a survey of european gasoline exposures for the period 1999-2001

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ABSTRACT

This report presents data on measured occupational exposures to gasoline vapour in European Union countries in the period 1999-2001. The exposure measurements were taken in order to complement an earlier review of recent exposure data for the period of 1993-1998, published as report 2/00. The surveyed operations were selected on the basis of past high exposures, newly implemented vapour recovery measures, or a general lack of information. In addition to inhalation exposures, analytical data are presented on composition of the gasolines handled during the monitored work activities. Most of the surveyed operations covered gasoline according to product specifications in force after 1 January 2000, when the maximum content of benzene in gasoline was reduced to 1% by volume.

KEYWORDS

Gasoline (CAS 86290-81-5), gasoline vapour (CAS 68514-15-8), occupational exposure, exposure monitoring, benzene

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CONTENTS

			Page
SUMMARY			**V**
1.	**INTRODUCTION AND BACKGROUND**		**1**
2.	**MONITORING STRATEGY**		**2**
	2.1.	SELECTION OF JOB GROUPS	2
	2.2.	METHODOLOGY	2
	2.3.	OCCUPATIONAL EXPOSURE LIMITS	3
	2.4.	COLLECTION OF PRODUCT SAMPLES	4
3.	**RESULTS**		**5**
	3.1.	CONDUCTED SURVEYS	5
	3.2.	PRODUCT COMPOSITION	5
	3.3.	EXPOSURE DATA – BACKGROUND	5
	3.3.1.	Sample details	5
	3.3.2.	Calculation of gasoline vapour exposures	6
	3.3.3.	Data quality assurance	7
	3.3.4.	Statistical analysis	7
	3.4.	EXPOSURE DATA – SUMMARY OF RESULTS	8
	3.4.1.	Job group results – gasoline vapour	8
	3.4.2.	Job group results – selected constituents	10
	3.4.3.	Job group results – short notes	10
	3.4.3.1.	On-site refinery operators (JG 1.1)	10
	3.4.3.2.	Off-site refinery operators (JG 1.2)	10
	3.4.3.3.	Laboratory workers (JG 1.4)	10
	3.4.3.4.	Road tanker drivers (JG 2.1.3)	11
	3.4.3.5.	Terminal gantry man (JG 2.1.6)	11
	3.4.3.6.	Drum filler (JG 2.1.7)	11
	3.4.3.7.	Distribution terminal maintenance workers (JG 2.1.8)	11
	3.4.3.8.	Railcar loading without vapour recovery (JG 2.2.1)	12
	3.4.3.9.	Railcar loading with vapour recovery (JG 2.2.2)	12
	3.4.3.10.	Other rail terminal workers (JG 2.2.7)	12
	3.4.3.11.	Marine deck crew (JG 2.3.2)	12
	3.4.3.12.	Marine jetty staff (JG 2.3.5)	12
	3.4.3.13.	Other ship crew (JG 2.3.6)	12
	3.4.3.14.	Service station attendants – no vapour recovery on pumps (JG 3.1.1)	12
	3.4.3.15.	Service station attendants – with vapour recovery on pumps (JG 3.1.2)	13
	3.4.3.16.	Cashiers and shop workers (JG 3.2)	13
	3.4.3.17.	Miscellaneous service station personnel (JG 3.5)	13
4.	**DISCUSSION**		**14**
	4.1.	DATA AVAILABILITY	14
	4.2.	NEW INFORMATION FOR EXISTING EXPOSURE SITUATIONS	14
	4.3.	NEW EXPOSURE SITUATIONS	15
	4.4.	MEASURED LEVELS IN COMPARISON WITH EXPOSURE LIMITS	16
5.	**REFERENCES**		**17**

APPENDIX 1 – SHORT SURVEY DESCRIPTIONS **18**

APPENDIX 2 – GASOLINE COMPOSITION RESULTS **21**

APPENDIX 3 – MONITORING RESULTS AND SAMPLE DETAILS **23**

APPENDIX 4 – EXTERNAL QUALITY CONTROL SAMPLES **55**

APPENDIX 5 – STATISTICAL ANALYSIS OF RESULTS FOR SELECTED GASOLINE CONSTITUENTS **56**

SUMMARY

Regulatory risk assessment of marketed substances requires information on exposures during production, handling and use. CONCAWE collected exposure information on gasoline for this purpose. An inventory of data available from member companies for 1993-1998 was published in 2000. The present report contains newly measured, complementary data, obtained via a joint monitoring programme conducted in member companies' operations during 1999-2001. The focus of the programme was on job groups in exposure situations where previously collected data were limited, as well as on some new situations where additional vapour recovery facilities, required under EU environmental legislation, had been introduced. In addition, the monitoring programme yielded the first exposure data for the joint European oil industry on gasoline with benzene levels below 1% by volume. In line with data needs for risk assessment, the monitoring programme included work conditions that were assumed to be associated with increased exposure. The programme produced chemically speciated data for both gasoline and the vapour to which workers were exposed.

The monitoring programme resulted in satisfactory numbers of data for the majority of the selected job groups, but some data gaps remain, primarily where the logistics of exposure monitoring are complicated. The results suggested that some existing job groups, as established for occupational hygiene purposes, should be split or further defined due to the disparate findings from several surveys. The vast majority of the results showed exposure levels in compliance with exposure limits for gasoline and a number of its constituents.

1. INTRODUCTION AND BACKGROUND

In preparation of a risk assessment for gasoline, according to the European Existing Substances Regulation 793/93/EEC [1], CONCAWE carried out a review of relevant inhalation exposure data available from member companies. This review, published as report 2/00, identified a series of data gaps [2]. In addition, gasoline composition specifications changed as of 1 January 2000 under European Parliament and Council Directive 98/70/EC [3]. Therefore new compositional data for product and vapour were deemed necessary for the risk assessment. This report presents the results of a monitoring campaign designed to fill data gaps.

2. MONITORING STRATEGY

2.1. SELECTION OF JOB GROUPS

In occupational exposure assessment, it is common practice to group workers who are assumed to have similar levels and types of exposure together into so-called job groups or homogeneous exposure groups [4]. This approach is intended to allow the most efficient use of assessment resources.

On the basis of the previously prepared overview [2], monitoring priorities were set to generate new information for work situations where elevated exposures had previously been reported. It was further planned to complete initial information on those situations where new vapour control technology was likely to have had an effect on occupational exposure. In addition, several job groups had been identified for which there appeared to be a complete lack of measured data. Conditions of geographic and seasonal coverage were selected in such a way that the data could be accepted as representative of EU countries. Exposure measurement results were also compared with occupational exposure limits.

The attempted measurements were both short-term (defined in this report as ‘peak’ with duration of less than one hour) to investigate identified tasks with potentially elevated exposures, and long-term (full-shift) to quantify total exposure from all occupational sources. A minimum number of six measurements per job group was specified in line with international recommendations to allow inferences about average exposure level and variability [4].

2.2. METHODOLOGY

The monitoring campaign was carried out by personnel of CONCAWE member companies. A certified analytical laboratory, specialised in occupational exposure monitoring of volatile organic compounds, was contracted for the analyses. The existing gasoline vapour method was reviewed and, where necessary, adapted to technical advances.

A protocol was established in order to ensure a consistent approach. Inhalation exposures were measured using an updated version of the method, published in CONCAWE report 8/86 [5], for speciated gasoline vapour (150 components). This method allows the accurate detection of prioritised constituents such as those with a health hazard classification or an occupational exposure limit. A detailed description of the sampling and analytical method is published under separate cover [6]. Briefly, the method consists of a sampling procedure in which gasoline vapour is collected in the worker’s breathing zone in two tubes packed with suitable sorbents. In the subsequent analytical procedure the trapped vapour components are desorbed thermally, separated using gas chromatography, and quantified. Airborne concentrations are calculated by dividing the detected quantities by the sampled air volume. This method is comparable to internationally recommended practice for volatile hydrocarbons [7].

The logistics of sampling tubes dispatch and receipt were handled by a single office. In line with established occupational hygiene practice, exposure monitoring was conducted using portable equipment carried by individual workers, with the tubes in the person’s breathing zone. Only in the case of service station shop staff was

stationary monitoring deemed acceptable as representative of personal exposures, similar to the approach adopted in the previous review (report 2/00).

Recorded sampling information and analytical results were submitted to CONCAWE and anonymised. Calculated exposure data were grouped according to a defined job group matrix and tabulated and some descriptive statistics were calculated where there were sufficient results.

2.3. OCCUPATIONAL EXPOSURE LIMITS

Occupational exposure limits (OELs) have been set nationally and internationally for many hazardous substances. They refer to the airborne concentrations of the hazardous substances. The limits used in this report are the most recently published at the time of writing. There is no widely accepted occupational exposure limit for gasoline vapour in Europe, but both the Netherlands and Sweden have established a national 8-hour time-weighted average (TWA) occupational exposure limit for gasoline vapour, of 240 mg/m^3 and 200 mg/m^3 respectively. In addition, the American Conference of Governmental Industrial Hygienists (ACGIH) has adopted an 8-hour TWA limit of 890 mg/m^3 and a short-term limit of 1480 mg/m^3.

Occupational exposure limits have also been published for a number of individual gasoline components by the European Commission's Directorate-General for Employment and Social Affairs, the ACGIH and various EU countries. These components include benzene, toluene, xylenes, butane, n-hexane, as well as methyl-tertiary-butyl ether (MTBE), which may be added to motor gasolines. Year 2000 limit values used in this report are shown in **Table 1** for gasoline and several of its components.

Table 1 Selected occupational exposure limits for gasoline and components in EU and US

Substance	8-Hour TWA Occupational Exposure Limit (mg/m^3)							
	European Union	ACGIH[(2)]	France	Germany	NL	Sweden	UK	Finland
Gasoline	-	890	-	-	240	200	-	-
Benzene	3.25[(1)]	1.6	16	3.2 - 8[(3)]	3.2	1.5	16[(4)]	9
n-Butane	-	1950	1900	2400	-	-	-	1900
n-Hexane	72	175	170	180	90	90	72	180
MTBE	-	150	-	-	180	-	92	180
Toluene	188	190	375	190	150	200	191	190
Xylene	221	440	435	440	210	200	441	440

Note 1: Value as of June 2003; interim value 9.75 mg/m^3 [8]

Note 2: ACGIH states values for vapours in parts per million (ppm); conversion to mg/m^3 may lead to small variations, depending on the assumed pressure and temperature

Note 3: Depending on the nature of the operation

Note 4: Value applicable until June 2000, current value 9.75 mg/m^3

2.4. COLLECTION OF PRODUCT SAMPLES

The survey programme required the collection of gasoline product samples for analytical characterisation. The results were intended to serve several purposes:

- to confirm that the handled petroleum product was actually a gasoline;
- to provide a basis for interpretation of exposure monitoring results that showed unusual component patterns;
- to provide a data set of joint product and exposure phase composition for further use in risk assessment.

3. RESULTS

3.1. CONDUCTED SURVEYS

Nineteen surveys were conducted as part of the exposure monitoring programme. Surveys frequently covered several job groups operating at the same work site or operating out of the same centre. Often surveys were conducted on consecutive days as a result of the need to limit travel to work sites by monitoring personnel. Summary details of the surveys are provided in **Appendix 1**.

3.2. PRODUCT COMPOSITION

For most surveys, one or more bulk gasoline samples were submitted for analysis. Selected analytical data have been summarised in **Appendix 2**, and fully detailed analytical reports are kept on file at CONCAWE. The compositional data confirm the inherent variability of gasoline, associated with different refinery processes and crude oil sources, but have also allowed the definition of a composition envelope for some selected parameters in the form of 10- and 90-percentiles. These may be used for risk assessment of prioritised hazardous constituents (e.g. those with an OEL). One research grade product appeared to fall outside the compositional envelope for most parameters.

Three submitted samples of product handled during a monitored work shift appeared not to be gasoline and in fact were afterwards identified as a light virgin naphtha and jet fuel (twice). The analytical results have not been included in **Appendix 2**.

3.3. EXPOSURE DATA – BACKGROUND

3.3.1. Sample details

Approximately 250 exposure measurements were carried out. These included samples covering an entire work shift and samples which covered specific tasks that took less than a shift. In some instances both types of samples were taken on the same individual worker to study the contribution of specific tasks to overall exposure. On a number of occasions two samples had to be taken to cover a work shift due to high temperature and/or humidity conditions (which restricted the flow rate that could be achieved) in accordance with the protocol.

Details of all samples have been included in a database held at CONCAWE. Selected relevant information for each of the samples is included in **Appendix 3**. In a number of cases there were quality control issues, e.g. shipment in one package of bulk samples and exposure sample tubes, as indicated in **Appendix 3**. In one instance, a repeat survey was conducted because of contamination of field blanks, and the first set of results was discarded. In the other instances the data were retained.

The following information is recorded in a workbook that formed the basis for **Appendix 3**:

- survey code and location,
- Job Group(s) and codes according to the system adopted in report 2/00 [2],
- coded information on individual worker (only when available, this was not part of the initially requested sample documentation – in a limited number of cases there are multiple samples for an individual),
- date of monitoring,
- air sample volume,
- type of sample (full-shift, part-shift, or peak covering a single task of less than 1 hour),
- sample duration,
- laboratory remarks regarding quality status of submitted samples and general pattern of analytes,
- field notes including types and quantities of product handled and any unusual circumstances that could influence exposure levels,
- sum of detected components in micrograms,
- quantities of priority components in the samples,
- calculated exposure levels for gasoline vapour and priority components in mg/m^3,
- number of detected components out of the 150 which define gasoline vapour according to the CONCAWE method,
- the three components detected in greatest quantities.

3.3.2. Calculation of gasoline vapour exposures

Gasoline vapour exposures were calculated as the sum of detected constituents only in each sample. This approach was adopted, because the alternative, in which a default value is assumed for all non-detected constituents, would in many cases result in unrealistic exposure figures due to the large number of these non-detected constituents. However, information is provided on number of components detected out of 150 in this report for each sample, and therefore an approach using a default value for all non-detected components remains possible. The adopted approach may result in some underestimates of exposure at low exposure levels, where only a few components were detected and often in quantities just above the detection limit, but is believed to be more appropriate, especially at more elevated levels. An estimate of the influence of this approach is that 30-40 mg/m^3 could be added to exposure results of samples with a large number (i.e. >120) of non-detected gasoline constituents, assuming a default value of half the detection limit and a sampling volume of 2 litres of air.

As an additional element of information, the three components detected in greatest quantity, usually in the C_4-C_5 range, have also been identified and listed in **Appendix 3.**

3.3.3. Data quality assurance

The quality of the survey results was verified using conventional occupational hygiene approaches:

- By including a minimum of three field blanks within each survey, i.e. sample tubes that were opened, sealed and shipped to and from the monitoring location, but not used for actual sample collection. These tubes were intended to detect sample contamination during storage and transit.

