Human exposure information for EU substance risk assessment of gas oils

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ABSTRACT

Information is presented on inhalation and dermal exposures to gas oils for workers in European manufacturing and distribution operations and for consumers, for use in substance risk assessment according to EU regulations. Similar, but more limited, information is also presented for exposures resulting from the use of gas oils by workers outside the oil industry.

KEYWORDS

Gas oils, diesel fuel, home heating oil, occupational exposure, risk assessment

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SUMMARY

CONCAWE is currently undertaking a risk assessment on the group of gas oils and their blending components (refinery streams) in the frame work of EU chemical substances regulations.

Information on levels of human exposure resulting from the manufacturing, distribution and use of gas oils and blending components forms an essential input into the risk assessment, in particular in the risk characterisation section where exposure levels are compared with no-effect levels derived from toxicological assessments of various health effects. Technical guidance for the collection of exposure information to support risk assessment has been followed, including direct measurement of exposure levels and indirect, modelling approaches. Exposure estimates were developed for workers and for consumers, but not for the general public, as at present there is no technical guidance for complex substances such as gas oils for their indirect exposure via the environment.

Compositional information for bulk product and the vapour phase is also presented, including details for several petroleum-derived hydrocarbon substances present in gas oil for which occupational exposure limits have been set.

Inhalation exposure data were retrieved and collated from member companies and open literature, and supplemented with new measurements from a dedicated monitoring campaign. Dermal exposure levels were estimated using a simple modelling approach.

The collection and collation of exposure information for gas oils vapour from CONCAWE member companies confirmed that worker exposure by inhalation is generally well below the exposure limit of 100 mg/m^3 recommended by the American Conference of Governmental Industrial Hygienists (ACGIH); that a wide range of control measures are in place; and that occurrences of elevated exposure appear to be infrequent. Exposures are often simultaneous with other petroleum products, in particular gasoline, making it difficult to characterise those originating from gas oils alone. Inhalation and dermal exposures were estimated to be of the same order of magnitude. Some deficiencies in protective glove selection were detected and highlighted for improvement.

Higher exposure levels, often exceeding the ACGIH recommended limit, were reported for cleaning and inspection of home heating oil tanks, however adequate protective measures appeared to be in place. Guidance for worker health protection for this scenario was developed in at least one EU country.

Conservative estimates of consumer exposure resulting from car refuelling with automotive diesel were 1 milligram per day via inhalation and 21 milligram per day as dermal exposure per refuelling event. The inhalation estimate was based on measured data, whereas the dermal estimate was derived through modelling. Consumer exposure estimates were considerably lower than worker exposure estimates.

1. INTRODUCTION

1.1. PURPOSE OF REPORT

CONCAWE is currently undertaking a programme of voluntary risk assessments on groups of major marketed petroleum products under the frame work of EU chemical substances regulations. Gas oils and their blending components (refinery streams) are the second group of products in the programme, following gasoline.

Information on levels of human exposure resulting from the manufacturing, distribution and use of petroleum products and their blending components forms an essential input into the risk assessment, in particular for the risk characterisation section which compares exposure levels experienced by workers and consumers with no-effect levels derived from toxicological assessments for various health endpoints. Technical guidance for the conduct of risk assessments has been developed and revised in recent years by European authorities. The guidance provides for several approaches to developing exposure information. This includes indirect, modelled calculations; however these tend to produce conservative (high) exposure estimates to reflect the uncertainty associated with this approach. More direct estimates, based on actual exposure measurements in circumstances representative of normal handling and use are therefore preferred.

A special task force (H/STF-29) was set up to generate where possible the exposure information needed for the risk assessment of gas oils and other petroleum products. This report provides the result of the work of H/STF-29 on gas oils and should be considered as supporting the Exposure Assessment chapter of the Human Health section of an EU-style substance risk assessment of gas oils being prepared by CONCAWE. This type of substance risk assessment requires the definition of so-called Reasonable Worst Case (RWC) exposures where several, reasonably foreseeable, adverse conditions combine to produce a relatively elevated exposure. Where a sufficient number of measured data on exposure levels is available the RWC is often characterised as the 90^{th} percentile of the data distribution. The median (50^{th} percentile) of the same distribution is then considered as the typical exposure level.

1.2. SCOPE

Activities considered include the manufacturing, distribution and use of petroleum products known collectively as gas oils. The CONCAWE grouping scheme for classification and labelling [1] includes straight-run gas oils, cracked gas oils, hydrocracked gas oils, vacuum gas oils and the group “other gas oils”. As with other petroleum products, their nomenclature reflects the final refining processing step. Further, the assessment is applicable to products blended with these refinery products, in particular automotive diesel fuel, home heating oil and industrial gas oils. Some finished gas oils are used in lubricant blending and preliminary estimates of exposure associated with use of these lubricants have been developed. Use of gas oils in cutback bitumen is not included. Also not included are the combustion products resulting from the use of gas oils as a fuel.

The grouping of refinery-produced gas oils and blended products reflects similarities in physical properties, composition and end use.

It is further brought to the attention of the reader that the exposure assessments in this report, and any judgments expressed on these, cannot replace adequate workplace health risk assessments as required by legislation under the EU's Chemical Agents Directive. For example, whereas gas oils at ambient temperature have low volatility, road tanker drivers loading gas oils may also be exposed to vapour of gasoline which has a much higher volatility. In those instances the gasoline vapour exposure is likely to dominate over the gas oil vapour exposure and needs to be taken into account in the workplace risk assessment.

An essential element of this exposure assessment is the estimation of dermal exposure to liquid gas oils. The techniques to measure dermal exposure are not as far advanced, or as standardised, as that for inhalation exposure, and consequently assessors need to rely on indirect or modelling approaches. These tend to produce conservative (i.e. high) estimates which should be interpreted more as pointing towards priorities for exposure control, rather than reflecting realistic dermal exposure levels that can be linked plausibly with anticipated health effects (or a lack thereof).

2. PRINCIPLES OF EXPOSURE ESTIMATION FOR RISK ASSESSMENT

2.1. TECHNICAL GUIDANCE FOLLOWED

The principal guidance for the development of exposure estimates within the framework of EU substance risk assessment is the Technical Guidance Document (TGD) on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances, and Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market [2]. The most recent version of the TGD was issued in 2003 by the European Chemicals Bureau, with revisions to Chapter 2 on Exposure Assessment which are relevant to this report.

The TGD has been developed principally for risk assessment of single component substances or, at most, simple mixtures. In contrast, gas oils are complex substances of variable composition and the available guidance on exposure assessment is therefore not complete or relevant in all aspects. Where necessary, therefore, this guidance has been adapted to the needs of complex substances and this is indicated in the present report.

2.2. CRITERIA FOR REPRESENTATIVENESS OF COLLECTED INFORMATION

The information presented in this report is considered broadly representative of CONCAWE member company operations in the EU on the basis of the approach adopted by the task force. This conclusion is based on the following:

- initial exposure descriptions and estimates were developed, using a standard template, by members of the task force who are all qualified and experienced occupational health professionals; their employing companies included some of the major EU-based CONCAWE member companies;

- companies not represented on the task force were contacted and invited to advise on any modifications to improve the reliability of the assessments; as part of that process, these companies were also asked to submit available exposure measurements.

The template used for the exposure description contained several prompts that allowed information to be expressed in terms compatible with the TGD, in particular with regard to inputs needed to estimate dermal exposure.

Exposures in downstream user populations were not specifically targeted. Data are presented where available, but the exposure assessment should not be considered as systematic or complete in this respect.

3. SUBSTANCE CHARACTERISATION

Gas oils are used as a fuel for diesel engines in applications such as on and off-highway automotive use; rail transport; power generation and marine propulsion; for gas turbines in power generation; and for burner installations in domestic, industrial, agricultural, fishing, mining and construction areas. Gas oils may also be used in specialised industrial processes (e.g. lubrication applications in engineering companies) and as a component in formulated products (e.g. drilling muds, printing inks and lubricating oils), but the amounts used in these applications are minor compared with the fuel uses.

There are a number of product names and synonyms in general use for marketed gas oils and a summary of the more common ones is as follows:

Automotive fuels for diesel engines:
- Automotive gas oil (AGO),
- Automotive diesel fuel,
- Diesel,
- Diesel fuel oil,
- Diesel fuel No 2,

Railway engine gas oil

Heating oils (Distillate fuel oils):
- Domestic heating oils,
- Industrial heating oils,
- Domestic fuel oil,
- Industrial fuel oil,
- Industrial gas oil (IGO),
- Light fuel oil
- No 2 fuel oil

There are many categories of professional users with occupational exposure to gas oils. These include vehicle mechanics, road hauliers with dedicated refuelling facilities, farmers, construction workers operating power generators, railway engine personnel, boiler maintenance engineers and more.

The most recently published comprehensive description of the health and environmental characteristics of gas oils, relevant to risk assessment, is contained in CONCAWE product dossier 95/107 [3]. This indicates that the group of gas oils comprises the following six classes:

- straight-run gas oil components (9 EINECS numbers)
- cracked gas oil components (16 EINECS numbers)
- hydro-cracked gas oil components (2 EINECS numbers)
- vacuum gas oil components (11 EINECS numbers)
- other gas oil components (27 EINECS numbers)
- distillate fuels (4 EINECS numbers)

The EINECS (or CAS) definitions typically refer to the final refining process step and describe the substance as a complex mixture of hydrocarbons having carbon numbers predominantly in a range, e.g.C_{13} to C_{30}.

It is further noted that some automotive diesel fuels contain straight-run kerosine components [4].

3.1. PHYSICO-CHEMICAL PROPERTIES

Summary information on physico-chemical properties is presented in CONCAWE's Gas Oils product dossier [3]. Volatility data are required for inhalation exposure estimation. Gas oils are generally of relatively low volatility. Their saturated vapour pressure is variable, e.g. the figure of 0.4 kPa at 40°C is given in the product dossier. Other sources give ranges of 0.07-0.13 kPa at 20°C.

3.2. COMPOSITION OF BULK PRODUCT AND VAPOUR PHASE

It is generally considered that the hazards to human health and the environment of petroleum substances are determined by the overall composition of the "whole" product and not by individual chemical constituents which are generally present only in minor amounts. There exist a considerable number of toxicity studies on various gas oils to justify this statement. Therefore, the principal metric of the exposure estimation should reflect the "whole" substance. However, for several reasons the exposure assessment also needs to generate descriptive information on some specific constituents, present at low levels in gas oils, for incorporation into the risk assessment. Firstly, several of the constituent substances present have been prioritised for risk assessment under the EU Existing Chemicals legislation, but consideration of the health impact of exposures arising from the manufacture and use of gas oil and other oil products has been excluded from these "single substance" risk assessment. Therefore the gas oils risk assessment is an appropriate means to describe these contributions. Second, some constituents have been assigned occupational exposure limits (OEL) or have been classified under the Dangerous Substances Directive (DSD), with increased regulatory interest in their control inside and outside the workplace.

The following general criteria were therefore applied when identifying which individual gas oil constituents should be included in this exposure assessment:

- substances which have been prioritised for Existing Substances Regulation risk assessment,
- substances with an assigned OEL,
- substances which are classified for health-hazardous properties under the DSD, in particular very toxic, toxic, carcinogenic, mutagenic and reprotoxic substances.

3.2.1. Investigations of chemical composition of liquid substance and vapour phase

Several reports on composition are available from the German Society for Petroleum and Coal Science and Technology (DGMK) [4, 5]. Further, a specific analytical program was commissioned by CONCAWE as part of the gas oils risk

assessment [6, 7]. This program addressed both blended products and refinery streams.

