Human exposure information for EU substance risk assessment of kerosine

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ABSTRACT

Information is presented on inhalation and dermal exposures to kerosine for workers in European manufacturing, distribution and aviation refuelling operations, for use in substance risk assessment according to EU regulations.

KEYWORDS

Kerosine, kerosene, jet fuel, home heating oil, occupational exposure, risk assessment

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SUMMARY

CONCAWE is currently undertaking a risk assessment on the group of substances collectively referred to as kerosines, including their blending components (refinery streams) in the frame work of EU chemical substances regulations.

Information on levels of human exposure resulting from the manufacture, distribution and use of kerosines 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 as well as indirect, modelling approaches.

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

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 kerosine vapour from CONCAWE member companies confirmed that worker exposure levels are generally low, that a wide range of control measures are in place, and that occurrences of elevated exposure appear to be infrequent. More elevated exposures, usually of a duration less than a full work shift, may be encountered during maintenance tasks when kerosine-containing equipment has to be opened (e.g. for in-line filter changes).

Published data on inspection and maintenance operations inside fuel tanks of aircraft indicate that inhalation and dermal exposures may be high when kerosine fuel residues are still present. Exposure control under these circumstances relies heavily on personal protective equipment.

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. Kerosines and their blending components (refinery streams) are the third group of products in the programme, following gasoline and gas oils.

Information on levels of human exposure resulting from the manufacture, 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 collect and where necessary generate the exposure information needed for the risk assessment of petroleum products. This report provides the result of the work of H/STF-29 on kerosines and should be considered as supporting the Exposure Assessment chapter of the Human Health section of an EU-style substance risk assessment of kerosines 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 within a small proportion of the exposed population. 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.

A similar report has been published for gas oils [13].

1.2. SCOPE

The activities that have been considered include the manufacture, distribution and use of petroleum products known collectively as kerosines. The CONCAWE grouping scheme for classification and labelling petroleum products [1] includes straight-run kerosine, cracked kerosine and the group ‘kerosine-unspecified’ within the broad category ‘kerosines’. 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 aviation fuel (jet fuel), home heating oil and automotive fuel. Consumer applications include use of kerosine as lighter fuel, lamp oil and as degreaser or cleaner. Use of kerosine in cutback bitumens is included, although this application is in the process of being phased out. Not included are the combustion products resulting from the use of kerosines as a fuel.

The grouping of refinery-produced kerosines and blended products reflects similarities in physical properties and composition, as well as 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.

An essential element of this exposure assessment is the estimation of dermal exposure to liquid kerosine. The techniques available to measure dermal exposure are not as far advanced, or as standardised, as those 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, kerosines 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.

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 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 via their CONCAWE Scientific Council member 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, however where data were available these are presented, but the exposure assessment should not be considered as systematic or complete in this respect.

3. SUBSTANCE CHARACTERISATION

This section contains extracts of report 99/52 [4].

Kerosine is the generic name for the lighter end of a group of petroleum substances known as middle distillates, the heavier end being gas oils. It consists predominantly of hydrocarbons in the C_9 to C_{16} carbon number range.

A comprehensive description of the health and environmental characteristics of kerosines, relevant to risk assessment, is contained in CONCAWE product dossier 94/106 [3]. This indicates that the group of kerosines comprises the following classes:

- straight-run kerosines (4 EINECS numbers),
- cracked kerosines (11 EINECS numbers),
- other kerosines (16 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_9 to C_{16}.

Kerosines are primarily used as:

- jet fuel,
- fuel for industrial and domestic heating appliances,
- automotive fuel (Swedish diesel MK-1),
- industrial solvent in the formulation of products such as cleaning agents, pesticides and printing inks,
- diluent for certain lubricants such as two-stroke engine oils.

In addition, kerosines are used for domestic cooking and as lamp oils. A known misuse of kerosine is as a fire-eater's fluid.

Aviation turbine or jet fuels fall broadly into three main types:

- kerosine type, usually blends of different kerosine components,
- "wide cut" type, in which kerosine components are blended with low flash point naphthas, for example, heavy straight-run naphtha, to give more volatile fuels covering the C_4 to C_{16} carbon number range,
- high flash point kerosine type, blends of kerosine components having a minimum closed cup flash point of 60°C.

The main grades of jet fuel are as follows.

Jet A-1	kerosine type fuel used in civil aircraft. Maximum freezing point of -47°C.
Jet A	as Jet A-1, but with a freezing point of - 40°C maximum. This grade is only available in the USA and Canada.
Jet B	wide cut type used in civil aircraft.
JP-4 (AVTAG)	wide cut type used in military aircraft.
JP-5 (AVCAT)	high flash point kerosine type used in naval aircraft.
JP-8 (AVTUR)	kerosine type used in military aircraft.

Wide cut fuels are limited in availability and are mainly used in military aircraft. They constitute only about 0.3% of the total consumption of kerosines in the EU and are of decreasing importance.

In Europe, domestic and industrial fuels based on kerosines are similar in composition to Jet A-1. Domestic fuels can be used for firing hot water boilers for central heating systems and for cooking appliances fitted with a flue.

A small quantity of kerosine is manufactured for use in flueless applications such as small space heaters, open cooking stoves and for lamps. Such premium grade kerosines are more severely refined than standard grade kerosines.

Solvents extracted from the kerosine range of hydrocarbons are widely used in the preparation of formulated products. Typically, these solvents boil over the range from 160 to 300°C, although some are of a narrow cut boiling between, for example, 180 to 205°C. Such solvents are used in special applications such as printing inks. Kerosine-derived solvents are products of the petrochemical industry, rather than the petroleum industry and are not considered in detail in this exposure profile. It should be noted that in some cases the same EINECS number has been assigned to the solvent and the parent petroleum product.

3.1. PHYSICO-CHEMICAL PROPERTIES

Summary information on physico-chemical properties is presented in CONCAWE's Kerosines/Jet Fuels product dossier [3]. Volatility data are required for inhalation exposure estimation. Kerosine vapour pressure data appear to be ranging from low to moderate volatility depending on the product type. The typical (Reid) saturated vapour pressure is 1.4 kPa at 37.8°C, but the specification for wide-cut military JP-4 is 14-21 kPa at 37.8°C. Commercial aircraft fuel such as Jet A1 is considerably less volatile than JP-4 according to boiling point distribution data summarised in the CONCAWE Exposure Profile: Kerosines/Jet Fuels [4]. Company information sources (Safety Data Sheets) list the vapour pressure of Swedish automotive diesel fuel environmental class 1 (EC-1 or MK-1) as less than 0.5 kPa at 20 or 40°C.

3.2. COMPOSITION OF BULK PRODUCT AND VAPOUR PHASE

Kerosines consist predominantly of a complex mixture of hydrocarbons in the C_9 to C_{16} carbon number range, with a typical distillation range of approximately 145 to

300°C. The predominant types of hydrocarbons found in kerosines are normal and branched chain alkanes, cycloalkanes, alkylbenzenes and alkylnaphthalenes [4].

It is generally considered that the hazards to human health and the environment of petroleum substances are determined by 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 kerosines to justify this statement. Therefore, the principal metric of the exposure estimation should reflect the "whole" substance or for example the airborne fraction of the whole product for assessment of inhalation exposure. However, for two reasons the exposure assessment also needs to generate descriptive information on some specific constituents 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 kerosines and other oil products has been excluded from these "single substance" risk assessments. Therefore the kerosines risk assessment is an appropriate means to describe these exposures. Secondly, 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.

In analogy with the gas oils exposure assessment, the following general criteria were therefore applied when identifying which individual kerosine constituents should be included in this exposure assessment:

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

Constituents identified according to these criteria were: benzene, toluene, xylene, 1,3,5-trimethylbenzene and naphthalene.

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

A recent report on kerosine composition is available from the German Society for Petroleum and Coal Science and Technology (DGMK) [5]. Further, a specific analytical program was commissioned by CONCAWE as part of the kerosines risk assessment [6, 7]. This program addressed both blended products and some 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 DGMK and CONCAWE programmes for the liquid analyses and the vapour analyses are presented in **Appendix 1**.

In addition, the CONCAWE analytical program also reported total hydrocarbon concentrations for the saturated vapour phase which ranged from 40,000 to 102,000 mg/m^3 at 20°C with one outlier (sample 17, defined as a light kerosine) of 275,000 [6]. Assuming a conversion factor from mg/m^3 to part per million (ppm) by volume of

5, derived for n-nonane as a surrogate for kerosine vapour, these vapour phase results were equivalent to approximately 8000 to 20,000 ppm (v/v). These levels would suggest that the vapour pressure of the tested kerosine samples was considerably higher than that of the gas oil samples tested for the gas oils risk assessment [13].

3.3. OCCUPATIONAL EXPOSURE LIMITS

There is at present no European occupational exposure limit for kerosines. In 2003 the American Conference of Governmental Industrial Hygienists set a Threshold Limit Value (TLV®) for 8-hour time-weighted average inhalation exposure to kerosine vapour of 200 mg/m^3, total hydrocarbons, with a skin notation; the skin notation implies that dermal uptake may contribute significantly to the body burden. The TLV is not applicable in situations where kerosine or jet fuel exposure contains appreciable amounts of the aerosol [8]. From the data reported in section 3.2.1 above it is clear that at typical ambient temperatures the saturated vapour phase concentrations are higher than the TLV®, hence the potential exists for overexposure in poorly ventilated circumstances.

In Italy the ACGIH TLV of 200 mg/m^3 for kerosine has been adopted in most collective labour agreements.

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].

In Sweden the following values have been derived for workplace assessments [10]:

- 250 mg/m^3 for kerosine / jet fuel,
- 350 mg/m^3 for Swedish EC1 diesel fuel.

In most EU Member States, exposure limits exist for some individual constituents of kerosines however there is limited consistency between countries. Some of these limits may be exceeded in the saturated vapour phase on the basis of the analysis results presented in **Appendix 1**, e.g. benzene, toluene, combined xylenes, cyclohexane and n-hexane. However compliance with the above mentioned limit values in the range of 100-350 mg/m^3 for kerosine will, in almost all cases, also result in exposures to the individual constituents that are below these national limits.

4. ACTIVITIES INVOLVING EXPOSURE TO KEROSINE

4.1. OIL INDUSTRY OPERATIONS

Descriptions of the circumstances leading to exposure to kerosines, and the typical measures in place to control such exposures, have been developed following approaches applied previously to gasoline [11, 12] and gas oils [13]. 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 of these exposures. The emphasis is on patterns of use and control which form the basis for modelled exposure estimates.

In the manufacturing work environment (refineries, tank farms), production and storage systems are essentially closed and provisions are in place to limit evaporative losses. Where contact with kerosines is anticipated (e.g. during change-out of in-line filter cartridges) procedures are in place to remove as much as possible of substance residues prior to the operation, e.g. by draining and 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 with vapour recovery. In other circumstances, where top loading occurs (rail cars, road tankers) some form of forced or extraction ventilation is often in place.

Kerosines 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 kerosines and are able to provide appropriate recommendations.

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

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, Jetty Operator and Specialist Cleaner. 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 a number of EU countries.

4.1.2. Distribution operations

Descriptions of exposure circumstances in distribution operations were developed and validated for operations involving the movement of kerosine products to and from terminals and depots by road tanker, rail car and ships/barges. They include

deliveries to private households (home heating oil) and industrial customers. The job titles include road tanker driver (top or bottom loading), terminal operator, rack operator, vehicle mechanic, equipment maintenance, specialist cleaner, rail car operators and ship deck crew. Exposure information is presented in **Appendix 2**.

4.1.3. Aviation refuelling operations

Descriptions of exposure circumstances in aircraft refuelling and associated activities on airport tank farms are also provided in **Appendix 2**. They include aircraft refuellers, vehicle mechanics and tank farm staff.

4.1.4. Automotive diesel fuel

Kerosines are used in Sweden as environmental class 1 fuel for diesel cars. Exposure estimates for distribution work and customer car refuelling can be derived from analogous gas oils (diesel) operations described in CONCAWE report 1/06, provided a correction for the difference in volatility is introduced.

Kerosines are blended, along with various gas oil types, into automotive diesel fuel in particular in winter grades [32]. Assessments of exposure to (the vapour of) these fuels are unlikely to distinguish between kerosine- and gas oil derived hydrocarbons in view of the partial overlap in composition.

4.2. OTHER OPERATIONS ASSOCIATED WITH OCCUPATIONAL USE OF KEROSINES

Detailed descriptions in template format of other circumstances associated with occupational exposure to kerosines have not been developed by the task force. However, some descriptions of tasks and typical control measures were available from occupational hygiene survey reports. Exposure estimates for these categories of workers may also in part be based on analogy with other, more precisely characterised operations.

4.2.1. Aircraft maintenance including wing tank internal inspections

Aircraft maintenance activities form an operation with potential significant occupational exposure to kerosine. These activities include draining of fuel systems, maintenance on pre-drained equipment and fuel tank entry.

4.3. CONSUMER USE OF THE SUBSTANCE

In addition to the automotive diesel fuel (see section 4.1.4 above), consumer uses of kerosines listed in the previously published exposure profile [4] include lighter fuel for barbeques and open fires; refill lamp oils; in heating and cooking appliances; and as a degreaser or cleaner of mechanical components. For most of these uses the information available was insufficient to develop quantitative estimates.

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 for individuals who are not otherwise exposed as either consumer or worker.

Following emission to air or water, kerosine constituents partition differently across the 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 may also originate from other sources, and analytical data on their occurrence in the environment is not, per se, indicative of exposures originating from kerosines.

A number of studies have been reported in the literature on health effects in people living in the vicinity of airports. Generally, these studies rely on indirect measures of exposure, such as distance between emission source and home address, which are not usable in the context of substance risk assessment.

