Health Protection Agency

Compendium of Chemical Hazards: Diesel.

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HPA Compendium of Chemical Hazards

Diesel

Key Points

Fire

- Flammable
- Vapour / air mixtures may be explosive
- Use foam and liquid-tight protective clothing with breathing apparatus

Health

- Irritating to eyes, respiratory ststem and skin
- Severe lung injury may occur following aspiration of liquid
- Possible carcinogen

Environment

- Dangerous for the environment
- Inform Environment Agency of substantial incidents

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CHAPD HQ
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Version 1

Contents

Diesel

General information

Key Points

Fire

- Flammable
- Vapour / air mixtures may be explosive
- Use foam and liquid-tight protective clothing with breathing apparatus

Health

- Irritating to eyes, respiratory system and skin
- Chemical pneumonitis may arise following aspiration of vomitus (secondary to ingestion) or inhalation of aerosol (or aspiration of liquid) during manual siphoning
- Prolonged skin exposure may cause skin irritation
- Possible carcinogen
- Diesel is considered not to be a human reproductive or developmental toxicant

Environment

- Dangerous for the environment
- Inform Environment Agency of substantial incidents

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Background

Diesel is a complex mixture of chemicals mainly obtained from the distillation of crude oil. The product is thought to be named after Dr Rudolf Diesel, a German engineer who, in 1892, patented an oil-burning internal combustion engine. Modern diesel engines also incorporate features of a design (patented between 1886 and 1890) by the Yorkshireman Herbert Akroyd Stuart .

In the UK, 'diesel' or DERV refers to a fuel for running cars, vans and lorries. However, the term 'diesel' is also used to describe a range of different fuels such as 'artic' and 'marine' diesel or as an alternative name for kerosene, all of which differ considerably in composition and physical properties.

In 2004, approximately 700 litres (150 gallons) of diesel was sold every second in the UK. Most diesel is ultra-low in sulphur content in order to limit the emission of sulphur-containing pollutants from engine exhaust fumes.

Diesel is not considered to be particularly toxic and accidental poisoning is very rare. However, if diesel is swallowed, medical advice should be obtained immediately as there is a small risk of short-term lung damage if vomiting occurs or if droplets of diesel are inhaled. Long-term skin exposure to diesel may result in eczema (dermatitis) and should be avoided.

The use of diesel to clean skin and hair should be strongly discouraged as this practice has been known to cause serious kidney damage.

Production and Uses

Key Points

Production and uses

- Diesel is produced by mixing fractions of crude oil distillates (petrochemicals) with various, brand-specific additives.
- Approximately 22 thousand million litres (5 thousand million gallons) of diesel were sold in the UK in 2004, equating to 700 litres (150 gallons) per second.

Diesel is produced by blending straight-run middle distillates (minimum 40%) with varying proportions of straight-run gas oil, light vacuum distillates, light thermally-cracked distillates and light catalytically-cracked distillates.

The quantity of diesel released by HM Revenue and Customs for consumption in the UK in 2004 was approximately 22 thousand million litres (5 thousand million gallons), the majority (99.7%) of which was “ultra-low sulphur diesel” for automotive engines. Diesel is also used as a cleaning solvent for tanks, engines and refinery equipment.

Frequently Asked Questions

What is diesel?

Diesel is a complex mixture of hydrocarbons produced by mixing fractions obtained from the distillation of crude oil with brand-specific additives to improve performance. It is a liquid under normal conditions with a characteristic odour.

What is diesel used for?

In the UK, diesel is mainly used as a fuel for road vehicles, although other forms of transport (such as ships and trains) and electricity generators also use certain types of diesel.

How does diesel get into the environment?

Diesel is found in the environment as a result of accidental release from an industrial site or transport vehicle. There are no natural sources of diesel.

If there is diesel in the environment will I have any adverse health effects?

Like most chemicals, the amount of diesel you are exposed to must be above a certain level to cause adverse health effects. A short, one-off exposure to diesel will not normally cause any long-term health effects. Occasional skin exposure may lead to dermatitis (eczema). Breathing large quantities of diesel vapour or drinking diesel-based fluids may cause non-specific signs and symptoms of poisoning such as dizziness, headache and vomiting. A severe form of lung damage called pneumonitis may occur if liquid diesel is inhaled directly onto the lungs, for example, whilst manually siphoning a tank or from inhaling vomit after swallowing diesel. This is why it is important not to make someone sick if they have swallowed diesel.