The objective of the DGMK project was to generate data on substances that have been prioritised for European risk assessment [5]. The combined results of the liquid analyses and the vapour analyses are presented in **Appendix 1**. The results of the DGMK project were used in part to define components of interest for this particular CONCAWE project.

The CONCAWE analytical program also reported total hydrocarbon concentrations for the saturated vapour phase which ranged from 1620 to 6490 mg/m^3 at 20°C. Assuming a conversion factor from mg/m^3 to part per million (ppm) by volume of 5.2, derived for n-dodecane as a surrogate for gas oil vapour, these vapour phase results were equivalent to approximately 300 to 1250 ppm (v/v). These levels are in broad agreement with predictions based on the vapour pressures quoted in Section 3.1.

3.3. OCCUPATIONAL EXPOSURE LIMITS

There is at present no European occupational exposure limit for gas oils. In 2002 the American Conference of Governmental Industrial Hygienists set a Threshold Limit Value (TLV®) for 8-hour time-weighted average inhalation exposure to diesel fuel of 100 mg/m^3, total hydrocarbons, vapour and aerosol, with a skin notation; the skin notation implies that dermal uptake may contribute significantly to the body burden [8]. From the results reported in the previous section it is clear that at typical ambient temperatures the saturated vapour phase concentration is higher than the TLV®, hence the potential exists for overexposure in poorly ventilated circumstances.

In Germany a value of 100 mg/m^3 has been applied in workplace exposure surveys, based on a general approach for complex hydrocarbon mixtures with an aromatic content of more than 25% [9].

Within individual EU Member States, exposure limits exist for some individual constituents of gas oils however there is little consistency between countries. Some of these limits may be exceeded in the saturated vapour phase on the basis of the analysis results presented in Section 3.2.1, e.g. benzene, toluene and combined xylenes. However compliance with a limit value of 100 mg/m^3 for diesel fuel will, in almost all cases, also result in exposures to the individual constituents that are below these national limits.

4. ACTIVITIES INVOLVING EXPOSURE TO GAS OIL

4.1. OIL INDUSTRY OPERATIONS

Descriptions of the circumstances leading to exposure to gas oils, and the typical measures in place to control such exposures, have been developed following approaches applied previously to gasoline and described in several reports [10, 11]. Typical job titles and tasks carried in the European downstream petroleum industry are characterised in **Appendix 2**. In addition to estimations of the level of inhalation and dermal exposure, information is also presented, in line with TGD requirements, on frequency and duration. The emphasis is on patterns of use and control.

4.1.1. Manufacturing operations (refinery)

Work activities potentially resulting in occupational exposure in manufacturing operations include On-Site/Production Operator, Off-site/Tank Farm Operator, Mechanical Maintenance Technician, Quality Control Laboratory Technician, Railcar Loading Operator[1] and Jetty Operator. In some cases, multi-skilled operators may carry out tasks from all these titles.

The information presented in **Appendix 2** was validated by CONCAWE member companies for manufacturing operations in Belgium, Germany, Denmark, Spain, Finland, France, Italy, the Netherlands and the United Kingdom.

4.1.2. Distribution operations

Descriptions of exposure circumstances in distribution operations were developed and validated for all (15) EU Member States, Norway and Switzerland. These operations involve the movement of gas oil products to and from terminals and depots and include deliveries to service stations (automotive diesel fuel), private households (home heating oil) and industrial customers. The job titles included are: road tanker driver (top or bottom loading), terminal operator, rack operator, vehicle mechanic, equipment maintenance, specialist cleaner and drum filler. Exposure information is presented in **Appendix 2**.

4.1.3. Retail operations

Descriptions of exposure circumstances in retail activities are also provided in **Appendix 2**. They include service station attendants, pump calibration engineers, forecourt cleaners, mechanics and tank cleaners.

4.1.4. Risk management measures in use

In refining, distribution and use of petroleum products a large number of measures is in place to control risk to environment, health and safety. Some measures that apply to gas oil operations are described below.

[1] In the gasoline exposure reports rail car loading was assigned to the category of distribution workers, but since rail car loading is typically done off-site refineries, the scenario has been included here in the refinery category

In the manufacturing work environment (refineries, tank farms) production and storage systems are essentially closed and provisions are in place to limit evaporative losses of all hydrocarbons. Where contact with gas oils is anticipated (e.g. during change-out of in-line filter cartridges) procedures are in place to remove as much as possible of the residual substance prior to the operation, e.g. by flushing the systems. Activities that are likely to be associated with elevated exposures, such as tank entry for cleaning purposes, are conducted under permit-to-work systems in which personal protective equipment requirements are mandatory. Operator competency assurance programmes contain modules on health and safety at work.

In the distribution system some road tanker loading operations are conducted via bottom loading. In other circumstances, where top loading occurs (rail cars, road tankers) vapour recovery facilities may be in place.

Gas oils are generally recognised as presenting a skin irritation hazard and protective gloves are widely used. Some glove manufacturers have tested their products specifically for chemical resistance to permeation by gas oils (mainly diesel fuel) and are able to provide appropriate recommendations.

Safety data sheets are provided to customers and contain recommendations for safe handling and use.

4.2. OTHER OPERATIONS ASSOCIATED WITH OCCUPATIONAL USE OF GAS OILS

Detailed descriptions in template format of other circumstances associated with occupational exposure to gas oils have not been developed by the task force. However, some descriptions of tasks and typical control measures may be available from occupational hygiene survey reports, e.g. cleaning and inspection of underground and cellar storage tanks of home heating oil in private houses [12]. Exposure estimates for these categories of workers may also in part be based on analogy with other, more precisely characterised operations.

4.3. CONSUMER USE OF THE SUBSTANCE

The principal consumer uses of gas oils are as automotive diesel fuel and as home heating fuel. The principal exposure takes place during self-service car refuelling at service stations. Home heating oil deliveries are made by professional drivers and consumers are not expected to have direct contact.

4.4. INDIRECT EXPOSURE VIA THE ENVIRONMENT

The risk assessment process also requires information on so-called indirect exposure via the environment, i.e. the amounts to which members of the general public are exposed via air, water and food. The amounts are usually estimated based on substance production volume, using default parameters specified in the TGD. This type of exposure is mainly relevant to individuals who are not otherwise exposed as either consumer or worker.

For gas oils there are no actual measurements available of indirect exposure via the environment. Gas oil constituents partition differently across environmental compartments according to their chemical-physical properties such as boiling point and water solubility, hence levels in food, ambient air and water can not be linked to

health effects data obtained from testing “whole” products. In addition, most of the constituent substances also originate from other sources, and analytical data on their occurrence in the environment is not, per se, indicative of exposures originating from gas oils.

Due to the complexity of the environmental fate aspect and the absence of measured data no estimates of indirect exposure were developed.

5. QUANTIFICATION OF EXPOSURES

Due to their low volatility and known skin irritation hazard, it is assumed that under most circumstances personal exposure to gas oils is low. In order to confirm this assumption, and to generate appropriately defined quantitative estimates, collection of measured data for inhalation exposures from a cross-section of jobs/activities in the European petroleum industry was considered necessary. This was feasible because gas oil vapour in air can conveniently be sampled and analysed using routine occupational hygiene procedures. No such standardised procedures were available for dermal exposure assessment, nor was there an accepted biological monitoring method to quantify internal body burden of gas oil or its constituents.

Alternative procedures recommended by the TGD include simple modelling approaches and estimation on the basis of analogies with other substances of similar properties and in comparable operations.

5.1. INHALATION EXPOSURES

5.1.1. Measured data provided by CONCAWE member companies

As a first step, task force members reviewed company internal records to retrieve any existing measured data. Few of these were reported, and in some cases the results could not reliably be linked with operations solely involving exposure to gas oils. Data are summarised in **Table 1**, according to operational area (below).

Table 1 Measured inhalation exposure data available from member companies (expressed as total hydrocarbon)

Job title	Number of measurements	Median (mg/m^3)	Minimum (mg/m^3)	Maximum (mg/m^3)	Typical duration (minutes)	Notes
Manufacturing/Refinery						
On-site analysers operator	1	5	--	--	480	
Refinery laboratory worker	2	7	4	9	480	Only gas oil tests
Production operator	1	1	--	--	480	
Tank farm operator	4	4	2	18	480	
Waste water treatment plant operator	1	6	--	--	480	
Road tanker operations						
Drivers	13	2	<1	6	480	Full cycle of loading and deliveries
Gantry operator	6	7	<1	120	480	Gasoline traces in highest result; also 150' only
Top loading	6	85	44	535	20	Unusually high toluene in highest reading
Deliveries	1	100	--	--	4	
Retail (service stations)						
Area near diesel pumps	114	0.9	0.02	103	240	Stationary measurements of 4 hours; maximum result with spillage; 95-percentile 43 mg/m^3
Product use						
Domestic heating oil tank cleaning	2	190	180	195	30	Tank ventilation by suction pump on truck

5.1.2. Measured data from literature

A search of publicly available literature databases using key words returned essentially no useful information. Detectable benzene exposures are reported in the EU Risk Assessment Report for the scenario of heating oil tank cleaning, but no associated total hydrocarbon data are provided [13]. In view of the very low and variable benzene content of gas oils it is not possible to derive a reliable estimate of total hydrocarbons in air from these benzene measurements.

Some exposure information is presented in the documentation of the occupational exposure limit (Threshold Limit Value, TLV®) of the ACGIH, mainly relating to reports of incidents in confined spaces such as fuel tanks. However this concerns mainly analyses of saturated atmospheres rather than personal exposures [8].

Recently, measured data were reported for benzene and total hydrocarbons from an extensive exposure survey conducted in Germany on workers involved in cleaning and interior inspection of domestic heating oil storage tanks [12]. A distinction was made between buried tanks and tanks located in the cellar of houses. Teams of two workers, mainly employees of small companies, cleaned on average three tanks per work shift, each tank taking on average approximately 75 minutes; one of the two workers was inside the tank one third of the time. During tank entry mandatory respiratory protection was worn. Tank inspections were done by experts, also required to wear respiratory protection. Data are presented for the period of work inside the tank, as well as for the second worker who remained outside at the manhole. During tank entry, total hydrocarbon values were mostly in excess of 100 mg/m^3, up to a maximum of nearly 3000 mg/m^3. Corresponding benzene values were generally greater than 3.25 mg/m^3 (the European occupational exposure limit for 8-hour exposure). The report does not present 8-hour exposure estimates, however these can be derived from the presented information. The report specifies procedural and personal protection measures deemed necessary for adequate exposure control. The report does not present a specific quantitative assessment of dermal exposure.

5.1.3. Results of targeted exposure monitoring surveys

In view of the limited information on gas oil exposure available from member companies and from the literature, a number of jobs and activities were targeted for exposure monitoring. However it was recognised that in many occupational settings where gas oils are handled, concurrent exposure to other more volatile substances, in particular gasoline, may also occur. Although occupational exposure assessment clearly needs to take account of all substances, monitoring information from settings with confounding co-exposures were considered of limited value for the risk assessment gas oils and therefore work sites with exposures exclusively to gas oils were preferred.

Exposure monitoring surveys were undertaken by company staff, but sample analysis was centralised. A well-established sampling and analytical procedure was adopted (see 5.1.3.1), and an analytical laboratory was selected from several that had returned satisfactory responses to a quality assurance questionnaire. The selected laboratory is dedicated to occupational hygiene analysis, affiliated with a university and holds national accreditation for occupational hygiene analysis of hydrocarbon solvents based on satisfactory performance in round-robin tests.