In the context of risk assessments of petroleum products used as engine fuels, only the unburnt fuel constituents in the emissions are considered, as the combustion products are in many cases subject to regulatory control. One study evaluated available data to estimate population exposures to jet engine emissions in the vicinity of airports [33]. The author suggested that these emissions do not have a unique marker component to distinguish them from other sources (i.e. traffic around the airports), although n-C_9 to n-C_{12} are relatively abundant and could be candidate-markers. Available monitoring data for air near airports appear to be limited to classical pollutants. Levels appeared similar to those commonly found in urban environments, but not as high as those found in so-called street canyons.

5. QUANTIFICATION OF EXPOSURES

In view of the low to moderate volatility of kerosines at ambient temperatures, their known skin irritation hazard and generally established control practices, it is assumed that under most circumstances occupational exposure is likely to be low. In order to confirm this assumption, and to generate appropriately defined quantitative estimates as input into risk characterisation, 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 personal exposures to kerosine vapour in air can conveniently be sampled and analysed using routine occupational hygiene procedures. No such standardised procedure was available for dermal exposure assessment, nor was there an established biological monitoring method to quantify internal body burden of kerosine or its constituents, although for both there are literature reports of experimental approaches (see further in sections 5.1.2 and 5.2).

Alternative procedures recommended by the TGD and applied in this study 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 Member Companies

Available exposure data were summarised by a previous CONCAWE task force and published in 1999 [4]. These data together with those from more recent survey reports of bitumen cutback operations and aircraft refuelling operations in Italy and the UK are summarised in **Table 1**.

One member company evaluated the presence of C_9-components and naphthalene in end-of-shift urine samples of refinery operatives with potential exposure to kerosines; levels were very low and could not be distinguished from those in unexposed individuals and therefore further validation of this approach was not attempted.

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

Job title	Number of measurements	Arithmetic Mean (mg/m^3)	Minimum (mg/m^3)	Maximum (mg/m^3)	Typical duration (minutes)	Source
Manufacturing/Refinery						
Maintenance during turn-around	11	28	12.2	66.4	480	Profile [4]
Road tanker distribution operations						
Driver (top loading)	1	4.4	--	--	480	Profile
Top loading	2	16	4.5	27.2	40	Profile
Aircraft refuelling and associated operations						
Aircraft refuelling	5	0.6	0.15	1.6	30	Profile
Aircraft refuelling	1	57	--	--	150	Profile
Overwing loading	1	18.4	--	--	45	Profile
Refuelling technician – full shift	1	0.56	--	--	480	Member company 2003
Refuelling technician – fuel quality checks	1	0.16	--	--	15	Member company 2003
Refuelling technician – 1 helicopter	1	3.50	--	--	3	Member company 2003
Refuelling technician – 1 plane over-wing	1	4.55	--	--	15	Member company 2003
Refuelling 6-8 aircraft	6	0.85	0.53	1.91	480	Member company 2004
Road tanker - bottom loading	3	1.6	1.4	2.0	20	Profile
Yard operator – filter inspection	2	45	34	56	20	Profile
Yard operator – filter testing	2	77	68	86	90	Profile
Yard operator – fuel sampling and testing	2	18	9	28	25	Profile
Vehicle mechanic – hose repair/test	1	6.4	--	--	130	Profile
Domestic residence						
Replacement of storage vessel	2	16	8	23	120	Profile
Cutback bitumen operations						
Top loading road tanker	1	19	--	--	25	Member company 1999
Top loading road tanker (10% kerosine)	2	240	150	330	35	Member company 1999
Offloading tanker	1	24	--	--	30	Member company 1999
Paving – spray bar operator	2	216	145	287	480	Profile
Paving – spreader driver	2	27	23	31	480	Profile

5.1.2. Measured data from literature (including biomonitoring results)

A search of publicly available literature through the Biosis database resulted in a limited number of publications, which are all related to kerosine exposures during military aircraft operations in the USA. The two most relevant publications are summarised first [18, 19]. They describe exposures to kerosine in terms of total hydrocarbons. Publications related to a combination of JP-4, JP-5 and JP-8 exposure [20] or to a situation where mainly JP-4 was used [21-23] are not included in this report.

Carlton and Smith [18] measured jet fuel and benzene vapour exposures during aircraft fuel tank entry and repair at twelve U.S. Air Force bases. Breathing zone samples were collected on the workers who performed the repair. In addition, instantaneous samples were taken at various points during the procedures with SUMMA canisters. The highest 8-hour TWA fuel exposure found was 1304 mg/m^3. Mean was 160.8 mg/m^3 (n=77). Average results for Foam / No foam were: 182.6 and 14.2 mg/m^3 respectively. The highest 15-minute short-term exposure was 10,295 mg/m^3. Mean was 266.8 mg/m^3. Mean for Foam / No foam was: 430.8 and 52.1 mg/m^3 respectively. The results indicate that workers who repair fuel tanks containing explosion suppression foam have a significantly higher exposure to jet fuel as compared to workers who repair tanks without foam. It is assumed that these elevations result from the tendency for fuel, absorbed by the foam, to volatilize during the foam removal process. Fuel tanks that allow flow-through ventilation during repair resulted in lower exposures compared to those tanks that have only one access port and, as a result, cannot be ventilated efficiently. The instantaneous sampling results confirm that benzene exposures occur during fuel tank repair; levels up to 49.1 mg/m^3 were found inside the tanks during the repairs. As with jet fuel, these elevated benzene concentrations were more likely to occur in foamed tanks. The high temperatures associated with fuel tank repair, along with the requirement to wear vapour-permeable cotton coveralls for fire prevention reasons, could result in an increase in the benzene body burden of tank entrants. All entrants monitored during this study wore airline respirators during foam removal and initial tank entry. Once the workers removed the foam and residual fuel from the tank, some switched to air-purifying respirators with organic vapour cartridges.

In a study by Smith et al [19], the exposure to jet fuel (JP-8) vapour was assessed for four different job types: jet engine repair; jet engine test cell; C-5 aircraft fuels maintenance; and base fuels distribution centre. The JP-8 exposure assessment involved the collection of industrial hygiene breathing zone samples during two separate 8-hour work periods. Jet fuel is reported as naphthas (total hydrocarbon C_4 to C_{16}). The group's mean exposure to naphthas was 0.54 ppm (equivalent to 2.7 mg/m^3). The workers in C-5 aircraft fuels maintenance had the highest exposure with a mean of 1.06 ppm (equivalent to 5.3 mg/m^3).

Table 2 summarises the kerosine inhalation exposure data from these two publications.

Table 2 Measured kerosine inhalation exposure data from literature expressed as total hydrocarbons

Job title	Number of measurements	Arithmetic Mean (mg/m^3)	Reasonable worst case (mg/m^3)	Range (mg/m^3)	Typical duration (minutes)
Aircraft maintenance operations					
Aircraft tank repairs [18]	77	161	1304[a]	0.1 – 1304	480
Fuel tank entry [18]	248	267	10295[a]	3.9 - 10295	15
Aircraft maintenance [19]	18	2.8	no data	no data	480

[a]: 90^{th} percentile not reported, maximum value instead

Several other publications describe exposure assessment focussed on selected components such as benzene and naphthalene or C_9-C_{12} n-alkanes [24-26] or exposure assessment through breath analysis [27, 28].

Serdar et al [24] measured benzene, naphthalene and 1- and 2-naphthol in urine samples obtained from 322 US Air Force personnel categorized a priori as likely to have low, moderate or high exposure to jet fuel (JP-8). Aircraft fuel-system maintenance workers were assigned to the high-exposure group. The moderate exposure group consisted of workers who did not perform fuel tank maintenance but whose work involved regular contact with jet fuel jobs, e.g. fuel handling and distribution. Smokers were found to have significantly higher levels than non-smokers of pre-exposure and post-exposure samples of all analytes except naphthalene. Strong correlations were observed among post-exposure levels of naphthalene-based biomarkers in urine and naphthalene in air and breath. The authors conclude that JP-8 is a significant source of exposure to benzene and naphthalene. Among heavily exposed workers, JP-8 contributes about the same benzene dose as cigarette smoking and more than three times the naphthalene dose. The results show that urinary naphthalene as well as 1- and 2-naphthol can serve as short-term biomarkers of exposure to jet fuel. The authors conclude that naphthols are probably more useful because of their greater abundance and slower elimination kinetics.

Egeghy et al [25] studied the exposure to benzene and naphthalene among military personnel working with jet fuel (JP-8) to determine whether naphthalene might serve as a surrogate for JP-8. Benzene and naphthalene were measured in air and breath of 326 personnel in the US Air Force, who had been assigned a priori into low, moderate, and high exposure categories for JP-8. Median air concentrations for persons in the low, moderate, and high exposure categories were 3.1, 7.4, and 252 µg benzene/m^3 air; 4.6, 9.0, and 11.4 µg benzene/m^3 breath; 1.9, 10.3, and 485 µg naphthalene/m^3 air; and 0.73, 0.93 and 1.83 µg naphthalene/m^3 breath, respectively. In the moderate and high exposure categories, 5% and 15% of the benzene air concentrations were above the 2002 TLV of 1.6 mg/m^3. Prominent background sources for benzene were found, including cigarette smoke. The authors therefore concluded that, despite the fact that fuel handling and maintenance can lead to excessive benzene exposures, it would be inappropriate to use benzene as a surrogate for JP-8 exposure. However, naphthalene exposure was not unduly influenced by sources other than JP-8. Naphthalene concentrations measured in the low exposure category (median 1.9 $\mu g/m^3$) were greater than those reported in ambient air at locations other than Air Force bases (0.3-0.7 $\mu g/m^3$). This showed that essentially all Air Force personnel have incidental exposure to jet fuel vapours and exhaust emanating from aircraft and ground support equipment. The

difference in post-exposure breath levels between the low and moderate exposure categories was not significant for either compound despite a highly significant difference in external exposures. In the high exposure category, tremendous variability in breath levels was observed at a given exposure. The half times for benzene and naphthalene in breath were estimated at 41.8 and 21.6 minutes respectively. The authors concluded that personnel having regular contact with JP-8 was occasionally exposed to benzene at levels above the current TLV. Among heavily exposed workers, uptake of JP-8 components occurs via both inhalation and dermal contact. Naphthalene in air and breath can serve as useful measures of exposure to JP-8 and uptake of fuel components in the body. As biomonitoring of naphthalene or its products in breath or urine reflects both respiratory and dermal uptake of JP-8, the authors suggested it might be preferred to air monitoring for exposure assessment.

Pleil et al [26] described JP-8 exposure data from breath and environmental sampling from various investigations at Air Force Bases. Three types of JP-8 exposure scenarios were studied: incidental, exhaust and fuel vapour. Because JP-8 is a low volatility fuel, cold weather starts require longer pre-flight procedures and may create more unburnt fuel aerosol. During aircraft warm-up, the exhaust contains unburnt and partially burnt JP-8, exposing crew chiefs and other ground personnel to JP-8. Two types of breath sample sets were collected: incidental samples during the workday, with subjects essentially in equilibrium with their environment; and samples before and after the performance of some job function, demonstrating the incremental exposure attributable to that specific job. The C_9 to C_{12} n-alkanes (nonane, decane, undecane and docecane) were summed to provide a simple indicator of JP-8 fuel exposure. There was an overall elevation of ambient exposure to JP-8 related hydrocarbon compounds at Air Force Bases as compared to urban and suburban locations. The highest overall exposures to JP-8 alkanes were experienced by fuel system maintenance workers; they exhibited a chronic elevated level of JP-8 fingerprint compounds in their breath and had the greatest incremental exposure from performing their job functions. Personnel exposed to aircraft exhaust in the typical outdoor scenarios had measurable exposure; however, this was at least 10 times lower than their fuel-systems colleagues. When these workers performed their pre-flight duties inside a hangar, they exhibited elevated initial exposure levels that then decreased after the doors were opened and the aircraft engines were started. There was a slight measurable elevation in JP-8 fingerprint compounds in subjects at Air Force bases without direct aircraft or jet fuel contact as compared to the general population. JP-8 exposure in fuel systems workers as measured in their breath was equivalent for tank entry and attendant personnel, yet the ambient (potential) exposures were 40 times greater inside the fuel tanks. The authors concluded that the full-face forced-air respirators worn by tank entry personnel were extremely effective in eliminating inhalation exposure, and that the JP-8 in their breath resulted primarily from their activity in the vicinity of the aircraft outside the fuel tanks. Benzene exposure had three distinct sources: cigarette smoking; aircraft exhaust; and jet fuel vapour. Smoking was found to be by far the most important benzene source. In non-smokers, aircraft exhaust exposure was most significant in elevating benzene levels, and incidental and fuel systems work were equivalent in relevance for benzene exposure (at approximately half of the exhaust level). All US Air Force related groups exhibited statistically significant higher benzene levels than the controls; the authors concluded there was an overall moderate elevated benzene exposure at the bases from fuel and exhaust. Mean benzene concentrations were reported of 17.6 ppb (56.4 $\mu g/m^3$) around aircraft (n=9) and 2990 ppb (9540 $\mu g/m^3$) inside fuel tanks (n=16) during fuel system maintenance.

Reutman et al [27] monitored exposures for a study of potential reproductive endrocrine effects of low-dose hydrocarbons encountered by female US Air Force personnel. The internal dose of hydrocarbons was estimated by measuring aliphatic hydrocarbonds (C_6-C_{16}) and aromatics (BTEX) in exhaled breath. Reported group average levels were: BTEX 38.1 ppb (n=57) and C_6-C_{11} 174.9 ppb (n=22). Staff members were grouped in two exposure groups, high versus low, based on self-reported exposure and job category. BTEX levels were 73.5 and 3.8 ppb respectively, and aliphatics 279.6 and 70.1 ppb.

Tu et al [28] estimated JP-8 exposure at an air base using breath analysis. All personnel on this base had measurable levels of JP-8 in their breath. Post-shift concentrations in exhaled breath ranged from 0.2-11.5 mg/m^3. The concentrations observed suggest that exposure was considerably less than current guidelines for JP-8 exposure (US Navy Permissible Exposure Limit: 350 mg/m^3, 8-hrs TWA). The base personnel who exhibited the highest exposure to JP-8 were fuel cell workers (exposure tasks: drain fuel tanks; remove polyurethane foam; work inside fuel tank), fuel specialists (exposure tasks: receive JP-8 on base; refuel aircraft; quality check JP-8) and smokers, who smoked downwind from the flightline. The predominant route of exposure was via inhalation, although some individuals working directly with the fuel showed evidence of dermal exposure.