Can diesel cause cancer?

There is limited evidence from animal studies that prolonged exposure may increase the risk of developing skin cancer. There is not thought to be any risk of cancer from short-term, occasional exposure.

Can diesel affect or damage the unborn child?

There is no evidence to suggest that exposure of a mother to diesel may harm the unborn child. However, as with all chemicals, it is obviously best to avoid unnecessary contact if possible.

Diesel

Incident management

Key Points

Fire

- Flammable
- Vapours may be violently reactive with air
- Use foam and liquid-tight protective clothing with breathing apparatus

Health

- Toxicity occurs following ingestion, inhalation & skin absorption
- Possible carcinogen
- Irritating to eyes and skin
- Aspiration may cause serious lung injury

Environment

- Avoid release into the environment
- Inform Environment Agency of substantial incidents

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Hazard Identification[(a)]

Standard (UK) Dangerous Goods Emergency Action Codes

UN		**1202**	Diesel Fuel or Gas Oil or Heating Oil, Light	
EAC		**3Y**	Use normal foam. Wear normal fire kit in combination with breathing apparatus*. Spillages and decontamination run-off should be prevented from entering drains and watercourses. Substance can be violently or explosively reactive.	
APP		**-**		
Hazards	**Class**	**3**	Flammable liquid	
	Sub risks	**-**		
HIN		**30**	Flammable liquid (flash point between 23 °C and 61 °C inclusive) or flammable liquid or solid in the molten state with a flash point above 61 °C, heated to a temperature equal to or above its flash point, or self-heating liquid	

UN – United Nations number; EAC – Emergency Action Code; APP – Additional Personal Protection; HIN - Hazard Identification Number

* Normal fire fighting clothing i.e. fire kit (BS EN 469), gloves (BS EN 659) and boots (HO specification A29 and A30) in combination with self-contained open circuit positive pressure compressed air breathing apparatus (BS EN 137).

[a] Dangerous goods emergency action code list, HM Fire Service Inspectorate, Publications Section, The Stationery Office, 2004.

Chemical Hazard Information and Packaging for Supply Classification[a]

Classification	**Carc cat 3**	Category 3 carcinogen	
Risk phrases	**R40**	Limited evidence of a carcinogenic effect	
Safety phrases	**S(2)**	Keep out of the reach of children	
	S36/37	Wear suitable protective clothes and gloves	

[a] Approved supply list (seventh edition): information approved for the classification and labelling of substances and preparations dangerous for supply. Chemical (Hazard Information and Packaging for Supply) Regulations 2002. The Stationery Office, 2002.

Physicochemical Properties[a,b]

Volatility	Low volatility; vapour pressure < 1 mm Hg
Specific gravity	0.82 – 0.95 at 15 °C (water = 1)
Flammability	Flammable.
Lower explosive limit	0.6%
Upper explosive limit	6.5%
Water solubility	0.5 mg 100 mL^{-1}
Reactivity	Vapours may be violently reactive with air
Reaction or degradation products	May liberate irritating or toxic fumes during combustion
Odour	Characteristic odour

[a] International Chemical Safety Card (ICSC) entry for diesel fuel no 2. ISCS 1561. International Occupational Safety and Health Information Centre (CIS), 2004.
[b] CIRUS entry for diesel, 2005.

Threshold Toxicity Values[(a)]

THRESHOLD LEVELS		
EXPOSURE BY INHALATION		SYMPTOMS
ppm	mg m^{-3}	
-	-	Data not available

[a] Hydrocarbons (MEDITEXT® Medical Management). In: Klasco RK (Ed): TOMES® System. Thomson Micromedex, Greenwood Village, Colorado (Edition expires [03, 2006]).

Published Emergency Response Guidelines

Emergency Response Planning Guideline (ERPG) Values [a]

	Listed value (ppm)	Calculated value (mg m^{-3})
ERPG-1*	Data not available	
ERPG-2*		
ERPG-3*		

* Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour.

** Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

*** Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing life-threatening health effects.

Acute Exposure Guideline Levels (AEGLs) [b]

	mg m^{-3}				
	10 min	**30 min**	**60 min**	**4 hr**	**8 hr**
AEGL-1†	Data not available				
AEGL-2††					
AEGL-3†††					

† The level of the chemical in air at or above which the general population could experience notable discomfort.