A field protocol was developed, including forms for all targeted activities on which to record standard information to aid interpretation of measurement results.

5.1.3.1. Monitoring method and quality assurance

The monitoring method consisted of sampling air from the breathing zone through a small glass tube containing activated charcoal adsorbent by means of a small battery-operated pump. Sample analysis required desorption by means of a solvent, followed by gas chromatography and flame ionisation detection to quantify total hydrocarbon and separated components. This approach is similar to e.g. Method Determination of Hazardous Substances (MDHS) 96, issued by the UK Health and Safety Executive [14].

In order to verify the adequacy of the laboratory's performance for gas oil vapour samples, a series of 30 certified samples spiked with known quantities of 12 key volatile components known to be present in gas oil were analysed on three

occasions in 2003/2004. The spiked samples had been obtained from a national reference laboratory. The spiked amounts covered a range of concentrations (3 levels) that would be expected to occur in field samples of 10 litres of air at exposure levels from well below, at and to well above the exposure limits. In all instances all spiked components were correctly identified. Initial results (December 2003 results, **Appendix 3**) suggested some under-reporting by the laboratory for the lowest loading level. Adjustment of the calibration procedure resulted in satisfactory performance (February 2004 results). Only one component, naphthalene, was consistently reported at levels 10-15% below its loading levels.

5.1.3.2. Results

Fully detailed measurement results from exposure surveys are presented in **Appendix 4** and summarised in **Table 2**. The surveys targeted principally activities that were anticipated to involve only gas oils. However, several samples were found to contain individual components in relative quantities that suggested the presence of gasoline vapour and were hence of limited value for the current purpose, other than confirming that gas oil vapour exposures were generally low. A series of samples were taken during refuelling of trucks with diesel fuel on the premises of transport companies, with the principal aim of generating reliable exposure data in the absence of gasoline. These results are considered applicable also to consumers refuelling their cars at service stations.

Table 2 Summary table measured gas oil vapour exposures (2003-2004), measured as total hydrocarbons and expressed as n-dodecane equivalents

Job title	Number of measurements	Median value (mg/m^3)	Reasonable worst case (mg/m^3)	Range (mg/m^3)	Typical duration (minutes)
Manufacturing/Refineries					
Refinery laboratory worker	1	58[a]	--	--	100
Tank farm operator – sampling	3	5	11[b]	1 – 11	45
Tank farm operator – filter changing	5	5	20[b]	4 – 20	30
Rail car loading	3	6	28[b]	2 – 28	45
Jetty crew	1	3	--	--	120
Road tanker operations					
Loading (unspecified)	3	10	74[b]	1 – 74	20
Top loading	22	6	74	1 - 172	15
Bottom loading	2	2	4[b]	1 - 4	20
Deliveries	12	2	33	1 - 138	20
Full shift	8	1	6	0 - 11	480
Product use					
Refuelling (heavy goods vehicle)	9	5	11	0 - 17	15

[a]: included 20 mg/m^3 of acetone (laboratory solvent)
[b]: maximum value, instead of 90th percentile, due to small number of measurements

Out of approximately 70 measurements, two high exposures were examined regarding constituent levels. Both were obtained from short-term operations, the first involving a delivery to an industrial customer during which a tank was overfilled; the second, top loading of product with a temperature slightly above ambient. The constituent substance results are included in **Appendix 5** and compared with compositional data for two saturated vapour samples from the DGMK investigations. The relative quantities of cyclohexane, benzene, toluene, ethylbenzene and cumene appeared comparable in the two sets of results. None of the single constituent exposures for these two samples exceeded the equivalent OEL.

5.1.4. Modelled exposure estimates

5.1.4.1. Gas oils used as lubricant components

A relatively small volume of gas oils is used as blending component of industrial lubricants. No exposure measurement results were available to the task force. Exposures were modelled using the approach recommended in the TGD [2] and the results are included in **Appendix 6**. A similar approach was followed for the dermal exposure assessment (see further under 5.2). Several of the modelled estimates appear high when compared with the measured data for e.g. gas oil distribution operations in **Table 2** above. It should be noted that the modelled estimates have a high degree of associated uncertainty.

5.1.5. Estimates based on analogy with gasoline vapour exposures

Certain operations involving gas oils are essentially identical to some frequently monitored operations with gasoline, so in the absence of directly measured exposure data the exposure may be estimated using a conversion factor to account for the lower volatility of gas oils. This factor is assumed to be approximately 250 at ambient temperatures on the basis of volatility graphs for petroleum products.

CONCAWE has a reasonably comprehensive database of recent measurements of gasoline exposures, although some internal inconsistencies, as well as a low number of samples for some jobs and tasks of irregular frequencies, limit the usefulness of the database for read-across to other petroleum products. Comparison of median values for two of these tasks in **Table 2** with values recorded in previous CONCAWE Reports [10, 11] containing data of measured gasoline vapour exposures for rail car loading (6 x 250 = 1500 mg/m^3 predicted; versus 600 mg/m^3 measured) and road tanker top loading without vapour recovery (6 x 250 = 1500 mg/m^3; versus 500 mg/m^3 measured) suggest this may be reasonable in terms of order of magnitude. More data would be needed to further validate this approach.

5.2. DERMAL EXPOSURES

There is at present no reliable and widely accepted analytical approach to quantify dermal exposure to complex petroleum substances such as gas oils. Therefore, exposure estimates used in the gas oils risk assessment were based on modelling approaches.

The TGD provides criteria to be used when characterising the intensity, frequency and duration of dermal exposure, both in terms of number of events per work shift and in qualitative descriptive terms. **Table 3** presents the main definitions and exposure estimates used in the gas oils exposure assessment. The estimates are

combined with the assumed exposed surface, of which typical numbers are also included in the TGD (ranging from the palm of one hand – 210 cm^2 – to both hands and forearms – 2000 cm^2). The descriptive, rather than the frequency definitions were found to be most suitable to describe the judgments for the gas oils exposure assessment.

Table 3 TGD definitions to describe dermal exposure (non-dispersive use, direct handling)

Exposure Class	***Frequency***	***Description***	***Exposure estimates***
None	--		Very low [a]
Incidental	1 event/day	Splash or spill	0.1 mg/cm^2/day
Intermittent	2-10 events/day	Material transfer using a device [in a process plant] – requiring judgment	1 mg/cm^2/day
Extensive	> 10 events/day	Use of hands is required as part of work, e.g. taking wet objects from a bath to a draining rack	5 mg/cm^2/day

[a] the task force proposes to use a number of half of the next category as default: 0.05 mg/cm^2/day in instances where quantitative information is necessary.

Appendix 2 presents, in template form, descriptive profiles which were constructed to allow direct derivation of modelled exposure estimates by task for jobs in manufacturing, distribution and retail operations. The typical dermal exposure estimates are summarised in **Table 4**.

Table 4 Estimated daily dermal exposures to gas oils in manufacturing, distributions and retail

Job title	Typical estimates		Dermal exposure (mg.day^{-1})
	Type of contact	Surface (cm^2)	
Manufacturing			
Production/On-site operator	Incidental	420	42
Tank farm/Off-site operator	Intermittent	420	420
Mechanical maintenance	Incidental	420	42
Laboratory technician	Incidental	420	42
Rail car operator	Intermittent	420	420
Jetty crew	Incidental	420	42
Distribution operations			
Road tanker driver	Incidental	420	42
Terminal operator	Intermittent	420	420
Rack operator	Intermittent	420	420
Mechanic	Incidental	420	42
Retail (service stations)			
Refuelling attendant	Incidental	210	21
Pump calibration	Incidental	420	42
Forecourt cleaner	Very low	420	21
Mechanic	Very low	420	21

5.2.1. Effectiveness of protective gloves

In view of the wide-spread use of protective gloves reported in the templates and the potential health risk associated with exposures via the dermal route, a test programme was conducted on gloves typically in use in many European oil industry manufacturing and distribution operations. 19 pairs of gloves were collected by task force members from industrial operations and two from service stations. The gloves were submitted for chemical permeation testing according to EN 374-3 [15] in an appropriately accredited laboratory. The results are presented in **Appendix 7**.

The following was concluded from the test results:

- There is a large variation in the level of chemical protection provided by gloves commonly in use across Europe when handling gas oils (diesel).
- The majority of the gloves was considered to provide adequate to good chemical protection.
- Some gloves in use are not recommended by their manufacturers for these applications.
- Other gloves in use, whilst recommended, do not appear to provide the protection indicated by their manufacturers.
- Glove performance appears not to be a function solely of:
  - Base material (PVC, nitrile, etc.),
  - Glove thickness (when not taking account of support material).
- Customer gloves at service stations are no more than cosmetic and will provide splash protection only if immediately discarded.

The results of the test program have led to initiatives to improve practices in member companies and have been discussed with representatives of EU-based manufacturers and retailers of protective gloves.

For the purposes of risk assessment these results imply that the reasonable worst case circumstances should assume no dermal protection.

6. CONCLUSIONS

The collection and collation of exposure information for gas oils from CONCAWE member companies confirmed that worker exposure levels are generally low, that there are a wide range of control measures in place, and occurrences of elevated exposure appear to be infrequent. Exposures are often simultaneous with other petroleum products, in particular gasoline, and are therefore difficult to characterise as originating solely from gas oils.

6.1. AVAILABILITY OF MEASUREMENT DATA

The amount of measured inhalation exposure data provided by member companies was limited. The additional inhalation exposure data generated in surveys organised by the task force focussed primarily situations where no interference from other petroleum products was expected; in most cases the detected levels were well below an exposure limit of 100 mg/m^3 as a time-weighted 8 hour average. Exceedances of occupational exposure limits were not encountered.

Recently reported exposure data for cleaning of home heating oil tanks showed much higher exposure levels, often exceeding limit values for gas oils and/or constituents. The main part of this exposure occurs during tank entry; according to the survey report the operatives were wearing suitable respiratory protection during that part of the working day. As a result, their actual full-shift intake dose is not well defined by external exposure measurements, and is expected to be in reality much lower.

There were no measured data available for the estimation of dermal exposures to gas oils, reflecting the unavailability of an accepted, reliable methodology.

6.2. QUALITY OF EXPOSURE INFORMATION

The descriptions of tasks and exposure control measures included in the templates, in combination with measured data from the targeted exposure surveys, allow estimation of inhalation exposures of sufficient quality to satisfy the reliability requirements of the TGD [16].

The estimates of the dermal exposure levels, although also compliant with the procedure recommended in the TGD, are much more rudimentary. Recent investigations reported in the occupational hygiene literature indicate a tendency for the TGD model to overestimate actual dermal exposure [17].

6.3. EXPOSURE LEVELS FOR RISK CHARACTERISATION

On the basis of a breathing volume of 10 m^3 per 8 hour work shift, the measured full-shift exposure levels can be converted to provide an inhalation dose in milligram per working day. Similarly, short-term exposures such as consumer car refuelling can be converted into dose estimates.

The TGD recommends combining the inhalation dose with the dermal dose for comparison with no-effect levels of health effects resulting from chronic exposures. However, inhalation and dermal exposure to gas oils are considered qualitatively different, in that inhalation exposure is to volatile constituents, whereas dermal

exposure is to the heavy constituents due to evaporation from the skin of the light constituents. Therefore the derived inhalation and dermal exposure estimates have not been combined. **Table 5** presents estimates derived from the information collated in this report for some of the main categories, using reasonable worst case values for inhalation exposures.