5.1.3. Results of exposure monitoring surveys by Member Companies

In view of the fact that the information on kerosine exposure available from member companies and from the literature did not adequately describe all known uses and tasks, a number of jobs and activities were targeted for exposure monitoring.

Exposure monitoring surveys were undertaken by company staff or consultants, but sample analysis was centralised. The same methodology and the same, appropriately qualified laboratory were used as for the gas oils exposure assessment [13]. A field protocol was developed, including forms for all targeted activities on which to record standard information to aid interpretation of measurement results.

Within this exercise it was not possible to incorporate the fuel tank activities associated as described in the literature overview in 5.1.2. Unpublished reports form EU based commercial and military aviation operators suggest that fuel tank entries do occur, but generally only after allowing sufficient ventilation of up to several days. Entries in wet tanks are limited to urgencies.

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 kerosine vapour samples, a test atmosphere was generated at a reference laboratory. The atmosphere contained known quantities of four relatively volatile kerosine constituents: toluene, n-octane, n-nonane and n-decane. Ten two-hour samples were taken by the contract analytical laboratory with acceptable results (**Appendix 3**).

All field surveys were required to include blank samples in order to detect any contamination that may have been present as a background in the adsorbent material or may have occurred during sample transit.

5.1.3.2. Results

A series of surveys was conducted, see **Table 3**. Detailed measurement results are presented in **Appendix 4**. Summary results are presented in **Table 4**. Several samples were taken during work shift where operatives also handled aviation gasoline; the results of these have been excluded from this report, but will be presented in a future CONCAWE report on gasoline exposure data [in preparation].

Table 3 Short descriptions of exposure monitoring surveys conducted by CONCAWE member companies in 2004-2005

Country	Season	Number of samples	Type of operation
UK	Summer	35	Aircraft refuelling and associated tank farm, fuel quality testing and equipment maintenance activities at an international airport
Spain	Summer	35	Aircraft refuelling and associated tank farm, fuel quality testing and equipment maintenance activities at an international airport
UK	Winter	27	Aircraft refuelling and associated tank farm, fuel quality testing and equipment maintenance activities at two regional airports
UK	Winter	60	Home heating oil distribution from a top-loading and a bottom-loading/vapour recovery depot
Italy	Spring	15	Aircraft refuelling and equipment maintenance activities at an international airport
France	Autumn	20	Aircraft refuelling and equipment maintenance activities at an international airport
France	Autumn	20	Aircraft refuelling and associated tank farm, fuel quality testing and equipment maintenance activities at two airports
France	Winter	9	Aircraft refuelling and equipment maintenance activities at an aircraft manufacturing site

Table 4 Measured kerosine inhalation exposure data generated by CONCAWE, expressed as n-nonane equivalents

Job title	Number of measurements	Median value (mg/m^3)	Reasonable worst case (mg/m^3)	Range (mg/m^3)	Typical duration (minutes)
Aviation fuel tank farm operations at airports					
Tank farm operator	9	1	6	0.2 – 21.4	480
Tank farm operator – fuel sampling	5	3	4.6[a]	2.5 – 4.6	15
Tank farm operator – filter changing	5	5	20[a]	4 – 20	60
Tank farm supervisor	3	1.2	2.4[a]	0.3 – 2.4	480
Vehicle service bay and maintenance workers	12	2.4	9.1	0.5 – 31.2	480
Maintenance work on valves	3	19	290[a]	3 – 290	60
Bridger tanker deliveries	3	1	2.3[a]	0.3 – 2.3	30
Aircraft refuelling operations at airports					
Full-shift hydrant operations	9	0.1	0.3	0.1 – 0.6	480
Single plane by hydrant	12	0.8	1	< 1 – 3.4	20
Full-shift by tanker	24	0.7	2.8	0.1 – 5.6	480
Single plane by tanker	5	< 1	< 1[a]	< 1	20
Tanker loading	2	1.7	1.7[a]	1.6 – 1.7	30
Tanker filter maintenance	1	4.9	--	--	60
Refuelling – unspecified	29	0.3	4.2	0.1 – 22.8	480
Refuelling single plane - unspecified	4	< 1	< 1[a]	< 1	20
Home heating oil distribution					
Road tanker drivers - full shift (top loading)	13	4	5.5	0.2 – 10	480
Road tanker drivers - full shift (bottom loading)	15	6	52	1 – 70	480
Road tanker drivers – top loading at depot	13	5.2	10	< 0.1 – 15	30
Road tanker drivers – bottom loading at depot	2	0.2	0.3[a]	0.1 – 0.3	30
Road tanker drivers – delivery to customers	2	2.5	4.9[a]	0.1 – 4.9	60
Supervisor	3	1	1.1[a]	0.4 – 1.1	480

[a]: maximum value, instead of 90th percentile, due to small number of measurements

5.1.4. Modelled exposure estimates

Exposures were modelled using the approach recommended in the TGD [2] and the results are included in **Appendix 5**. The modelling approach is based on estimation of exposure levels during well-defined tasks. Full-shift exposure levels are presented in **Table 5** and were derived from a combination of task exposure levels and the frequency and duration of each task as presented in **Appendix 2**. **Appendix 6** presents a comparison of measured data (mean, range and reasonable worst case) and EASE modelled ranges. Measured data either fall in the EASE ranges or are lower; hence this comparison provides reassurance that modelled data are suitable for use in risk assessment.

Table 5 Modelled full-shift exposures to kerosine vapour based on frequency and duration per task

Job title	EASE model inhalation exposure estimate (mg/m^3)
1.1 Production / On-site operator	1 – 9
1.2 Tank farm / Off-site operator	4 – 20
1.3 Mechanical maintenance	1 – 15
1.4 Laboratory technician	1 – 8
1.7 Jetty staff	0.5 – 3
2.1 Road tanker driver (top loading)	5 – 26
2.1 Road tanker driver (bottom loading)	0.5 – 1.3
2.2 Subsidiary road tanker driver (bottom loading, vapour recovery)	10 – 63
2.2 Subsidiary road tanker driver (bottom loading, remote venting)	11 – 67
2.2 Subsidiary road tanker driver (top loading)	14 – 81
2.3 Terminal operator (with drum filling)	0.5 – 19
2.3 Terminal operator (no drum filling)	0.2 – 6.5
2.4 Terminal rack operator (top loading)	25 – 94
2.4 Terminal rack operator (bottom loading)	0 – 0.5
2.5 Rail car operator (with vapour recovery)	0 – 13
2.5 Rail car operator (no vapour recovery)	50 – 100
2.6 Ship deck crew	0 – 9
2.7 Jetty staff	0 – 7
2.8 Terminal vehicle mechanic	5 – 11
2.9 Terminal equipment maintenance	50 – 100
3.1 Aircraft refueller	13 – 25
3.2 Yard operator	3 – 44
3.3 Airport rail car operator	0 – 0.5
3.4 Airport vehicle mechanic	5 – 23
3.5 Airport tank/interceptor cleaning/inspection	50 – 100
3.6 Airport terminal operator	5 – 43
3.7 Aircraft maintenance worker	50 – 100
4.1 Domestic heating oil supplier	0 – 50
4.2 Domestic heating engineer	0 – 0.5

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 kerosines. Therefore, exposure estimates used in the kerosine risk assessment have to be based on modelling approaches. Results from experimental approaches may be used as supporting information.

The TGD [2] 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 A5.2 (Appendix 5)** presents the main definitions and exposure estimates used in the kerosine 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 kerosine exposure assessment.

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. For each job type, the task with the highest dermal exposure estimate was taken forward as the overall reasonable worst case estimate of the daily exposure; the estimates are presented in **Table 6**.

Table 6 Estimated daily reasonable worst case (RWC) dermal exposures to kerosines in manufacturing, distribution and aviation refuelling operations *(based on the highest task-based exposure estimate and assuming that exposed individuals do not wear gloves)*

Job title	Typical estimates		RWC dermal exposure ($mg.d^{-1}$)
	Type of contact	Surface (cm^2)	
Manufacturing			
Production/On-site operator	Incidental	840	84
Tank farm/Off-site operator	Intermittent	420	420
Mechanical maintenance	Intermittent	420	420
Laboratory technician	Incidental	420	42
Rail car operator	Intermittent	420	420
Jetty staff	Intermittent	420	420
Distribution operations			
Road tanker driver	Incidental	840	84
Subsidiary / Commercial road tanker driver	Incidental	420	42
Terminal operator	Intermittent	840	840
Rack operator	Intermittent	420	420
Rail car operator	Intermittent	420	420
Deck crew: ships / barges	Intermittent	420	420
Jetty staff	Incidental	420	42
Vehicle mechanic	Intermittent	420	420
Equipment maintenance	Incidental	840	84
Aviation refuelling operations			
Aircraft refueller	Incidental	420	42
Yard operator	Incidental	840	84
Rail car operator	Incidental	420	42
Vehicle mechanic	Intermittent	420	420
Terminal operator	Intermittent	840	840

Note: specialist cleaning activities are not included in above table.

Some recent publications describe developments in kerosine dermal exposure assessment. A tape stripping method was developed to assess the dermal exposure to naphthalene as marker for kerosine exposure [29, 30]. Chao et al [31] applied this method to measure dermal exposure of 124 fuel cell maintenance workers in the US Air Force. For the high exposure group, the geometric mean whole body dermal exposure to naphthalene (as a marker for JP-8) was reported to be 4180 ng/m^2), with a GSD of 9.35. The authors concluded that this study clearly demonstrated the efficiency and suitability of the tape-strip technique for the assessment of dermal exposure to JP-8 and that naphthalene could serve as a useful marker of exposure

and uptake of JP-8 and its components. It also showed that the skin provides a significant route for JP-8 exposure.

Based on the data provided by Chao et al, it is possible to derive an estimate for the dermal exposure to kerosine. On the basis of compositional analysis the average naphthalene content of kerosine is 0.18%. The average naphthalene dermal exposure for the high exposure group of 4180 ng/m^2 is translated to a kerosene exposure of 2.3 mg/m^2. With an average body surface area of 1.9 m^2, this is equivalent to 4.4 mg/day. A worst-case (95-percentile) estimate for the high exposure group is calculated with the formula GM*(GSD)^1.645 and amounts to 170 mg/day. The results of the study by Chao et al are not directly comparable with the estimates from the EASE dermal exposure model for the following reasons:

- the EASE model applies to dermal exposure on hands and arms only, whereas the study by Chao et al included other body regions as neck and feet;
- the EASE model provides an estimate of the amount of kerosine potentially deposited on the skin, whereas the method applied by Chao et al determines the quantity of kerosine retained in the upper layers of the stratum corneum following exposure, thus providing a measure of absorbed dermal dose available for metabolism and systemic circulation;
- the EASE model was applied for job types in manufacturing, distribution and aircraft refuelling operations, whereas Chao et al studied dermal exposure during aircraft maintenance where higher dermal exposures can be expected.

Although the EASE estimates are not totally different from the values derived from the study by Chao et al, the modelled levels between 42 – 840 mg/day for jobs in manufacturing, distribution and aircraft refuelling operations appear on the high side when compared with the measured levels for the fuel cell maintenance workers. Similar findings have been reported elsewhere [17].

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 European industry operations. In analogy with the previous exercise for gas oils, 17 pairs of gloves were collected by task force members from distribution and aviation operations. The gloves were submitted for chemical permeation testing according to EN 374-3 [15] in an appropriately accredited laboratory, using a Jet A-1 sample provided by a CONCAWE member company refinery. The results are presented in **Appendix 7**.

Similar conclusions were reached as for gas oils:

- There is a large variation in the level of chemical protection provided by gloves commonly in use across Europe when handling kerosines (jet fuel);
- A number 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).

A test feature not reported previously for gas oils by the testing laboratory, i.e. swelling and discolouration of the glove material, indicated a certain degree of degradation for many of the tested gloves.

As for gas oils, these results 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 inadequate or no dermal protection.

6. CONCLUSIONS

The collection and collation of exposure information for kerosines 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. Some of the studies reported in the literature showed higher exposure levels.

6.1. AVAILABILITY OF MEASUREMENT DATA

As with gas oils, the measured inhalation exposure data provided by member companies for kerosines was not complete for all uses of the substance. The additional inhalation exposure data generated in surveys organised by the task force focussed on the main uses of kerosines as managed by CONCAWE member companies' operations, with little interference from other petroleum products; the detected levels were mainly low. The main category of workers with more elevated exposures, though infrequent and of limited duration, were the maintenance workers. Values above occupational exposure limits were not encountered, with the exception of one previously reported data point for a spray application of bitumen cutback with kerosine. There were no new data for this application.

Measurement data for dermal exposure, obtained using experimental methodologies, were only available from literature sources.

Data retrieved from the open literature focus primarily on aircraft maintenance operations, including fuel tank entries. Both the potential inhalation levels (not accounting for respiratory protection) and detected dermal exposures were high in these circumstances. Biological monitoring data (exhaled breath) confirmed that in these circumstances the exposures (combined inhalation and dermal) were sometimes elevated.

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 and from literature reports, 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 more experimental in nature.

6.3. EXPOSURE LEVELS FOR RISK CHARACTERISATION

The information collated in this report can be used to derive exposure levels for use in risk assessment. On the basis of breathing volume (typically of 10 m^3 per 8 hour work shift) the measured or modelled full-shift exposure levels can be converted to provide an inhalation dose in milligram per working day for comparison with appropriate no-effect levels. Similarly, short-term exposures can be converted into dose estimates. The collected information is adequate for estimation of both typical and worst-case or 95^{th} percentile estimates.

The dermal exposure estimates represent external exposure that is material that may be present on the skin. Further considerations, not covered in the present report, are required before these can be translated into a dose. The estimates are based on the task within the job title with the highest dermal contact level and are therefore worst-case 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 exposures to kerosines are considered as qualitatively and quantitatively 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. It is therefore suggested not to combine the inhalation and dermal exposure estimates.

