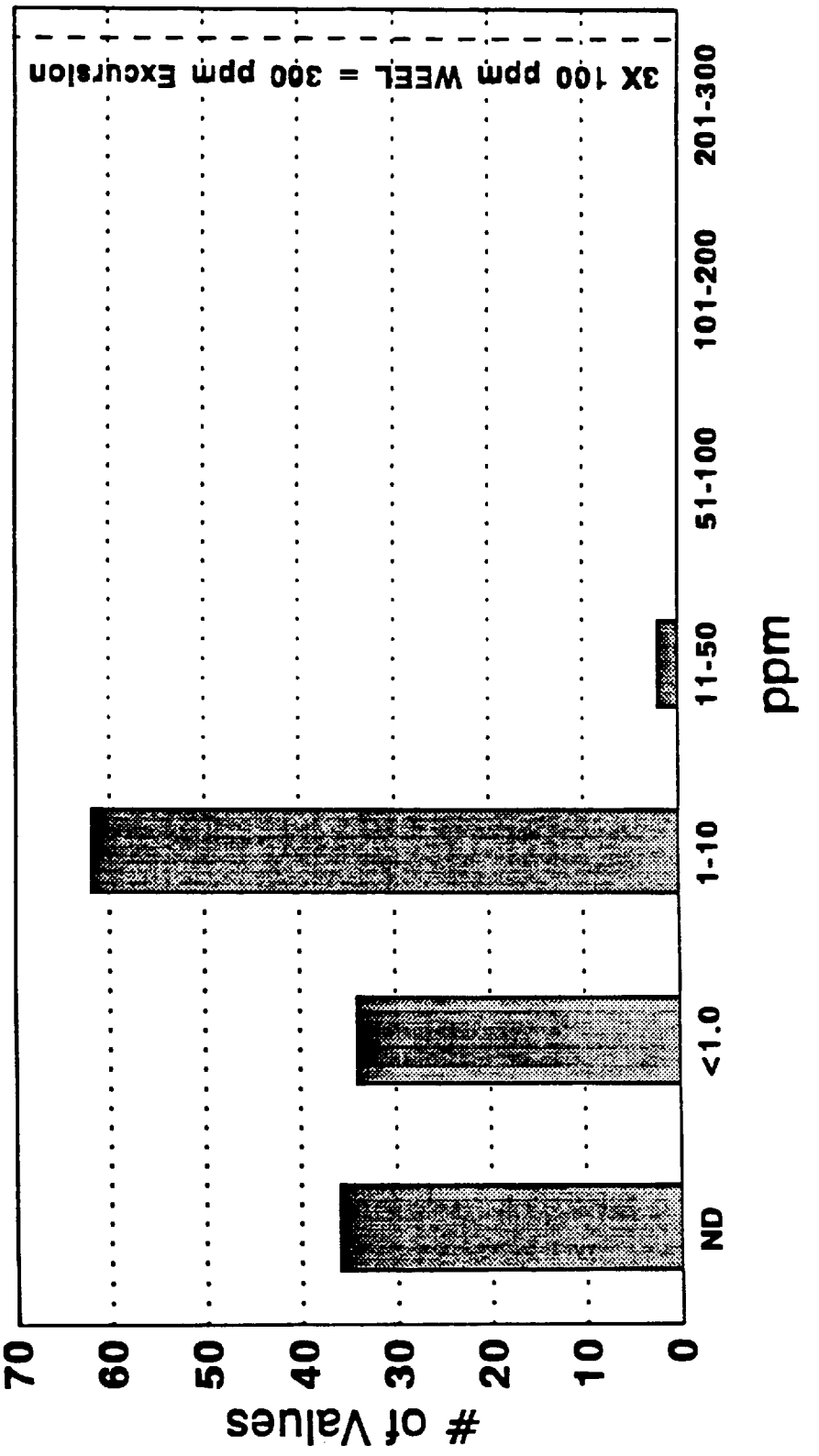
Occupational Exposure - MTBE
Distribution - Personal Samples

Operation	Exposure Type	# Values All	# Values ND	Concentration, ppm Min.	Concentration, ppm Max.	Concentration, ppm Median	Concentration, ppm G.M.	Concentration, ppm G.S.D.
All	Short-term	134	36	0.01	14	0.85	0.49	7.2
	Task	10	1	0.26	4	1.0	1.0	2.4
	8-hr TWA	100	25	0.01	2.2	0.11	0.13	4.0
	Ex Shift	47	1	0.06	6.2	0.71	0.63	2.9