Table 5 Reasonable Worst Case Gas Oil Exposure estimates for selected jobs/tasks

Job/Task	Frequency	Duration	Inhalation level (mg/m^3)	Inhalation dose (mg/day)	Dermal dose (mg/day)
Refinery tank farm operator	5 day/week	480	18	180	420
Road tanker driver	5 day/week	480	6	60	42
Refuelling private vehicle	once a week	5	11	1	21

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APPENDIX 1: COMPOSITIONAL DATA

Table A1.1 Composition bulk products gas oils: selected components (g/100 g)

	D1	D2	D3	D4	CW 9	CW 11	CW 18	CW 19	CW 20	CW 21	CW 27	CW 28
n-Pentane	<0.005	<0.005	<0.005	<0.005	NR	NR	NR	NR	NR	NR	NR	NR
n-Hexane	NA	NA	NA	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyclohexane	0.016	0.013	0.011	0.016	NR	NR	NR	NR	NR	NR	NR	NR
Benzene	0.004	0.004	0.003	0.006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Heptane	NA	NA	NA	NA	0.02	0.01	0.01	0.02	0.03	0.00	0.00	0.00
Toluene	0.05	0.05	0.07	0.05	0.00	0.00	0.01	0.02	0.00	0.00	0.01	0.00
n-Octane	NA	NA	NA	NA	0.04	0.11	0.05	0.14	0.17	0.04	0.02	0.04
Ethyl benzene	0.04	0.04	0.08	0.04	0.01	0.02	0.01	0.05	0.03	0.03	0.01	0.01
m+p-Xylene	NA	NA	NA	NA	0.04	0.07	0.05	0.25	0.18	0.13	0.04	0.03
o-Xylene	NA	NA	NA	NA	0.03	0.04	0.03	0.12	0.09	0.07	0.02	0.02
n-Nonane	NA	NA	NA	NA	0.20	0.43	0.19	0.62	0.84	0.20	0.04	0.17
n-Decane	NA	NA	NA	NA	0.42	1.02	0.49	0.77	1.04	0.39	0.11	0.69
Iso-propylbenzene	0.02	0.02	0.05	0.02	NR	NR	NR	NR	NR	NR	NR	NR
Tetralin	0.08	0.10	0.26	0.15	NR	NR	NR	NR	NR	NR	NR	NR
Naphthalene	0.11	0.09	0.05	0.08	0.02	0.11	0.02	0.07	0.09	0.12	0.10	0.09
1-Methyl-naphthalene	0.19	0.17	0.08	0.16	NR	NR	NR	NR	NR	NR	NR	NR
2-Methyl-naphthalene	0.30	0.26	0.13	0.24	NR	NR	NR	NR	NR	NR	NR	NR
2,6-Di-methyl-naphthalene	0.08	0.08	0.03	0.07	NR	NR	NR	NR	NR	NR	NR	NR

D1: German home heating oil winter grade
D2: German home heating oil mid-season grade
D3: German automotive diesel winter grade
D4: German automotive diesel mid-season grade
CW9: German automotive diesel fuel
CW11: German home heating fuel
CW18: Italian diesel fuel (Oct. 2003)
CW19: French diesel fuel (Feb. 2003)
CW20: French diesel fuel (April 2003)
CW21: French heating oil (Dec. 2003)
CW27: Italian ultra-low sulphur diesel fuel (Nov. 2003)
CW28: Italian diesel fuel (Nov. 2003)

ND: Not detected
NR: Not reported

Table A1.2 Composition saturated vapour phase gas oils: selected components (mg/m^3) at 20 °C, 1 atm

	D1	D2	D3	D4	CW 9	CW 11	CW 18	CW 19	CW 20	CW 21	CW 27	CW 28
n-Pentane	ND	ND	ND	ND	879	63	138	41	65	23	59	63
n-Hexane	NA	NA	NA	NA	145	52	74	83	136	23	27	21
Cyclohexane	170	140	120	170	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	41	41	31	62	36	6.6	14	ND	ND	11	12	5
n-Heptane	NA	NA	NA	NA	93	72	79	130	246	52	23	27
Toluene	150	130	200	150	127	45	77	102	218	66	48	25
n-Octane	NA	NA	NA	NA	32	91	73	142	233	72	25	39
Ethyl benzene	40	38	73	41	25	25	41	87	150	64	33	27
p-Xylene	NA	NA	NA	NA	66	63	74	198	332	171	45	42
o-Xylene	NA	NA	NA	NA	31	18	25	63	99	64	13	13
n-Nonane	NA	NA	NA	NA	64	121	99	231	400	152	19	64
n-Decane	NA	NA	NA	NA	80	131	174	128	341	213	46	99
Iso-propylbenzene	9.4	8.5	22	9.9	NA	NA	NA	NA	NA	NA	NA	NA
Tetralin	2.9	3.5	9.2	5.3	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	2.9	2.3	1.4	2.1	NA	NA	NA	NA	NA	NA	NA	NA
1-Methylnaphthalene	1.2	1.1	0.5	1.0	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	1.6	1.4	0.7	1.3	NA	NA	NA	NA	NA	NA	NA	NA
2,6-Di-methyl-naphthalene	0.16	0.16	0.05	0.14	NA	NA	NA	NA	NA	NA	NA	NA

D1: German home heating oil winter grade
D2: German home heating oil mid-season grade
D3: German automotive diesel winter grade
D4: German automotive diesel mid-season grade
CW9: German automotive diesel fuel
CW11: German home heating fuel
CW18: Italian diesel fuel (Oct. 2003)
CW19: French diesel fuel (Feb. 2003)
CW20: French diesel fuel (April 2003)
CW21: French heating oil (Dec. 2003)
CW27: Italian ultra-low sulphur diesel fuel (Nov. 2003)
CW28: Italian diesel fuel (Nov. 2003)

Notes: ND: not detected
NA: not analysed
Vapour samples CW report nonane and isopropyl-benzene combined

APPENDIX 2: GAS OIL EXPOSURE INFORMATION FOR JOBS AND TASKS IN EUROPEAN OIL INDUSTRY

Appendix 2.1 Manufacturing

Appendix 2.1.1 Production/On-site Operator

Job Type:	Production/On-site Operator		
Operational area:	Production		
Overview of tasks:	Operators carry out tasks involved in controlling plants which process hydrocarbon streams to produce gas oil.		
Typical number of staff per shift per site?	2 - 20 (most 2 - 10)		
Usual shift hours?	8 - 12 hours		
Maximum number of shifts worked per year per operator	225 (8 hour shift) - 144 (12 hour shift)	Is job rotation operated?	50% of sites use job rotation

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
1. Sample collection. 0.5 or 1 litre sample collected from in line sample point	0 - 4 per shift.	1 - 3 minutes	Automated	X	Stand up wind	X	Gauntlets/ gloves	PVC / neoprene / nitril / Leather
			Closed system, e.g. Dopak type	X	Other - specify		Other - specify	
			Local exhaust ventilation	X				
			General ventilation	X				
			Splash guard	none-splash				
			Other - specify					

Potential for skin contact: Usually open system with splashing potential. Closed system by exception. Some sites indicate no splashing or overfilling. Hands kept clean, leather gloves may be worn

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		One hand front and back	420
Incidental	X		
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
2. Draining equipment: e.g. pumps, lines, gauges prior to maintenance work	2 - 5 per week	15 - 60 minutes	Automated		Drain and flush	X	Gauntlets/ gloves - specify type	PVC / neoprene / nitril / Leather
			Closed system	X	Other - specify		Other - specify	
			General ventilation	X				
			Other - specify	vacuum truck				

Potential for skin contact: Usually open system with splashing potential. Closed system by exception.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front and back	840
Incidental	X		
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
3. Quality control tests, e.g. density, flammability. Carried out in dedicated laboratory area.	2 - 4 per shift	10 minutes	Automated	X	Standard laboratory practice	X	Gauntlets/ gloves - specify type	disposable gloves
			Closed system	x	Other - specify		Other - specify	
			Local exhaust ventilation (fume cupboard)	X				
			General ventilation (on bench)	X				
			Other - specify					

Potential for skin contact: Only small quantities of product handled. Minimal potential for skin contact.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	One hand front	210
Incidental			
Intermittent			
Extensive			

Additional comments: Level of controls vary depending on the nature of the test.

Appendix 2.1 Manufacturing

Appendix 2.1.2 Tank farm/Off-site Operator

Job Type:	Tank farm/Off-site Operator
Operational area:	Production
Overview of tasks:	Ancillary operations carried out by refinery workers in the management of product storage.
Typical number of staff per shift per site?	2 - 16 (Typical 2 - 3)
Usual shift hours?	8 - 12 hours
Maximum number of shifts worked per year per operator	225 (8 hour shift) - 144 (12 hour shift)
Is job rotation operated?	Not normally. Yes at two sites

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
1.a. Sample collection. 0.5 litre sample collected from in line sample point	2 - 8 per shift, typical 4 per shift	2 - 3 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC / Leather
			Closed system, e.g. Dopak type		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify	Splash guard	Not available in all cases			

Potential for skin contact: Usually open system with splashing potential. Closed system by exception. Some sites indicate no splashing or overfilling. Hands kept clean, leather gloves may be worn

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		One hand front and back	420
Incidental	X		
Intermittent			
Extensive			

Additional comments: Automatic QMI (on line quality measurements) at some sites.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
1.b. Top-middle-bottom sample (3 samples) from bulk storage tank	0 - 4 per shift	15 - 20 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC / leather
			Closed system	some	Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify					

Potential for skin contact: May be open system with splashing potential. Contact with product from surface contamination of sample container and sample container line.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental			
Intermittent	X		
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
2. Manual tank dipping/ullage measurement. Dip tape dropped into bulk storage tank via man hole on top of tank.	1 - 8 per month, typically 3 per month	5 - 10 minutes	Automated	X in some cases	Stand up wind	X	Gauntlets/ gloves	PVC / Leather
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify					

Potential for skin contact: Usually automated with periodic manual checks. During manual checks contact with product from surface contamination of dipping tape.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Additional comments:Only when export shipments: Dipping of tank(s) before and after t

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
3. Discharge of tank water bottoms. Open tap at base of bulk storage tank, allow water to flow until discharged - waste water either collected in container or controlled drainage system.	Max 2 per shift. Typical 1 - 2 per week	5 - 10 mins	Automated		Stand up wind	X	Gauntlets/ gloves - specify type	PVC / Leather
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify	vacuum truck				

Potential for skin contact: Usually open system with splashing potential.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	One hand front	210
Incidental			
Intermittent			
Extensive			

Additional comments:Only when export shipments: Dipping of tank(s) before and after t

Additional comments:Normally no splashing. Checking through opened lid in drain

Appendix 2.1 Manufacturing

Appendix 2.1.3 Mechanical Maintenance

Job Type:	Mechanical maintenance		
Operational area:	Production		
Overview of tasks:	Maintenance and cleaning activities on process equipment and vessels		
Typical number of staff per shift per site?	2 - 8 (one site max. 25)		
Usual shift hours?	8 hours		
Maximum number of shifts worked per year per operator	Approx. 225. Not known for specialist contractors	Is job rotation operated?	Not normally

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
1. Maintenance on pre-drained and flushed equipment.	3 - 12 per month	1 - 4 hours	Automated		Pre-drained and flushed equipment	X	Gauntlets/gloves	PVC
	Max 1 per shift		Closed system, e.g. Dopak type		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify					

Potential for skin contact: Although equipment has been pre-drained and flushed, there is still potential for residual product to be present and therefore there is some potential for skin contact with surface contamination.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Additional comments: Includes emptying and steaming of lines.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
2. Tank Cleaning. Removal of sludge from drained bulk storage tank.	1 - 5 per year Typical 2 per year	8-12 hours	Forced ventilation	X	PTW	X	Gauntlets/Gloves	PVC
			General ventilation	X	Specialist contractor	X	Other - specify	PVC coverall
			Other - specify		Drain and flush	X		Impervious knee length boots
					Other - specify			Breathing Apparatus as required - see comments
								Other

Potential for skin contact: High potential for skin contact if insufficient personal protection worn.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	X		

Additional comments: Risk assessment carried out prior to tank entry to determine exact controls. Standard confined space entry requirements to check oxygen and vapour levels applied prior to entry. Clean the tank from the entrance, as far as possible, prior to entry. Enter tank to remove residue using air-supplied Breathing Apparatus until measurements indicate it is satisfactory to downgrade the respiratory protection requirement.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
3. Interceptor cleaning. Removal of sludge from drained interceptor	0 - 2 per year	8 - 12 hours	Forced ventilation	X	PTW	X	Gauntlets/Gloves	PVC
			General ventilation	X	Specialist contractor?	X	Other - specify	PVC coverall
			Other - specify					Impervious knee length boots

Potential for skin contact: High potential for skin contact if insufficient personal protection worn.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	X		

Additional comments: Interceptors not dedicated to gas oil. Standard confined space entry requirements to check oxygen and vapour levels applied. If necessary appropriate respiratory protection would be worn.