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APPENDIX 1: COMPOSITIONAL DATA

Table A1.1 Composition bulk product kerosines: selected components (g/100 g)

	D1	D2	CW2	CW4	CW 5	CW 6	CW 7	CW 12	CW 13	CW 15	CW 16	CW 17
n-Pentane	<0.005	<0.005	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01
n-Hexane	NA	NA	0.00	0.01	0.02	0.00	0.09	0.00	0.01	0.02	0.00	0.04
Cyclohexane	0.017	0.011	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzene	0.003	0.005	0.00	0.01	0.01	0.00	0.03	0.00	0.01	0.01	0.00	0.01
n-Heptane	NA	NA	0.06	0.17	0.27	0.01	0.35	0.16	0.07	0.14	0.00	0.30
Toluene	0.07	0.12	0.10	0.45	0.19	0.03	0.34	0.15	0.10	0.11	0.00	0.16
n-Octane	NA	NA	0.62	1.17	1.01	0.03	0.89	1.23	0.26	0.44	0.00	1.19
Ethyl benzene	0.09	0.14	0.20	0.37	0.21	0.04	0.25	0.31	0.11	0.06	0.00	0.26
m+p-Xylene	NA	NA	0.63	1.57	0.54	0.15	0.84	1.45	0.30	0.36	0.00	0.66
o-Xylene	NA	NA	0.34	0.72	0.30	0.11	0.44	0.78	0.17	0.17	0.00	0.44
n-Nonane	NA	NA	1.93	3.54	2.12	0.95	2.35	3.16	1.10	1.30	0.01	7.10
n-Decane	NA	NA	4.50	3.97	3.89	3.33	4.35	4.14	0.92	3.99	0.30	11.38
Iso-propylbenzene	0.04	0.08	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Tetralin	0.25	0.41	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Naphthalene	0.06	0.10	0.16	0.41	0.08	0.13	0.40	0.16	0.01	0.28	0.01	0.05
1-Methylnaphthalene	0.08	0.12	0.28	0.48	0.15	0.29	0.40	0.12	0.01	0.34	0.04	0.00
2-Methyl-naphthalene	0.12	0.14	0.34	0.78	0.17	0.37	0.55	0.20	0.02	0.56	0.06	0.01
2,6-Di-methyl-naphthalene	0.04	0.02	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

D1: German Jet A1 winter grade
D2: German Jet A1 mid-season grade
CW2: French Jet A1
CW4: British Jet A1
CW5: Dutch Jet A1
CW6: US JP-5
CW7: British Jet A1
CW12: French jet fuel
CW13: French jet fuel
CW15: French straight run jet fuel
CW16: Spanish refined kerosine
CW17: Spanish light kerosine

NA: Not analysed
NR: Not reported

Source: [5] for samples D1 - D2; [7] for samples CW2 - CW17

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

	D1	D2	CW2	CW4	CW 5	CW 6	CW 7	CW 12	CW 13	CW 15	CW 16	CW 17
n-Pentane	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
n-Hexane	NA	NA	80	225	575	60	4800	210	790	1665	< 10	2070
Cyclohexane	130	84	125	1445	675	40	3375	295	860	1285	< 10	1215
Benzene	22	37	20	135	200	< 10	1165	90	350	750	< 10	30
n-Heptane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	160	250	705	2420	1085	65	3760	1545	1130	1845	< 10	2110
n-Octane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethyl benzene	66	99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
m-Xylene	NA	NA	1735	4430	1775	1125	3465	6920	2475	1315	< 10	6540
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Nonane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Decane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iso-propylbenzene	12	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetralin	6.2	10	180	220	150	995	305	160	185	185	980	305
Naphthalene	1.1	1.8	45	145	< 15	135	170	30	60	130	80	80
1-Methylnaphthalene	0.47	0.54	15	35	15	15	60	< 15	< 15	60	40	< 15
2-Methyl-naphthalene	0.36	0.53	20	85	25	325	95	45	15	55	125	< 15
2,6-Di-methyl-naphthalene	0.05	0.03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total hydrocarbons (g/m^3)	NR	NR	40	83	48	85	96	102	98	44	61	275

D1: German Jet A1 winter grade
D2: German Jet A1 mid-season grade
CW2: French Jet A1
CW4: British Jet A1
CW5: Dutch Jet A1
CW6: US JP-5
CW7: British Jet A1
CW12: French jet fuel
CW13: French jet fuel
CW15: French straight run jet fuel
CW16: Spanish refined kerosine
CW17: Spanish light kerosine

NA: Not analysed
NR: Not reported

Source: [5] for samples D1 - D2; [6] for samples CW2 - CW17

APPENDIX 2: KEROSINE 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:	Operation of plants which process hydrocarbon streams to produce kerosine, involving valve operation, sample collection, blowing down gauges, draining down lines/vessels in preparation for maintenance		
Typical number of staff per shift per site?	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?	Yes - job share on rotation with control panel operator

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Sample collection. 0.5 litre sample collected from in line sample point	2 - 4 per shift	2 - 3 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Closed system, e.g. Dopak type		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Splash guard	X				
			Other - specify					

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	x		
Intermittent			
Extensive			

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Draining equipment: e.g. pumps, lines, gauges prior to maintenance work	2 - 5 per week	15 - 30 minutes	Automated		Drain and flush	X	Gauntlets/ gloves - specify type	PVC
			Closed system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

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			

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional 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		Standard laboratory practice	X	Gauntlets/ gloves - specify type	Disposable gloves
			Closed system		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 e.g. dipping, sampling, discharge of tank water bottoms
Typical number of staff per shift per site?	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.

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	2 - 4 per shift	2 - 3 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Closed system, e.g. Dopak type		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify	Splash guard				

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	x		
Intermittent			
Extensive			

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1.b. Top-middle-bottom sample from bulk storage tank	2 - 4 per shift	15 - 20 minutes	Automated		Other - specify		Gauntlets/ gloves	PVC
			Closed system				Visor	
			Local exhaust ventilation				Other - specify	
			General ventilation	X				
			Splash Guard	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			
Intermittent	x		
Extensive			

Additional comments:

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 per month	5 - 10 minutes	Automated	X	Stand up wind	X	Gauntlets/ gloves	PVC
			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:

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 - 2 per week	5 - 10 minutes	Automated		Stand up wind	X	Gauntlets/ gloves - specify type	PVC
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			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	x	One hand front	210
Incidental			
Intermittent			
Extensive			

Additional comments:

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 which may involve exposure to kerosine liquid and vapour when draining, cleaning, opening up and working on normally enclosed equipment.		
Typical number of staff per shift per site?	2 - 4		
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.	Additional PPE used?	Specify type
1. Maintenance on pre-drained and flushed equipment.	3 - 6 per month	1 - 8 hours	Automated		Pre-drained and flushed equipment	X	Gauntlets/gloves	PVC
			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 drained and flushed, there is still potential for product residue to be present and therefore there is some potential for skin contact with contaminated surfaces.

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

Additional comments:

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.		
Typical number of staff per shift per site?	4 - 8		
Usual shift hours?	8		
Maximum number of shifts worked per year per operator	225	Is job rotation operated?	Not normally

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

Potential for skin contact: Only small quantities (up to 600 ml) of product handled. Minimal potential for skin contact.

Dermal contact level		Skin surface area	Total surface area (cm2)
Very low		One hand front	210
Incidental	x		
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.	Additional 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 - 2 per shift	10 - 20 minutes	Closed system, e.g. bottle washing machine	X	Standard laboratory practice	X	Gauntlets/ gloves	Disposable 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, local exhaust ventilation is installed.

Appendix 2.1 Manufacturing

Appendix 2.1.5 Rail Car Operator

Job Type:	Rail Car Operator		
Operational area:	Rail car loading		
Overview of tasks:	Loading of rail cars, including handling of loading arms or hoses, connection/disconnection, 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?	Depending on rail car loading activity

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional 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	1 - 2 trains per shift	8 - 12 hours	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system	X	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:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional 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	1 - 2 trains per shift	8 - 12 hours	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: Potential for skin contact during contact with contaminated loading hoses and some spillage during disconnection of loading hoses where breakaway couplings are not available.

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

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.	Additional PPE used?	Specify type
3. Sample collection. Top middle-bottom sample from each rail car. NOT NORMALLY CARRIED OUT	1 - 2 trains per shift	60 - 70 minutes per train	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			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			
Incidental			
Intermittent			
Extensive			
Not applicable	x		

Additional comments:

Appendix 2.1 Manufacturing

Appendix 2.1.6 Specialist Cleaner

Product:	**Kerosine**
Job Type:	**Specialist cleaning tasks**
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
			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.

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	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 kerosines. Standard confined space entry requirements to check oxygen and vapour levels applied. If necessary appropriate respiratory protection would be worn.

Appendix 2.1 Manufacturing

Appendix 2.1.7 Jetty Staff also known as Harbour Staff

Job Type:	Jetty staff		
Operational area:	Marine jetty		
Overview of tasks:	Supervision of ship/barge loading operations, sampling, tank dipping, handling of hoses.		
Typical number of staff per shift per site?	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

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Connection/ disconnection of supply hoses	1 - 2 per week	20 - 30 minutes	Automated		Draining of hose before disconnection	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 hose and spillage, a few litres, during hose disconnection.

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

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Sample collection. 0.5 litre sample collected from in line sample point	1 per ship loading (1 - 2 ships per week)	2 - 3 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify	Splash guard				

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:

Appendix 2.2 Distribution

Appendix 2.2.1 Road Tanker Driver (1)

Product:	**Kerosine**
Job Type:	**Road Tanker Driver**
Operational area:	**Terminal Gantry and Delivery Site - E.g. Delivery to Airports**
Overview of tasks:	**Top and bottom loading of road tanker vehicles. Road tanker flushing to dump trolley following change of grade. Delivery to industrial and domestic customer storage. Fuel testing for water. Some drivers may be involved in top loading heated cut back bitumen (potential exposure to Kerosine vapour).**
Typical number of staff per shift per site?	**10-20**
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. 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		Two hands front	420
Incidental	x		
Intermittent			
Extensive			

Additional comments: Vapour recovery not present in all cases.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Delivery to customer storage: connection/ disconnection of hose	2 - 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		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			

Additional comments:

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 following change of grade. 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		Two hands front and back	840
Incidental	x		
Intermittent			
Extensive			

Additional comments:

For any other standard task involving potential exposure to Kerosine performed please list details below

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
4. Top loading road tanker. Lance is manually lowered into manhole on top of tanker.	1 - 2 per shift	30 - 45 minutes	Automated		Stand upwind	X	RPE - specify type	
			Closed system		SOP		Full face mask	
			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.	420
Incidental	X		
Intermittent			
Extensive			

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

Appendix 2.2 Distribution

Appendix 2.2.2 Subsidiary/Commercial Road Tanker Driver (2)

Product:	**Kerosine**
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 distribution of heating oil.**

Typical number of staff per shift per site?	**10 - 20**
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. 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		Two hands front	420
Incidental	x		
Intermittent			
Extensive			

Additional comments: Vapour recovery not present in all cases.

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

For any other standard task involving potential exposure to Kerosine performed please list details below

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Top loading of road tanker. Lance is manually lowered into manhole on top of tanker.	1 - 2 per shift.	30 - 45 minutes	Automated		Stand upwind	X	RPE - specify type	
			Closed system		SOP		Full face mask	
			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: 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:

Appendix 2.2 Distribution

Appendix 2.2.3 Terminal Operator

Product:	**Kerosine**
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). return of tank flushigs to storage. Drum filling and rail car deliveries may be carried out.**

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. Sample collection. 0.5 litre sample collected from in line sample point	**1 per day**	**2 - 3 minutes**	**Automated**		**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			Closed system, e.g. Dopak type		**Other - specify**		**Other - specify**	
			Local exhaust ventilation					
			General ventilation	**X**				
			Other - specify	**Splash guard**				

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	**x**		
Intermittent			
Extensive			

Additional comments:

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.	**1-2 per month**	**5 - 10 minutes**	**Automated**	**X**	**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			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:

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 per month**	**5 - 10 minutes**	**Automated**		**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			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			

Additional comments:

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.	1-2 per year	5 minutes	Automated		Drain filter housing prior to removal of filter.	X	Gauntlets/ gloves	PVC
			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 and back	840
Incidental			
Intermittent	x		
Extensive			

Additional comments:

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 fortnight	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	1 per week-10 days	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			

Additional comments:

Appendix 2.2 Distribution

Appendix 2.2.4 Rack Operator

Product:	**Kerosine**
Job Type:	**Rack Operator**
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. 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 top loading available. Frequency indicated is for 100% bottom loading.

For any other standard tasks routinely performed please list details below:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Top loading of road tankers. Lance is lowered into manhole on top of tanker.	**8 - 10 per shift**	**30- 45 minutes**	**Automated**		**Stand upwind**		**RPE - specify type**	
			Closed system		**SOP**		**Full face mask**	
			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: during contact with contaminted 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.

Appendix 2.2 Distribution

Appendix 2.2.5 Rail Car Operator

Job Type:	Rail Car Operator		
Operational area:	Rail car loading		
Overview of tasks:	Loading of rail cars, including handling of loading arms or hoses, connection/disconnection, 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?	Depending on rail car loading activity

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Top loading rail cars. Fill rail cars via top loading (with or without vapour recovery). Handling of loading hoses.	1 - 2 trains per shift	8 - 12 hours	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: Potential for skin contact during contact with contaminated lance and hoses and some spillage during disconnection of loading hoses where breakaway couplings are not available.