Occupational Exposures - MTBE

Distribution - Personal Samples

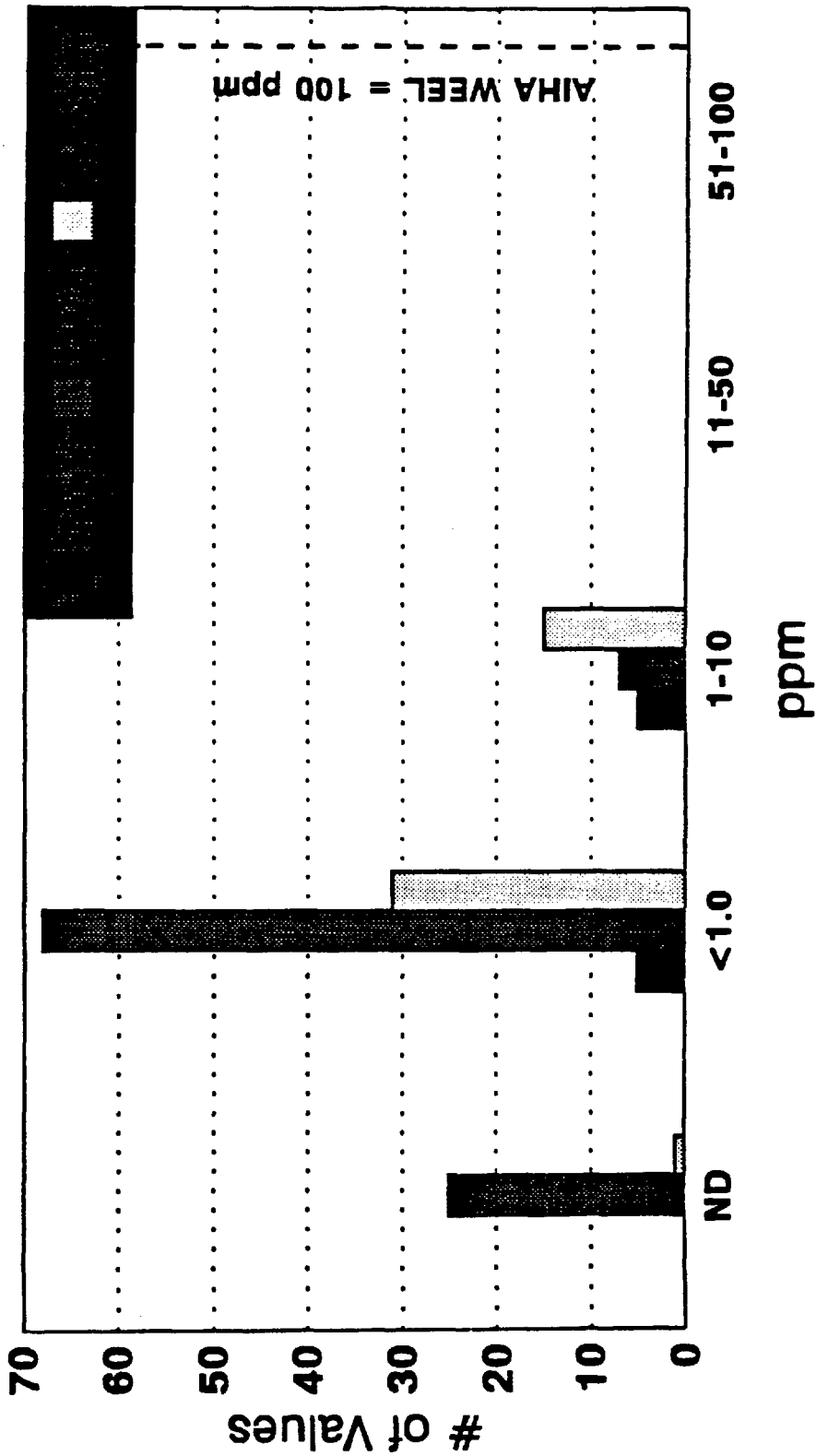
Short-term Exposure Data



Occupational Exposures - MTBE

Distribution - Personal Samples

Activity/Workshift Exposures



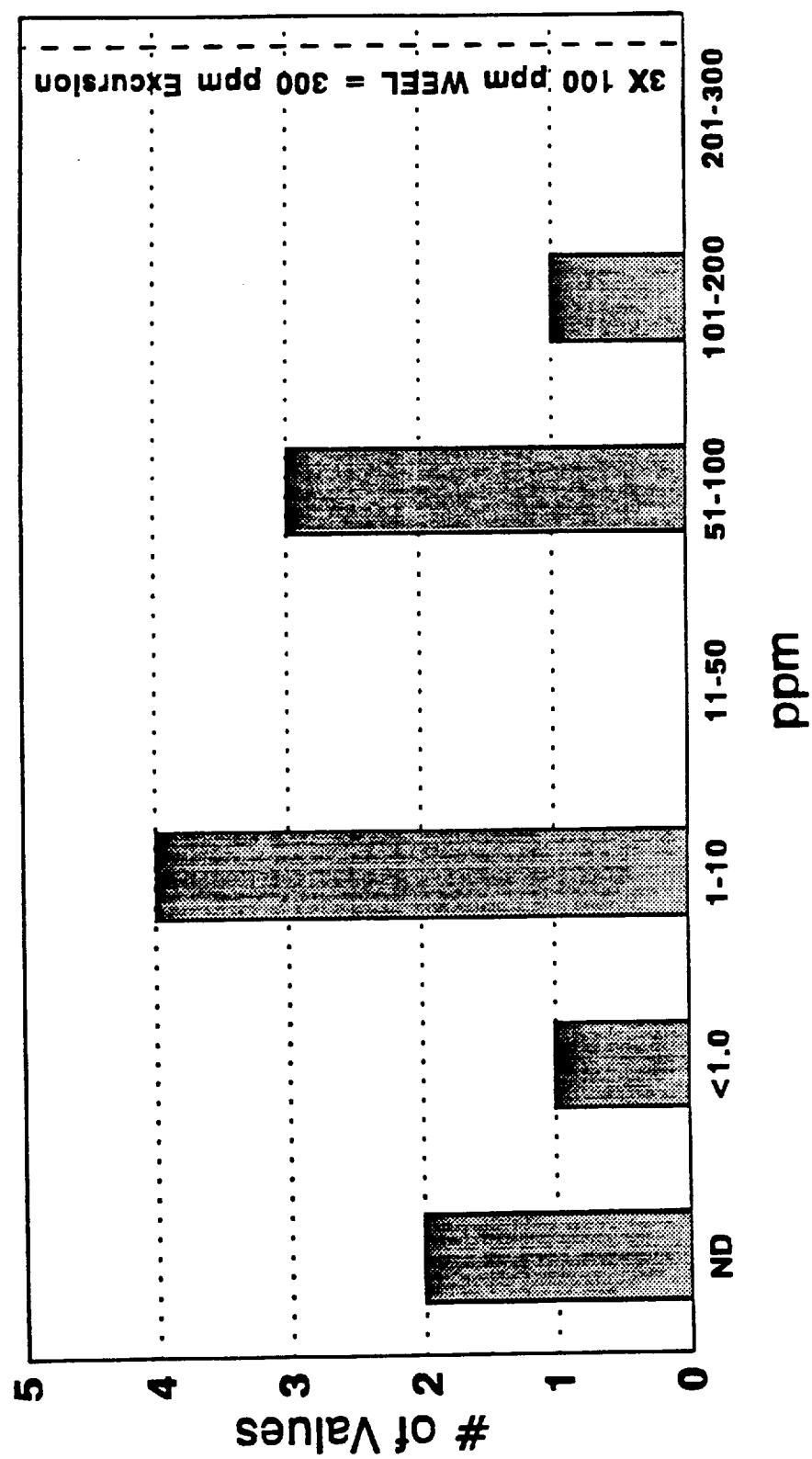
Occupational Exposure - MTBE
Service Station - Personal Samples

Operation	Exposure Type	# Values All	# Values ND	Concentration, ppm Min.	Concentration, ppm Max.	Concentration, ppm Median	Concentration, ppm G.M	Concentration, ppm G.S.D.
Service Station	Short-term	11	2	0.16	136	2.8	4.7	11.5
	Task	5	0	0.01	2.7	0.34	0.75	2.8
	8-hr TWA	13	0	0.09	34	0.59	0.77	4.7
	Ex Shift	11	0	0.01	17	1.1	2.8	4.5