For any other standard tasks involving potential exposure to gas oil performed please list details below:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
4. draining equipment (pumps and valves)	2 per month	30 mins	Automated		PTW	X	RPE - specify type	
			Closed system		Stand up wind	X	Full face mask	
Most sites carried out by production operator			Local exhaust ventilation		Drain and flush		Half mask	
			General ventilation	X	Purge		Filtering	
			Other - specify		Other - specify		Air supplied	
							Gauntlets - specify type	
							PVC	X
							Nitrile	
							Other	
							Face shield?	
							Impervious coverall?	

Potential for skin contact:

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front and back	840
Incidental	X		
Intermittent			
Extensive			

Additional comments:product residues are caught in bin and removed by vacuumtruck (up to 50 litres)

Appendix 2.1 Manufacturing

Appendix 2.1.4 Laboratory Technician

Job Type:	Laboratory Technician		
Operational area:	Production laboratory		
Overview of tasks:	A variety of quality control tasks, e.g. density, flash point, sulphur, particulate, viscosity, distillation		
Typical number of staff per shift per site?	1 - 25, majority 4 - 8		
Usual shift hours?	8 (by 12 by exception)		
Maximum number of shifts worked per year per operator	188 / 225	Is job rotation operated?	Not normally

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
1. Laboratory tests. Carried out in dedicated laboratory area.	3 - 40 per shift	1 - 2 min. per sample	Automated (test conducted in closed system)	X	Standard laboratory practice	X	Gauntlets/ gloves	Disposable nitrile gloves
	Typical 3 - 6		Local exhaust ventilation - fume cupboard or LEV above lab equipment	X	Other - specify		Other - specify	
			General ventilation - on bench	X				
			Other - specify					

Potential for skin contact: Only small quantities of product handled. Minimal potential for skin contact.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	One hand front	210
Incidental			
Intermittent			
Extensive			

Additional comments: Level of controls vary depending on the nature of the test.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
2. Sample bottle washing. Emptying of product from sample bottles into waste collection system. Loading of drained bottles into washing machine.	1 - 40 per shift typical 6 per shift	5 - 20 min. (10 min)	Closed system, e.g. bottle washing machine	X	Standard laboratory practice	X	Gauntlets/ gloves	Disposable nitrile gloves
			General ventilation	X	Other - specify		Other - specify	
			Other - specify					

Potential for skin contact: Some potential for spashing during drainage of bottles, breakage and surface contamination depending on care in handling.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Additional comments: Normally carried out in dedicated work area. In some cases: single-use bottles are applied

Appendix 2.1 Manufacturing

Appendix 2.1.5 Rail Car Operator

Job Type:	Rail Car Operator	Rail Car Operator - not carried out at all refineries, but also carried out at some terminals in Germany for one company	
Operational area:	Rail car loading		
Overview of tasks:	Loading of rail cars, including handling of loading arms or hoses and sample collection		
Typical number of staff per shift per site?	1 - 2		
Usual shift hours?	8 - 12 hours		
Maximum number of shifts worked per year per operator	225 (8 hour shift) - 144 (12 hour shift)	Is job rotation operated?	Not normally (yes in one case)

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
1. Top loading rail cars. Fill rail cars via top submerged loading (with or without vapour recovery), including opening and closing of hatches	Maximum 2 trains per shift (20 -24 rail cars) Typically less	8 - 12 hours	Automated - in some cases automatic connection/disconn	X	Stand up wind	X	Gauntlets/ gloves	nitrile, PVC
			Vapour recovery system	X	Other - specify		Other - specify	Vapour filter mask - German legal requirement
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with contaminated lance.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental			
Intermittent	X		
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
2. Bottom loading rail cars. Fill rail cars via bottom loading (with or without vapour recovery). Handling of loading hoses. NO RAIL CAR BOTTOM LOADING CARRIED OUT	No rail car bottom loading carried out		Closed system - breakaway couplings		Stand up wind		Gauntlets/ gloves	
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation					
			Other - specify					

Potential for skin contact:

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			

Additional comments: No bottom loading of rail cars takes place in Europe

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
3. Sample collection. Top middle-bottom sample from each rail car NOT NORMALLY CARRIED OUT			Automated		Stand up wind		Gauntlets/ gloves	
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation					
			Other - specify					

Appendix 2.1 Manufacturing

Appendix 2.1.6 Jetty Staff also known as Harbour Staff

Job Type:	Jetty staff also known as Harbour Staff		
Operational area:	Marine/Harbour jetty		
Overview of tasks:	Operators carry out tasks involved in the loading of marine vessels with gas oil		
Typical number of staff per shift per site?	2 - 7		
Usual shift hours?	8 - 12 hours		
Maximum number of shifts worked per year per operator	225 (8 hour shift) - 144 (12 hour shift)	Is job rotation operated?	Not normally (yes in one case)

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
1. Connection/ disconnection of supply hoses one connection/ disconnection per ship/barge	1 - 7 ships per shift	20 - 30 minutes	Automated		Draining of hose before disconnection	YES or it is not necessary	Gauntlets/ gloves	PVC / neoprene / Leather
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with contaminated hose and spillage, a few litres, during hose disconnection.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front & back	840
Incidental	X		
Intermittent			
Extensive			

Additional comments: Typical number of staff : 1 staff operator + 1 specialist contractor. Gravity draining hose after disconnection: up to 50 litres gasoil

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	PPE used?	Specify type
2. Sample collection. 0.5/ 1 litre sample collected from in line sample point	1 - 3 samples per ship/barge. Up to 9 per shift	2 - 3 minutes	Automated / Closed system	x	Stand up wind	X	Gauntlets/ gloves	PVC / neoprene / Leather
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify	Splash guard	Not available in all cases			

Potential for skin contact: Usually open system with splashing potential. Closed system by exception.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		One hand front and back	420
Incidental			
Intermittent	X		
Extensive			

Additional comments: Specialist Contractor in some cases

Appendix 2.2 Distribution

Appendix 2.2.1 Road Tanker Driver (1)

Product:	**Gas Oil/Diesel**	
Job Type:	**Road Tanker Driver (1)**	
Operational area:	**Terminal gantry and delivery site - normally retail site**	
Overview of tasks:	**Operators load road tanker vehicles at top loading or bottom landing gantries, drive vehicles and discharge product to customer storage vessels. Drivers will be dedicated to either top loading or bottom loading.**	
Typical number of staff per shift per site?	**20 - 50**	Up to 200 by exception
Usual shift hours?	**8 - 12 hours**	Mainland Europe and Scandinavia 8/9 hours; UK 12 hours
Maximum number of shifts worked per year per operator	**144 (12 hour shifts) - 225 (8 hour shifts)**	

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Top loading road cars. Lance is manually lowered into manway on top of road car.	1 - 2 per shift	30 - 45 minutes	Local exhaust ventilation		Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with contaminated lance.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Additional comments: Pick up by third party road tanker drivers are mainly top loading only

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Bottom loading road cars. Hose connection/ disconnection.	1 - 5 per shift	30 - 45 minutes	Closed system - breakaway couplings	X	Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system	X	Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Minimal potential for spillage and contact with contaminated equipment during hose handling, in particular with breakaway couplings.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	Two hands front	420
Incidental			
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Delivery to customer storage: connection/ disconnection of hose	1 - 4 per shift	20 - 30 minutes	Closed system - breakaway couplings	X	Draining of hose into product tank prior to disconnection	X	Gauntlets/ gloves	PVC
			Vapour recovery system	X	Stand up wind	X	Other - specify	
			General ventilation	X	Other - specify			
			Other - specify					

Potential for skin contact: Minimal potential for spillage and contact with contaminated equipment during hose handling. Some potential for spillage during hose disconnection.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	Two hands front	420
Incidental			
Intermittent			
Extensive			

Appendix 2.2 Distribution

Appendix 2.2.2 Subsidiary/Commercial Road Tanker Driver (2)

Product:	**Gas Oil/Diesel**	
Job Type:	**Subsidiary/Commercial road tanker driver (2)**	
Operational area:	**Terminal gantry and delivery site - commercial and domestic premises**	
Overview of tasks:	**Operators load road tanker vehicles at top loading or bottom landing gantries, drive vehicles and discharge product to customer storage vessels. Drivers will be dedicated to either top loading or bottom loading. Mainly top loading, but some bottom loading. Mainly distribution of heating and marine gas oil.**	
Typical number of staff per shift per site?	**10 - 20**	Lowest 1 driver
Usual shift hours?	**8 - 12 hours**	Day shift only; majority are 8 hour shifts
Maximum number of shifts worked per year per operator	**144 (12 hour shifts) - 225 (8 hour shifts)**	

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Top loading road cars. Lance is manually lowered into manway on top of road car.	1 - 2 per shift	30 - 45 minutes	Local exhaust ventilation		Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with contaminated lance.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Additional comments: Pick up by third party road tanker drivers are mainly top loading only

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Bottom loading road cars. Hose connection/ disconnection.	1 - 2 per shift	30 - 45 minutes	Closed system - breakaway couplings	X	Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system	X	Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Minimal potential for spillage and contact with contaminated equipment during hose handling, in particular with breakaway couplings.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	Two hands front	420
Very low			
Very low			
Very low			
Incidental			
Extensive			

Additional comments: **Drivers only top load or bottom load. In assessing exposures these tasks should not be combined.**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Delivery to customer storage: hose with trigger gun.	5 - 10 per shift	20 - 30 minutes	Automatic cut off on nozzle	X	Stand up wind	X	Gauntlets/ gloves	PVC
			General ventilation	X	Other - specify		Other - specify	
			Other - specify					

Potential for skin contact: Some potential for spillage during loading of storage tanks via nozzle.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		One hand front	210
Incidental	X		
Intermittent			
Extensive			

Additional comments: Delivery to domestic and commercial customers, e.g. farmers, construction companies.