- By including samples with a known quantity ('spikes') of n-hexane, benzene, toluene and ortho-xylene in the analytical programme. A number of these spikes were prepared, but due to an administrative error only four of these were actually analysed. The results are presented in **Appendix 4**. The loaded and detected quantities were in good agreement.

- Several field samples were taken in duplicate; these are listed in **Table A3.15** for the following pairs: {1158/6625 and 1158/8495}, {1160/6619 and 1160/7106} and {1160/6642 and 1160/6687}. There was good agreement in the results for each of the pairs.

- The contract laboratory reported satisfactory performance in a national quality assurance scheme [9].

These results provided confidence in the accuracy of the data results supporting the overall survey findings.

3.3.4. Statistical analysis

Exposure data results by job group for gasoline vapour and the priority constituents have been analysed to determine a number of statistical parameters. For the calculation of these statistics the same rule used in report 2/00 for non-detected components was applied, i.e. a value of 75% of the limit of detection (LOD). These data are presented in **Tables 2 and 3** for gasoline vapour, and **Appendix 5** for the priority constituents.

The following statistics were calculated:

- arithmetic mean, AM (average): this parameter was presented in previous reviews, and is therefore most informative for time trend analysis. However, where there are only few results the AM is sensitive to a single extreme value.

- geometric mean, GM: occupational exposures are often found to be log-normally distributed and this is best described by the GM [4]. This parameter is less sensitive to extreme values than the AM.

- median (50-percentile): this value does not imply a defined data distribution, and is less sensitive to a single extreme value. Increasingly, median values are recommended in risk assessments for 'typical', long-term exposure situations.

- 10- and 90-percentiles: these values give an indication of data variability. In addition, the 90-percentile may be used in risk assessment as a surrogate for the 'reasonable worst case' exposure when various exposure determinants combine unfavourably, resulting in an elevated level.

The full set of statistical parameters was only applied to data sets of 6 or more. For the remainder, only the AM and the minimum and maximum results are presented as conventions dictate that statistical inferences based on very low sample numbers are inappropriate.

3.4. EXPOSURE DATA – SUMMARY OF RESULTS

3.4.1. Job group results – gasoline vapour

Full data sets from each Job Group monitored are tabulated and reported in **Appendix 3**.

Data sets which included results from gasoline still produced according to the product specification prior to 2000, have been kept separate – this applies to **Table sets A3.4a & 4b, A3.14a & 14b, A3.16a & 16b.** The main difference in product specification from the occupational hygiene viewpoint is the allowable benzene content, which was reduced from a maximum of 5% to a maximum of 1% by volume. For the statistical analysis of gasoline vapour results the exposure data from both product specifications have been recombined. However, the benzene results have been evaluated separately.

Summaries of the calculated results have been tabulated in **Table 2** (full-shift samples) and **Table 3** (peak samples) for gasoline vapour for each job group. The same codes have been used for the job groups (JG) as in report 2/00.

Table 2 Full-shift exposure results for gasoline vapour (mg/m^3) – sum of detected constituents

Job group	Number of samples	Average	Geometric mean	Median	10-percentile(1)	90-percentile(2)
Off-site refinery operator (JG 1.2)	6	12	6.3	8.3	1.5	27
Laboratory technician blending test gasoline for research (JG 1.4)	7	420	188	252	56	834
Laboratory technician octane rating for research (JG 1.4)	3	14	-	-	8.9 (min)	16.2 (max)
Road tanker driver (JG 2.1.3)	33	47	15	15	1.4	107
Gantry man (JG 2.1.6)	3	82	-	-	10.9 (min)	201 (max)
Drum filler (JG 2.1.7)	2	9	-	-	-	-
Railcar top loading without VR (JG 2.2.1)	16	613	180	135	17	1568
Railcar top loading with VR (JG 2.2.2)	21	33	20	26	6.8	77
Other railcar loading workers (JG 2.2.7)	5	1.3	-	-	0.2 (min)	5.6 (max)
Jetty staff (JG 2.3.5)	4	3.5	-	-	0.8 (min)	9.8 (max)
Service station attendants – no VR (JG 3.1.1)	26	14	8.8	10.5	2.1	29
Service station attendants – with VR (JG 3.1.2)	7	7.7	7.0	7.1	4.5	12
Service station shop personnel (JG 3.2)	13	1.4	0.8	1.4	0.2	2.8
Miscellaneous service station personnel (JG 3.5)	6	1.4	0.5	0.5	0.2	3.5

(1) For data sets of less than 6 measurements the minimum result is listed
(2) For data sets of less than 6 measurements the maximum result is listed

Table 3 Peak exposure results for gasoline vapour (mg/m^3) – sum of detected constituents

Job group	Number of samples	Average	Geometric mean	Median	10-percentile(1)	90-percentile(2)
On-site refinery operator (JG 1.1)	6	5.3	2.0	0.8	0.8	14.5
Off-site refinery operator (JG 1.2)	7	9.5	1.9	0.8	0.7	26
Laboratory technician testing gasoline for production (JG 1.4)	2	73	-	-	-	-
Laboratory technician octane rating for production (JG 1.4)	4	38	-	-	8.0 (min)	89 (max)
Road tanker driver (JG 2.1.3) – loading at terminal	15	64	18	19	2	213
Road tanker driver (JG 2.1.3) – delivery to service station	7	57	29	35	9	129
Drum filler (JG 2.1.7)	10	272	179	183	71	545
Railcar top loading with VR (JG 2.2.2)	3	47	-	-	37 (min)	66 (max)
Marine deck crew (JG 2.3.2)	6	23	5.1	6.2	0.6	63
Jetty staff (JG 2.3.5)	6	32	8.3	16.6	0.8	79
Miscellaneous ship personnel (JG 2.3.6)	4	145	-	-	9.4 (min)	332 (max)
Miscellaneous service station personnel (JG 3.5)	1	44	-	-	-	-

(1) For data sets of less than 6 measurements the minimum result is listed
(2) For data sets of less than 6 measurements the maximum result is listed

3.4.2. Job group results – selected constituents

Summary tables have been prepared for the following selected gasoline constituents and are included in **Appendix 5**: n-hexane, benzene, toluene, xylene. It is noteworthy that in many samples these constituents were not detected. The concentration figures indicated in the Tables in **Appendix 3** in italic characters are based on a calculation using 75% of the analytical detection limit, divided by the sample volume. These figures may in some cases appear to be rather high in comparison with other monitoring methods, however the maximum safe sampling volume in this campaign was set to ensure adequate sampling of the most volatile constituent, propane.

Data on all 150 gasoline constituents are available in the database for all samples, except where quality issues have arisen during analysis. In many instances, analytical results were 'non-detectable'. The limit of detection was set by the laboratory for each component at 0.5 µg. Corresponding air concentrations, in mg/m^3 were calculated using the sample volume in litres. Results for priority components (n-hexane, benzene, toluene, xylenes and ethylbenzene) are included in **Appendix 3**. For calculation purposes, in line with the approach adopted for report 2/00, concentrations based on non-detectable results were calculated using a value of 75% of the detection limit. These latter results are indicated in italic characters in the tables of **Appendix 3**. Ethylbenzene is included as a priority constituent in the tables in **Appendix 3**, but since in the majority of cases the result was non-detectable, no statistics were calculated.

3.4.3. Job group results – short notes

Short notes on the measurement results for the separate job groups are provided below.

3.4.3.1. On-site refinery operators (JG 1.1)

A limited data set (number of data (n)=6) of peak samples was generated for process sampling of reformate (a gasoline blending component rich in mono-aromatics).

(See **Table A3.1)**

3.4.3.2. Off-site refinery operators (JG 1.2)

Full-shift (n=6) and peak (n=7) samples were collected mainly for work in a tank farm. The highest value was recorded for a work shift during which a non-routine drum filling operation was undertaken.

(See **Table A3.2)**

3.4.3.3. Laboratory workers (JG 1.4)

Exposures during gasoline blending (n=6), quality testing (n=2) and octane number determination (n=7) were monitored in a production facility and in a research laboratory. It was reported that exposure control during test gasoline blending at the research facility depended on the required quantity, with small quantities of less than 10 litres being handled inside a fume cupboard and larger quantities of over 1 m^3 in a closed system. Intermediate quantities of 10-1000 litres were prepared,

typically once a month, in drums, either outdoors or inside the laboratory, with limited ventilation control. The submitted samples were taken during blending of intermediate quantities and thus represent a worst-case situation. The results for the production and research laboratories are presented separately.

Some samples taken during test engine cleaning with an organic solvent are also included in the table, but not used for exposure calculations..

(See **Table A3.3)**

3.4.3.4. Road tanker drivers (JG 2.1.3)

Exposure monitoring focussed on road distribution work with bottom loading and vapour recovery (JG 2.1.3). It appeared that at some service stations where deliveries were made there were no vapour recovery facilities. This was however unlikely to impact on exposure levels due to the established practice of remote venting of vapours displaced from the underground storage tanks. Exposure data were tabulated separately for gasolines of pre-2000 and post-2000 specification in order to assess changes in benzene exposure. Full-shift samples were available for pre-2000 (n=28) and post-2000 (n=5) situations. There was no discernible difference, therefore the data have been combined. There were also peak sample data for loading operations at terminals and deliveries to service stations. These data have also been combined for pre-2000 and post-2000 operations, because there was no detectable benzene in many samples. The available number of samples is as follows: pre-2000 loading n=13, post-2000 loading n=2, pre-2000 deliveries n=4, post-2000 deliveries n=3.

(See **Table A3.4a&b)**

3.4.3.5. Terminal gantry man (JG 2.1.6)

Only three samples were taken for this job group. This does not appear to be a homogeneous job group, inasmuch as these operators are involved in road tanker loading in some terminals and not at all in others where the operation is carried out entirely by the drivers. Consequently, data read-across should only be done with caution.

(See **Table A3.5)**

3.4.3.6. Drum filler (JG 2.1.7)

Several surveys were conducted for drum filling operations. In all cases the drum filling operation was the only gasoline exposure that took place during the shift and monitoring was conducted for the entire duration of the operation. Most of the filling operations took less than one hour and hence are listed as peaks (n=10), but two samples took almost 2 hours, so the results were adjusted to 8 hours for full-shift exposure calculation.

(See **Table A3.6)**

3.4.3.7. Distribution terminal maintenance workers (JG 2.1.8)

Only two full-shift samples were taken on terminal maintenance workers, showing essentially no exposure to gasoline vapour.

(See **Table A3.7)**

3.4.3.8. Railcar loading without vapour recovery (JG 2.2.1)

All but one of the 16 available full-shift exposure data were taken at the same location. Contrary to the protocol, these samples were shipped together with the bulk samples. Other quality control issues were loose or missing caps on the sample tubes. As it was not possible to repeat the survey these results have not been discarded; clearly, they should be viewed with caution.

(See **Table A3.8)**

3.4.3.9. Railcar loading with vapour recovery (JG 2.2.2)

During eight of the measurements (n=21), petroleum products other than gasolines, e.g. light virgin naphtha and jet fuel, were loaded as well. Three peak samples were taken to assess exposure during the loading of one railcar.

(See **Table A3.9)**

3.4.3.10. Other rail terminal workers (JG 2.2.7)

Five full-shift samples were available for the control room operator of a railcar loading facility. All results for the priority constituents were non-detectable.

(See **Table A3.10)**

3.4.3.11. Marine deck crew (JG 2.3.2)

Three ship loading operations were covered with peak samples, however, in the third case the loading was not started due to adverse weather conditions. These were all from the same location.

(See **Table A3.11)**

3.4.3.12. Marine jetty staff (JG 2.3.5)

Four full-shift exposure measurements and six peak samples were taken at three different locations.

(See **Table A3.12)**

3.4.3.13. Other ship crew (JG 2.3.6)

Four peak samples were taken on the first officer of ships during loading activity. Although the type of work (loading and hose disconnection) would fit with job group 2.3.2 and the exposure data should be seen in the same context, the first officer was put provisionally in job group 2.3.6 due to the lack of information on other performed duties.

(See T**able A3.13)**

3.4.3.14. Service station attendants – no vapour recovery on pumps (JG 3.1.1)

A total of 26 full-shift samples were taken, all in Southern-European countries. In a number of cases two samples were needed according to the protocol to cover the work shift in view of high ambient temperatures. The half-shift data are included in

Table A3.14, but have been combined to full-shift data for the statistical calculations. In addition, pre-2000 and post-2000 gasoline operations have been presented separately in **Tables A3.14a and b**, but in view of the many undetectable results for benzene the calculations have been done for the combined results.

(See **Table A3.14a&b)**

3.4.3.15. Service station attendants – with vapour recovery on pumps (JG 3.1.2)

Seven work shifts were sampled, for a total of ten samples. These included three sets of duplicates for quality control purposes.

(See **Table A3.15)**

3.4.3.16. Cashiers and shop workers (JG 3.2)

A combination of stationary samples, taken inside service station shops, and personal samples on cashiers was available. As in the previous report (2/00), stationary samples inside shops are considered to adequately represent exposures of personnel. Exposure measurements were separately tabulated for pre- and post 2000 gasolines (n=7 and n=6, respectively), however since no benzene was detected in any of the samples, the data have been recombined in **Tables 2 and 3**. In general, not more than 5 gasoline constituents were detectable, typically iso-butane, iso-pentane and the C_4 mixture of n-butane, butene-1, and iso-butene.

(See **Table A3.16a&b)**

3.4.3.17. Miscellaneous service station personnel (JG 3.5)

Six full-shift samples were available for a job group of cleaners and for station managers. In one instance, a full-shift sample and a peak sample were taken on a yard supervisor involved in a bulk product delivery. This appeared to be the main exposure event during the work shift.

(See **Table A3.17)**

4. DISCUSSION

4.1. DATA AVAILABILITY

This survey has complemented the information obtained previously from member companies and summarised in report 2/00. The monitoring surveys reported here were undertaken to either replace older exposure information that appeared out of date, or generate more comprehensive information on new situations as seen from an exposure control perspective. In addition, some 'reasonable worst case' situations (e.g. summertime, high temperature), necessary for risk assessment, were included in the campaign.

It should be noted that the data presented in this report were obtained with a method that captures all constituents of gasoline vapour, whereas the majority of data presented in report 2/00 were generated with methods that may not have fully captured the very light constituents, i.e. propane and butanes. Hence, gasoline vapour exposure may have slightly been underestimated in 2/00 (reported as Total Hydrocarbons or THCs). It is noted that these very light constituents are not among the priority constituents for health risk assessment.