†† The level of the chemical in air at or above which there may be irreversible or other serious long-lasting effects or impaired ability to escape.

††† The level of the chemical in air at or above which the general population could experience life-threatening health effects or death.

[a] American Industrial Hygiene Association (AIHA). Emergency Response Planning Guideline values and Workplace Environmental Exposure Level Guides Handbook, Fairfax, VA, 2005.

[b] U.S. Environmental Protection Agency.

Exposure Standards, Guidelines or Regulations

Occupational standards

WEL	LTEL(8 hour reference period): No guideline value specified
	STEL(15 min reference period): No guideline value specified

Public health guidelines

DRINKING WATER QUALITY GUIDELINE	No guideline value specified
AIR QUALITY GUIDELINE	No guideline value specified
SOIL GUIDELINE VALUE AND HEALTH CRITERIA VALUES	No guideline values specified

WEL – Workplace exposure limit; LTEL - Long-term exposure limit; STEL – Short-term exposure limit

Health Effects[a]

Major route of exposure

- Toxicity may occur following ingestion, inhalation or skin exposure.

Immediate Signs or Symptoms of Acute Exposure[b-d]

- Inhalation: May cause headache, dizziness, drowsiness, incoordination and euphoria. Aspiration into the lungs causes pneumonitis with choking, coughing, wheeze, breathlessness, cyanosis and fever.
- Ingestion: Often no symptoms occur but there may be nausea, vomiting and occasionally diarrhoea.
- Ocular exposure: This product is expected to be pH neutral but may be irritating to the eyes causing an immediate stinging and burning sensation with lachrymation.
- Dermal exposure: Irritant. Drying and cracking due to defatting action. There may be transient pain with erythema, blistering and superficial burns.

For more information see TOXBASE (http://www.spib.axl.co.uk)

[a] TOXBASE: Diesel oil, 2002.
[b] TOXBASE: Petroleum distillates – features and management, 2002.
[c] TOXBASE: Eye irritants, 2002.
[d] TOXBASE: Skin decontamination – irritants, 1996.

Decontamination and First Aid[a,b]

Important Notes

- Many patients remain well and need no treatment.
- Ambulance staff, paramedics and emergency department staff treating chemically-contaminated casualties should be equipped with NHS approved liquid-tight PPE and blow-over respirators with a A2B2EK filter, where appropriate.

Dermal exposure[c]

- Remove patient from exposure.
- Remove all soiled clothing.
- Wash the contaminated area thoroughly with soap and water.
- Treat symptomatically.

Ocular exposure[d]

- Remove patient from exposure.
- Remove contact lenses if necessary and immediately irrigate the affected eye thoroughly with water or 0.9% saline for at least 10-15 minutes.

Inhalation[e]

- Remove patient from exposure and give oxygen.
- Maintain a clear airway and adequate ventilation.
- Apply other measures as indicated by the patient's clinical condition.

Ingestion[e]

- Gastric lavage should not be undertaken. Consider gastric aspiration within 1 hour of ingestion, if very large amounts have been undertaken, provided the airway can be protected.
- Give oxygen if symptomatic.
- Patients who have ingested small amounts and have had no symptoms suggestive of aspiration (choking, coughing, vomiting) or other features since the exposure can be observed at home under supervision for 6 hours after ingestion, with advice to attend hospital if features develop.
- Patients who have had features of possible aspiration should be referred to hospital.
- Patients with persistent respiratory symptoms, drowsiness or convulsions should be admitted to hospital.

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[a] Decontamination and chemical personal protective equipment in the National Health Service: Current provision, consensus opinion, specification and training implications. A report on progress. The National Focus on Chemical Incidents, 2001.
[b] TOXBASE: Diesel oil, 2002.
[c] TOXBASE: Skin decontamination – irritants, 1996.
[d] TOXBASE: Eye irritants, 2002.
[e] TOXBASE: Petroleum distillates – features and management, 2002.
TOXBASE - http://www.spib.axl.co.uk

Diesel

Toxicological overview

Key Points

Kinetics and metabolism

- As diesel is a mixture of chemicals, there is no definitive ADME (absorption, distribution, metabolism and excretion) data