Appendix 2.2 Distribution

Appendix 2.2.3 Terminal Operator

Product:	**Gas Oil/Diesel**
Job Type:	**Terminal Operator**
Operational area:	**Terminal tank farm and yard**
Overview of tasks:	**Tank farm activities (e.g. filter cleaning, dipping/sampling/discharge of tank water bottoms) and general site cleaning. In addition, drum filling and rail car deliveries may be carried out. Rail car loading also carried out at some depots in Germany. No drum filling carried out by companies.**
Typical number of staff per shift per site?	**1 - 4**
Usual shift hours?	**8 - 12 hours**
Maximum number of shifts worked per year per operator	**144 (12 hour shifts) - 225 (8 hour shifts)**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1.a. Sample collection. 0.5 litre sample collected from in line sample point	0 - 2 per shift	2 - 3 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC or nitrile
			Closed system, e.g. Dopak type		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify	Splash guard	May not be present			

Potential for skin contact: Usually open system with splashing potential. Closed system by exception.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		One hand front & back	420
Incidental	X		
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1.b. Top-middle-bottom sample (3 samples) from bulk storage tank	0 - 2 per shift	15 - 20 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC or nitrile
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify					

Potential for skin contact: Usually open system with splashing potential. Contact with product from surface contamination of sample container and sample container line.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Manual tank dipping/ullage measurement. Dip tape dropped into bulk storage tank via man hole on top of tank.	1 - 4 per month	5 - 10 minutes	Automated	X	Stand up wind	X	Gauntlets/ gloves	PVC or nitrile
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify					

Potential for skin contact: Usually automated with periodic manual checks. During manual checks contact with product from surface contamination of dipping tape.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Discharge of tank water bottoms. Open tap at base of bulk storage tank, allow water to flow until discharged - waste water either collected in container or controlled drainage system.	1 - 3 per week	5 - 10 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC or nitrile
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify					

Potential for skin contact: Usually open system with splashing potential. Most exposure to the drained 'water bottoms'.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	One hand front	210
Incidental			
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
4. Filter cleaning: Cleaning in line basket filters. Open lid and remove basket. Clean out debris.	1 - 30 per week	5 minutes	Automated		Drain filter housing prior to removal of filter.	X	Gauntlets/ gloves	PVC or nitrile
			Closed system, e.g. Dopak type		Stand up wind	X	Other - specify	
			Local exhaust ventilation		Other - specify			
			General ventilation	X				
			Other - specify					

Potential for skin contact: Usually open system with splashing potential.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front & back	840
Incidental			
Intermittent	X		
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
5. 200l drum filling: lance manually lowered into drums located on a conveyor. See additional comments	1 drum filling operation per week	1 hour	Automated cut off.	X	Specialist contractor used	X	Gauntlets/ gloves	PVC
			Local exhaust ventilation	X	Safe Operating Procedure	X	Apron	PVC
			General ventilation	X	Other - specify		Other - specify	
			Other - specify					

Potential for skin contact: Potential for skin contact with contaminated lance.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental			
Intermittent	X		
Extensive			

Additional comments: Non-routine activity for most terminal operations. Drum filling factilities only located in a few depots. Normally with local exhaust ventilation, but some locations where drum filling is infrequent may rely on general ventilation. This may be performed by a contractor either at the depot or at the contractors drum filling facility.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
6. Off-loading rail car delivery to storage. Connection/ disconnection of hose from each rail car Not all terminals are rail fed. May be carried out by contractor staff	3 per week	45 - 60 minutes	Automated		Draining of hose into product tank prior to disconnection	X	Gauntlets/ gloves	PVC
			Local exhaust ventilation	X	Stand up wind	X	Other - specify	
			General ventilation	X	Other - specify			
			Other - specify					

Potential for skin contact: Minimal potential for spillage and contact with contaminated equipment during hose handling. Some potential for spillage during hose disconnection.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	Two hands front	420
Incidental			
Intermittent			
Extensive			

Appendix 2.2 Distribution

Appendix 2.2.4 Rack Operator

Product:	**Gas Oil/Diesel**
Job Type:	**Rack Operator - Job Type only present in one company; another has a Supervisor who monitors drivers loading**
Operational area:	**Terminal gantry**
Overview of tasks:	**Operators are dedicated to loading road tanker vehicles at top loading or bottom landing gantries.**
Typical number of staff per shift per site?	**1 - 2**
Usual shift hours?	**8 - 12 hours**
Maximum number of shifts worked per year per operator	**144 (12 hour shifts) - 225 (8 hour shifts)**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Top loading road cars. Lance is lowered into manway on top of road car.	8 - 10 per shift	30 - 45 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with contaminated lance.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental			
Intermittent	X		
Extensive			

Additional comments: Number of top loading operations dependent on whether there is also bottom loading available. Frequency indicated is for 100% top loading. **In assessing exposures top and bottom loading tasks should not be combined.**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Bottom loading road cars. Hose connection/ disconnection.	8 - 10 per shift	30 - 45 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Closed system - breakaway couplings	X	Other - specify		Other - specify	
			Vapour recovery system	X				
			General ventilation	X				
			Other - specify					

Potential for skin contact: Minimal potential for spillage and contact with contaminated equipment during hose handling, in particular with breakaway couplings.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front	420
Incidental	X		
Intermittent			
Extensive			

Additional comments: Number of bottom loading operations dependent on whether there is also bottom loading available. Frequency indicated is for 100% bottom loading. **In assessing exposures top and bottom loading tasks should not be combined.**

Appendix 2.2 Distribution

Appendix 2.2.5 Vehicle Mechanic

Product:	**Gas Oil/Diesel**
Job Type:	**Vehicle mechanic - Not carried out at Company depots. All performed by road car owners (where contracted out) or contractor**
Operational area:	**Vehicle Service Bay**
Overview of tasks:	**Operators carry out maintenance on road tanker vehicles including: vehicle hose inspections, repair and pressure testing; tank compartment inspection. It is usual for these activities to be contracted out.**

Typical number of staff per shift per site?	**2**
Usual shift hours?	**8 hours**
Maximum number of shifts worked per year per operator	**225**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Hose inspection, repair and pressure testing	**5 per shift**	**10 minutes**	**Automated**		**Safe Operating Procedure**	**X**	**Gauntlets/ gloves**	**PVC**
			Local exhaust ventilation		**Other - specify**		**Other - specify**	
			General ventilation	**X**				
			Other - specify					

Potential for skin contact: Hose may have internal surface contamination with product.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		**Two hands front**	**420**
Incidental	**X**		
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Road vehicle storage tank inspection. Visual inspection from tank manhole. By exception staff may need to enter tank.	**5 per shift**	**10 minutes**	**Automated**		**Permit to Work - if tank entry is required**	**X**	**Gauntlets/ gloves**	**PVC**
			Local exhaust ventilation	**X**	**Other - specify**		**Respiratory Protection**	**Air-supplied Breathing Apparatus**
			General ventilation	**X**			**Body protection**	**Impervious coverall and boots**
			Other - specify				**Other - specify**	

Potential for skin contact: Potential for contact with contaminated internal tank surfaces and small quantities of fuel at base of tank in the event that tank entry is required.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	**X**		

Additional comments: Permit to work requirements to entry into a confined space applies, drainage and venting of the tank and checking for oxygen and hydrocarbon levels. If necessary, air supplied breathing apparatus will be worn.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Drainage of fuel from vehicle fuel tank or product storage tank. Fuel pumped into separate container	**1 per shift**	**5 minutes**	**Closed system**		**Safe Operating Procedure**	**X**	**Gauntlets/ gloves**	**PVC**
			Local exhaust ventilation		**Other - specify**		**Other - specify**	
			General ventilation	**X**				
			Other - specify	**Use of fuel retriever**				

Potential for skin contact: Potential for contact with contaminated internal tank surfaces and spillage during fuel transfer

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		**2 hands front**	**420**
Incidental	**X**		
Intermittent			
Extensive			

Appendix 2.2 Distribution

Appendix 2.2.6 Equipment Maintenance

Product:	**Gas Oil/Diesel**
Job Type:	**Equipment maintenance**
Operational area:	**Terminal**
Overview of tasks:	**Preparing equipment for maintenance; performing maintenance. Normally contracted out, but task 'preparing equipment for maintenance' may be done by company staff.**

Typical number of staff per shift per site?	**Contractor as required**
Usual shift hours?	**8 hours**
Maximum number of shifts worked per year per operator	**Specialist contractor - variable**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Preparing equipment for maintenance, e.g. isolate and drain down pumps, gauges, lines	1 - 4 per month may be more	30 minutes	Automated		Specialist Contractor	X	Gauntlets/ gloves	PVC
			Local exhaust ventilation		PTW	X	Other - specify	
			General ventilation	X	Other - specify			
			Other - specify					

Potential for skin contact: Potential for contact with contaminated surfaces

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		Two hands front & back	840
Incidental	X		
Intermittent			
Extensive			

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Carry out maintenance on equipment, e.g. replace pump packing	1 - 4 per month	up to 8 hours	Automated		Specialist Contractor	X	Gauntlets/ gloves	PVC
			Local exhaust ventilation		PTW	X	Other - specify	
			General ventilation	X	Drained and flushed	X		
			Other - specify		Other - specify			

Potential for skin contact: Small potential for contact with contaminated surfaces

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	X		

Additional comments: Work only carried out on equipment after draining and flushing.

Appendix 2.2 Distribution

Appendix 2.2.6 Specialist Cleaning Tasks

Product:	**Gas Oil/Diesel**
Job Type:	**Specialist cleaning tasks - Contracted out by all companies**
Operational area:	**Terminal**
Overview of tasks:	**Cleaning tanks and interceptors**

Typical number of staff per shift per site?	**2 - 3**
Usual shift hours?	**8 hours**
Maximum number of shifts worked per year per operator	**Specialist Contractor - variable**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1.Tank Cleaning. Removal of sludge from drained bulk storage tank.	7 - 10 year cycle per tank	Up to 8 hours	Forced ventilation	X	Specialist Contractor	X	Gauntlets/ gloves	PVC or nitrile
			General ventilation		Drained, flushed and vented	X	Other - specify	PVC coverall
			Other - specify		Permit to Work	X		Impervious knee length boots
					Other - specify			Breathing Apparatus as required - see comments
								Other?

Potential for skin contact: High potential for skin contact if insufficient personal protection worn.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	X		

Additional comments: Risk assessment carried out prior to tank entry to determine exact controls. Standard confined space entry requirements to check oxygen and vapour levels applied prior to entry. Clean the tank from the entrance, as far as possible, prior to entry. Enter tank to remove residue using air-supplied Breathing Apparatus until measurements indicate it is satisfactory to downgrade the respiratory protection requirement. According to national legislation.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Road vehicle tank cleaning. May be carried out by vehicle maintenance staff	1 per year	15 - 30 minutes	Forced ventilation	X	Specialist Contractor	X	Gauntlets/ gloves	PVC or nitrile
			General ventilation		Drained, flushed and vented	X	Other - specify	PVC coverall
			Other - specify		Permit to Work	X		Impervious knee length boots
					Other - specify			Breathing Apparatus as required - see comments
								Other?

Potential for skin contact: High potential for skin contact if insufficient personal protection worn.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	X		

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Interceptor cleaning. Removal of sludge from drained interceptor	1 - 2 per year	up to 8 hours	Forced ventilation - only as required	X	Specialist contractor?	X	Gauntlets/Gloves	PVC
			General ventilation	X	Permit to Work	X	Other - specify	PVC coverall
			Other - specify		Other - specify			Impervious knee length boots
								Breathing Apparatus as required - see comments
								Other?