Occupational Exposures - MTBE

Service Station - Personal Samples

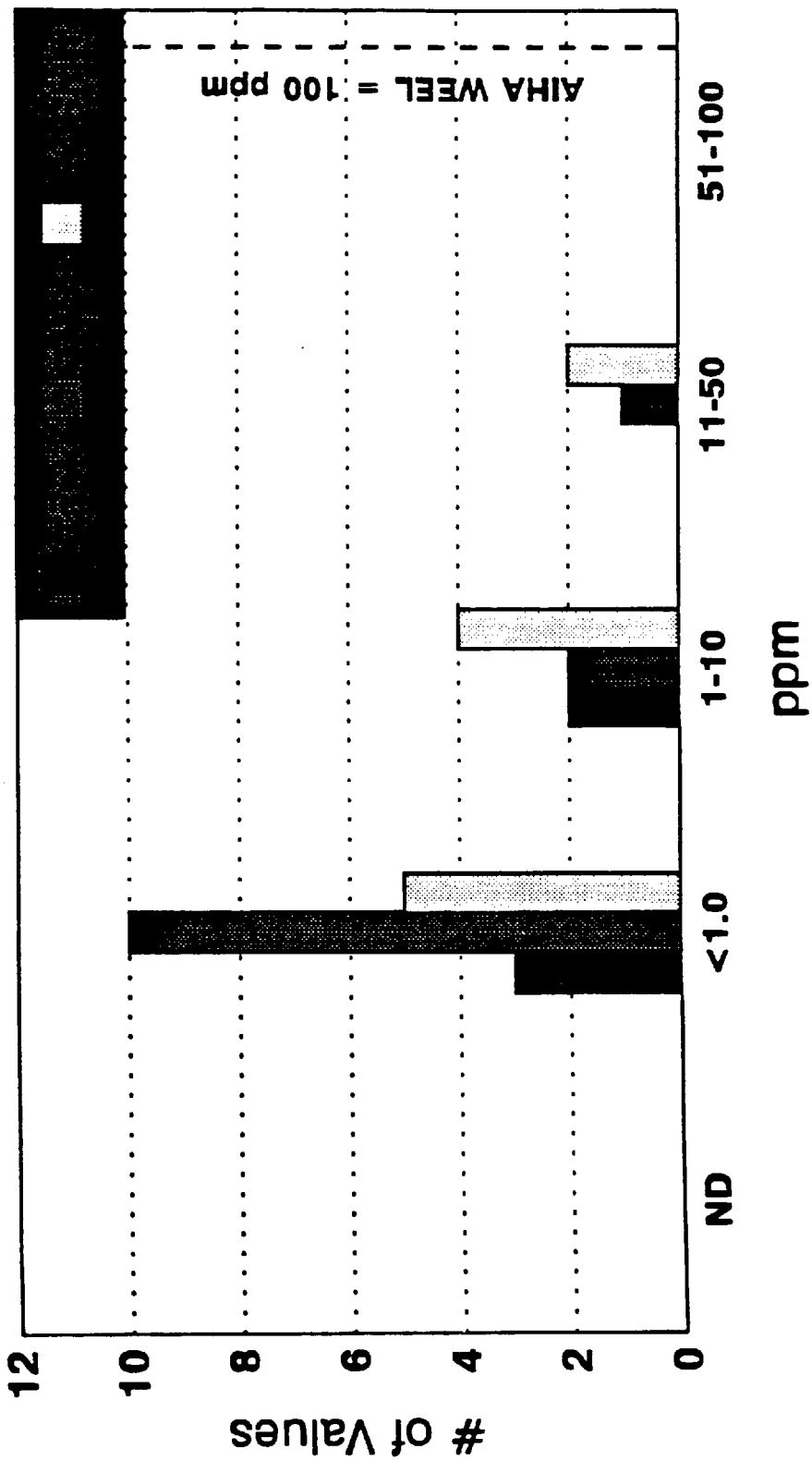
Short-term Exposure Data



Occupational Exposures - MTBE

Service Station - Personal Samples

Activity/Workshift Exposures



Summary

- The data set is typical of industry operations
- The data set is representative of employee exposures
- The data set spans a 10 year period with the majority of the data post CAA oxyfuel initiation (92% since '90)
- 50% of the data represents oxyfuel winter months, with 45% of all data reflective of the '92 - '93 season

Conclusions

- Personal occupational exposures to MTBE are generally well within the AIHA 100 ppm WEEL, ranging as:

26% below Limit of Detection	36% between 1 & 100 ppm
34% between LOD & 1 ppm	4% in excess of 100 ppm

Conclusions

- Short-term exposures to MTBE are generally well within an excursion value of three times the 100 ppm WEEL (300 ppm).