Health effects of acute exposure

- Diesel may be irritating to the eyes, respiratory system and skin
- The main hazard associated with diesel is chemical pneumonitis that may arise following aspiration of vomitus (secondary to ingestion) or inhalation of aerosol (or aspiration of liquid) during manual siphoning

Health effects of chronic exposure

- Prolonged skin exposure to diesel may cause a variety of dermatitic conditions and is generally a result of inadequate or inappropriate use of personal protective equipment
- Diesel does not have a measurable effect on human reproduction or development
- There is currently no unequivocal evidence to link diesel with the incidence of cancer in humans but there is limited evidence for carcinogenicity in animals following prolonged exposure

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Toxicological Overview

Diesel is a complex mixture of hydrocarbons produced by blending several fractions of crude oil distillates with brand-specific chemical additives[a] (Annex I) [1]. The actual chemical composition of diesel varies widely according to the geographical source of crude oil, but generally comprises C_8 – C_{21} aliphatic hydrocarbons (boiling range 160 – 360 ºC) with up to 25% aromatic compounds.

The (UK) technical terms for diesel are “Class A1 Fuel Oil” and “Class A2 Fuel Oil” and refer to use in domestic and agricultural vehicles, respectively (Annex II). For the purpose of this document, “diesel” will be used as a synonym for A1 fuel oil.

Given its complex and highly variable composition, diesel is defined by physical characteristics rather than by chemical constituents (Annex III) [2].

This note does not consider diesel fumes arising from use in vehicle engines or from uncontrolled combustion.

[a] Diesel may also contain dyes or markers and up to 5% fatty acid methyl esters (FAME) in compliance with EN 14214:2003. Examples of additives are given at Annex I.

Summary of health effects

The principal adverse effect arising from the ingestion of diesel is chemical pneumonitis (secondary to aspiration of vomitus) [3, 4].

There is limited evidence to suggest that diesel may be nephrotoxic [5, 6].

Ingestion of diesel or acute exposure to vapour may lead to general signs of intoxication such as mild CNS symptoms (dizziness, headache, nausea) and vomiting [7, 8].

Skin exposure to diesel may result in dermatitis [3, 7].

Certain types of diesel are non-genotoxic animal carcinogens and are classified as Category 3 carcinogens under CHIP [8, 9].

Kinetics and metabolism

As diesel is a mixture of chemicals, there is no definitive ADME data available for either animals or humans [9]. The onset of local or systemic effects following dermal, oral or pulmonary exposure indicates that these are all potential routes of absorption for diesel.

Sources and route of human exposure

Occupational exposure may potentially occur during manual filling or discharge operations within the petrochemical industry [10], repair or service of diesel engines or from practices where diesel is used as a cleaning agent or solvent [9].

Domestic exposure to diesel is uncommon, although limited skin exposure may occur whilst refuelling domestic vehicles and pulmonary exposure may result from aspiration of liquid during manual siphoning. Leakage of diesel onto hot engine manifolds may liberate a respirable aerosol of micrometer-sized diesel particles [11].

Large-scale environmental contamination has occurred following the release of diesel from storage tanks and sea tankers [9] and some concern has been expressed over health effects of vapour arising from contaminated soil [12].

Diesel accounted for all spillages resulting from road traffic incidents in the UK during 2003 and 42% of all significant[18] (Environment Agency Category 1 or 2) pollution incidents for the same period [13].

[18] Significant refers to a Category 1 or 2 incident as defined by the Environment Agency's National Incident Recording System (Common Incident Classification, or CIC).

Health Effects of Acute / Single Exposure

Human Data

General toxicity

Under normal conditions of storage, handling or use as fuel, diesel should not present a hazard to health providing excessive skin contact is avoided [14]. The main hazard associated with diesel is chemical pneumonitis that may arise following aspiration of vomitus (secondary to ingestion) or inhalation of aerosol (or aspiration of liquid) during manual siphoning [4, 8].

There are few studies investigating the toxicity of diesel *per se*. Therefore, toxicological evaluations of diesel tend to be derived by considering the toxicity of similar (middle distillate) products such as kerosene and petrol [4, 8, 9, 11]. However, such comparisons do not take into account the toxicity of brand-specific additives, the effects of which cannot be predicted from complex hydrocarbon mixtures. Therefore, this note will mainly consider studies that are specific to diesel.

Inhalation

One study has examined the effects of a combined exposure to diesel (5 ppm) and acetaldehyde (0.5 ppm) in Gulf War veterans but did not report any adverse effects in healthy volunteers [15].