The main remaining shortfalls in available data relate to those job groups where the irregular nature makes it difficult to schedule exposure monitoring. In addition, there were some unexpected findings from the present programme, which would benefit from further investigation and more precise definition of job groups (i.e. laboratory workers and first officers of ships).

The largest data set, for road tanker drivers loading with vapour recovery (JG 2.1.3), was further analysed statistically according to recommendations of EN 689 [4]. The estimated geometric standard deviations of the full-shift samples and of the peak measurements during loading were 4.8 and 5.0, respectively, suggesting a rather large variability in the data set. A further analysis of the full-shift samples by survey code indicated that the results differed significantly between surveys. This latter finding suggests that caution should be applied when extrapolating these results to other work locations.

4.2. NEW INFORMATION FOR EXISTING EXPOSURE SITUATIONS

Monitoring for refinery operators (JGs 1.1 and 1.2) was primarily undertaken to cover potential peak exposures in process areas and full-shift exposures for off-site operators working in tank farms. Both jobs were involved in product sampling, the activity often assumed to result in the potentially highest exposure. Average measured peak exposures, however, were low.

The data collected in this survey have suggested that different levels of exposure may be experienced in production laboratories and in research labs (JG 1.4), with higher levels experienced on occasion in research labs. Consequently, it may be more appropriate not to group workers from these two environments in one job group.

A considerable number of additional measurements was taken on road tanker drivers operating bottom loading with vapour recovery (JG 2.1.3). These measurements covered full-shift exposures, as well as exposures during the two tasks where most exposure occurs, i.e. tanker loading at terminals and making

deliveries to service stations. Of the two tasks the loading usually gave slightly higher exposure levels, but the deliveries tended to take considerably more time, thereby contributing more to overall shift exposure.

Drum fillers (JG 2.1.7) exposure data were not available for report 2/00, and hence the only data available were from the 1984-1985 survey [4]. The new survey data confirmed that, in general, drum filling is rarely done for gasoline, and is most likely a work activity in fuel development departments. It usually takes less than a full-shift, with no other gasoline exposure in the remainder of the shift.

Railcar loading without vapour recovery (JG 2.2.1) was assessed in several 'reasonable worst-case' situations, i.e. in summer. Unfortunately, the largest set of exposure measurements was suspect due to quality control issues. The detected exposure levels were substantially higher than those reported in 2/00. Loading with vapour recovery (JG 2.2.2) also resulted in somewhat higher measured exposures than reported before. Peak measurements for loading one rail car corresponded essentially with the full-shift findings, with typically between 10 and 20 rail cars being loaded per shift.

Monitoring of exposures during ship loading (JGs 2.3.2, 2.3.5 and 2.3.6) confirmed that these exposures are irregular, and therefore difficult to assess. The unexpected peak exposures detected for first officers suggest that further detailed investigation may be necessary, as they have now been placed in a poorly defined 'miscellaneous ship personnel' group.

The findings in this survey for service station shop personnel (JG 3.2) are well in line with previous findings. In addition, some data have been generated for station cleaners and managers (JG 3.5).

4.3. NEW EXPOSURE SITUATIONS

Facilities with vapour recovery systems for which no or only limited data had been reported in 2/00 were the main new exposure situations of interest.

A further 21 full-shift measurements can now be added to the 8 results registered previously for rail car loading (JG 2.2.2), along with a few peak measurements for the loading of one rail car.

Attendants at non-self service stations with vapour recovery on the pumps have also been monitored in this survey. Exposures appeared to be approximately half of those experienced by attendants of stations without this facility (this report and 2/00).

The effect of the reduction of benzene in gasoline to levels below 1% by volume could not be studied in detail due to the large number of non-detectable results reported in the present survey.

4.4. MEASURED LEVELS IN COMPARISON WITH EXPOSURE LIMITS

Full-shift exposure statistics for gasoline vapour as well as prioritised constituents measured in this survey were compared with OELs established in European countries. Potential non-compliance of gasoline exposure, e.g. in the form of the 90-percentile level or the arithmetic mean, was detected for research laboratory workers when engaged in intermediate quantity blending operations, and for worst-case rail car loading without vapour recovery, though the latter conclusion is based on suspect data. The same conclusion of potential non-compliance was drawn for the benzene exposures in these two scenarios when comparing the measurement results with the OEL. The results reinforce the need for effective exposure control programmes for these operations.

All other data sets for gasoline vapour and for single constituents appeared to be in compliance with limit values.

5. REFERENCES

1. EU (1993) Council Regulation (EEC) No. 793/93 of 23 March 1993 on the evaluation and control of the risks of existing substances. Official Journal of the European Communities No. L84, 05.04.1993

2. CONCAWE (2000) A review of European gasoline exposure data for the period 1993-1998. Report No. 2/00. Brussels: CONCAWE

3. EU (1998) Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC. Official Journal of the European Communities No. L350, 28.12.1998

4. CEN (1995) Workplace atmospheres – Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy. EN 689:1995. Brussels: Comité Européen de Normalisation

5. CONCAWE (1986) Method for monitoring exposure to gasoline vapour in air. Report No. 8/86. Brussels: CONCAWE

6. CONCAWE (2002) Method for monitoring exposure to gasoline vapour in air - revision 2002. Report No. 8/02. Brussels: CONCAWE

7. CEN (2000) Indoor, ambient and workplace air – Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography – Part 1: Pumped sampling (ISO 16017-1:2000). EN ISO 16017-1:2000. Brussels: Comité Européen de Normalisation

8. EU (1997) Council Directive 97/42/EC of 27 June 1997 amending for the first time Directive 90/394/EEC on the protection of workers from the risks related to exposure to carcinogens at work. Official Journal of the European Communities No. L179, 08.07.1997

9. Shell (2001) Methods used for analysis of pumped and diffusive thermal desorption samples and bulk samples. Overview report for CONCAWE STF-25. Chester: Shell Global Solutions

APPENDIX 1 SHORT SURVEY DESCRIPTIONS

Survey code:	J1133
Region:	Southern Europe
Season:	Summer 1999
Tasks surveyed:	Distribution via rail and road
Comments:	

Survey code:	J1135
Region:	Southern Europe
Season:	Summer 1999
Tasks surveyed:	Service stations (attended), distribution by road (terminal to service station)
Comments:	Bottom loading, with vapour recovery facilities at terminal

Survey code:	J1136
Region:	Southern Europe
Season:	Summer 1999
Tasks surveyed:	Service stations (attended), distribution by road (terminal to service station)
Comments:	Bottom loading, with vapour recovery facilities at terminal

Survey code:	J1143
Region:	Southern Europe
Season:	Summer 1999
Tasks surveyed:	Service stations (attended), distribution by road (terminal to service station)
Comments:	Bottom loading, with vapour recovery facilities at terminal

Survey code:	J1144
Region:	Southern Europe
Season:	Summer 1999
Tasks surveyed:	Service stations (attended), distribution by road (terminal to service station)
Comments:	Bottom loading, with vapour recovery facilities at terminal

Survey code:	J1149
Region:	Western Europe
Season:	Late autumn 1999
Tasks surveyed:	Ship loading at refinery
Comments:	3 operations surveyed, but last was aborted before loading started due to adverse weather – suggesting frequency of exposure is less than daily. Gasoline already according to year 2000 specifications.

Survey code:	J1150
Region:	Southern Europe
Season:	Winter 1999-2000
Tasks surveyed:	Service stations (attended)
Comments:	

Survey code:	J1157
Region:	Western Europe
Season:	Winter 1999-2000
Tasks surveyed:	Service stations (self-service)
Comments:	Gasoline already according to year 2000 specifications.

Survey code:	J1158
Region:	Southern Europe
Season:	Winter 1999-2000
Tasks surveyed:	Service stations (attended)
Comments:	

Survey code:	J1160
Region:	Southern Europe
Season:	Spring 2000
Tasks surveyed:	Service stations (attended)
Comments:	

Survey code:	J1165
Region:	Southern Europe
Season:	Spring 2000
Tasks surveyed:	Distribution via road from terminal to service station
Comments:	Peak samples during loading at terminal and delivery at station I parallel with full-shift sample

Survey code:	J1171
Region:	Northern Europe
Season:	Spring 2000
Tasks surveyed:	Railcar loading, fuel blending and testing in research facility
Comments:	Fuel test survey repeated due to sample quality problems (see J3561)

Survey code:	J1178
Region:	Western Europe
Season:	Summer 2000
Tasks surveyed:	Refinery operations (process and tank farm), fuel testing in quality control laboratory of production facility
Comments:	

Survey code:	J1179
Region:	Central Europe
Season:	Summer 2000
Tasks surveyed:	Railcar loading
Comments:	Some non-gasoline petroleum products also loaded during monitored shifts

Survey code:	J2237
Region:	Central Europe
Season:	Summer 2000
Tasks surveyed:	Railcar loading
Comments:	

Survey code:	J2582
Region:	Western Europe
Season:	Summer/Autumn 2000
Tasks surveyed:	Barrel filling; railcar loading
Comments:	Barrel filling operations monitored for their entire duration – no other exposure to gasoline during work shifts

Survey code:	J2911
Region:	Western Europe
Season:	Autumn 2000
Tasks surveyed:	Barrel filling; jetty operations
Comments:	Barrel filling operations monitored for their entire duration – no other exposure to gasoline during work shifts

Survey code:	J3559
Region:	Southern Europe
Season:	Spring 2001
Tasks surveyed:	Ship loading at refinery
Comments:	

Survey code:	J3561
Region:	Northern Europe
Season:	Spring 2001
Tasks surveyed:	Fuel blending and testing in research facility
Comments:	

APPENDIX 2 GASOLINE COMPOSITION RESULTS

Date of survey	Survey code	Product name or type	Results in volume percentage (% v/v)									
			TOTAL C_3	TOTAL C_4	TOTAL C_5	TOTAL C_6	TOTAL C_7	TOTAL C_8	TOTAL C_9	TOTAL C_{10}	TOTAL C_{11}	TOTAL C_{12}+
nov/99	J1149	ULG95	0.13	12.8	19.7	19.1	17.2	21.1	7.0	2.4	0.44	0.15
nov/99	J1149	ULG97	0.08	12.3	22.4	15.4	16.1	23.3	7.7	2.3	0.39	0.12
feb/00	J1157	LRP	0.12	11.3	22.7	13.7	18.3	24.7	6.4	2.3	0.47	0.12
feb/00	J1157	ULG	0.11	11.5	19.3	20.0	20.6	17.8	7.9	2.2	0.46	0.12
feb/00	J1157	ULG-super	0.11	10.5	22.7	12.6	18.3	25.6	7.2	2.4	0.49	0.12
jul/00	J1179	Regular	0.0	0.45	30.3	30.7	17.8	12.9	6.5	1.1	0.32	0.0
apr/01	J3471	96	0.01	1.5	24.9	21.3	19.0	17.9	9.4	1.8	0.57	0.02
jul/00	J1179	Premium	0.0	1.3	25.3	18.7	20.2	19.5	11.5	2.6	0.83	0.02
feb/00	J3559	95	0.04	6.5	21.6	17.3	19.4	26.1	7.6	1.2	0.39	0.0
feb/00	J1160	97	0.61	5.2	22.3	24.3	18.9	16.8	9.7	1.9	0.33	0.0
feb/00	J1160	95	0.24	8.2	20.9	20.7	18.4	17.5	9.6	2.1	0.37	0.0
aug/00	J2237	U95	0.01	6.1	12.2	11.5	26.9	26.4	12.0	3.9	0.92	0.16
aug/00	J2237	U98	0.01	5.2	21.6	11.7	21.8	27.5	8.7	1.1	0.31	0.01
feb/00	J1158	Leaded	0.37	5.0	20.6	22.9	19.9	17.6	10.6	2.6	0.45	0.0
feb/00	J1158	ULG	0.68	6.4	21.0	22.0	20.0	17.7	10.2	1.6	0.31	0.0
may/00	J1165	ULG	0.04	3.0	28.5	22.5	19.7	14.6	6.4	1.1	0.19	0.0
jul/99	J1133	Super	0.0	0.62	8.0	17.1	20.3	27.3	16.6	6.6	3.0	0.54
jul/99	J1133	Unleaded	0.01	1.6	15.5	18.3	18.4	22.0	13.6	5.3	2.3	0.55
nov/00	J2911	99 RON	0.40	7.1	18.1	8.2	23.0	30.3	9.9	2.4	0.7	0.02
aug/00	J2911	97	0.12	5.5	20.1	17.4	21.1	22.1	9.7	2.7	1.0	0.24
nov/00	J2911	95	0.26	12.5	19.3	19.9	16.3	20.9	7.7	2.3	0.71	0.14
sep/00	J2582	98	0.39	7.8	21.0	6.2	18.6	26.5	11.2	4.6	2.3	1.1
sep/00	J2582	Research special	0.02	0.15	0.19	60.0	36.6	1.7	0.5	0.3	0.3	0
sep/00	J2582	87	0.39	4.1	12.7	29.2	14.0	20.5	15.4	2.9	0.4	0.41
sep/00	J2582	93	0.27	4.7	22.8	21.4	19.0	16.9	10.4	3.1	0.9	0.6
sep/00	J2582	82	0.10	2.9	9.9	11.6	35.4	7.0	8.4	10.9	4.1	1.2
10-perc.			0.005	0.97	11.1	11.6	16.8	13.8	6.5	1.1	0.31	0.0
Median			0.11	5.4	21.0	18.9	19.2	20.7	9.5	2.4	0.47	0.12
90-perc.			0.40	11.9	25.1	26.8	25.0	26.9	12.8	5.0	2.3	0.58