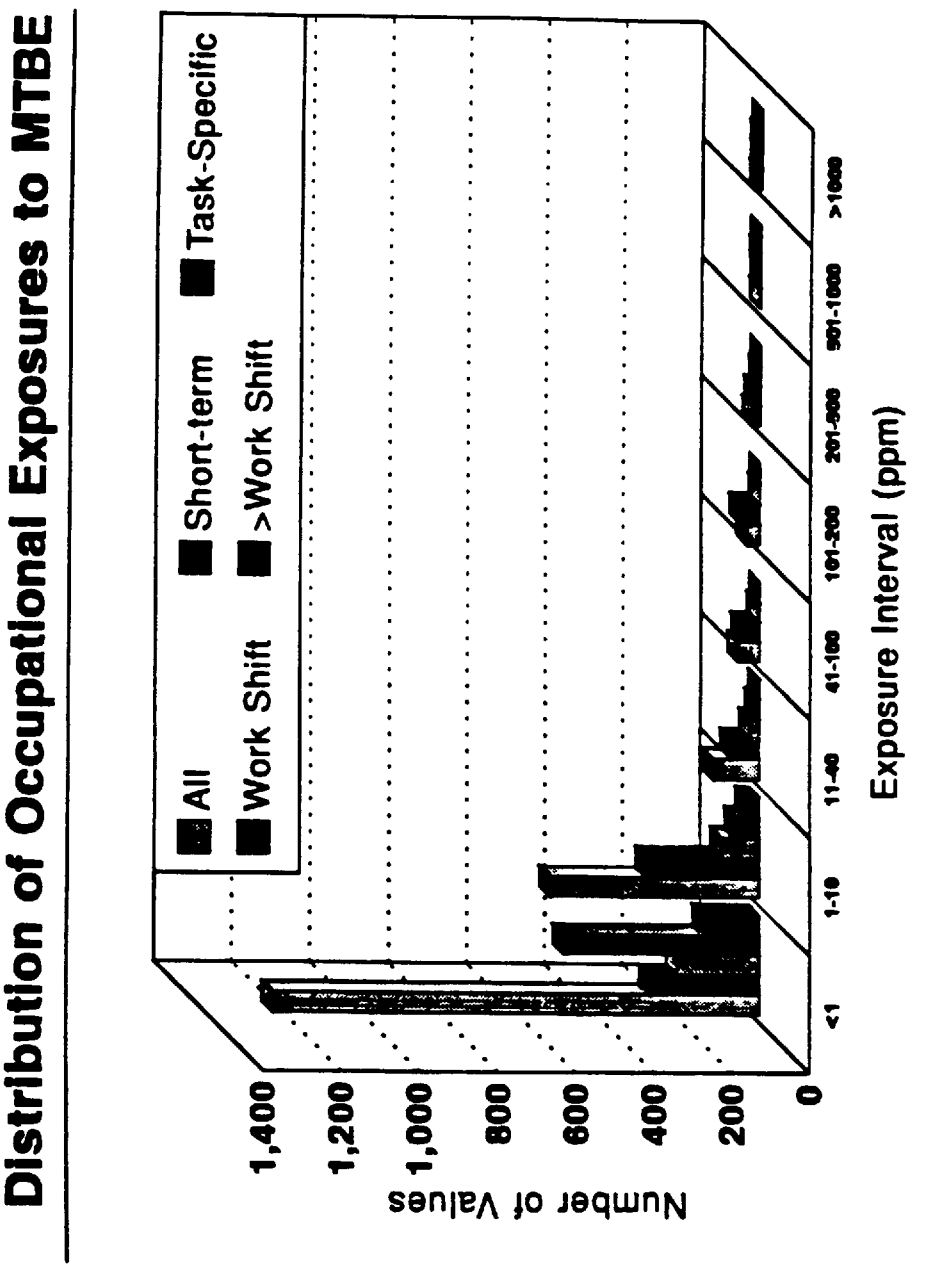
19% below Limit of Detection	59% between 1 & 300 ppm
20% between LOD & 1 ppm	2% in excess of 300 ppm

Conclusions

- Data demonstrate exposures in excess of 100 ppm TWA or 300 ppm Short-Term occur infrequently and are generally limited to specific non-routine or extraordinary tasks. Once determined, respiratory protection or other ventilation techniques are used to control exposures in these situations

Occupational settings ranked in order of exposure potential would be:

	ppm	
	G.M. Short-term	G.M. TWA
1. Transporting Neat MTBE	11.0	0.24
2. Blending Neat MTBE	5.1	0.58
3. Service Station	4.7	0.77
4. Transporting MTBE/Fuel Mix	3.3	0.13
5. Manufacturing-Maintenance	1.0	0.14
6. Distributing	0.85	0.13
7. Manufacturing-Routine	0.84	0.06
8. Blending MTBE/Fuel Mix	0.58	0.10



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