Potential for skin contact: High potential for skin contact if insufficient personal protection worn.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	X		

Additional comments: Interceptors not dedicated to gas oil. Standard confined space entry requirements to check oxygen and vapour levels applied. If necessary appropriate respiratory protection would be worn.

Appendix 2.3 Retail

Appendix 2.3.1 Service Station Attendant

Product:	**Gas Oil/Diesel**
Job Type:	**Service Station Attendant. The majority are service attended with the exception of UK.**
Operational area:	**Retail site**
Overview of tasks:	**Refuelling customer vehicles. On average, diesel sales comprise 40% of total fuel sales.**

Typical number of staff per shift per site?	**1-3**
Usual shift hours?	**8 hours**
Maximum number of shifts worked per year per operator	**225**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Refuelling vehicles with gas oil	20 - 30 per shift	3 - 6 minutes	Local exhaust ventilation		Stand up wind	X	Gauntlets/ gloves	PVC/nitril/none
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with drips from filling nozzle.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		One hand front	210
Incidental	X		
Intermittent			
Extensive			

Appendix 2.3 Retail

Appendix 2.3.2 Pump Calibration Engineer

Product:	**Gas Oil/Diesel**
Job Type:	**Pump calibration engineer**
Operational area:	**Retail forecourt**
Overview of tasks:	**Operators test pumps to check calibration of flow rate.**

Typical number of staff per shift per site?	**Contractor**
Usual shift hours?	**8 hours**
Maximum number of shifts worked per year per operator	**225**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. 20 litres of fuel pumped into measuring can to check calibration of pump.	**15 - 20 diesel nozzles per day**	**3 - 5 minutes**	**Local exhaust ventilation**		**Use of dedicated contractor**	**X**	**Gauntlets/ gloves**	**PVC**
			Drain and Flush		**Permit to Work**		**Other - specify**	
			General ventilation	**X**	**Other - specify**			
			Other - specify					

Potential for skin contact: Potential for skin contact with fuel during filling of container if fuel splashes

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		**Two hands front**	**420**
Incidental	**X**		
Intermittent			
Extensive			

Additional comments: In and around the forecourt for approximately 5 hours per day.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Interceptor cleaning. Removal of sludge from drained interceptor	**1 per year**	**up to 8 hours**	**Forced ventilation**	**X**	**PTW**	**X**	**Gauntlets/Gloves**	**PVC**
			General ventilation	**X**	**Specialist contractor**	**X**	**Other - specify**	**PVC coverall**
			Other - specify		**Other - specify**			**Impervious knee length boots**
								Breathing Apparatus as required - see comments
								Other?

Potential for skin contact: High potential for skin contact if insufficient personal protection worn.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	**X**		

Additional comments: Interceptors not dedicated to gas oil. Standard confined space entry requirements to check oxygen and vapour levels applied. If necessary appropriate respiratory protection would be worn.

Appendix 2.3 Retail

Appendix 2.3.3 Forecourt Cleaner

Product:	**Gas Oil/Diesel**
Job Type:	**Forecourt Cleaner (may be shared with shop work)**
Operational area:	**Retail forecourt**
Overview of tasks:	**General cleaning activities, including spillage clearance. Operator is working in and around forecourt with potential for exposure to ambient levels of products sold on forecourt. May also include shop work away from forecourt.**
Typical number of staff per shift per site?	**1**
Usual shift hours?	**8 hours**
Maximum number of shifts worked per year per operator	**225**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1.Spillage clearance	Rare - 1 per month (>1 litre)	5 - 10 minutes	Refuelling gun fitted with automatic cut off	X	Standard Operating Procedure	X	Gauntlets/ gloves	PVC
			General ventilation	X	Contain with sorbent	X	Other - specify	
			Other - specify		Other - specify			

Potential for skin contact: Potential for skin contact with contaminated adsorbent material.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	2 hands front	420
Incidental			
Intermittent			
Extensive			

Additional comments: Spillages during refuelling vehicles may occur when customers use Heavy Goods Vehicle nozzles to refuel cars as they are operated at a higher flow rate.

Appendix 2.3 Retail

Appendix 2.3.4 Specialist Cleaning Tasks

Product:	**Gas Oil/Diesel**
Job Type:	**Specialist cleaning tasks**
Operational area:	**Retail site**
Overview of tasks:	**Cleaning tanks. Please note that interceptors are not dedicated to diesel and do not require routine cleaning. If necessary they are pumped out - minimal potential for exposure.**

Typical number of staff per shift per site	**2 - 3**
Usual shift hours	**8 hours**
Maximum number of shifts worked per year per operator	**Specialist Contractor - not known**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1.Tank Cleaning. Removal of sludge from drained bulk storage tank.	**Rare event**	**Up to 8 hours**	**Forced ventilation**	**X**	**Specialist Contractor**	**X**	**Gauntlets/ gloves**	**PVC**
			General ventilation		**Drained, flushed and vented**	**X**	**Other - specify**	**PVC coverall**
			One site indicated use of specialist equipment to clean and remove sludge. Not necessary to enter tank	**X**	**Permit to work**	**X**		**Impervious knee length boots**
					Other - specify			**Breathing Apparatus**
								Other?

Potential for skin contact: High potential for skin contact if insufficient personal protection worn.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	**X**		

Additional comments: Risk assessment carried out prior to tank entry to determine exact controls. Standard confined space entry requirements to check oxygen and vapour levels applied prior to entry. Clean from the man way entrance as far as possible. Enter tank to remove residue using air-supplied Breathing Apparatus.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Inspection of tank - reported by one company	**rare event**	**1 hour**	**Automated**		**PTW**	**X**	**RPE - specify type**	
			Closed system		**SOP**		Full face mask	
			Forced ventilation	**X**	**Drain and flush**		Half mask	
			General ventilation	**X**	**Purge**		Filtering	
			Other - specify		**Other - specify**		Air supplied	**X**
							Gauntlets - specify type	
							PVC	**X**
							Nitrile	
							Other	
							Face shield?	
							Impervious coverall?	**X**

Potential for skin contact: Entry into tank to inspect integrity of walls after tank has been cleaned. Risk assessment carried out prior to tank entry to determine exact controls. Standard confined space entry requirements to check oxygen and vapour levels applied prior to entry.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low			
Incidental			
Intermittent			
Extensive			
Not applicable - PTW	**X**		

Additional comments: Programme to replace all tanks with double-walled skins with leak detection by 2012. This will eliminate requirement to enter tanks for inspection purposes.

Appendix 2.3 Retail

Appendix 2.3.5 Vehicle Mechanic

Product:	**Gas Oil/Diesel**
Job Type:	**Vehicle mechanic**
Operational area:	**Vehicle Service Bay - normally dealer owned I.e. not operated/managed by retail site**
Overview of tasks:	**Operators carry out maintenance on customer vehicles which may be fuelled by diesel. Exposure to diesel may occur when the fuel tank needs to be drained. Not a routine occurrence.**

Typical number of staff per shift per site	**1-2**
Usual shift hours	**8 hours**
Maximum number of shifts worked per year per operator	**225**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Drainage of fuel from fuel tank/working on fuel tank	Rare event. Max 2 per month	10 - 20 minutes	Local exhaust ventilation		Standard Operating Procedure	X	Gauntlets/ gloves	PVC
			General ventilation	X	Other - specify		Other - specify	
			Other - specify	Use of fuel retriever equipment				

Potential for skin contact: Potential for skin contact with contaminated surfaces and product during temporary transfer to storage container.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low	X	2 hands front	420
Incidental			
Intermittent			
Extensive			

APPENDIX 3: QUALITY CONTROL TEST RESULTS FOR GAS OIL VAPOUR EXPOSURE MONITORING

Spike level	Month analysis	Number of spikes	Component (µg / tube)											
			benzene	toluene	ethyl-benzene	m-xylene	o-xylene	p-xylene	1,3,5-trimethyl-benzene	naphtha-lene	n-nonane	n-decane	n-undecane	n-dodecane
1	Spiked amount		15.1 ± 0.6	74.6 ± 3.0	29.8 ± 1.2	60.2 ± 2.4	59.9 ± 2.4	60.1 ± 2.4	15.1 ± 0.6	15.3 ± 0.6	15.2 ± 0.6	15.0 ± 0.6	15.2 ± 0.6	15.3 ± 0.6
	Dec. 03	4	13.5 ± 1.3	63.5 ± 9.6	23.9 ± 4.9	49.0 ± 10.4	47.4 ± 10.2	49.5 ± 10.5	12.2 ± 2.3	11.7 ± 2.2	11.6 ± 2.3	12.3 ± 2.3	12.4 ± 2.3	10.7 ± 3.7
	Jan. 04	3	11.8 ± 4.2	58.7 ± 21.5	22.8 ± 8.6	45.2 ± 17.1	43.4 ± 16.6	45.4 ± 17.3	11.5 ± 4.3	11.0 ± 4.4	12.0 ± 4.4	11.7 ± 4.3	12.4 ± 4.5	12.4 ± 4.7
	Feb. 04	3	14.4 ± 0.5	72.5 ± 5.1	29.9 ± 1.6	59.3 ± 2.9	59.7 ± 2.6	59.6 ± 2.9	15.1 ± 0.6	13.2 ± 0.6	14.6 ± 0.5	15.1 ± 0.5	15.0 ± 0.6	15.4 ± 0.9
2	Spiked amount		40.2 ± 1.6	199 ± 8	79.5 ± 3.2	160 ± 6	160 ± 6	160 ± 6	40.2 ± 1.6	40.9 ± 1.6	40.4 ± 1.6	40.1 ± 1.6	40.5 ± 1.6	40.7 ± 1.6
	Dec. 03	3	37.9 ± 0.5	190 ± 2	75.7 ± 0.7	156 ± 2	152 ± 2	157 ± 3	38.6 ± 0.8	37.1 ± 1.0	36.9 ± 0.6	38.9 ± 0.4	38.6 ± 0.5	41.9 ± 0.3
	Jan. 04	4	38.0 ± 0.3	190 ± 1	75.0 ± 1.0	149 ± 3	141 ± 3	149 ± 3	37.0 ± 1.8	31.5 ± 4.2	38.6 ± 2.2	37.5 ± 2.5	38.6 ± 2.7	37.8 ± 3.1
	Feb. 04	3	39.4 ± 1.0	198 ± 4	80.0 ± 1.5	159 ± 3	160 ± 4	159 ± 3	40.3 ± 1.2	35.2 ± 1.8	38.9 ± 1.1	40.2 ± 1.2	38.9 ± 1.0	38.6 ± 0.8
3	Spiked amount		161 ± 6	797 ± 32	318 ± 13	642 ± 26	640 ± 26	642 ± 26	161 ± 6	164 ± 6	162 ± 6	161 ± 6	162 ± 6	163 ± 6
	Dec. 03	3	149 ± 2	747 ± 8	300 ± 3	627 ± 8	604 ± 7	631 ± 8	151 ± 4	130 ± 11	145 ± 3	149 ± 6	142 ± 8	152 ± 10
	Jan. 04	3	137 ± 26	671 ± 156	275 ± 55	550 ± 99	535 ± 92	552 ± 99	147 ± 15	145 ± 13	153 ± 17	149 ± 12	149 ± 14	146 ± 16
	Feb. 04	4	160 ± 2	801 ± 13	319 ± 9	635 ± 18	637 ± 24	639 ± 19	159 ± 11	144 ± 15	153 ± 10	157 ± 14	150 ± 14	149 ± 13