APPENDIX 2 (CONT'D) GASOLINE COMPOSITION RESULTS

Date of survey	Survey code	Product name or type	Results in volume percentage (% v/v)											
			n-Hexane	Benzene	Toluene	Xylene	Ethyl-benzene	n-Paraffins	Iso-paraffines	Olefins	Naph-Thenes	Aromatics	Oxygenates	
nov/99	J1149	ULG95	3.5	0.55	9.2	9.1	1.9	13.8	42.9	10.5	3.2	29.4	0	
nov/99	J1149	ULG97	2.5	0.52	10.1	10.8	2.3	13.2	39.6	11.6	2.4	33.0	0	
feb/00	J1157	LRP	1.9	0.71	12.6	10.3	2.0	12.5	39.0	12.6	2.4	33.1	0	
feb/00	J1157	ULG	3.8	0.85	12.1	11.5	2.7	13.6	31.3	14.2	3.7	36.6	0	
feb/00	J1157	ULG-super	1.7	0.69	13.0	10.6	2.2	11.7	38.6	12.0	2.2	35.1	0	
jul/00	J1179	Regular	3.6	0.97	5.3	9.0	1.5	10.6	42.1	14.6	5.1	27.5	0	
apr/01	J3471	96	2.6	0.84	10.4	12.1	2.6	8.2	35.1	12.0	3.9	37.0	3.6	MTBE
jul/00	J1179	Premium	2.4	1.0	7.8	14.3	2.4	8.3	35.5	9.6	3.4	43.1	0	
feb/00	J3559	95	2.6	0.86	9.1	10.9	2.0	13.5	40.7	10.3	3.8	31.6	0	
feb/00	J1160	97	1.3	0.60	10.6	11.7	1.8	11.5	43.1	2.8	6.7	35.8	0	
feb/00	J1160	95	1.2	0.89	10.7	11.4	2.3	11.2	38.7	7.2	4.6	36.0	2.1	MTBE
aug/00	J2237	U95	0.65	2.2	12.4	16.2	4.4	7.7	16.2	15.9	3.6	54.1	0.01	ethanol
aug/00	J2237	U98	0.93	0.84	10.4	16.5	3.1	10.8	31.4	7.7	2.6	45.3	2.1	MTBE
feb/00	J1158	Leaded	1.2	0.60	11.6	11.9	2.0	10.6	41.0	3.2	6.3	38.6	0	
feb/00	J1158	ULG	1.3	0.75	12.4	12.2	2.2	12.6	40.3	2.6	4.8	39.7	0	
may/00	J1165	ULG	1.4	0.94	11.3	9.8	1.7	10.2	38.3	12.0	4.2	31.1	4.0	MTBE
jul/99	J1133	Super	0.72	0.76	8.4	12.0	2.1	4.3	38.0	4.8	6.2	43.6	0	
jul/99	J1133	Unleaded	0.81	0.76	7.0	10.1	1.7	4.8	41.6	7.0	5.3	36.8	2.4	MTBE
nov/00	J2911	99 RON	0.54	0.22	14.4	12.0	2.4	8.9	47.9	3.8	1.1	37.5	0	
aug/00	J2911	97	2.8	0.95	10.3	13.7	2.7	13.2	30.7	7.6	3.9	43.9	0	
nov/00	J2911	95	1.05	0.77	4.8	7.4	1.4	12.6	43.7	10.7	5.8	26.4	0	
sep/00	J2582	98	0.4	0.50	12.0	9.6	1.9	9.4	42.9	6.3	2.4	36.3	0.35	
sep/00	J2582	Research special	1.1	0.02	0.97	0.51	0.05	1.5	0.92	94.9	0.3	1.9	0	
sep/00	J2582	87	1.3	0.45	4.0	6.9	1.1	14.5	33.9	22.6	6.6	18.8	0	
sep/00	J2582	93	3.3	0.78	14.1	11.6	2.2	15.4	34.5	3.7	5.4	39.2	0	
sep/00	J2582	82	0.87	0.38	1.9	2.4	0.5	20.0	26.3	8.8	10.4	21.4	8.6	ethanol
10-perc.			0.69	0.42	4.4	7.2	1.3	6.3	28.5	3.5	2.3	23.9	0	
Median			1.3	0.76	10.4	11.1	2.1	11.4	38.7	10.0	3.9	36.2	0	
90-perc.			3.38	0.96	12.8	14.0	2.7	14.2	43.0	15.3	6.5	43.8	3.0	

APPENDIX 3 MONITORING RESULTS AND SAMPLE DETAILS

Notes

The following general points apply to the tables in this appendix:

- unless otherwise indicated, handled gasolines were produced to comply with specifications of 98/70/EC ('post-2000', i.e. containing less than 1% v/v of benzene)

- where concentrations were calculated from non-detectable analytical results these are indicated in italic characters. The basis for calculation is 75% of the detection limit.

Abbreviations

Bz	=	benzene
C4 mix	=	n-Butane, Butene-1 and Isobutene
RPE	=	Respiratory Protective Equipment
UL. ULG	=	Unleaded gasoline (number indicates octane rating)
VR - VRU	=	Vapour recovery (unit)
GOA	=	Gas oil, type A
GOB	=	Gas oil, type B
G95	=	Gasoline, octane rating 95
SUL	=	Super unleaded gasoline
HC	=	Hydrocarbons
LVN	=	Light virgin naphtha
L96	=	Leaded gasoline, octane rating 96

Table A3.1 On-site operators (1.1)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components out of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1178/8438	29/6/00	peak	10		sampling reformate (high grade heavy naphtha, Bz 4%)	12.3	*0.8*	1.3	4.2	*0.8*	1.7	6	Toluene	Isopentane	Ethyl Benzene
J1178/8475	29/6/00	peak	10		sampling reformate (high grade heavy naphtha, Bz 4%)	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	0			
J1178/8467	30/6/00	peak	11		sampling reformate (high grade heavy naphtha, Bz 4%)	16.6	*0.7*	1.5	2.8	*0.7*	*0.7*	6	Isopentane	C_4 mix	n-Pentane
J1178/8494	30/6/00	peak	10		sampling reformate (high grade heavy naphtha, Bz 4%)	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	0			
J1178/8466	4/7/00	peak	10		sampling reformate (high grade heavy naphtha, Bz 4%)	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	0			
J1178/8468	4/7/00	peak	10		sampling reformate (high grade heavy naphtha, Bz 4%)	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	0			

Table A3.2 Off-site operators (1.2)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1178/7770	19/6/00	full-shift	483		gauger, offsites - pump drain/full-shiftair/fill, manual tank de-water; gloves, no RPE – light cat. Naphtha. Gasoline unleaded (Bz 0.3-0.8%)	7.0	0.6	*0.1*	0.4	*0.1*	*0.1*	12	n-Pentane	Isopentane	Propane
J1178/8457	21/6/00	full-shift	454	not typical gasoline	gauger, offsites - manual tank de-watering and tank-dipping during filling - isomerate/alkylate (Bz 0%), heavy cat. Naphtha (Bz 1.9%)	1.8	*0.1*	*0.1*	*0.1*	0.6	0.1	6	Propane	m- and p-Xylene	Isopentane
J1178/8434	22/6/00	full-shift	451		gauger, offsites – manual tank de-watering and sampling; gloves, no RPE - UL (Bz .0.4%), reformate (Bz 4%), cat. naphtha (Bz 0.9%), light cat. naphtha (Bz 0.4%), mogas blend component (Bz 0.7%)	9.6	0.3	0.3	0.6	0.2	*0.1*	18	Propane	Isopentane	C_4 mix
J1178/8416	23/6/00	full-shift	488		gauger, offsites - water draw-off (RPE for reformate), tank roof checks (RPE), drum (45 gal.) filling with UL95 from sample point (not routine) - UL (Bz 0.5%), reformate (Bz 4%), cat. naphtha (Bz 0.9%). Crude, mogas blend component (Bz 0.7%)	43.7	4.1	0.6	1.2	0.6	0.2	33	Isopentane	2- Methyl Pentane	n- Hexane + 2- Methyl Pentene-1
J1178/8421	26/6/00	full-shift	454	not typical gasoline	gauger, offsites - area monitoring, sampling above tanks, water draw-offs, gloves, no RPE - naphthas (Bz 0.6-0.8%)	10.4	*0.1*	*0.1*	1.4	0.5	0.1	12	Propane	Toluene	m- and p-Xylene
J1178/8435	27/6/00	full-shift	498	not typical gasoline. caps loose	gauger, offsites - water draw-off during tank filling with reformate (Bz 4%), gloves, no RPE	1.1	*0.1*	0.3	0.5	*0.1*	*0.1*	4	Toluene	Benzene	m- and p-Xylene
J1178/6634	21/6/00	peak	12		manual tank dipping, 97unleaded Bz 0.3%	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	0			
J1178/8433	21/6/00	peak	11		manual tank dipping, 97unleaded Bz 0.3%	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	0			
J1178/8455	21/6/00	peak	10	front caps loose	manual tank dipping, 97unleaded Bz 0.3%	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	0			
J1178/8426	22/6/00	peak	11	all caps loose	manual tank dipping, 95unleaded Bz 0.3%	4.4	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	2	Isopentane	C_4 mix	
J1178/8447	22/6/00	peak	10	back caps loose	manual tank dipping, 95unleaded Bz 0.5%	1.3	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	1	Isopentane		
J1178/8462	22/6/00	peak	12	front caps loose	manual tank dipping, 97unleaded Bz 0.3%	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	0			
J1178/8486	22/6/00	peak	11		manual tank dipping, 95unleaded Bz 0.4%	57.7	*0.7*	*0.7*	*1.5*	*0.7*	*0.7*	11	Isopentane	C_4 mix	Isobutane

Table A3.3 Laboratory technicians (1.4) – R&D and production labs

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl benzene		Comp1	Comp2	Comp3
J1171/8456	8/5/00	full-shift	454		oxygenated gasoline blending (Bz<0.6%), partly in blending room with fume hood, no RPE	91.2	1.6	1.6	4.0	1.7	0.4	29	Isopentane	C_4 mix	n-Pentane
J1171/8474	8/5/00	full-shift	418	not typical gasoline pattern	engine repair (disassembly), solvent use, no gasoline	2.7	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	5	n-Heptane	Methyl Cyclo-hexane	2- Methyl Hexane + Cyclo-hexane
J1171/6689	9/5/00	full-shift	372	not typical gasoline pattern	octane number determination of oxygenated gasolines (Bz<0.6%), no RPE, fume hood	15.4	0.5	0.5	2.3	1.0	0.3	22	Methyl Tertiary Butyl Ether	Toluene	Isopentane
J1171/7130	9/5/00	full-shift	384	not typical gasoline pattern	engine repair, solvent use, no gasoline	4.0	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	7	n-Heptane	2- Methyl Hexane + Cyclo-hexane	Methyl-Cyclo-hexane
J1171/8461	9/5/00	full-shift	383	back tube overload C_4	oxygenated gasoline blending (Bz<0.6%), partly in blending room with fume hood, no RPE	252.4	3.7	9.2	8.8	5.3	1.3	53	Isopentane	C_4 mix	Methyl Tertiary Butyl Ether
J1171/7120	11/5/00	full-shift	445	contaminated field blank (iso-octane, BTX)	oxygenated gasoline blending (Bz <0.6%), only in blending room with fume hood, no RPE	3.9	*0.1*	*0.1*	0.2	*0.1*	*0.1*	8	Isopentane	C_4 mix	Cis-Hexene-3 + trans-Hexene-2
J1171/8459	11/5/00	full-shift	423		engine repair (disassembly)	1.8	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	3	C_4 mix	Propane	n-Heptane
J1171/6617	15/5/00	full-shift	420	tube bent	engine repair (disassembly)	1.4	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	2	C_4 mix	Propane	
J1171/7115	6/6/00	full-shift	420	not typical gasoline. large hexane or MTBE peak on back tube (not identified). Tubes probably reversed (basis iso-pentane result)	oxygenated gasoline blending inside blending room, no ventilation used	188.1	*0.2*	*0.2*	1.5	*0.2*	*0.2*	30	2.2.4-Trimethyl Pentane	Isopentane	n- Hexane or MTBE

Table A3.3 Laboratory technicians (1.4) – R&D and production labs (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl benzene		Comp1	Comp2	Comp3
J3561/6690	21/2/01	full-shift	420		octane number determination, small fume hood on test machine, no gloves/RPE - 6 L iso-octane, 1 L toluene, 1 L n-heptane, 1 L round test sample	8.9	*0.2*	*0.2*	2.2	*0.2*	*0.2*	5	2.2.4-Trimethyl Pentane	Toluene	n-Heptane
J3561/8408	3/4/01	full-shift	466		blending 3800 L gasoline in blending room under movable hoods (2.5hr) and gasoline handling in open air (2hr) - remaining time paper work - no gloves/RPE	670.5	9.0	4.8	20.5	9.0	2.2	66	Isopentane	C_4 mix	Methyl Tertiary Butyl Ether
J3561/6697	4/4/01	full-shift	487	detector overload C_4	blending 4100 L gasoline in blending room under movable hoods (3hr) and gasoline handling in open air (2hr) - remaining time paper work - no gloves/RPE	707.3	9.1	7.7	20.0	18.2	3.7	75	Isopentane	C_4 mix	Isobutane
J3561/7106	5/4/01	full-shift	215		blending 1500 L gasoline in blending room under movable hoods (2.5hr) and gasoline handling in open air (1.5hr) - no gloves/RPE	1025.0	7.3	2.0	12.0	3.8	0.9	44	Isopentane	C_4 mix	Isobutane
J3561/7796	22/2/01	full-shift	290		octane number determination; small fume hood on test machine, no gloves/RPE - 0.3 L iso-octane, 0.1 L n-heptane, 1.5 L round test sample, 4 L diesel	16.2	*0.3*	0.3	4.3	0.4	*0.3*	7	2.2.4-Trimethyl Pentane	Toluene	Isopentane
J1178/8422	16/6/00	peak	13		octane rating testing in ventilated test engine house - UL97 (Bz 0.32%)	8.7	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	3	Isobutane	C_4 mix	Isopentane
J1178/8427	16/6/00	peak	15	front caps loose	testing gasoline sample – distillation, density, gums, pH, Bz content - no gloves or RPE - UL95 (Bz 0.25%)	46.3	*0.6*	*0.6*	6.1	4.0	*0.9*	14	Isopentane	Toluene	C_4 mix
J1178/8481	23/6/00	peak	15		testing gasoline sample – distillation, density, gums, pH, Bz content - no gloves or RPE - UL95	100.0	4.9	1.0	3.5	1.1	*0.5*	18	Isopentane	n-Pentane	2- Methyl Pentane
J1178/8440	28/6/00	peak	15	not typical gasoline	octane rating testing in ventilated test engine house - isomerate (Bz 0%)	8.0	*0.5*	*0.5*	1.0	*0.5*	*0.5*	6	Isopentane	2- Methyl Pentane	2.2.4-Trimethyl Pentane
J1178/8453	5/7/00	peak	15		octane rating testing in ventilated test engine house - light cat naphtha (Bz 0.4%), reformate (Bz 4%)	89.0	1.6	1.0	4.5	*0.5*	*0.5*	22	Isopentane	2.2.4-Trimethyl Pentane	C_4 mix

Table A3.3 Laboratory technicians (1.4) – R&D and production labs (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl benzene		Comp1	Comp2	Comp3
J1178/8476	5/7/00	peak	15	not typical gasoline	octane rating testing in ventilated test engine house - blend component light cat naphtha (Bz 0.4%)	46.1	*0.5*	0.9	5.4	*0.5*	*0.5*	11	2.2.4-Trimethyl Pentane	Isopentane	Toluene