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

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Sample collection from each rail car	2-3 trains per week	60 - 70 minutes per train	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			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			

Additional comments:

Appendix 2.2 Distribution

Appendix 2.2.6 Deck Crew

Job Type:	**Deck Crew: ships/barges**		
Operational area:	**Marine jetty**		
Overview of tasks:	**Loading of ships/barges using flexible hoses and venting via cargo tank releif valves. Connection/disconnection of cargo lines, checking tank fill levels, tank dipping.**		
Typical number of staff per shift per site?	**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**

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Connection/ disconnection of supply hoses	**1 per week-10 days**	**20 - 30 minutes**	**Automated**		**Draining of hose before disconnection**	**X**	**Gauntlets/ gloves**	**PVC**
			Vapour recovery system	**(X)**	**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**	**420**
Incidental	**x**		
Intermittent			
Extensive			

Additional comments: Vapour recovery in one country.

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 week**	**5 - 10 minutes**	**Automated**	**X**	**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			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			
Intermittent	**x**		
Extensive			

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Venting of cargo tank relief valves.	1 per week-10 days	5 - 10 minutes	Automated	X	Stand up wind	X	Gauntlets/ gloves	PVC
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			General ventilation	X				
			Other - specify					

Potential for skin contact:

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

Additional comments:

Appendix 2.2 Distribution

Appendix 2.2.7 Jetty Staff

Job Type:	Jetty staff		
Operational area:	Marine jetty		
Overview of tasks:	Supervision of ship/barge loading operations, sampling, tank dipping, handling of hoses.		
Typical number of staff per shift per site?	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

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Connection/ disconnection of supply hoses (Terminal Operator)	1 per week-10 days	20 - 30 minutes	Automated		Draining of hose before disconnection	X	Gauntlets/ gloves	PVC
			Vapour recovery system	(X)	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	420
Incidental	x		
Intermittent			
Extensive			

Additional comments: Vapour recovery in one country.

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Sample collection. 0.5 litre sample collected from in line sample point (Terminal Operator)	1 per ship delivery 1 per week-10 days	2 - 3 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system		Other - specify		Other - specify	
			General ventilation	X				
			Other - specify	Splash guard				

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	x		
Intermittent			
Extensive			

Additional comments:

Appendix 2.2 Distribution

Appendix 2.2.8 Vehicle Mechanic

Product:	**Kerosine**
Job Type:	**Vehicle mechanic**
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. Kerosine may be used as a degreasant for washing vehicle components.**

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			
Intermittent	**x**		
Extensive			

Additional comments:

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**	**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.

Appendix 2.2 Distribution

Appendix 2.2.9 Equipment Maintenance

Product:	**Kerosine**
Job Type:	**Equipment maintenance**
Operational area:	**Terminal**
Overview of tasks:	**Preparing equipment for maintenance; performing maintenance; meter proving and minor repairs to metering equipment**
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	Infrequent	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 and back	840
Incidental	x		
Intermittent			
Extensive			

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Meter proving and servicing	1-2 per year	5 - 10 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			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:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Carry out maintenance on equipment, e.g. replace pump packing	Infrequent	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 2.2.10 Specialist Cleaning Tasks

Product:	**Kerosine**
Job Type:	**Specialist cleaning tasks**
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
			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.

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	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 Aviation Refuelling Operations

Appendix 2.3.1 Aircraft Refueller

Product:	**Kerosine**
Job Type:	**Aircraft Refueller (Usually combined with yard staff tasks)**
Operational area:	**Airport Apron**
Overview of tasks:	**Refuelling of aircraft by tanker, refuelling of aircraft via hydrant system, bottom loading of road tankers.**
Typical number of staff per shift per site?	**1-5**
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. Refuelling aircraft via tanker.	5 - 30 aircraft per shift	10-45minutes	Dry break coupling	X	Standard Operating Procedure	X	Gauntlets/ gloves	PVC or other
			Self shuting tanks on aircraft	X			Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with drips from aircraft coupling.

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

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Refuelling aircraft via hydrant system.	20 - 30 aircraft per shift	10-45minutes	Dry break coupling	X	Standard Operating Procedure	X	Gauntlets/ gloves	PVC or other
			Self shuting tanks on aircraft	X			Other - specify	
			General ventilation	X				
			Other - specify					

Potential for skin contact: Potential for skin contact during contact with drips from aircraft coupling.

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

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. 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
Incidental			
Intermittent			
Extensive			

Additional comments:

Appendix 2.3 Aviation Refuelling Operations

Appendix 2.3.2 Yard Operator

Product:	**Kerosine**
Job Type:	**Yard Operative (Usually combined with Aircraft Refueller tasks)**
Operational area:	
Overview of tasks:	**Fuel testing for water and specific gravity, testing of cylindrical water filters for efficiency, filter changing, meter proving and meter servicing.**

Typical number of staff per shift per site?	**1-5**
Usual shift hours?	**8 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. 1 L sample of fuel from each tank in tank farm from in-line sampling point.	**3-6 tanks per day**	**20-30 minutes**	**Local exhaust ventilation**		**Standard Operating Procedure**	**X**	**Gauntlets/ gloves**	**PVC**
			Drain and Flush				**Other - specify**	
			General ventilation	**X**	**Other - specify**			
			Closed System	**X**				

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		**One hand front and back**	**420**
Incidental	**x**		
Intermittent			
Extensive			

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Meter proving and servicing - Manual tank dipping/ullage measurement. Dip tape dropped into bulk storage tank via man hole on top of tank.	**1 per month**	**5 - 10 minutes**	**Automated**	**X**	**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			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:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
3. Testing of cylindrical water fiters, and changing filter.	3-6 tanks per week	5 - 10 minutes	Automated		Stand up wind	X	Gauntlets/ gloves - specify type	PVC
			Closed system		Other - specify		Other - specify	
			Local exhaust ventilation					
			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 and back	840
Incidental	x		
Intermittent			
Extensive			

Additional comments:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
4. Discharge of tank water bottoms. Open tap tank, allow water to flow until discharged - waste water either collected in container or controlled drainage system.	1 - 2 per week	5 - 10 minutes	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			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			

Additional comments:

For any other standard tasks routinely performed please list details below:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
5. Sampling bowsers (road tankers)	3-12 vehicles per day	10 mins per vehicle	Automated		PTW		RPE - specify type	
			Closed system		SOP		Full face mask	
			Local exhaust ventilation		Drain and flush		Half mask	
			General ventilation	x	Purge		Filtering	
			Other - specify		Other - specify		Air supplied	
							Gauntlets - specify type	
							PVC	
							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	420
Incidental	x		
Intermittent			
Extensive			

Additional comments:

Appendix 2.3 Aviation Refuelling Operations

Appendix 2.3.3 Rail Car Operator

Job Type:	Rail Car Operator		
Operational area:	Rail car unloading		
Overview of tasks:	Bottom unloading of rail cars, including handling of loading arms or hoses, connection/disconnection, 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?	Depending on rail car loading activity

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
1. Unloading of rail cars. Hose/coupling connection disconnection	1 - 2 trains per shift	30-45 mins	Automated		Stand up wind	X	Gauntlets/ gloves	PVC
			Vapour recovery system	X	Other - specify		Other - specify	
			General ventilation	X				
			Other - specify					

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

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

Additional comments:

Appendix 2.3 Aviation Refuelling Operations

Appendix 2.3.4 Vehicle Mechanic

Product:	**Kerosine**
Job Type:	**Vehicle mechanic**
Operational area:	**Vehicle Service Bay**
Overview of tasks:	**Vehicle maintenance including hose repair and pressure testing. Use of kerosine as a degreasant for washing vehicle components.**
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. 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			
Intermittent	X		
Extensive			

Additional comments:

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

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
2. Internal inspection of vehicle tanks	2-4 vehicles per year	30 mins	Automated		PTW	x	RPE - specify type	
			Closed system		Gas Tested	x	Full face mask	
			Local exhaust ventilation	x	Drain and flush	x	Half mask	
			General ventilation	x	Purge	x	Filtering	
			Other - specify		Other - specify		Air supplied	x
							Gauntlets - specify type	
							PVC	
							Nitrile	
							Other	
							Face shield?	
							Impervious coverall?	

Potential for skin contact: Low

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

Additional comments: BA supplied where necessary

Appendix 2.3 Aviation Refuelling Operations

Appendix 2.3.5 Specialist Cleaning Tasks

Product:	**Kerosine**
Job Type:	**Tank Cleaning/Tank Inspection**
Operational area:	**Tank Farm**
Overview of tasks:	**Specialist activity involving cleaning out deposits from bulk storage tanks.**

Typical number of staff per shift per site?	**1-3**
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 deposits from drained bulk storage tanks.	**Rare Task**	**8 Hours**	**Dilution Ventilation**	**X**	**Specialist Contractor**	**X**	**Gauntlets/ gloves**	**PVC**
			General ventilation		**Drained, Flushed and Vented**	**X**	**Other - specify**	**PVC coverall**
			Other - specify		**Permit to Work**	**X**		**Impervious knee length boots**
					Gas Tested	**X**		**Breathing Apparatus**
								Other - Specify

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. Interceptor cleaning. Removal of sludge from drained interceptor	**1 per year**	**up to 8 hours**	**Forced ventilation**	**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
								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 kerosine. Standard confined space entry requirements to check oxygen and vapour levels applied. If necessary appropriate respiratory protection would be worn.

Appendix 2.3 Aviation Refuelling Operations

Appendix 2.3.6 Storage Terminal Operator

Product:	**Kerosine**
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). Return of tank flushigs to storage.**

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.a. Sample collection. 0.5 litre sample collected from in line sample point	**1 - 2 per shift**	**2 - 3 minutes**	**Automated**		**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			Closed system, e.g. Dopak type		**Other - specify**		**Other - specify**	
			Local exhaust ventilation					
			General ventilation	**X**				
			Other - specify	**Splash guard**				

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	**x**		
Intermittent			
Extensive			

Additional comments:

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.	**2 - 3 per month**	**5 - 10 minutes**	**Automated**	**X**	**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			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:

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 - 2 per week**	**5 - 10 minutes**	**Automated**		**Stand up wind**	**X**	**Gauntlets/ gloves**	**PVC**
			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		**One hand front**	**210**
Incidental	**x**		
Intermittent			
Extensive			

Additional comments:

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.	10 - 30 per week	5 minutes	Automated		Drain filter housing prior to removal of filter.	X	Gauntlets/ gloves	PVC
			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 and back	840
Incidental			
Intermittent	x		
Extensive			

Additional comments:

For any other standard tasks routinely performed please list details below:

Task	Frequency	Duration	Engineering Controls?	Select as approp.	Procedural controls?	Select as approp.	Additional PPE used?	Specify type
5. Fuel test for water content and solids	1- 5 per shift	10 - 20 minutes	Automated		PTW		RPE - specify type	
			Closed system		SOP		Full face mask	
			Local exhaust ventilation		Drain and flush		Half mask	
			General ventilation	x	Purge		Filtering	
			Other - specify		Other - specify		Air supplied	
							Gauntlets - specify type	
							PVC	
							Nitrile	
							Other	disposable
							Face shield?	
							Impervious coverall?	

Potential for skin contact:

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

Additional comments:

APPENDIX 3: QUALITY CONTROL TEST RESULTS FOR KEROSINE VAPOUR EXPOSURE MONITORING

Constituent	Toluene	n-Octane	n-Nonane	n-Decane
Test atmosphere concentration (mg/m^3)	1.23	4.46	3.55	2.32
Average recovery (%) and relative standard deviation (n=10)	89 $\pm$ 3	91 $\pm$ 2	89 $\pm$ 2	85 $\pm$ 3

APPENDIX 4: INHALATION EXPOSURE MEASUREMENTS FOR EUROPEAN KEROSINE OPERATIONS

Table Appendix 4

Date	*Duration (min)*	*Job and Tasks*	*mg(eq.n-nonane)/m^3*	*benzene (mg/m^3)*	*toluene (mg/m^3)*	*n-nonane (mg/m^3)*	*n-decane (mg/m^3)*	*n-undecane (mg/m^3)*	*n-dodecane (mg/m^3)*	*Notes*
National airport, UK										
24/08/04	527	Tank farm operator: full shift	1.2							
24/08/04	524	Vehicle service bay staff: full shift	3.1							
24/08/04	420	Vehicle service bay staff: full shift	4.9							
24/08/04	250	Tank farm operator: hydrant pit maintenance	1							
24/08/04	160	Tank farm operator: hydrant pit maintenance	0.37							
24/08/04	13	Tank farm operator (sample code 1): Jet A1 sampling	2.5							
24/08/04	12	Tank farm operator (sample code 1): Jet A1 sampling	4.6	0.1						
24/08/04	57	Tank farm operator: millipore testing into one aircraft	3							Ethanol 2 mg/m^3
24/08/04	30	Tank farm operator (sample code 1): Jet A1 sampling	3.2							
24/08/04	130	Tank farm operator: check valve chambers at airfield	0.19							
24/08/04	4	Tank farm operator (Sample code 1): transfer of Jet A1 filters to waste container	2.4							
24/08/04	32	Tank farm operator (sample code 1): Jet A1 sampling	2.8							
25/08/04	332	Plane refuelling staff: hydrant operations	0.07							
25/08/04	190	Plane refuelling staff: hydrant operations	0.09							
25/08/04	318	Plane refuelling staff: hydrant operations	0.07							
25/08/04	370	Plane refuelling staff: hydrant operations	0.15							
25/08/04	326	Plane refuelling staff: hydrant operations	0.09							
25/08/04	320	Plane refuelling staff: hydrant operations	0.13							
25/08/04	20	Plane refuelling staff: hydrant operations	n.d.							
25/08/04	105	Vehicle service bay: drainage vehicle pipework prior to repair work	31.2	0.1		1.7	1.7	1.2		
25/08/04	22	Plane refuelling staff: hydrant operation (single plane)	0.38							
25/08/04	17	Plane refuelling staff: hydrant operation (single plane)	n.d.							
25/08/04	23	Plane refuelling staff: hydrant operation (single plane)	n.d.							
25/08/04	19	Plane refuelling staff: hydrant operation (single plane)	n.d.							