APPENDIX 4: INHALATION EXPOSURE MEASUREMENTS FOR GAS OILS OPERATIONS

Job title or work task	Date	Place	Duration	THC [2] mg/m^3	Selected components in mg/m^3 [3]					Comments (or sample ref.)
					Benzene	Toluene	Ethyl-benzene	Xylenes	n-hexane	
Road tanker loading	27.02.04	Germany	20	9.4						
Road tanker loading	27.02.04	Germany	18	74.3	0.5	2.1		1.1	3.2	Gasoline co-exposure
Rail cars loading	01.03.04	UK	34	28.3	0.2	2.3				Gasoline traces
Rail cars loading	01.03.04	UK	113	5.5	0.04					
Jetty crew ship loading	02.03.04	UK	120	3.2	0.2					
Road tanker driver	02.03.04	UK	26	0.9						Gasoline traces
Bottom loading road tanker	02.03.04	UK	19	3.6	0.1					
Top loading road tanker	03.03.04	UK	11	2.2	0.1					
Top loading road tanker	03.03.04	UK	11	3.7						
Rail car loading	03.03.04	UK	105	2.1						Gasoline traces
Tank farm sampling	03.03.04	UK	45	0.7	0.02					
Refinery lab technician (ULSD analysis)	03.03.04	UK	100	57.5	0.6	7.6			1.6	Acetone 20 mg/m^3
Refuelling Heavy Goods Vehicle (HGV)	28.10.03	NL	11	0.6						
Refuelling HGV	28.10.03	NL	13	0.2						
Refuelling HGV	28.10.03	NL	11	16.9						

[2] Total Hydrocarbons, quantified as n-dodecane equivalent

[3] Naphthalene was also considered a component of interest, but was not detected (< 1 mg/m^3) in any of the samples

Job title or work task	Date	Place	Dura-tion	THC [2] mg/m[3]	Selected components in mg/m[3]					Comments (or sample ref.)
					Benzene	Toluene	Ethyl-benzene	Xylenes	n-hexane	
Refuelling HGV	04.11.03	NL	13	5.3						
Refuelling HGV	04.11.03	NL	17	1.9						
Refuelling HGV	04.11.03	NL	12	5.6						
Refuelling HGV	10.11.03	NL	14	5.6	0.1					
Refuelling HGV	10.11.03	NL	12	4.7	0.1					
Refuelling HGV	10.11.03	NL	12	8.9	0.1					
Road tanker driver	13.11.03	NL	604	0.4						
Road tanker driver	13.11.03	NL	360	0.7						
Road tanker driver	13.11.03	NL	375	1.4						
Road tanker driver	13.11.03	NL	330	3.6	0.03					
Road tanker driver	27.11.03	NL	350	0.5						
Road tanker driver	27.11.03	NL	587	3.3	0.02					
Delivery	13.11.03	NL	26	Nd						
Delivery	13.11.03	NL	9	1.2						
Delivery	13.11.03	NL	27	2.2						
Delivery	13.11.03	NL	25	0.1						
Delivery	13.11.03	NL	15	0.7						
Delivery	13.11.03	NL	15	5.4						
Delivery	13.11.03	NL	12	0.7						
Delivery	13.11.03	NL	45	0.7						
Delivery	27.11.03	NL	10	13.7	0.1					
Delivery	27.11.03	NL	13	138.3	1.1	4.4		3.0	4.0	Tank overfilled
Delivery	27.11.03	NL	15	34.3	0.2	1.0				
Delivery	27.11.03	NL	14	20.2	0.1					
Road tanker top loading	16.01.04	B	19	2.5						
Road tanker top loading	16.01.04	B	19	0.3						
Road tanker top	16.01.04	B	15	3.0	0.05					

Job title or work task	Date	Place	Duration	THC [2] mg/m^3	Selected components in mg/m^3 [3]					Comments (or sample ref.)
					Benzene	Toluene	Ethyl-benzene	Xylenes	n-hexane	
loading										
Road tanker top loading	16.01.04	B	12	111.4	0.3	2.2			1.1	Previous truck load: Gasoline
Road tanker top loading	16.01.04	B	20	1.6						
Road tanker top loading	16.01.04	B	14	1.3						
Road tanker top loading	16.01.04	B	26	6.3	0.1					
Road tanker top loading	16.01.04	B	19	0.1						
Road tanker top loading	16.01.04	B	14	5.8	0.1					
Road tanker top loading	16.01.04	B	29	8.7	0.1					
Road tanker top loading	16.01.04	B	11	1.0						
Tank farm – filter change	01.12.03	B	43	6.2	0.03					
Tank farm – filter change	01.12.03	B	43	4.6	0.04					
Tank farm – filter change	05.12.03	B	47	4.0	0.02					
Tank farm – filter change	05.12.03	B	47	4.2	0.03					
Tank farm – filter change	12.12.03	B	50	20.4	0.1			1.2		
Tank sampling	09.12.03	B	16	10.8	0.2					
Tank sampling	12.12.03	B	12	4.5						
Road tanker top loading	30.06.04	D	13	75.2	0.5	1.9		1.5	1.4	Home heating oil (30 °C)
Road tanker top loading	30.06.04	D	29	55.4	0.5	1.7			2.4	Diesel fuel (36 °C)
Road tanker top loading	30.06.04	D	16	7.2						HH oil
Road	30.06.04	D	8	172.1	1.2	4.1	1.7	4.1	7.5	HH oil

Job title or work task	Date	Place	Dura-tion	THC [2] mg/m[3]	Selected components in mg/m[3]					Comments (or sample ref.)
					Benzene	Toluene	Ethyl-benzene	Xylenes	n-hexane	
tanker top loading										
Road tanker top loading	30.06.04	D	28	14.4	0.1					HH oil
Road tanker top loading	30.06.04	D	19	8.0						HH oil
Road tanker top loading	30.06.04	D	8	3.1						HH oil
Road tanker top loading	30.06.04	D	14	65.6	0.3	1.7		2.8		HH oil
Road tanker top loading	30.06.04	D	22	24.8	0.2					HH oil
Road tanker driver – bottom loading/VR at terminal, no VR at delivery site	08.02.05	UK	360	1.3	ND	ND	ND	ND	ND	Industrial/heating gas oil
Road tanker bottom loading/VR	08.02.05	UK	28	0.5	ND	ND	ND	ND	ND	Industrial/heating gas oil
Road tanker driver – bottom loading/VR at terminal, no VR at delivery site	09.02.05	UK	318	11	0.1	ND	ND	ND	ND	Industrial/heating gas oil

APPENDIX 5: EUROPEAN GAS OIL CONSTITUENT CONCENTRATIONS IN SATURATED VAPOUR SPACE AND DURING TWO MEASURED ELEVATED OCCUPATIONAL EXPOSURES (2001 - 2004)

Analysed hydrocarbon component in routine analysis *Figures in mg/m^3*	Saturated vapour (product at 20°C) [5]		Exposure during tank overfill at industrial customer site: 138 mg/m^3	Highest exposure during road tanker top loading (product at 30°C): 172 mg/m^3
	Diesel fuel	Home heating oil		
n-Pentane	ND	ND		7.6
2-Methylbutane				7.9
n-Hexane			4.0	7.5
2-Methylpentane			4.2	9.3
3-Methylpentane			2.0	5.0
Methylcyclopentane				3.4
Cyclohexane	170	140	3.5	2.9
n-Heptane			4.8	5.1
n-Octane			4.4	6.5
Iso-octane			1.4	1.6
n-Nonane			3.3	5.5
n-Decane			2.1	5.4
n-Undecane			1.1	2.1
Benzene	62	41	1.1	1.2
Toluene	150	130	4.4	4.1
Ethylbenzene	41	38		1.7
Cumene	9.9	8.5		1.1
m-Xylene			1.8	2.6
p-Xylene				
o-Xylene			1.2	1.5
Mesitylene	29	24		
1,2,3-Trimethylbenzene				1.1
1,2,4-Trimethylbenzene			1.4	2.9
1,2,3,5-Tetramethylbenzene				
Tetraline	5.3	3.5		
Naphthalene	2.1	2.3		

ND Not Detected

APPENDIX 6: INHALATION AND DERMAL EXPOSURE ESTIMATES (EASE) FOR GAS OIL USES IN LUBRICANT APPLICATIONS

Application	Inhalation estimate (ppm)	Dermal estimated $mg.cm^{-2}.day^{-1}$	Total dermal exposure (two hands, one-sided) $mg.day^{-1}$	Notes
Flute grinding, metal processing, spindle oils	100-200	0.1-1	210	Ambient temperature
Gear oils	10-20	0-0.1	21	Ambient temperature
Process & extender oils	1-3	'very low'	--	Elevated temperature
Mould release oils	500-1000	0.1-1	210	Ambient temperature

Notes:
- Assume applied product is 100% gas oil (worst case)
- Volatility parameters used:
  - gas oil at 25 °C: 0.13 kPa (ambient temperature)
  - gas oil at 80 °C: 1.4 kPa (elevated temperature)
- Surface of two hands, one-sided: 420 cm^2

APPENDIX 7: GAS OILS PERMEABILITY TEST RESULTS FOR SELECTED GLOVES

Glove n°	Country of use	Operation of use	Type/ Brand clearly identified	Base material[4]	Test results:			Comments
					thickness (mm)	break through time (min)	EN 374-3 class	
1	Germany	Refinery	Yes	NBR	1.33	1-3	0	
2	Germany	Refinery	Yes	NBR	0.95	54-70	2	
3	Italy	Refinery/Terminal	Yes	N.A.	1.15	60-74	2	
4	UK	Refinery	Yes	PVC	1.26	178-200	4	
5	Italy	Laboratory	No	N.A.	0.11	> 480	6	
6	Italy	Laboratory	Yes	Nitrile	0.12	282-458	5	
7	UK	Laboratory	No	N.A.	0.13	1-3	0	
8	Norway	Refinery	Yes	Nitrile	0.58	> 480	6	Manufacturer test data for kerosene: EN 374 class 5
9	France	Refinery	Yes	PVC	1.40	158-214	4	Manufacturer recommends for oil refineries
10	UK	Refinery	Yes	PVC	1.46	118-126	3	Manufacturer recommends for oil refineries
11	Netherlands	Distribution	Yes	Nitril-PVC	1.86	96-118	3	
12	UK	Distribution	Yes	PVC	1.28	86-142	3	
13	Netherlands	Refinery/Distribution	Yes	PVC	1.35	198-220	4	
14	UK	Distribution	Yes	N.A.	1.25	62-78	3	
15	Netherlands	Customers retail stations	No	N.A.	0.02	0	0	
16	UK	Customers retail stations	No	N.A.	0.01	0	0	
17	Italy	Distribution drivers	Yes	PVC	1.70	1-3	0	
18	Italy	Refinery	Yes	Neoprene	1.90	> 480	6	
19	Netherlands	Distribution drivers	No	N.A.	1.82	78-102	3	
20	Denmark	Retail stations	Yes	Nitrile	1.44	1-3	0	Manufacturer lists as “tough industrial”, not “chemical resistant”
21	Denmark	Distribution drivers	Yes	Nitrile	1.61	1-3	0	Manufacturer recommends glove for construction work

EN 374-3 Class	Break-through time (min)	Manufacturer advice ‘for this substance’
0	< 10	Choose a different glove
1	10 – 30	Choose a different glove
2	30 – 60	Caution: not for heavy exposure
3	60 – 120	Caution: not for heavy exposure
4	120 – 240	Recommended but change every 2 – 4 hours
5	240 – 480	Highly recommended
6	> 480	Highly recommended

[4] N.A.: no information available
NBR: nitril butadiene rubber
PVC: polyvinylchloride