Table A3.4a Road tanker drivers (2.1.3) – post-2000 specification gasoline

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1133/6656	13/7/99	full-shift	286	none	1st part shift	102.8	0.8	0.5	1.5	0.7	0.2	37	Isopentane	C_4 mix	Isobutane
J1133/6639	13/7/99	full-shift	185	none	2nd part shift of J1133/6656	123.1	1.0	0.7	2.1	1.3	0.2	37	Isopentane	C_4 mix	Isobutane
J1133/6673	13/7/99	full-shift	200	none	1st part shift	290.7	2.1	1.6	3.9	1.6	0.3	47	Isopentane	C_4 mix	Isobutane
J1133/6611	13/7/99	full-shift	285	detector overload backtube C_4 and iso-pentane	2nd part shift of J1133/6673	554.0	6.6	4.6	11.4	4.5	0.9	67	Isopentane	2- Methyl 2- Butene + 2.2- Dimethyl Butane	2- Methyl Pentane
J1133/6663	14/7/99	full-shift	220	none	1st part shift	230.1	1.7	1.3	4.3	2.5	0.5	48	Isopentane	C_4 mix	Isobutane
J1165/6603	5/4/00	full-shift	375		Tanker driver full trip (loading, driving, delivery), return to terminal	1.0	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	2	Isopentane	n-Pentane	
J1165/8442	6/4/00	full-shift	246		Tanker driver full trip (loading, driving, delivery), return to terminal	1.0	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	3	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2- Dimethyl Butane
J1160/8413	2/3/00	peak	43		Off-loading at station with VR	34.9	0.3	0.2	1.2	1.3	0.2	22	Isopentane	C_4 mix	Isobutane
J1165/6675	5/4/00	peak	51		Delivery at station – Corresponding sample: J1165/6603	35.2	0.5	0.2	2.0	1.1	0.2	27	Isopentane	n-Pentane	C_4 mix
J1165/6677	5/4/00	peak	18		Loading tanker at terminal - Corresponding sample: J1165/6603	19.1	*0.4*	*0.4*	1.0	*0.4*	*0.4*	10	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2- Dimethyl Butane
J1165/6613	6/4/00	peak	16		Loading tanker at terminal- Corresponding sample: J1165/8442	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	0			
J1165/6686	6/4/00	peak	47		Delivery at station - Corresponding sample: J1165/8442	5.9	*0.1*	*0.1*	0.5	0.3	*0.1*	8	Isopentane	n-Pentane	Toluene

Table A3.4b Road tanker drivers (2.1.3) – pre-2000 specification gasoline

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1144/6616	26/7/99	full-shift	343		mixed loads 95, 97, 98, GOA	67.6	1.4	0.8	1.2	0.5	*0.2*	28	Isopentane	n-Pentane	Methyl Tertiary Butyl Ether
J1144/7113	26/7/99	full-shift	383		mixed loads 95, 97, 98, GOA	3.8	*0.2*	*0.2*	*0.2*	0.2	*0.2*	4	Isopentane	C_4 mix	n-Pentane
J1144/7128	26/7/99	full-shift	555		mixed loads 95, 98 – Corresponding peak sample(s): 7125 & 7132	15.2	0.4	0.3	0.9	0.4	0.2	17	Isopentane	n-Pentane	Methyl Tertiary Butyl Ether
J1143/6646	27/7/99	full-shift	242		driver full-shift 95, 97, 98, GOA	17.4	*0.3*	*0.3*	1.2	*0.3*	*0.3*	12	Isopentane	C_4 mix	n-Pentane
J1143/7101	27/7/99	full-shift	301		grades 95, 97, GOA	8.3	*0.4*	*0.4*	0.9	*0.4*	*0.4*	5	Isopentane	C_4 mix	Toluene
J1143/7134	27/7/99	full-shift	321		1 load GOB + 1 load gasoline	5.8	*0.2*	*0.2*	0.6	*0.2*	*0.2*	6	Isopentane	C_4 mix	n-Pentane
J1143/7140	27/7/99	full-shift	289		grades 95, 97, GOA	6.7	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	5	Isopentane	C_4 mix	n-Pentane
J1143/6676	28/7/99	full-shift	302		mixed loads 95, 97, 98, GOA	0.7	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	1	Isopentane		
J1143/7127	28/7/99	full-shift	421		mixed loads 95, 97, 98, GOA	11.6	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	4	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1143/7130	28/7/99	full-shift	373		mixed loads 95, 97, 98, GOA	2.6	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	3	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	Toluene
J1143/7136	28/7/99	full-shift	477		mixed loads 95, 97, 98, GOA	4.6	*0.2*	*0.2*	0.5	*0.2*	*0.2*	6	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane

Table A3.4b Road tanker drivers (2.1.3) – pre-2000 specification gasoline (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1144/7102	29/7/99	full-shift	458		all grades (95, 97, 98, GOA)	10.1	*0.2*	*0.2*	0.4	*0.2*	*0.2*	8	Isopentane	2-Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1144/7107	29/7/99	full-shift	475		all grades (95, 97, 98, GOA)	46.2	*0.6*	1.2	5.5	1.5	*0.6*	12	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	Toluene
J1144/7108	29/7/99	full-shift	471		all grades (95, 97, 98, GOA)	1.3	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	2	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	
J1144/7123	29/7/99	full-shift	364		all grades (95, 97, 98, GOA) - Corresponding sample(s): J1144/6612	46.1	0.4	0.8	1.4	*0.3*	*0.3*	18	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1136/6626	9/8/99	full-shift	357		driver all grades (UL95, UL98, L96, diesel)	28.5	0.7	*0.3*	1.0	0.5	*0.3*	19	Isopentane	C_4 mix	n-Pentane
J1136/6654	9/8/99	full-shift	332	back caps loose	driver all grades (UL95, UL98, L96, diesel)	59.7	1.1	0.6	1.9	0.8	*0.3*	24	Isopentane	C_4 mix	n-Pentane
J1136/6675	9/8/99	full-shift	243		driver all grades (UL95, UL98, L96, diesel)	58.5	1.1	0.8	2.0	0.8	*0.4*	24	Isopentane	n-Pentane	C_4 mix
J1136/6677	9/8/99	full-shift	246	front caps loose	driver all grades (UL95, UL98, L96, diesel) - sample pump problem?	16.0	*0.3*	*0.3*	0.7	*0.3*	*0.3*	7	Isopentane	C_4 mix	n-Pentane
J1135/6619	10/8/99	full-shift	246	caps loose	all gasoline grades, VR installed but not operational	13.5	0.4	*0.3*	0.9	0.5	*0.3*	8	Isopentane	n-Pentane	C_4 mix
J1135/6649	10/8/99	full-shift	226		all gasoline grades, VR installed but not operational	164.4	2.2	1.2	3.3	1.0	*0.5*	26	Isopentane	C_4 mix	n-Pentane
J1135/6666	10/8/99	full-shift	256		all gasoline grades, VR installed but not operational	1.4	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	1	Isopentane		

Table A3.4b Road tanker drivers (2.1.3) – pre-2000 specification gasoline (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1136/6643	12/8/99	full-shift	226		2nd delivery of the day (all gasolines), VRU at stations	9.2	*0.4*	*0.4*	0.8	*0.4*	*0.4*	7	Isopentane	2-Methyl Pentane	n-Pentane
J1136/6686	12/8/99	full-shift	246		2nd delivery of the day (all gasolines), no VRU at one stations	27.7	0.7	0.6	1.1	0.7	*0.4*	12	Isopentane	C_4 mix	n-Pentane
J1136/6692	12/8/99	full-shift	250		2nd delivery of the day (all gasolines), no VRU at one stations	7.6	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	4	Isopentane	C_4 mix	n-Pentane
J1135/6650	13/8/99	full-shift	342		UL95, UL98, L96, diesel - VRU at terminal but not all stations	47.8	0.8	0.6	1.2	0.5	*0.2*	26	Isopentane	C_4 mix	n-Pentane
J1135/6662	13/8/99	full-shift	362		UL95, UL98, L96, diesel - VRU at terminal but not all stations	82.8	1.6	1.3	2.0	0.8	*0.2*	25	Isopentane	C_4 mix	n-Pentane
J1135/7110	13/8/99	full-shift	242		UL95, UL98, L96, diesel - VRU at terminal but not all stations	29.5	0.7	0.4	0.7	*0.3*	*0.3*	17	Isopentane	C_4 mix	n-Pentane
J1144/7125	26/7/99	peak	18		bottom loading W, Y, G95 - Corresponding sample(s): 7128	37.5	*3.6*	*3.6*	*3.6*	*3.6*	*3.6*	2	Isopentane	C_4 mix	
J1144/7132	26/7/99	peak	55		delivering at service station	51.9	1.3	0.8	2.3	1.2	*0.3*	25	Isopentane	C_4 mix	Methyl Tertiary Butyl Ether
J1144/7138	26/7/99	peak	10		bottom loading W, Y, G95	271.4	*5.4*	*5.4*	*5.4*	*5.4*	*5.4*	11	Isopentane	C_4 mix	Isobutane
J1144/7148	26/7/99	peak	35		bottom loading W, Y, G95	40.2	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	11	Isopentane	C_4 mix	n-Pentane
J1143/6605	27/7/99	peak	60		driver making delivery at station	243.9	4.0	2.8	5.0	2.9	0.6	44	Isopentane	C_4 mix	n-Pentane
J1143/6670	27/7/99	peak	27		loading 95, 97, 98, GOA	8.9	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	2	Isopentane	C_4 mix	
J1143/7116	27/7/99	peak	14		loading 95, 97, 98, GOA	10.4	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*	2	Isopentane	C_4 mix	
J1143/7109	28/7/99	peak	32		loading 95, 98, GOA	124.3	1.0	1.6	3.7	1.9	*1.0*	16	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane

Table A3.4b Road tanker drivers (2.1.3) – pre-2000 specification gasoline (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1143/7120	28/7/99	peak	51		driver making delivery at station	10.5	*0.2*	0.4	0.8	0.4	*0.2*	10	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1143/7149	28/7/99	peak	30		loading 95, 97, GOA	15.3	*1.4*	*1.4*	*1.4*	*1.4*	*1.4*	3	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1144/6612	29/7/99	peak	31		loading 95, 97, 98, GOA - Corresponding sample(s): J1144/7123	149.1	*1.0*	2.4	4.3	1.4	*1.0*	18	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	C_4 mix
J1144/7133	29/7/99	peak	38		loading 95, 97, 98, GOA	255.7	2.0	4.0	5.1	*1.1*	*1.1*	19	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	C_4 mix
J1144/7141	29/7/99	peak	97		driver making delivery at station	16.2	*0.4*	*0.4*	0.6	*0.4*	*0.4*	8	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1136/6687	9/8/99	peak	60		Loading UL95: 13m3, L96: 3m3	*1.4*	*1.4*	*1.4*	*1.4*	*1.4*	*1.4*	0			
J1135/6698	10/8/99	peak	28		loading one gasoline grade. VR installed but not operational	2.7	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	1	Isopentane		
J1136/6693	12/8/99	peak	20		loading UL: 5m3, L96: 3.6m3, diesel: 2.3m3	3.8	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	1	Isopentane		
J1135/7118	13/8/99	peak	30		Load UL95: 8.7m3, UL98: 3m3, diesel: 20m3, VRU at terminal	19.9	*0.7*	*0.7*	1.4	*0.7*	*0.7*	9	Isopentane	C_4 mix	Methyl Tertiary Butyl Ether

Table A3.5 Gantry man at road tanker terminal (2.1.6)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1135/6665	10/8/99	full-shift	251	front caps loose	gantry operator, bottom loading, VR installed but not operational	33.3	0.6	*0.5*	1.3	*0.5*	*0.5*	10	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1136/6635	12/8/99	full-shift	265		gantry man - on duty during all loading of UL, SUL, L, ADO	200.8	3.5	0.5	3.6	2.1	0.5	38	Isopentane	C_4 mix	n-Pentane
J1135/7104	13/8/99	full-shift	368		Gantryman - UL95, UL98, L96, diesel - VRU at terminal	10.9	0.5	*0.3*	0.5	*0.3*	*0.3*	10	Isopentane	C_4 mix	n-Pentane

Table A3.6 Drum fillers (2.1.7)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J2582/6613	31/8/00	peak	34		filling 40 barrels (2 operators)	798.3	3.9	1.9	36.5	13.1	2.8	38	Isopentane	C_4 mix	Isobutane
J2582/8459	31/8/00	peak	34		filling 40 barrels (2 operators)	212.1	0.8	*0.6*	7.0	2.0	*0.6*	17	Isopentane	C_4 mix	Isobutane
J2582/6683	6/9/00	peak	37		filling 30 barrels (2 operators) - 22% ethanol, very low Bz UL	144.2	2.1	*0.5*	1.3	*0.5*	*0.5*	27	Isopentane	C_4 mix	n-Heptane
J2582/8490	6/9/00	peak	37		filling 30 barrels (2 operators) - 22% ethanol, very low Bz UL	453.2	6.7	1.5	5.9	3.3	*0.6*	39	Isopentane	C_4 mix	n-Heptane
J2582/6658	10/10/00	peak	32	front & back caps loose	moving barrels to/from filling operator	76.8	2.1	*0.7*	1.6	0.9	*0.7*	18	Isopentane	C_4 mix	Isobutane
J2582/8488	10/10/00	peak	36	front & back caps loose	filling 32 barrels	104.0	2.6	*0.5*	1.7	1.1	*0.5*	22	Isopentane	C_4 mix	Isobutane
J2911/6659	25/10/00	peak	31		filling 30 barrels	153.3	4.1	*0.8*	9.1	2.2	*0.8*	13	Isopentane	C_4 mix	n-Pentane
J2911/8411	25/10/00	peak	33		moving barrels to/from filling operator	19.8	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	5	Isopentane	C_4 mix	n-Pentane
J2911/6616	7/11/00	part shift	109	not typical gasoline pattern - 411 ug unidentified HC	barrel filling with nozzle	34.6	11.2	*0.2*	1.6	*0.2*	*0.2*	10	Unidenti-fied C_5-C_6		
J2911/7800	7/11/00	part shift	109	not typical gasoline pattern - 442 ug unidentified HC	barrel filling with nozzle	36.7	11.1	*0.2*	1.6	*0.2*	*0.2*	12	Unidenti-fied C_5-C_6		
J2911/7112	30/11/00	peak	45		moving barrels to/from filling operator	238.5	1.1	*0.5*	9.9	4.2	0.9	24	Isopentane	C_4 mix	n-Pentane
J2911/7115	30/11/00	peak	45		filling barrels	516.5	2.4	0.7	20.1	9.2	2.0	35	Isopentane	C_4 mix	n-Pentane