Date	Duration (min)	Job and Tasks	mg(eq.n-nonane)/m^3	benzene (mg/m^3)	toluene (mg/m^3)	n-nonane (mg/m^3)	n-decane (mg/m^3)	n-undecane (mg/m^3)	n-dodecane (mg/m^3)	Notes
25/08/04	19	Plane refuelling staff: hydrant operation (single plane)	0.25							
26/08/04	515	Plane refuelling staff: hydrant operations	0.11							
26/08/04	300	Vehicle service bay staff: full shift	0.46							
26/08/04	90	Tank farm operator: hydrant pit maintenance	n.d.							
26/08/04	445	Plane refuelling staff: hydrant operations	0.63							
26/08/04	510	Vehicle service bay staff: full shift	2.4							
26/08/04	115	Tank farm operator: change of Jet A1 in-line filters	21.4	0.2		1	1.1			
26/08/04	38	Tank farm operator: change of Jet A1 in-line filters	24.8	0.2		1.3	1.1			
National airport, Spain										
14/09/04	520	Plane refuelling staff: 6 planes by tanker - fill and drain one tank	0.21							
14/09/04	445	Plane refuelling staff: 10 planes by tanker - fill and drain one tank	0.17							
14/09/04	528	Plane refuelling staff: 1 plane by tanker; 11 planes by hydrant - fill up tanker	0.07							
14/09/04	543	Plane refuelling staff: 11 planes by tanker; 2 planes by hydrant	0.28							
14/09/04	599	Plane refuelling staff: 3 planes by tanker; 2 tanks drained and filled	0.06							
15/09/04	372	Plane refuelling staff: 8 planes by tanker; 1 plane by hydrant	0.14							
15/09/04	776	Plane refuelling staff: 18 planes by tanker	0.2							
15/09/04	766	Plane refuelling staff: 17 planes by tanker; drain and fill one tank; assists with filter change	0.27							
15/09/04	733	Plane refuelling staff: 16 planes by tanker; refill 3 tanks	0.3							
15/09/04	587	Plane refuelling staff: 4 planes by tanker; 1 tank drained and filled	1							
16/09/04	362	Plane refuelling staff: 2 planes by hydrant; unspecified number of planes by tanker; 4 tanks drained and filled	0.19							
16/09/04	758	Plane refuelling staff: 18 planes by tanker; 4 tanks drained and filled	0.16							
16/09/04	744	Plane refuelling staff: 16 planes by tanker; 1 tank drained and filled; checked drain sumps	0.65							
16/09/04	757	Plane refuelling staff: 20 planes by tanker; 2 tanks drained and filled; tanker refuelled	0.21							

Date	Duration (min)	Job and Tasks	mg(eq.n-nonane)/m^3	benzene (mg/m^3)	toluene (mg/m^3)	n-nonane (mg/m^3)	n-decane (mg/m^3)	n-undecane (mg/m^3)	n-dodecane (mg/m^3)	Notes
14/09/04	30	Refuelling F50 by tanker	n.d.							
14/09/04	13	Refuelling A320 by hydrant	0.4							
14/09/04	11	Refuelling metro 3 by tanker overwing	0.31							
15/09/04	19	Loading 2 tankers	1.6							
15/09/04	34	Refuelling ATR and CRJ by tanker	0.05							
15/09/04	22	Refuelling CRJ by tanker	n.d.							
15/09/04	41	Filter change on dispenser	19.7	0.04		1.5	1.3			
15/09/04	43	Filter change on dispenser-continued	19	0.02		1.2	1.6			
15/09/04	17	Refuelling A319 by hydrant	3.4							
16/09/04	31	Refuelling B737 by hydrant	0.08							
16/09/04	31	Refuelling B737 by hydrant	0.58							
16/09/04	17	Refuelling B737 by hydrant	n.d.							
16/09/04	30	Tanker filling and vehicle refuelling	1.7							
16/09/04	37	Refuelling DH3-tanker-long wait for plane	n.d.							
16/09/04	12	Refuelling A320 by tanker	n.d.							
Two regional airports, UK										
07/12/04	94	Refuelling 2 planes by tanker; discharging bridger tanker	3.5							
07/12/04	252	Refuelling 6 planes by tanker	3.1							
07/12/04	222	Refuelling 4 planes by tanker	3.4							
07/12/04	121	Refuelling 2 planes by tanker	1.5							
07/12/04	127	Refuelling 2 planes by tanker	1							
07/12/04	110	Yard maintenance and administration duties	2.2							
08/12/04	178	Refuelling 5 planes by tanker	0.69							
08/12/04	230	Refuelling 6 planes by tanker	1.5							
08/12/04	304	Refuelling 13 planes and 2 helicopters by tanker	1.8							
08/12/04	41	Bridger tanker driver - unloading into airport fuel tanks	0.3							
08/12/04	98	Refuelling staff: changing fuel filters on tanker, filling tanker, taking and testing sample	4.9							
08/12/04	91	Refuelling 3 planes by tanker	2.2							
09/12/04	28	Bridger tanker driver - unloading into airport fuel tanks	2.3							
09/12/04	277	Refuelling 13 planes by tanker	2							

Date	Duration (min)	Job and Tasks	mg(eq.n-nonane)/m^3	benzene (mg/m^3)	toluene (mg/m^3)	n-nonane (mg/m^3)	n-decane (mg/m^3)	n-undecane (mg/m^3)	n-dodecane (mg/m^3)	Notes
09/12/04	48	Bridger tanker driver - unloading into airport fuel tanks	0.56	0.02						
09/12/04	250	Refuelling 2 planes by tanker; uplifting and transferring fuel between tanks	5.6	0.04						
09/12/04	185	Refuelling 6 planes by tanker	1.7							
Heating oil distribution depot, UK, bottom loading/vapour recovery										
07/02/05	532	Tanker driver, 1 loading, 10 deliv. Kerosine (15 m^3 total), 3 deliv. gas oil (15 m^3 total)	3.4	0.03						
07/02/05	493	Tanker driver, 1 loading, 12 deliv. Kerosine (16 m^3 total), 1 deliv. gas oil (1.3 m^3)	15.2	0.2						
07/02/05	513	Tanker driver, 2 loadings, 9 deliv. Kerosine (15 m^3 total), 3 deliv. gas oil (10 m^3 total)	14.2	0.1						
07/02/05	400	Tanker driver, 1 loading, 9 deliv. Kerosine (11 m^3 total), 2 deliv. gas oil (6 m^3 total)	33.1	0.4	1.1	1.2				2-Methylbutane 1.5 mg/m^3
07/02/05	506	Depot supervisor	1.1							Dichlorobenzene 1.1
08/02/05	537	Tanker driver, 2 loadings, 16 deliv. Kerosine (14 m^3 total), 2 deliv. gas oil (3 m^3 total)	41	0.2		1.4	1.8	1.7	1.2	
08/02/05	456	Tanker driver, 1 loading, 4 deliv. Kerosine (7 m^3 total), 2 deliv. gas oil (2 m^3 total) - small spillage	5.4	0.03						
08/02/05	519	Tanker driver, 2 loadings, 9 deliv. Kerosine (10 m^3 total), 4 deliv. gas oil (6 m^3 total)	5.2	0.04						
08/02/05	506	Depot supervisor	0.68							p-dichlorobenzene 0.7 mg/m^3
08/02/05	426	Tanker driver, 1 loading, 5 deliv. Kerosine (5 m^3 total), 4 deliv. gas oil (12 m^3 total)	3.9	0.02						
08/02/05	360	Tanker driver, 3 loadings, 2 deliv. gas oil (48 m^3 total)	1.3							
08/02/05	299	Tanker Driver-Loading only (15 m^3 gasoil)	0.47							
08/02/05	244	Tanker Driver-Loading only (7 m^3 kerosene)	n.d.							
09/02/05	318	Tanker driver, 1 loading, 5 deliv. gas oil (18 m^3 total)	10.9	0.1						2-Methylbutane 1.4 mg/m^3

Date	Duration (min)	Job and Tasks	mg(eq.n-nonane)/m^3	benzene (mg/m^3)	toluene (mg/m^3)	n-nonane (mg/m^3)	n-decane (mg/m^3)	n-undecane (mg/m^3)	n-dodecane (mg/m^3)	Notes
09/02/05	523	Tanker driver, 1 loading, 8 deliv. Kerosine (8 m^3 total), 3 deliv. gas oil (9 m^3 total)	8.2	0.1						
09/02/05	434	Tanker driver, 1 loading, 17 deliv. Kerosine (18 m^3 total)	70.1	0.9	2.3	1.9	1.7	1		2-Methylbutane 3.8 mg/m^3
09/02/05	29	Tanker Driver-Loading only (18 m^3 kerosene)	0.27							
09/02/05	359	Tanker driver, 1 loading, 4 deliv. Kerosine (8 m^3 total), 4 deliv. gas oil (9 m^3 total)	1							
09/02/05	203	Tanker driver, 2 loadings, 2 deliv. Kerosine (12 m^3 total), 3 deliv. gas oil (9 m^3 total)	2.3	0.03						
09/02/05	22	Tanker Driver-Loading only (3 m^3 kerosene and 7 m^3 gas oil)	0.12							
10/02/05	502	Tanker driver, 2 loadings, 14 deliv. Kerosine (20 m^3 total), 1 deliv. gas oil (1 m^3)	60	0.8	2.1	1.7	1.5			
10/02/05	546	Tanker driver, 1 loading, 5 deliv. Kerosine (14 m^3 total), 5 deliv. gas oil (16 m^3 total)	1.1	0.1						
10/02/05	443	Tanker driver, 1 loading, 12 deliv. Kerosine (15 m^3 total), 1 deliv. gas oil (3 m^3)	6	0.1						
10/02/05	64	Tanker delivery to depot (38 m^3 kerosine)	0.14							
Heating oil distribution depot, UK, top loading/no vapour recovery										
16/02/05	335	Depot supervisor	0.43							
16/02/05	477	Tanker driver, 1 loading, 4 deliv. Kerosine (4 m^3 total), 4 deliv. gas oil (13 m^3 total)	5.5	0.02						
16/02/05	36	Tanker Driver-Loading only (5 m^3 kerosene and 12 m^3 gas oil)	3.4	0.02						
16/02/05	40	Tanker Driver-Loading only (8 m^3 kerosene and 5 m^3 gas oil)	5.2	0.04						
16/02/05	52	Tanker Driver-Loading only (7 m^3 kerosene and 4 m^3 gas oil)	3.1	0.03						
16/02/05	352	Tanker driver, 1 loading, 5 deliv. Kerosine (5 m^3 total), 5 deliv. gas oil (12 m^3 total)	5.5	0.1						

Date	Duration (min)	Job and Tasks	mg(eq.n-nonane)/m^3	benzene (mg/m^3)	toluene (mg/m^3)	n-nonane (mg/m^3)	n-decane (mg/m^3)	n-undecane (mg/m^3)	n-dodecane (mg/m^3)	Notes
17/02/05	493	Tanker driver, 1 loading, 1 deliv. Kerosine (1 m^3), 5 deliv. gas oil (17 m^3 total)	3.3							
17/02/05	45	Tanker Driver-Loading only (11 m^3 kerosene)	15	0.1						2-Methylbutane 1 mg/m^3
17/02/05	440	Tanker driver, 2 loadings, 2 deliv. Kerosine (16 m^3 total)	4.7	0.04						
17/02/05	453	Tanker driver, 1 loading, 6 deliv. Kerosine (11 m^3 total), 3 deliv. gas oil (4 m^3 total)	4.6							
17/02/05	35	Tanker Driver-Loading only (11 m^3 kerosene and 4 m^3 gas oil)	10	0.1						
21/02/05	38	Tanker Driver- 2 Loadings (total 11 m^3 kerosene and 6 m^3 gas oil)	6.8	0.1						
21/02/05	266	Tanker driver, 2 loadings, 10 deliv. Kerosine (11 m^3 total), 4 deliv. gas oil (6 m^3 total)	2.6	0.02						
21/02/05	29	Tanker Driver-Loading only (7 m^3 kerosene and 1 m^3 gas oil)	10.4	0.1						
21/02/05	554	Tanker driver, no loading, 9 deliv. Kerosine (14 m^3 total), 2 deliv. gas oil (4 m^3 total)	0.18							
21/02/05	414	Tanker driver, 1 loading, 11 deliv. Kerosine (12 m^3 total), 1 deliv. gas oil (5 m^3 total)	4.2	0.03						
21/02/05	46	Tanker Driver-Loading only (12 m^3 kerosene and 5 m^3 gas oil)	5.6	0.04						
22/05/05	58	Tanker delivery to depot (37 m^3 kerosine or gas oil)	4.9							
22/05/05	423	Tanker driver, no loading, 9 deliv. Kerosine (10 m^3 total), 1 deliv. gas oil (6 m^3)	0.85							
22/05/05	14	Tanker Driver-Loading only (8 m^3 kerosene and 2 m^3 gas oil)	1.1							
22/05/05	364	Tanker driver, 1 loading, 5 deliv. Kerosine (8 m^3 total), 1 deliv. gas oil (2 m^3)	2	0.02						
22/05/05	328	Tanker driver, 1 loading, 2 deliv. Kerosine (2 m^3 total), 2 deliv. gas oil (15 m^3 total)	10	0.02						
22/05/05	23	Tanker Driver-Loading only (2 m^3 kerosene and 15 m^3 gas oil)	n.d.							