It has been stated that inhalation of diesel vapour may lead to CNS / respiratory depression and cardiac arrhythmias [7]. There do not, however, appear to be any specific case studies to confirm these effects; it is assumed that the (limited) presence of low molecular weight hydrocarbons in diesel is sufficient to contribute to such signs of toxicity [16]. Most clinical instances of myocardial sensitisation occur following exposure to volatile solvents such as those found in adhesives, lighter fluid, nail polish remover and aerosol propellants [17]. Diesel vapour (at 37°C) predominantly contains C_{10+} hydrocarbons [18].

Direct aspiration of diesel [19] or aspiration of contaminated vomit is a secondary source of pulmonary exposure that may lead to chemical (lipoidal) pneumonitis [20], a delayed onset and potentially fatal lung disorder characterised by cyanosis, dyspnoea and chest x-ray opacities [21].

Ingestion

The signs of toxicity following oral intake are generally stated to include nausea, vomiting, diarrhoea, irritation of the aero-digestive and GI tracts [7]. In one reported case of intentional self-poisoning, chemical pneumonitis was observed (which may have been due to aspiration of vomitus) [22].

Dermal / ocular exposure

Eye exposure to diesel may cause transient pain and/or hyperaemia [7]. Diesel is generally considered to be less irritating to the eyes than other middle distillate fuels such as kerosene or petrol [8].

Acute dermal exposure may result in local irritation (erythema, pruritis) which is generally more severe than that seen with other middle distillate products [23]. The incorporation of additives (such as biocides) may augment dermal sensitivity to diesel [24]. It has been suggested that the inclusion of visible markers (dyes) may increase the self-perceived dermal irritancy of diesel [25].

Neurotoxicity

No reports on the neurological effects of human diesel exposure were available in the literature. However, diesel is known to contain a number of potentially neurotoxic substances [11] and exposure to other mid-distillate fuels has resulted in neurological disorders including drowsiness, neurasthenia and decreased sensorimotor speed [4].

Nephrotoxicity

Several case studies have cited acute renal failure (secondary to acute renal tubular necrosis) as a potential complication following acute exposure to diesel [6, 8, 9, 26]. Signs included oliguria (progressing to anuria), nausea, abdominal cramps and diarrhoea.

Delayed effects following an acute exposure

There is limited evidence to suggest that long-term pulmonary residua may occur following chemical pneumonitis (as a result of aspiration-induced pneumonitis) [20, 27]: these chronic effects are of unknown clinical relevance [28].

Animal and In-Vitro Data

General toxicity

The oral toxicity of diesel is relatively low, with two studies reporting LD_{50} values of 7.5 g kg^{-1} [29] and 16 ml kg^{-1} in the rat[19] [30]. Diesel was reported as being non-irritating to the eyes but severely irritating to skin of rabbits [29]. No deaths were reported following acute dermal exposure to 5 g kg^{-1} in rats [9].

In a study using rats, a Ct of 1440 mg min m^{-3} was not lethal if given as a 4 hour exposure, but the same Ct was lethal for a 6 hour exposure [4].

[19] Conversion from ml kg^{-1} to g kg^{-1} was not possible, as the density of the material used in the study was not stated.

Delayed effects following an acute exposure

The available literature pertaining to the long-term effects of diesel following acute exposure is mainly concerned with jet fuels [11, 31] and thus its relevance is uncertain due to the presence of chemical additives and different hydrocarbon profile. In general, single (acute) oral, dermal and ocular exposures do not appear to result in persistent effects.

Health Effects of Chronic / Repeated Exposure

Human Data

General toxicity

Under normal industrial or domestic use, dermal contamination is the most likely exposure scenario. Chronic or repeat exposure to diesel may result in dermatitis although there is some evidence to suggest that hyperkeratosis may be a common feature of regular contact with diesel [8].

Inhalation

There are currently no unequivocal studies to relate chronic or repeated diesel exposures to long-term pulmonary dysfunction (other than that associated with aspiration of contaminated water or vomit). There is limited evidence to suggest that chronic exposure to long-chain hydrocarbon mixtures may be associated with a tightness of chest and breathing difficulties, although a review of the duration and extent of exposure in such circumstances was not reported [31]. In one case, a lorry driver was exposed to (an unknown concentration of) diesel vapour over a ten day period. Signs and symptoms included abdominal cramps, nausea, vomiting, acute renal failure, anaemia and thrombocytopenia [32].