Table A3.7 Road terminal mechanics (2.1.8)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1133/6653	13/7/99	full-shift	285	none		0.4	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	1	Isopentane		
J1133/6699	14/7/99	full-shift	393	none		0.9	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	3	Isopentane	C_4 mix	Isobutane

Table A3.8 Rail car loading without vapour recovery (2.2.1)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J2237/6673	5/7/00	full-shift	210	front caps loose, shipped with bulk sample in approved container	10 cars loaded with UL98, 2 samples	94.8	1.0	0.7	4.9	1.8	0.6	30	Isopentane	C_4 mix	n-Pentane
J2237/8406	6/7/00	full-shift	300	front & back caps loose, shipped with bulk sample in approved container - detector overload C_4	12 cars loaded with UL98, 2 samples	1894.9	14.1	12.2	57.9	21.9	5.6	65	Isopentane	n-Pentane	Methyl Tertiary Butyl Ether
J2237/8441	6/7/00	full-shift	210	front caps missing/back caps missing, shipped with bulk sample in approved container	10 cars loaded with UL98, 2 samples	594.5	6.1	3.2	13.8	3.8	1.4	44	Isopentane	C_4 mix	n-Pentane
J2237/7143	7/7/00	full-shift	180	front caps loose/back caps missing, shipped with bulk sample in approved container	10 cars loaded with UL95, 2 samples	175.6	2.0	0.9	4.4	0.9	*0.4*	27	Isopentane	C_4 mix	n-Pentane
J2237/7774	7/7/00	full-shift	165	front & back caps loose, shipped with bulk sample in approved container	10 cars loaded with UL95, 2 samples	1125.5	14.4	8.4	34.4	14.9	4.6	60	Isopentane	C_4 mix	n-Pentane
J2237/7775	12/7/00	full-shift	345	front & back caps loose, shipped with bulk sample in approved container	19 cars loaded with UL98, 2 samples	12.6	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	7	Isobutane	Isopentane	n-Pentane
J2237/7752	17/7/00	full-shift	240	front & back caps loose, shipped with bulk sample in approved container	18 cars loaded with UL95, 2 samples	1219.0	17.0	7.9	43.0	13.6	5.8	57	Isopentane	C_4 mix	n-Pentane

Table A3.8 Rail car loading without vapour recovery (2.2.1) (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J2237/7781	20/7/00	full-shift	360	front & back caps loose, shipped with bulk sample in approved container - detector overload C_4	20 cars loaded with UL95, 2 samples	1314.7	18.8	10.6	46.5	21.5	5.9	72	Isopentane	C_4 mix	n-Pentane
J2237/7144	26/7/00	full-shift	420	front & back caps loose, shipped with bulk sample in approved container	18 cars loaded with UL98, 2 samples	51.6	0.7	0.4	2.4	0.7	0.4	25	Isopentane	C_4 mix	n-Pentane
J2237/6646	28/7/00	full-shift	450	front/back caps loose, shipped with bulk sample in approved container	20 cars loaded with UL95, 2 samples	75.8	1.0	0.5	2.4	0.6	0.3	28	Isopentane	C_4 mix	n-Pentane
J2237/7140	1/8/00	full-shift	180	front/back caps loose, shipped with bulk sample in approved container	10 cars loaded with UL98, 2 samples	1729.0	16.0	10.0	38.0	8.8	2.9	54	Isopentane	C_4 mix	n-Pentane
J2237/8448	2/8/00	full-shift	180	front caps missing/back caps loose, shipped with bulk sample in approved container	10 cars loaded with UL95, 2 samples	20.9	*0.3*	*0.3*	1.2	*0.3*	*0.3*	7	Isopentane	n-Pentane	C_4 mix
J2237/8451	10/8/00	full-shift	230	front caps loose/back caps missing, shipped with bulk sample in approved container	20 cars loaded with UL95, 2 samples	9.6	*0.3*	*0.3*	1.0	0.7	*0.3*	7	Isopentane	n-Pentane	C_4 mix
J2237/6674	16/8/00	full-shift	220	front caps missing/back caps missing, shipped with bulk sample in approved container	20 cars loaded with UL98, 2 samples	38.2	*0.3*	*0.3*	1.4	*0.3*	*0.3*	12	Isopentane	n-Pentane	C_4 mix

Table A3.8 Rail car loading without vapour recovery (2.2.1) (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J2237/7772	17/8/00	full-shift	210	front caps missing/back caps missing, shipped with bulk sample in approved container - detector overload C_4	20 cars loaded with UL95, 2 samples	1405.8	18.3	8.3	34.2	12.2	3.5	57	Isopentane	n-Pentane	C_4 mix
J2582/8497	31/8/00	full-shift	309		gantryman - railcar loading with aviation fuel(5), diesel(3) and UL gasoline: 5x100 t. - 1 sampled	37.6	0.8	0.2	1.5	0.6	0.2	21	Isopentane	C_4 mix	n-Pentane

Table A3.9 Railcar loading with vapour recovery (2.2.2)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1171/7800	11/5/00	part shift	211		half-time in control room, half-time loading area, RPE when closing tanks; 14 railcars 65m3 each (4 oxygenated. 10 not), VR on	12.5	*0.3*	*0.3*	0.4	*0.3*	*0.3*	7	C_4 mix	Isopentane	Isobutane
J1171/7135	16/5/00	part shift	135		half-time in control room, half-time loading area, RPE when closing tanks; 10 railcars 60-75m3 each (oxygenated), VR on	17.5	*0.5*	*0.5*	0.9	*0.5*	*0.5*	8	C_4 mix	Isopentane	Methyl Tertiary Butyl Ether
J1171/7112	22/5/00	part shift	290		half-time in control room, half-time loading area, RPE when closing tanks; 20 railcars 65m3 each (10 oxygenated. 10 not), VR on	2.4	*0.2*	*0.2*	0.2	*0.2*	*0.2*	2			
J1171/6683	29/5/00	part shift	363		half-time in control room, half-time loading area, RPE when closing tanks; 15 railcars 65m3 each (5 oxygenated. 10 not), VR off	6.8	*0.2*	*0.2*	0.2	*0.2*	*0.2*	6	Isopentane	C_4 mix	n-Pentane
J1171/7787	30/5/00	part shift	223		half-time in control room, half-time loading area, RPE when closing tanks; 16 railcars 65m3 each (all oxygenated), VR off	0.3	*0.3*	*0.3*	0.3	*0.3*	*0.3*	0			
J1133/6604	13/7/99	full-shift	280		carried out other duties than railcar loading	96.7	0.8	0.6	2.3	1.6	0.3	43	Isopentane	C_4 mix	Isobutane
J1133/6683	13/7/99	full-shift	260			77.0	0.8	0.7	3.4	2.2	0.4	51	Isopentane	C_4 mix	Isobutane
J1133/6622	16/7/99	full-shift	210			8.7	*0.1*	*0.1*	0.4	0.2	*0.1*	13	Isopentane	C_4 mix	2- Methyl Pentane
J1179/6620	11/7/00	full-shift	196	Aromatics not identified	operator 1 (railcar lid opening/closing etc.) - Rail cars: 7 premium, 9 LVN	51.9	NA	NA	NA	NA	NA	NA	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1179/6672	11/7/00	full-shift	183		operator 2 (mainly console operation) - Rail cars: 6 premium, 9 LVN	42.4	3.9	0.7	1.8	0.7	0.2	20	Isopentane	n-Pentane	n Hexane + 2- Methyl Pentene-1
J1179/6687	11/7/00	full-shift	240	tubes wrong way around?	operator 1 (railcar lid opening/closing etc.) - Rail cars: 11 premium, 5 LVN, 4 Jet	19.0	0.6	*0.2*	0.5	*0.2*	*0.2*	17	C_3-C_5 alkane range	C_6 alkane range	C_7 alkane range + MTBE

Table A3.9 Railcar loading with vapour recovery (2.2.2) (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1179/7132	11/7/00	full-shift	215		operator 2 (mainly console operation) - Rail cars: 11 premium, 5 LVN, 4 Jet	14.3	0.5	*0.2*	0.6	0.3	*0.2*	15	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1179/7797	11/7/00	full-shift	227		operator 2 (mainly console operation) - Rail cars: 7 premium, 9 LVN	40.9	2.6	0.5	1.8	0.6	*0.2*	19	Isopentane	n-Pentane	2 Methyl Pentane
J1179/8491	11/7/00	full-shift	183	Some toluene in back tube	operator 1 (railcar lid opening/closing etc.) - Rail cars: 6 premium, 9 LVN	76.7	11.9	1.6	2.0	0.5	*0.2*	24	n- Hexane + 2- Methyl Pentene-1	2- Methyl Hexane + Cyclo-hexane	Isopentane
J1179/7125	12/7/00	full-shift	64		operator 1 (railcar lid opening/closing etc.) - Rail cars: 6 regular	17.7	*0.6*	*0.6*	1.0	*0.6*	*0.6*	5	Isopentane	n-Pentane	C_4 mix
J1179/7128	12/7/00	full-shift	72		operator 2 (mainly console operation) - Rail cars: 6 regular	37.3	1.5	*0.6*	1.7	*0.6*	*0.6*	10	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1179/8412	12/7/00	full-shift	232		operator 1 (railcar lid opening/closing etc.) - Rail cars: 3 premium, 12 regular	51.8	1.5	0.4	2.9	1.7	0.4	28	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1179/8445	12/7/00	full-shift	227		operator 2 (mainly console operation) - Rail cars: 3 premium, 12 regular	26.1	0.8	*0.2*	1.0	0.5	*0.2*	15	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1179/6619	13/7/00	full-shift	311		operator 1 (railcar lid opening/closing etc.) - Rail cars: 5 premium, 10 LVN, 15 diesel	35.1	5.7	0.7	0.5	0.2	*0.1*	22	n- Hexane + 2- Methyl Pentene-1	2- Methyl Hexane + Cyclo-hexane	n-Pentane

Table A3.9 Railcar loading with vapour recovery (2.2.2) (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1179/7133	13/7/00	full-shift	355		operator 2 (mainly console operation) - Rail cars: 5 premium, 10 LVN, 15 diesel	15.4	1.5	0.2	0.5	0.3	*0.1*	17	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1179/7148	13/7/00	full-shift	220		operator 1 (railcar lid opening/closing etc.) - Rail cars: 17 premium	49.5	1.1	0.4	2.4	1.4	0.2	25	Isopentane	n-Pentane	MTBE
J1179/6612	13/7/00	peak	15		operator 1 (railcar lid opening/closing etc.) - Rail cars: 1 premium	36.5	0.9	*0.5*	1.5	*0.5*	*0.5*	11	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1179/6700	13/7/00	peak	15		operator 1 (railcar lid opening/closing etc.) - Rail cars: 1 premium	39.2	0.8	*0.5*	1.5	*0.5*	*0.5*	11	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane
J1179/7790	13/7/00	peak	15		operator 1 (railcar lid opening/closing etc.) - Rail cars: 1 premium	66.2	1.2	*0.5*	2.6	1.4	*0.5*	14	Isopentane	n-Pentane	MTBE

Table A3.10 Railcar loading – control room operator (2.2.7)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1171/7751	11/5/00	adjust	211		in control room, remainder of day other fuels loaded	0.3	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	1	C_4 mix		
J1171/6616	16/5/00	adjust	130		in control room, remainder of day other fuels loaded	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	0			
J1171/6659	22/5/00	adjust	291		in control room (except 5 min, in loading area), remainder of day other fuels loaded	0.2	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	1	C_4 mix		
J1171/6697	29/5/00	adjust	360		in control room (except 10 min, in loading area), remainder of day other fuels loaded, VR off	5.6	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	7	C_4 mix	Isopentane	n-Pentane
J1171/8410	30/5/00	adjust	405		in control room (except 5 min, in loading area), remainder of day other fuels loaded, VR off	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	0			

Table A3.11 Marine deck crew (2.3.2)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1149/6681	20/11/99	peak	142		marine deck crew MV2 – disconnect	51.6	1.4	0.2	1.7	0.7	0.2	40	C_4 mix	Isobutane	n-Pentane
J1149/7794	20/11/99	peak	157		marine deck crew MV2 – loading	11.3	0.2	*0.1*	0.4	0.2	*0.1*	16	C_4 mix	Isopentane	Isobutane
J1149/6653	22/11/99	peak	121		marine deck crew MV1- loading	73.5	0.9	*0.2*	1.1	0.7	*0.2*	22	C_4 mix	Isopentane	Isobutane
J1149/7784	22/11/99	peak	36		marine deck crew MV1 – disconnect	0.6	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	2	Isobutane	Isopentane	
J1149/6610	23/11/99	peak	29		marine deck crew MV3 - connecting product-free loading line, no loading	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	0			
J1149/7782	23/11/99	peak	29		marine deck crew MV3 - connecting product-free loading line, no loading	1.1	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	1	Isopentane		

Table A3.12 Marine jetty crew (2.3.5)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J2911/7787	22/11/00	full-shift	555			0.8	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	3	C_4 mix	Isopentane	Isobutane
J2911/7751	23/11/00	full-shift	405			9.8	*0.1*	*0.1*	0.3	*0.1*	*0.1*	14	C_4 mix	Isopentane	Isobutane
J3559/7774	20/3/01	full-shift	256		connect/disconnect loading arms, take samples and supervise loading operations - no VR, tanks blanketed with nitrogen	0.6	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	1	Isopentane		
J3559/6684	21/3/01	full-shift	275		connect/disconnect loading arms, take samples and supervise loading operations - no VR, tanks blanketed with nitrogen	2.9	*0.1*	*0.1*	0.3	*0.1*	*0.1*	5	Isopentane	C_4 mix	n-Pentane
J1149/7764	20/11/99	peak	155		jetty crew – loading MV2	6.1	0.2	*0.1*	0.4	0.2	*0.1*	12	C_4 mix	Isopentane	Isobutane
J1149/7771	20/11/99	peak	136		jetty crew – disconnect MV2	27.1	0.5	0.1	0.6	0.3	0.1	29	C_4 mix	Isopentane	Isobutane
J1149/6611	22/11/99	peak	121		jetty crew – loading MV1	27.1	0.4	*0.1*	0.7	0.4	*0.1*	20	C_4 mix	Isopentane	Isobutane
J1149/7119	22/11/99	peak	36		jetty crew – disconnect MV1	130.8	1.7	*0.2*	2.0	1.0	0.3	26	C_4 mix	Isopentane	Isobutane
J1149/7757	23/11/99	peak	29		jetty crew - MV3 connecting product-free loading line, no loading	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	0			
J3559/8435	22/3/01	peak	20		disconnection of loading arm	0.9	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	1	Isopentane		