Date	Duration (min)	Job and Tasks	mg(eq.n-nonane)/m^3	benzene (mg/m^3)	toluene (mg/m^3)	n-nonane (mg/m^3)	n-decane (mg/m^3)	n-undecane (mg/m^3)	n-dodecane (mg/m^3)	Notes
22/05/05	35	Tanker Driver-Loading only (6 m^3 kerosene and 5 m^3 gas oil)	2							
23/05/05	358	Tanker driver, 1 loading, 3 deliv. Kerosine (5 m^3 total), 2 deliv. gas oil (2 m^3 total)	0.79							
23/05/05	32	Tanker Driver-Loading only (3 m^3 kerosene and 10 m^3 gas oil)	3.7	0.03						
23/05/05	332	Tanker driver, 1 loading, 1 deliv. Kerosine (3 m^3), 2 deliv. gas oil (10 m^3 total)	4							
Regional airport, Italy										
19/04/05	120	Refuelling airplanes	0.1							
19/04/05	100	Depot activities	n.d.							
19/04/05	215	Filling tanker and refuelling airplanes	0.04							
20/04/05	450	Depot activities	0.64							
20/04/05	422	Refuelling airplanes	0.34							
20/04/05	510	Depot activities and airplane refuelling	4.8	0.03						
20/04/05	510	Depot activities and airplane refuelling	0.06							
21/04/05	408	Refuelling airplanes	1.3							
21/04/05	470	Refuelling airplanes	0.33							
National and regional airports, France										
18/10/05	103	Filter inspection	34.5	0.2		1.1	1.8	1		
18/10/05	40	Morning shift Jet A1	0.61							
19/10/05	515	Refuelling airplanes	0.23							
19/10/05	439	Refuelling airplanes	0.27							
19/10/05	425	Refuelling airplanes	0.21							
19/10/05	482	Refuelling airplanes	0.41							
19/10/05	426	Refuelling airplanes	0.2							
19/10/05	465	Refuelling airplanes	0.91							
19/10/05	450	Refuelling airplanes	0.14							
20/10/05	531	Maintenance worker	9.36							
20/10/05	446	Maintenance worker	1.44							
20/10/05	135	Jet A1 purging	6.84	0.04						
03/11/05	477	Refuelling station supervisor	0.76							
20/10/05	469	Refuelling station supervisor	0.31							
20/10/05	122	Jet A1 purging	13.5	0.04						

Date	Duration (min)	Job and Tasks	mg(eq.n-nonane)/m^3	benzene (mg/m^3)	toluene (mg/m^3)	n-nonane (mg/m^3)	n-decane (mg/m^3)	n-undecane (mg/m^3)	n-dodecane (mg/m^3)	Notes
National airport, France										
25/10/05	60	Maintenance worker: Vehicle test outside (e.g.pressure test)	2.6							
25/10/05	55	Maintenance worker: valve dismanting (in garage)	290	1	4.6	22.4	8.5	3.3		n-Octane 16.2 mg/m^3
25/10/05	90	Maintenance worker: assembling valve (in garage)	18.8			1.7	1.3	1.2		
25/10/05	80	Plane refuelling staff (A340,C8, venting)	0.33							
25/10/05	120	Plane refuelling staff (A319,A330,A320,F68,venting)	0.34							
25/10/05	135	Plane refuelling staff (A320,D12,venting)	0.44							
25/10/05	57	Plane refuelling staff (777)	n.d.							
25/10/05	20	Plane refuelling staff (A319)	n.d.							
25/10/05	27	Plane refuelling staff (A319)	n.d.							
25/10/05	23	Plane refuelling staff (A320)	n.d.							
26/10/05	240	Maintenance worker: dumping Jet A1 in tank & other mechanical tasks	2.16							
26/10/05	120	Maintenance worker: several minor maintenance tasks	1.08							
26/10/05	250	Plane refuelling staff	0.23							
26/10/05	270	Plane refuelling staff (A319,A320,BAE146,B777,145)	1.11							
27/10/05	360	Maintenance worker: several maintenance tasks	0.97							
27/10/05	160	Plane refuelling staff (A318,B777)	0.12							
27/10/05	250	Plane refuelling staff (A320,BAE)	0.88							
Aircraft manufacturing site, France										
04/11/05	395	Maintenance worker	2.42							
04/11/05	457	Refuelling station supervisor	2.43							
04/11/05	367	Plane refuelling staff	0.33							
04/11/05	265	Plane refuelling staff	4.08							
04/11/05	410	Plane refuelling staff	3.68							
04/11/05	397	Plane refuelling staff	2.86							
04/11/05	365	Plane refuelling staff	0.22							
04/11/05	63	Jet A1 purging	22.8			1.3				m-Xylene 1.1

APPENDIX 5: EASE MODELLING OF INHALATION AND DERMAL EXPOSURES

Parameters for inhalation exposure for generic scenarios with inhalation exposure to kerosine vapour. For all scenarios, it is assumed that no aerosols are formed. EASE is a general model that can be used to predict workplace exposure to any substance hazardous to health. The model is based on three parameters (Tickner 2005):

(i) the tendency of the substance to become airborne; kerosine falls into the category: liquid with low vapour pressure.
(ii) the way in which the substance is used; for kerosine the relevant patterns of use are: used in closed systems, non-dispersive use and wide-dispersive use.
(iii) the means of controlling exposure or of preventing the substance from entering the workplace atmosphere (pattern of control).

EASE yields an inhalation exposure estimate, expressed in ppm. In this report inhalation exposures are all expressed in mg/m^3. The EASE estimates are converted from ppm into mg/m^3, using a molecular weight (MW) for kerosine vapour of 120. This means that 1 ppm equals 120 / 24 = 5 mg/m^3. The MW for kerosine vapour (120) is lower than for the liquid kerosine (157.7).

Table A5.1: EASE inhalation estimates

Pattern of use	Pattern of control				Inhalation exposure estimate (mg/m^3)
Closed	Breached No	Full Containment			0 – 0.5
	Breached Yes	Local Exhaust Ventilation			2.5 – 5.0
		Segregation			15 – 25
		Direct Handling	With Dilution Ventilation		50 – 100
			Uncontrolled Direct Handling		250 – 350
Non-dispersive use	Full Containment	Breached No			0 – 0.5
		Breached Yes	Local Exhaust Ventilation		2.5 – 5.0
			Segregation		15 – 25
			Direct Handling	With Dilution Ventilation	50 –100
				Uncontrolled Direct Handling	250 – 350
	Local Exhaust Ventilation				2.5 – 5.0
	Segregation				15 - 25
	Direct Handling	With Dilution Ventilation			50 – 100

Pattern of use	Pattern of control				Inhalation exposure estimate (mg/m^3)
		Uncontrolled Direct Handling			250 – 350
Wide-dispersive use	Segregation				50 – 100
	Direct Handling	With Dilution Ventilation			500 – 700
		Uncontrolled Direct Handling			1000 – 1500

Parameters for dermal exposure modelling

In the EASE dermal model, the four categories for dermal contact level and their estimated ranges for exposure are:

Table A5.2 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.

The typical areas of skin contamination are:

210 cm^2 palm of one hand
420 cm^2 palms of both hands
840 cm^2 front and back of both hands
2000 cm^2 hands and forearms

Table A5.3

Job Type and Main Exposure Tasks	Pattern of Control	EASE Model inhalation exposure estimates (mg/m^3)	EASE Model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use and control	*Dermal contact level*	*Surface area (cm^2)*	
1.1 Production / On-site operator							0 – 84
Sample collection from in-line sampling point (0.5 litre sample).	General ventilation. Splash guard. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Draining equipment (e.g. pumps, lines, gauges) prior to maintenance work.	General ventilation. Drain and flush. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	840	0 – 84
Quality control tests in dedicated lab area..	Fume cupboard. Standard laboratory practice. Disposable gloves. Eye protection.	2.5 – 5.0	ND-LEV	ND-DH	Very low	210	Negligible
1.2 Tank farm / Off-site operator							42 – 420
Sample collection from in-line sampling point (0.5 litre sample).	General ventilation. Splash guard. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Sample collection (top-middle-bottom) from bulk storage tank.	General ventilation. Splash guard. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Intermittent	420	42 – 420
Manual dipping via man hole on top of tank (usually automated with periodic manual checks).	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Draining tank water bottoms.	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Very low	210	Negligible

Job Type and Main Exposure Tasks	Pattern of Control	EASE Model inhalation exposure estimates (mg/m^3)	EASE Model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use and control	*Dermal contact level*	*Surface area (cm^2)*	
1.3 Mechanical maintenance							42 – 420
Maintenance on pre-drained and flushed equipment.	General ventilation. Pre-drained and flushed equipment. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Intermittent	420	42 – 420
1.4 Laboratory technician							0 – 42
Laboratory tests in dedicated lab area.	Automated (depending on test). Fume cupboard. General ventilation. Standard laboratory practice. Disposable gloves. Eye protection.	2.5 – 5.0	ND-LEV	ND-DH	Incidental	210	0 – 21
Sample bottle washing.	Closed system (bottle washing machine). General ventilation. Standard laboratory practice. Disposable gloves. Eye protection.	50 – 100	ND-DH-DV (bottles emptied manually)	ND-DH	Incidental	420	0 – 42
1.5 Rail car operator							42 – 420
Top loading rail cars - with or without vapour recovery (VR).	VR system (depending on situation). General ventilation. Stand up wind. Gloves. Eye protection.	0 – 0.5 (with VR) 50 – 100 (without VR)	C-FC C-B-DH-DV	ND-DH	Intermittent	420	42 – 420

Job Type and Main Exposure Tasks	Pattern of Control	EASE Model inhalation exposure estimates (mg/m^3)	EASE Model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use and control	*Dermal contact level*	*Surface area (cm^2)*	
1.6 Specialist cleaning tasks							N/A – PTW
Tank cleaning. Removal of sludge from drained bulk storage tank.	Forced ventilation. Specialist contractor. Drained, flushed and vented. Permit to work. Gloves. Impervious coverall and boots. Eye protection. Breathing apparatus as required by confined space entry procedure.	50 – 100	ND-DH-DV				N/A – PTW
Interceptor cleaning. Removal of sludge from drained interceptor.	Forced ventilation. General ventilation. Specialist contractor. Permit to work. Gloves. Impervious coverall and boots. Eye protection. Breathing apparatus as required by confined space entry procedure.	50 – 100	ND-DH-DV				N/A – PTW
1.7 Jetty staff							42 – 420
Connecting and disconnecting loading arms / hoses.	General ventilation. Draining hose before disconnection. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	840	0 – 84
Sample collection from in-line sampling point.	General ventilation. Splash guard. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Intermittent	420	42 – 420

C closed system
B breached
DH direct handling
DV dilution ventilation
FC full containment
LEV local exhaust ventilation
ND non-dispersive use

Table A5.4

Job Type and Main Exposure Tasks	**Pattern of Control**	**EASE model Inhalation exposure estimates (mg/m^3)**	**EASE Model parameters**	***EASE Dermal exposure model***			**EASE Dermal exposure estimates (mg/day)**
				Pattern of use and control	**Dermal contact level**	**Surface area (cm^2)**	
2.1 Road tanker driver							0 – 84
Bottom loading of road cars. Hose connection / disconnection (closed VR system).	Closed system – breakaway couplings. VR system. General ventilation. Stand up wind. Gloves. Eye protection.	0 – 0.5	C-FC	ND-DH	Incidental	420	0 – 42
Bottom loading of road cars. Hose connection / disconnection (remote venting).	Closed loading system – breakaway couplings. VR with remote venting. General ventilation. Stand up wind. Gloves. Eye protection.	15 – 25	C-B-S	ND-DH	Incidental	420	0 – 42
Top loading of road cars.	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Incidental	420	0 – 42
Delivery to customer storage. Hose connection / disconnection (closed VR system).	Closed system – breakaway couplings. VR system. General ventilation. Draining of hose into product tank prior to disconnection. Stand up wind. Gloves. Eye protection.	0 – 0.5	C-FC	ND-DH	Very low	420	Negligible

Job Type and Main Exposure Tasks	**Pattern of Control**	**EASE model Inhalation exposure estimates (mg/m^3)**	**EASE Model parameters**	***EASE Dermal exposure model***			**EASE Dermal exposure estimates (mg/day)**
				Pattern of use and control	**Dermal contact level**	**Surface area (cm^2)**	
Delivery to customer storage. Hose connection / disconnection (remote venting).	Closed system – breakaway couplings. Remote venting. General ventilation. Draining of hose into product tank prior to disconnection. Stand up wind. Gloves. Eye protection.	15 – 25	C-B-S	ND-DH	Very low	420	Negligible
Drainage of fuel from vehicle fuel tank following change of grade. Fuel pumped into separate container.	General ventilation. Use of fuel retriever. Safe operating procedure. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	840	0 – 84
2.2 Subsidiary / Commercial road tanker driver							0 – 42
Bottom loading of road cars. Hose connection / disconnection (closed VR system).	Closed system – breakaway couplings. VR system. General ventilation. Stand up wind. Gloves. Eye protection.	0 – 0.5	C-FC	ND-DH	Incidental	420	0 – 42
Bottom loading of road cars. Hose connection / disconnection (remote venting).	Closed loading system – breakaway couplings. VR with remote venting. General ventilation. Stand up wind. Gloves. Eye protection.	15 – 25	C-B-S	ND-DH	Incidental	420	0 – 42
Top loading of road cars.	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Incidental	420	0 – 42

Job Type and Main Exposure Tasks	Pattern of Control	EASE model Inhalation exposure estimates (mg/m^3)	EASE Model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use and control	Dermal contact level	Surface area (cm^2)	
Delivery to customer storage. Hose with trigger gun.	Automatic cut-off on nozzle. General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Incidental	210	0 – 21
2.3 Terminal operator							84 – 840
Sample collection from in-line sampling point (0.5 litre sample).	General ventilation. Splash guard. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Manual tank dipping/ullage measurement via man hole on top of bulk storage tank (usually automated with periodic manual checks).	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Draining tank water bottoms.	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Very low	210	Negligible
Filter cleaning.	General ventilation. Drain filter housing prior to removal of filter. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Intermittent	840	84 – 840
Filling 200 litre drums.	Automated cut-off. LEV (depending on situation). General ventilation. Specialist contractor used. Safe operating procedure. Gloves. Apron. Eye protection.	2.5 – 5 (with LEV) 50 – 100 (without LEV)	ND-LEV ND-DH-DV	ND-DH	Intermittent	420	42 – 420