Table A3.13 Ship personnel – other (2.3.6)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1149/6673	20/11/99	peak	130		1st officer – marine deck crew MV2 - disconnect	9.4	0.1	*0.1*	0.2	*0.1*	*0.1*	15	C_4 mix	Isobutane	Isopentane
J1149/6699	20/11/99	peak	157		1st officer – marine deck crew MV2 - loading	133.2	2.3	0.6	2.8	2.1	0.4	38	C_4 mix	Isobutane	Isopentane
J1149/6656	22/11/99	peak	121		1st officer – marine deck crew MV1 - loading	105.1	1.1	*0.1*	1.5	1.1	0.3	29	C_4 mix	Isopentane	Isobutane
J1149/6663	22/11/99	peak	36		1st officer – marine deck crew MV1- disconnect	332.3	5.3	0.8	6.4	3.0	0.7	43	C_4 mix	Isopentane	Isobutane

Table A3.14a Service station attendant – no vapour recovery (3.1.1) – post-2000 specification gasoline

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1150/8414	16/12/99	full-shift	240	none	Morning	6.3	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	7	Isopentane	C_4 mix	Isobutane
J1150/8420	16/12/99	full-shift	240	none	Morning	4.6	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	6	Isopentane	C_4 mix	Isobutane
J1150/8444	16/12/99	full-shift	240	none	Afternoon	0.6	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	2	Isopentane	Isobutane	
J1150/8488	16/12/99	full-shift	240	none	Afternoon	2.7	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	4	Isopentane	C_4 mix	Isobutane
J1150/8418	17/12/99	full-shift	240	none	Morning	4.6	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	5	3-Methyl Pentane	3- Methyl Heptane	Isopentane
J1150/8490	17/12/99	full-shift	240	none	Morning	2.5	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	4	Isopentane	C_4 mix	Isobutane

Table A3.14b Service station attendant – no vapour recovery (3.1.1) – pre-2000 specification gasoline

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1144/6659	26/7/99	full-shift	323		refuelling vehicles - typical daily through-put: L95: 4m3, L97: 3m3, UL98: 4m3, diesel (gas oil A): 6m3	16.4	0.4	*0.2*	0.4	*0.2*	*0.2*	14	Isopentane	C_4 mix	n-Pentane
J1144/7150	26/7/99	full-shift	320		refuelling vehicles - typical daily through-put: L95: 4m3, L97: 3m3, UL98: 4m3, diesel (gas oil A): 6m3	23.7	0.5	*0.3*	0.5	*0.3*	*0.3*	16	Isopentane	C_4 mix	n-Pentane
J1143/6640	27/7/99	full-shift	446		day through-put: UL95: 3.5m3, UL98: 2m3, Leaded97: 1.5m3, diesel: 3m3	50.5	0.9	0.6	0.9	0.3	*0.2*	26	Isopentane	C_4 mix	n-Pentane
J1143/7147	27/7/99	full-shift	457		day through-put: UL95: 3.5m3; UL98: 2m3, Leaded97: 1.5m3, diesel: 3m3	29.4	0.6	*0.3*	0.5	*0.3*	*0.3*	17	Isopentane	C_4 mix	n-Pentane
J1143/7114	28/7/99	full-shift	368	front caps loose	day through-put: UL95: 1.3m3, UL98: 0.05m3, Leaded97: 1.1m3, diesel: 5m3	9.4	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	5	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1143/7117	28/7/99	full-shift	378		day through-put: UL95: 1.3m3, UL98: 0.05m3, Leaded97: 1.1m3, diesel: 5m3	10.5	*0.2*	*0.2*	0.4	*0.2*	*0.2*	7	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1144/7111	29/7/99	full-shift	465		attendant/cashier; shift through-put: UL95: 1.4m3, UL98: 0.5m3, L97: 2.4m3, GOA: 6.1m3	20.0	*0.3*	0.4	0.8	*0.3*	*0.3*	11	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1144/7115	29/7/99	full-shift	?		attendant/cashier; shift through-put: UL95: 1.4m3, UL98: 0.5m3, L97: 2.4m3, GOA: 6.1m3	20.7	*0.2*	0.4	0.6	*0.2*	*0.2*	15	Isopentane	n-Pentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane

Table A3.14b Service station attendant – no vapour recovery (3.1.1) – pre-2000 specification gasoline (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1144/7143	29/7/99	full-shift	457		attendant/cashier; shift through-put: UL95: 1.4m3, UL98: 0.5m3, L97: 2.4m3, GOA: 6.1m3	27.4	0.2	0.6	0.9	0.3	*0.2*	19	Isopentane	2- Methyl Butene-2 + 2.2-Dimethyl Butane	n-Pentane
J1135/6602	9/8/99	full-shift	237		station through-put: 5 m3 UL95: 2.5 m3, L96: 0.5m3 UL98 – Corresponding sample(s): 6697	11.5	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	6	Isopentane	C_4 mix	n-Pentane
J1135/6632	9/8/99	full-shift	239		station through-put: 5 m3 UL95: 2.5 m3, L96: 0.5m3 UL98 – Corresponding sample(s): 6680	1.3	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	1	Isopentane		
J1135/6680	9/8/99	full-shift	240	caps loose	station through-put: 5 m3 UL95: 2.5 m3, L96: 0.5m3 UL98 – Corresponding sample(s): 6632	2.2	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	3	Isopentane	C_4 mix	n-Pentane
J1135/6697	9/8/99	full-shift	240		station through-put: 5 m3 UL95: 2.5 m3, L96:. 0.5m3 UL98 – Corresponding sample(s): 6602	12.1	*0.3*	*0.2*	0.3	*0.2*	*0.2*	10	Isopentane	C_4 mix	n-Pentane
J1135/6623	12/8/99	full-shift	180		afternoon. day through-put: UL95: 2.5m3, UL98: 0.5m3, L96: 1.5m3 - Corresponding sample(s): 6630	10.8	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	6	Isopentane	C_4 mix	n-Pentane
J1135/6630	12/8/99	full-shift	250		morning. day through-put: UL95: 2.5m3, UL98: 0.5m3, L96: 1.5m3 - Corresponding sample(s): 7262	6.4	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	4	Isopentane	C_4 mix	n-Pentane
J1135/6641	12/8/99	full-shift	242		morning. day through-put: UL95: 2.5m3, UL98: 0.5m3, L96: 1.5m3 - Corresponding sample(s): 7146	26.1	0.6	*0.3*	0.6	*0.3*	*0.3*	14	Isopentane	C_4 mix	n-Pentane
J1135/7126	12/8/99	full-shift	252		afternoon. day through-put: UL95: 2.5m3, UL98: 0.5m3, L96: 1.5m3	3.7	0.1	*0.1*	0.1	*0.1*	*0.1*	11	Isopentane	C_4 mix	n-Pentane
J1135/7146	12/8/99	full-shift	236		afternoon, day through-put: UL95: 2.5m3, UL98: 0.5m3, L96: 1.5m3 - Corresponding sample(s): 6641	20.8	0.5	*0.4*	*0.4*	*0.4*	*0.4*	12	Isopentane	C_4 mix	n-Pentane
J1136/6601	10/8/99	half shift	230		afternoon, day through-put: UL95: 2.2m3, UL98: 0.7m3, L96: 1m3 - Corresponding sample(s): 6638	7.2	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	5	Isopentane	C_4 mix	n-Pentane

Table A3.14b Service station attendant – no vapour recovery (3.1.1) – pre-2000 specification gasoline (cont'd)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1136/6606	10/8/99	half shift	245		morning, day through-put: UL95: 2.2m3, UL98: 0.7m3, L96: 1m3 - Corresponding sample(s): 6608	35.7	0.8	0.5	0.9	*0.4*	*0.4*	17	Isopentane	C_4 mix	n-Pentane
J1136/6608	10/8/99	half shift	230		afternoon, day through-put: UL95: 2.2m3, UL98: 0.75m3, L96: 1m3 - Corresponding sample(s): 6606	8.8	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	5	Isopentane	C_4 mix	n-Pentane
J1136/6638	10/8/99	half shift	240		morning, day through-put: UL95: 2.2m3, UL98: 0.7m3, L96: 1m3 - Corresponding sample(s): 6601	16.4	*0.4*	*0.4*	0.5	*0.4*	*0.4*	7	Isopentane	C_4 mix	n-Pentane
J1136/6617	13/8/99	half shift	247		morning, day through-put: UL95: 2.9m3, UL98: 0.3m3, L96: 1.8m3 - Corresponding sample(s): 6633	1.0	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	1	Isopentane		
J1136/6625	13/8/99	half shift	260		morning, day through-put: UL95: 2.9m3, UL98: 0.3m3, L96: 1.8m3 - Corresponding sample(s): 6688	27.0	0.5	*0.3*	0.6	*0.3*	*0.3*	14	Isopentane	C4 mix	n-Pentane
J1136/6633	13/8/99	half shift	243		afternoon, day through-put: UL95: 2.9m3, UL98: 0.3m3, L96: 1.8m3 - Corresponding sample(s): 6617	1.5	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	1	Isopentane		
J1136/6688	13/8/99	half shift	225		afternoon, day through-put: UL95: 2.9m3, UL98: 0.3m3, L96: 1.8m3 - Corresponding sample(s): 6625	31.3	0.7	*0.4*	0.6	*0.4*	*0.4*	13	Isopentane	C_4 mix	n-Pentane
J1136/6694	13/8/99	half shift	245		morning, day through-put: UL95: 2.9m3, UL98: 0.3m3, L96: 1.8m3 - Corresponding sample(s): 7139	4.6	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	4	Isopentane	C_4 mix	trans -4 - Methyl – Cyclopen-tene
J1136/7139	13/8/99	half shift	235		afternoon, day through-put: UL95: 2.9m3, UL98: 0.3m3, L96: 1.8m3 - Corresponding sample(s): 6694	8.3	1.1	*0.4*	*0.4*	*0.4*	*0.4*	7	C_4 mix	Isopentane	n- Hexane + 2- Methyl Pentene-1

Table A3.15 Service station attendant – with vapour recovery (3.1.2*)*

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1158/6617	16/2/00	full-shift	328		Throughput of 6500 L gasolines	5.8	*0.1*	*0.1*	0.2	*0.1*	*0.1*	9	Isopentane	C_4 mix	Isobutane
J1158/6625	16/2/00	full-shift	336	Sorbent loss from back tube	Throughput of 6500 L gasolines (duplicate J1158/8495)	8.4	*0.1*	*0.1*	0.2	*0.1*	*0.1*	9	Isopentane	C_4 mix	Isobutane
J1158/8495	16/2/00	full-shift	336		Throughput of 6500 L gasolines	8.3	*0.1*	*0.1*	0.2	*0.1*	*0.1*	9	Isopentane	C_4 mix	Isobutane
J1160/6642	29/2/00	full-shift	436		station handled approx. 200 gasoline cars, average fill 35 litres (<1% Bz 1/10 leaded/unleaded) - no bulk delivery	2.2	*0.1*	*0.1*	0.1	*0.1*	*0.1*	6	Isopentane	C_4 mix	n-Pentane
J1160/6687	29/2/00	full-shift	437		station handled approx. 200 gasoline cars, average fill 35 litres (<1% Bz 1/10 leaded/unleaded) - no bulk delivery (J1160/6642 duplicate)	2.5	*0.1*	*0.1*	0.1	*0.1*	*0.1*	8	Isopentane	C_4 mix	n-Pentane
J1160/8452	29/2/00	full-shift	429		station handled approx. 200 gasoline cars, average fill 35 litres (<1% Bz 1/10 leaded/unleaded) - no bulk delivery	6.3	*0.1*	*0.1*	0.1	*0.1*	*0.1*	8	C_4 mix	Isopentane	Propane
J1160/8465	29/2/00	full-shift	288		station handled approx. 200 gasoline cars, average fill 35 litres (<1% Bz 1/10 leaded/unleaded) - no bulk delivery	7.1	*0.1*	*0.1*	0.2	*0.1*	*0.1*	10	Isopentane	C_4 mix	Isobutane
J1160/6619	2/3/00	full-shift	305		1 bulk delivery during shift	12.2	*0.1*	*0.1*	0.2	*0.1*	*0.1*	12	Isopentane	C_4 mix	Isobutane
J1160/6623	2/3/00	full-shift	309		1 bulk delivery during shift	9.1	*0.1*	*0.1*	0.2	*0.1*	*0.1*	12	Isopentane	C_4 mix	Isobutane
J1160/7106	2/3/00	full-shift	305		J1160/6619 duplicate	11.8	*0.1*	*0.1*	0.2	*0.1*	*0.1*	12	Isopentane	C_4 mix	Isobutane

Table A3.16a Service station shop personnel (3.2) – post-2000 specification gasoline

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1157/6622	1/2/00	full-shift	235		sales assistant at A-road station	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	0			
J1157/6664	1/2/00	full-shift	240		sales assistant at A-road station	0.4	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	2	Isopentane	C_4 mix	
J1157/6683	1/2/00	full-shift	237		sales assistant at A-road station	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	0			
J1157/6643	2/2/00	full-shift	240		sales assistant at A-road station	2.8	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	4	C_4 mix	Isopentane	Isobutane
J1157/6669	2/2/00	full-shift	249	detected 1-methyl-2-propylbenzene (discounted), but no other gasoline components	sales assistant at A-road station	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0			
J1157/6693	2/2/00	full-shift	240		sales assistant at A-road station	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	0			
J1157/7762	2/2/00	full-shift	240	back caps loose	sales assistant at A-road station	2.8	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	4	C_4 mix	Isopentane	Isobutane

Table A3.16b Service station shop personnel (3.2) – pre-2000 specification gasoline

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1144/7105	26/7/99	full-shift	315		kiosk operator – typical daily through-put: L95: 4m3, L97: 3m3, UL98: 4m3, diesel (gas oil A): 6m3	1.5	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	2	Isopentane	3- Methyl Pentane	
J1143/7103	27/7/99	full-shift	409		day through-put: UL95: 3.5m3, UL98: 2m3, Leaded97: 1.5m3, diesel: 3m3	1.4	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	2	Isopentane	C_4 mix	
J1135/6648	9/8/99	full-shift	478		station through-put: 5 m3, UL95: 2.5 m3, L96: 0.5m3, UL98	0.8	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	1	Isopentane		
J1136/6603	10/8/99	full-shift	467	front caps loose	day through-put: UL95: 2.2m3, UL98: 0.7m3, L96:1m3	2.6	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	5	Isopentane	C_4 mix	n-Pentane
J1135/6669	12/8/99	full-shift	479			2.2	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	3	Isopentane	C_4 mix	Propane
J1136/6634	13/8/99	full-shift	490		day through-put: UL95: 2.9m3, UL98: 0.3m3, L96:1.8m3	2.4	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	3	Isopentane	C_4 mix	Isobutane

Table A3.17 Other service station personnel (3.5)

Survey and sample code	Sample date	Type of sample	Sample duration (min.)	Lab remarks	Field notes and handled product information	Exposure mg/m^3						No. of detected components of 150	3 single highest components		
						Gasoline vapour	n-Hexane	Benzene	Toluene	Xylenes	Ethyl-benzene		Comp1	Comp2	Comp3
J1157/6660	1/2/00	full-shift	237		cleaner at A-road station	0.2	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	0			
J1157/7753	1/2/00	full-shift	240		manager at A-road station	0.5	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	2	C_4 mix	Isopentane	
J1157/7772	1/2/00	full-shift	240		cleaner at A-road station	0.5	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	2	Isopentane	C_4 mix	
J1157/6639	2/2/00	full-shift	240	back caps loose	cleaner at A-road station	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0			
J1157/6694	2/2/00	full-shift	249		cleaner at A-road station	0.5	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	2	C_4 mix	Isopentane	
J1160/6654	2/3/00	full-shift	280		Yard supervisor - involved in 1 bulk delivery - Corresponding sample J1160/6648	6.5	*0.1*	*0.1*	*0.2*	*0.1*	*0.1*	9	Isopentane	C_4 mix	Isobutane
J1160/6648	2/3/00	peak	34		Yard supervisor - involved in 1 bulk delivery- Corresponding sample J1160/6654	43.6	0.4	*0.2*	1.3	1.3	*0.2*	21	Isopentane	C_4 mix	Isobutane

APPENDIX 4 EXTERNAL QUALITY CONTROL SAMPLES

A series of certified samples for external quality control (EQC) was ordered from a national measurement institute. The samples had been loaded with a mixture of n-hexane, benzene, toluene and o-xylene. The three loading levels covered the agreed calibration range on the basis of the anticipated exposures. The certified samples were included at random with sample batches from field surveys. Due to an administrative error, samples were only included in some of the earlier surveys. The available results are presented in **Table A4.1**. The loading levels are presented with a 95-percent confidence interval. All quantities are in micrograms.