Job Type and Main Exposure Tasks	Pattern of Control	EASE model Inhalation exposure estimates (mg/m^3)	EASE Model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use and control	Dermal contact level	Surface area (cm^2)	
Off-loading rail car delivery to storage. Hose connection / disconnection.	LEV. General ventilation. Draining of hose into product tank prior to disconnection. Stand up wind. Gloves. Eye protection.	2.5 – 5	ND-LEV	ND-DH	Very low	420	Negligible
2.4 Rack operator							42 – 420
Bottom loading of road cars. Hose connection / disconnection.	Closed system – breakaway couplings. VR system. General ventilation. Stand up wind. Gloves. Eye protection.	0 – 0.5	C-FC	ND-DH	Incidental	420	0 – 42
Top loading of road cars.	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Intermittent	420	42 – 420
2.5 Rail car operator							0 – 42
Bottom loading of rail cars (with or without VR). Handling of loading hoses.	Closed system – breakaway couplings. VR system (depending on situation). General ventilation. Stand up wind. Gloves. Eye protection.	0 – 0.5 (with VR) 50 – 100 (without VR)	C-FC C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Sample collection from each rail car.	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42

Job Type and Main Exposure Tasks	Pattern of Control	EASE model Inhalation exposure estimates (mg/m^3)	EASE Model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use and control	Dermal contact level	Surface area (cm^2)	
2.6 Deck crew: ships/barges							42 – 420
Connecting and disconnecting loading arms / hoses.	General ventilation. Draining hose before disconnection. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Manual tank dipping/ullage measurement via man hole on top of bulk storage tank (usually automated with periodic manual checks).	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Intermittent	420	42 – 420
Venting of cargo tank relief valves.	Automated. General ventilation. Stand up wind. Gloves. Eye protection.	15 – 25	C-B-S	ND-DH	Very low	420	Negligible
2.7 Jetty staff							0 – 42
Connecting and disconnecting loading arms / hoses.	General ventilation. Draining hose before disconnection. Gloves. Eye protection.	50 –100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Sample collection from in-line sampling point (0.5 litre sample).	General ventilation. Splash guard. Stand up wind. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
2.8 Vehicle mechanic							42 – 420
Hose inspection, repair and pressure testing.	General ventilation. Safe operating procedure. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Intermittent	420	42 – 420

Job Type and Main Exposure Tasks	**Pattern of Control**	**EASE model Inhalation exposure estimates (mg/m^3)**	**EASE Model parameters**	***EASE Dermal exposure model***			**EASE Dermal exposure estimates (mg/day)**
				Pattern of use and control	**Dermal contact level**	**Surface area (cm^2)**	
Road vehicle storage tank inspection. Visual inspection from tank manhole. By exception staff may need to enter tank.	LEV. General ventilation. Impervious coverall and boots. Eye protection. Breathing apparatus as required by confined space entry procedure	2.5 – 5.0	C-B-LEV				N/A – PTW
2.9 Equipment maintenance							0 – 84
Preparing equipment for maintenance (e.g. isolate and drain down pumps, gauges, lines).	General ventilation. Specialist contractor. Permit to work. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	840	0 – 84
Meter proving and servicing.	General ventilation. Stand up wind. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Incidental	420	0 – 42
Maintenance on pre-drained and flushed equipment.	General ventilation. Specialist contractor. Permit to Work. Drained and flushed equipment. Gloves. Eye protection.	50 – 100	ND-DH-DV				N/A – PTW

Job Type and Main Exposure Tasks	**Pattern of Control**	**EASE model Inhalation exposure estimates (mg/m^3)**	**EASE Model parameters**	***EASE Dermal exposure model***			**EASE Dermal exposure estimates (mg/day)**
				Pattern of use and control	**Dermal contact level**	**Surface area (cm^2)**	
2.10 Specialist cleaning tasks							N/A – PTW
Tank cleaning. Removal of sludge from drained bulk storage tank.	Forced ventilation. Specialist contractor. Drained, flushed and vented. Permit to work. Gloves. Eye protection. Impervious coverall and boots. Breathing apparatus as required by confined space entry procedure.	50 – 100	ND-DH-DV				N/A – PTW
Interceptor cleaning. Removal of sludge from drained interceptor.	Forced ventilation. General ventilation. Specialist contractor. Permit to work. Gloves. Impervious coverall and boots. Eye protection. Breathing apparatus as required by confined space entry procedure.	50 – 100	ND-DH-DV				N/A – PTW

Table A5.5

Job Type & Main Exposure Tasks	Pattern of Control	EASE model Inhalation exposure estimates (mg/m^3)	EASE model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use & control	Dermal contact level	Surface area (cm^2)	
3.1 Aircraft refueller							0 – 42
Refuelling aircraft via tanker	Dry break coupling. Self shutting tanks on aircraft. General ventilation. Standard Operating Procedure.	15 – 25	C-B-S	ND-DH	Incidental	420	0 – 42
Refuelling aircraft via hydrant system	Dry break coupling. Self shutting tanks on aircraft. General ventilation. Standard Operating Procedure.	15 – 25	C-B-S	ND-DH	Incidental	420	0 – 42
Bottom loading road cars. Hose connection/ disconnection	Closed system – breakaway couplings. Vapour recovery system. General ventilation. Stand up wind. Gloves.	0 – 0.5	C-FC	ND-DH	Very low	420	Negligible
3.2 Yard operative							0 – 84
Fuel testing (1 litre sample of fuel from each tank in tank farm from in-line sample point)	Closed system. General ventilation. Standard Operating Procedure. Gloves.	0 – 0.5	C-FC	ND-DH	Incidental	420	0 – 42
Meter proving and servicing. Manual tank dipping/ullage measurement. Dip tape dropped into bulk storage tank via man hole on top of tank	Usually automated with periodic manual checks. General ventilation. Stand up wind. Gloves.	50 – 100	ND-DH-DV	ND-DH	Incidental	420	0 – 42

Job Type & Main Exposure Tasks	**Pattern of Control**	**EASE model Inhalation exposure estimates (mg/m^3)**	**EASE model parameters**	***EASE Dermal exposure model***			**EASE Dermal exposure estimates (mg/day)**
				Pattern of use & control	**Dermal contact level**	**Surface area (cm^2)**	
Testing of cylindrical water filters, and changing filter	General ventilation. Stand up wind. Gloves.	50 – 100	ND-DH-DV	ND-DH	Incidental	840	0 – 84
Discharge of tank water bottoms. Open tap tank, allow water to flow until discharged – waste water either collected in container or controlled drainage system	General ventilation. Stand up wind. Gloves.	50 – 100	C-B-DH-DV	ND-DH	Very low	210	Negligible
Sampling the vehicles	General ventilation.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
3.3 Rail car operator							0 – 42
Unloading of rail cars. Hose connection / disconnection	Vapour recovery system. General ventilation. Stand up wind. Gloves.	0 – 0.5	C-FC	ND-DH	Incidental	420	0 – 42
3.4 Vehicle mechanic							42 – 420
Hose inspection, repair and pressure testing	General ventilation. Safe Operating Procedure. Gloves.	50 – 100	ND-DH-DV	ND-DH	Intermittent	420	42 – 420
Internal inspection of vehicle tanks	General ventilation. Permit to work. Drain and flush. Purge. Gas tested. Respiratory protection with supply-air.	50 – 100	C-B-DH-DV	ND-DH			NA – PTW

Job Type & Main Exposure Tasks	Pattern of Control	EASE model Inhalation exposure estimates (mg/m^3)	EASE model parameters	*EASE Dermal exposure model*			EASE Dermal exposure estimates (mg/day)
				Pattern of use & control	Dermal contact level	Surface area (cm^2)	
3.5 Tank cleaning / tank inspection							NA – PTW
Tank cleaning. Removal of deposits from drained bulk storage tanks	Dilution ventilation. Permit to work. Drained, flushed and vented. Gas tested. Gloves. Impervious coverall and knee length boots. Breathing apparatus.	50 – 100	ND-DH-DV	ND-DH			NA – PTW
Interceptor cleaning. Removal of sludge from drained interceptor	Forced ventilation. General ventilation. Permit to work. Gloves. Coverall.	50 – 100	ND-DH-DV	ND-DH			NA – PTW
3.6 Terminal operator							84 – 840
Sample collection. 0.5 litre sample collected from in-line sample point	General ventilation. Splash guard. Stand up wind. Gloves.	50 – 100	C-B-DH-DV	ND-DH	Incidental	420	0 – 42
Manual tank dipping/ullage measurement. Dip tape dropped into bulk storage tank via man hole on top of tank	Usually automated with periodic manual checks. General ventilation. Stand up wind. Gloves.	50 – 100	ND-DH-DV	ND-DH	Incidental	420	0 – 42
Discharge of tank water bottoms. Open tap tank, allow water to flow until discharged – waste water either collected in container or controlled drainage system	General ventilation. Stand up wind. Gloves.	50 – 100	C-B-DH-DV	ND-DH	Incidental	210	0 – 21

Job Type & Main Exposure Tasks	**Pattern of Control**	**EASE model Inhalation exposure estimates (mg/m^3)**	**EASE model parameters**	***EASE Dermal exposure model***			**EASE Dermal exposure estimates (mg/day)**
				Pattern of use & control	**Dermal contact level**	**Surface area (cm^2)**	
Filter cleaning: cleaning in-line basket filters. Open lid and remove basket. Clean out debris.	General ventilation. Drain filter housing prior to removal of filter. Stand up wind. Gloves.	50 – 100	ND-DH-DV	ND-DH	Intermittent	840	84 – 840
Fuel test for water content and solids.	General ventilation. Gloves. Coverall.	50 - 100	ND-DH-DV	ND-DH	Intermittent	420	42 – 420
3.7 Aircraft maintenance worker							42 – 420
Draining fuel systems	General ventilation. Gloves. Eye protection.	50 – 100	C-B-DH-DV	ND-DH	Incidental	840	0 – 84
Maintenance on pre-drained equipment	General ventilation. Drained equipment. Gloves. Eye protection.	50 – 100	ND-DH-DV	ND-DH	Intermittent	420	42 – 420
Fuel tank entry	Forced ventilation. Permit to work. Drained and vented. Gas tested. Respiratory protection with supply air as required by confined space entry procedure. Gloves.	NA – PTW	NA – PTW	ND-DH			NA – PTW

Table A5.6

Job Type & Main Exposure Tasks	**Pattern of Control**	**EASE model Inhalation exposure estimates (mg/m^3)**	**EASE model parameters**	***EASE Dermal exposure model***			**EASE Dermal exposure estimates (mg/day)**
				Pattern of use & control	**Dermal contact level**	**Surface area (cm^2)**	
4.1 Domestic Heating Supplier				0 – 84			
Replacement of domestic heating oil storage vessels.	Full containment. Natural ventilation. Safe operating procedure. Gloves.	0 – 0.5	C-FC	ND-DH	Very low	840	Negligible
Draining of fuel storage tank.	Natural ventilation. Safe operating procedure. Gloves.	50 – 100	C-B-DH-DV	ND-DH	Incidental	840	0 – 84
4.2 Domestic Heating Engineer							0 – 42
Servicing of oil fired central heating system.	Full containment. Natural ventilation. Gloves.	0 – 0.5	C-FC	ND-DH	Incidental	420	0 – 42

APPENDIX 6: COMPARISON OF MEASURED AND MODELLED INHALATION EXPOSURE DATA BY TASK

Job Title and Exposure Tasks	Measured levels (mg/m^3)			Modelled range (mg/m^3)
	Mean	Reasonable WC	Range	
1.7/2.7 Jetty staff				
Connecting/disconnecting loading arms/hoses	No data	9	1-9	50-100
2.1 Road tanker driver and other distribution job titles				
Top loading tanker	7	27	<0.1-27	50-100
Bottom loading tanker	0.2	0.3	<0.1-0.3	15-25
Delivery to customer storage	3	5	0-5	3-5
3.1 Aircraft refueller				
Refuelling via tanker	7	23	<0.03-57	15-25
Refuelling via hydrant	0.7	3	<0.06-3.4	15-25
3.2 Yard operator / 3.6 Terminal operator				
In-line filter inspection and change	41	86	19-86	50-100
4.1 Domestic heating supplier				
Replacement of storage vessel, incl. drainage	16	23	8-23	50-100

APPENDIX 7: KEROSINE PERMEABILITY TEST RESULTS FOR SELECTED GLOVES

Glove n°	Country of use	Operation of use	Type/ Brand clearly identified	Base material[1]	Test results:			Comments
					thickness (mm)	break through time (min)	EN 374-3 class	
1	Norway	Refinery	Yes	Nitrile	0.58	> 480	6	Same as Gas Oils glove no. 8
2	Norway	Laboratory	No	N.A.	0.11	411-479	5	Swelling of samples during test
3	UK	Refinery	Yes	PVC	1.28	103-129	3	Same as Gas Oils glove no. 3
4	UK	N.A.	Yes	Nitrile	0.10	1-3	0	Swelling of samples during test
5	UK, Spain	Airport	Yes	Nitrile	1.86	0-2	0	Recommended as construction glove
6	UK	Airport	Yes	PVC	1.46	51-55	2	Swelling of samples during test
7	Italy	N.A.	Yes	PVC	1.65	0-2	0	Same as Gas Oils glove no. 17
8	France	N.A.	Yes	PVC	1.20	52-60	2	Swelling of samples during test
9	UK	Airport	Yes	PVC	1.90	47-63	2	Swelling of samples during test
10	UK	Airport	Yes	PVC	1.68	104-108	3	Swelling of samples during test
11	UK	Terminal	Yes	PVC	1.16	33-43	2	Swelling of samples during test
12	UK	Terminal laboratory	No	N.A.	0.16	1-3	0	Classed as disposable surgical glove
13	UK	Distribution drivers	No	N.A.	1.84	25-29	1	Swelling of samples during test
14	UK	Airport refuellers	Yes	PVC	1.39	63-67	3	Swelling of samples during test
15	UK	Tank farm airport	Yes	Nitrile	0.11	9-23	0	
16	UK	Heating oil distribution	Yes	PVC	1.18	37-41	2	Swelling of samples during test
17	UK	Heating oil distribution	Yes	PVC	1.09	27-37	1	Swelling and discolouration of samples during test

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

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