Table A4.1 Results of external quality control samples

	n-Hexane		Benzene		Toluene		o-Xylene	
Sample no.	Loaded	Detec-ted	Loaded	Detec-ted	Loaded	Detec-ted	Loaded	Detec-ted
7712	1.00 ± 0.03	1.00	1.01 ± 0.03	1.02	1.00 ± 0.03	0.98	1.00 ± 0.03	0.95
7718	50.7 ± 1.5	52.6	51.0 ± 1.5	53.9	50.5 ± 1.5	52.2	50.5 ± 1.5	51.5
7736	101 ± 3	106	102 ± 3	108	101 ± 3	117	101 ± 3	115
7740	101 ± 3	104	102 ± 3	107	101 ± 3	113	101 ± 3	111

APPENDIX 5 STATISTICAL ANALYSIS OF RESULTS FOR SELECTED GASOLINE CONSTITUENTS

Table A5.1a Full-shift exposure results for n-hexane (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile[(1)]	90-percentile[(2)]
Off-site refinery operator (1.2)	6	0.9	0.3	0.2	0.1	2.4
Laboratory technician blending test gasoline for research (1.4)	7	4.4	1.8	3.7	0.2	9.0
Laboratory technician octane rating for research (1.4)	3	0.3	-	-	0.2 (min)	0.5 (max)
Road tanker driver (2.1.3)	33	0.8	0.5	0.4	0.2	1.5
Gantry man (2.1.6)	3	1.5	-	-	0.5 (min)	3.5 (max)
Drum filler (2.1.7)	2	2.8	-	-	-	-
Railcar top loading without VR (2.2.1)	16	7.0	2.3	1.5	0.3	18
Railcar top loading with VR (2.2.2)	21	1.8	0.9	0.8	0.2	4.1
Other railcar loading workers (2.2.7)	5	0.2	-	-	0.1 (min)	0.3 (max)
Jetty staff (2.3.5)	4	0.1	-	-	0.1 (min)	0.1 (max)
Service station attendants – no VR (3.1.1)	26	0.4	0.3	0.3	0.2	0.6
Service station attendants – with VR (3.1.2)	7	0.1	0.1	0.1	0.1	0.1
Service station shop personnel (3.2)	13	0.2	0.2	0.2	0.2	0.2
Miscellaneous service station personnel (3.5)	6	0.2	0.1	0.2	0.1	0.2

(1) For data sets of less than 6 measurements the minimum result is listed
(2) For data sets of less than 6 measurements the maximum result is listed

Table A5.1b Peak exposure results for n-hexane (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile[(1)]	90-percentile[(2)]
On-site refinery operator (1.1)	6	0.8	0.8	0.8	0.8	0.8
Off-site refinery operator (1.2)	7	0.7	0.7	0.7	0.6	0.8
Laboratory technician testing gasoline for production (1.4)	2	2.7	-	-	-	-
Laboratory technician octane rating for production (1.4)	4	0.8	-	-	0.5 (min)	1.6 (max)
Road tanker driver (2.1.3) – loading	15	1.6	1.2	1.0	0.5	3.1
Road tanker driver (2.1.3) – delivery	7	1.0	0.5	0.4	0.2	2.4
Drum filler (2.1.7)	10	2.7	2.2	2.3	1.0	4.4
Railcar top loading with VR (2.2.2)	3	1.0	-	-	0.8 (min)	1.2 (max)
Marine deck crew (2.3.2)	6	0.7	0.5	0.6	0.2	1.2
Jetty staff (2.3.5)	6	0.6	0.5	0.5	0.3	1.2
Miscellaneous ship personnel (2.3.6)	4	2.2	-	-	0.1 (min)	5.3 (max)
Miscellaneous service station personnel (3.5)	1	0.4	-	-	-	-

(1) For data sets of less than 6 measurements the minimum result is listed
(2) For data sets of less than 6 measurements the maximum result is listed

Table-A5.2a Full-shift exposure results for benzene (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile(1)	90-percentile(2)
Off-site refinery operator (1.2)	6	0.3	0.2	0.2	0.1	0.5
Laboratory technician blending test gasoline for research (1.4)	7	3.7	1.6	2.0	0.2	8.3
Laboratory technician octane rating for research (1.4)	3	0.3	-	-	0.2 (min)	0.5 (max)
Road tanker driver (2.1.3)	33	0.6	0.4	0.4	0.2	1.2
Gantry man (2.1.6)	3	0.4	-	-	0.3 (min)	0.5 (max)
Drum filler (2.1.7)	2	0.2	-	-	-	-
Railcar top loading without VR (2.2.1)	16	4.0	1.4	0.8	0.3	10
Railcar top loading with VR (2.2.2)	21	0.5	0.4	0.4	0.2	0.7
Other railcar loading workers (2.2.7)	5	0.2	-	-	0.1 (min)	0.3 (max)
Jetty staff (2.3.5)	4	0.1	-	-	0.1 (min)	0.1 (max)
Service station attendants – no VR (3.1.1)	26	0.3	0.3	0.3	0.2	0.5
Service station attendants – with VR (3.1.2)	7	0.1	0.1	0.1	0.1	0.1
Service station shop personnel (3.2)	13	0.2	0.2	0.2	0.1	0.2
Miscellaneous service station personnel (3.5)	6	0.2	0.1	0.2	0.1	0.2

(1) For data sets of less than 6 measurements the minimum result is listed
(2) For data sets of less than 6 measurements the maximum result is listed

Table-A5.2b Peak exposure results for benzene (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile(1)	90-percentile(2)
On-site refinery operator (1.1)	6	1.0	0.9	0.8	0.8	1.4
Off-site refinery operator (1.2)	7	0.7	0.7	0.7	0.6	0.8
Laboratory technician testing gasoline for production (1.4)	2	0.8	-	-	-	-
Laboratory technician octane rating for production (1.4)	4	0.8	-	-	0.5 (min)	1.0 (max)
Road tanker driver (2.1.3) – loading	15	1.8	1.4	1.4	0.5	3.8
Road tanker driver (2.1.3) – delivery	7	0.7	0.4	0.4	0.2	1.6
Drum filler (2.1.7)	10	0.9	0.8	0.7	0.5	1.5
Railcar top loading with VR (2.2.2)	3	0.5	-	-	0.5 (min)	0.5 (max)
Marine deck crew (2.3.2)	6	0.3	0.3	0.2	0.2	0.6
Jetty staff (2.3.5)	6	0.3	0.2	0.2	0.1	0.5
Miscellaneous ship personnel (2.3.6)	4	0.4	-	-	0.1 (min)	0.8 (max)
Miscellaneous service station personnel (3.5)	1	0.2	-	-	-	-

(1) For data sets of less than 6 measurements the minimum result is listed
(2) For data sets of less than 6 measurements the maximum result is listed

Table A5.3a Full-shift exposure results for toluene (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile[1]	90-percentile[2]
Off-site refinery operator (1.2)	6	0.7	0.5	0.6	0.3	1.3
Laboratory technician blending test gasoline for research (1.4)	7	9.6	4.7	8.8	1.0	20
Laboratory technician octane rating for research (1.4)	3	2.9	-	-	2.2 (min)	4.3 (max)
Road tanker driver (2.1.3)	33	1.4	0.8	0.9	0.2	3.0
Gantry man (2.1.6)	3	1.8	-	-	0.5 (min)	3.6 (max)
Drum filler (2.1.7)	2	1.6	-	-	-	-
Railcar top loading without VR (2.2.1)	16	18	6.2	4.7	1.1	45
Railcar top loading with VR (2.2.2)	21	1.2	0.9	1.0	0.3	2.5
Other railcar loading workers (2.2.7)	5	0.2	-	-	0.1 (min)	0.3 (max)
Jetty staff (2.3.5)	4	0.2	-	-	0.1 (min)	0.3 (max)
Service station attendants – no VR (3.1.1)	26	0.4	0.4	0.4	0.2	0.8
Service station attendants – with VR (3.1.2)	7	0.2	0.2	0.2	0.1	0.2
Service station shop personnel (3.2)	13	0.2	0.2	0.2	0.1	0.2
Miscellaneous service station personnel (3.5)	6	0.2	0.2	0.2	0.1	0.2

(1) For data sets of less than 6 measurements the minimum result is listed
(2) For data sets of less than 6 measurements the maximum result is listed

Table A5.3b Peak exposure results for toluene (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile[1]	90-percentile[2]
On-site refinery operator (1.1)	6	1.7	1.3	0.8	0.8	3.5
Off-site refinery operator (1.2)	7	0.8	0.8	0.7	0.7	1.1
Laboratory technician testing gasoline for production (1.4)	2	4.8	-	-	-	-
Laboratory technician octane rating for production (1.4)	4	2.9	-	-	0.6 (min)	5.4 (max)
Road tanker driver (2.1.3) – loading	15	2.2	1.7	1.4	0.8	4.8
Road tanker driver (2.1.3) – delivery	7	1.8	1.3	1.2	0.6	3.4
Drum filler (2.1.7)	10	9.4	5.0	6.5	1.3	22
Railcar top loading with VR (2.2.2)	3	1.9	-	-	1.5 (min)	2.6 (max)
Marine deck crew (2.3.2)	6	0.8	0.6	0.6	0.3	1.4
Jetty staff (2.3.5)	6	0.8	0.7	0.6	0.4	1.4
Miscellaneous ship personnel (2.3.6)	4	2.7	-	-	0.2 (min)	6.4 (max)
Miscellaneous service station personnel (3.5)	1	1.3	-	-	-	-

(1) For data sets of less than 6 measurements the minimum result is listed
(3) For data sets of less than 6 measurements the maximum result is listed

Table A5.4a Full-shift exposure results for xylenes (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile(1)	90-percentile(2)
Off-site refinery operator (1.2)	6	0.4	0.3	0.4	0.1	0.6
Laboratory technician blending test gasoline for research (1.4)	7	5.5	2.0	3.8	0.2	13
Laboratory technician octane rating for research (1.4)	3	0.5	-	-	0.2 (min)	1.0 (max)
Road tanker driver (2.1.3)	33	0.6	0.4	0.4	0.2	1.0
Gantry man (2.1.6)	3	1.0	-	-	0.3 (min)	2.1 (max)
Drum filler (2.1.7)	2	0.2	-	-	-	-
Railcar top loading without VR (2.2.1)	16	6.4	2.1	1.4	0.3	18
Railcar top loading with VR (2.2.2)	21	0.7	0.5	0.5	0.2	1.6
Other railcar loading workers (2.2.7)	5	0.2	-	-	0.1 (min)	0.3 (max)
Jetty staff (2.3.5)	4	0.1	-	-	0.1 (min)	0.1 (max)
Service station attendants – no VR (3.1.1)	26	0.3	0.3	0.3	0.2	0.4
Service station attendants – with VR (3.1.2)	7	0.1	0.1	0.1	0.1	0.1
Service station shop personnel (3.2)	13	0.2	0.2	0.2	0.1	0.2
Miscellaneous service station personnel (3.5)	6	0.2	0.1	0.2	0.1	0.2

(1) For data sets of less than 6 measurements the minimum result is listed
(4) For data sets of less than 6 measurements the maximum result is listed

Table A5.4b Peak exposure results for xylenes (mg/m^3)

Job group	Number of samples	Average	Geometric mean	Median	10-percentile(1)	90-percentile(2)
On-site refinery operator (1.1)	6	0.8	0.8	0.8	0.8	0.8
Off-site refinery operator (1.2)	7	0.7	0.7	0.7	0.6	0.8
Laboratory technician testing gasoline for production (1.4)	2	2.6	-	-	-	-
Laboratory technician octane rating for production (1.4)	4	0.5	-	-	0.5 (min)	0.6 (max)
Road tanker driver (2.1.3) – loading	15	1.6	1.2	1.1	0.5	3.1
Road tanker driver (2.1.3) – delivery	7	1.1	0.8	1.1	0.4	1.9
Drum filler (2.1.7)	10	3.8	2.3	2.1	0.9	9.6
Railcar top loading with VR (2.2.2)	3	0.8	-	-	0.5 (min)	1.4 (max)
Marine deck crew (2.3.2)	6	0.5	0.4	0.6	0.2	0.7
Jetty staff (2.3.5)	6	0.5	0.4	0.4	0.3	0.8
Miscellaneous ship personnel (2.3.6)	4	1.6	-	-	0.1 (min)	3.0 (max)
Miscellaneous service station personnel (3.5)	1	1.3	-	-	-	-

(1) For data sets of less than 6 measurements the minimum result is listed
(5) For data sets of less than 6 measurements the maximum result is listed