Ingestion

Chronic, oral exposure to diesel is unlikely to arise under normal circumstances and there is currently no data available on the chronic effects of diesel ingestion in humans.

Dermal / ocular exposure

There are no reports on the effects of chronic ocular exposure to diesel in humans.

Acne and folliculitis have been reported in one subject who may have received chronic (occupational) exposure to diesel ([33] as reviewed in [8]). An investigation of Azerbaijan oil field workers identified hyperkeratosis as being associated with diesel exposure ([34] as reviewed in [8]).

Genotoxicity

There was evidence of increased chromosomal aberrations in a small cohort of drivers exposed to diesel ([35] as reviewed in [9]). However, the group size was small (6 smokers and 6 non-smokers) and the effects of exposure to other substances (such as diesel exhaust fumes) could not be discounted.

Carcinogenicity

In a multi-site, case-control study, there was evidence for an increased risk of prostate cancer and squamous cell carcinoma of the lung [36] but this effect could not be attributed to any particular chemical. The IARC have evaluated diesel fuels as being "not classifiable as to their carcinogenicity to humans (Group 3)" [9]: there is "inadequate evidence" to classify diesel as a human carcinogen and "limited evidence" for the carcinogenicity of diesel to experimental animals.

Reproductive and developmental toxicity

There is currently no information concerning the effects of diesel exposure on human reproduction and development. Exposure to diesel is not an indication for invasive prenatal diagnostic tests or termination of pregnancy [37].

Animal and In-Vitro Data

General toxicity

A number of studies have reported hyaline droplet nephropathy syndrome in rats; this pathological response is not considered to be relevant to humans [8].

Inhalation

In one study, mice were exposed to diesel vapour at concentrations of 65, 135 and 204 mg m^{-3}, 8 hours a day for 5 days (equating to a daily Ct of 31, 65 and 98 g min m^{-3}, respectively) [18]. Three of ten animals died in the highest dose group. There were no general effects noted in the lowest dose group.

Following exposure to diesel vapour (≤ 6 mg L^{-1}; ≤ 6h duration; ≤ 3 $week^{-1}$; ≤ 9 exposures), the primary signs of toxicity in rabbits were observed in the lung. Such effects included an increase in leukocytes in bronchial lavage (BAL) fluid and (non-dose dependent) changes in lung function parameters ([38] as reviewed by [8]).

No substantial signs of toxicity were observed in rats exposed to diesel aerosol (≤ 1.5 mg L^{-1}; 4h per day; 2 $week^{-1}$; 13 weeks): other signs deemed to be indicative of slight toxicity (including decreased weight and increase in BAL macrophages) were described as "generally reversible" following an eight week recovery period ([39] as reviewed by [8]).

Ingestion

There were no available reports on the chronic oral toxicity of diesel in animals.

Dermal / ocular exposure

Exposure of rabbits to diesel (4 or 8 ml kg^{-1}; 24h day^{-1}; 5 days $week^{-1}$) for 14 days resulted in dose-dependent dermal irritation and anorexia, leading to cachexia and death in the highest-dose group [29].

Genotoxicity

Diesel was reported as being negative in the Ames *Salmonella* assay [40]. (This was interpreted as diesel being "weakly mutagenic" by the IARC [9]). In the same study, diesel was determined to be non-mutagenic in the L5178Y (TK +/- and TK -/- strains) mouse lymphoma assay. Dimethyl sulphoxide extracts of diesel (containing aromatic or aliphatic fractions) did not induce mutations in *S. typhimurium* TA100 ([41] as reviewed by [9]). No effect was observed on the frequency of dominant lethal mutations in mice (CD-1) exposed to diesel (≤ 400 ppm; 6 h day^{-1}; 5 days $week^{-1}$) for a total of 8 weeks ([8, 42] as reviewed by [8]).

In-vivo bone marrow clastogenicity studies showed a clear increase in chromosome aberrations only at very high dose levels (6 ml kg^{-1} body weight) [41]. No details of the type of aberration were provided and no definitive conclusions can be drawn.

The available data indicate that diesel does not have any mutagenic potential.

Carcinogenicity

It is generally considered that most middle-distillate fuels (e.g. kerosene, petrol and diesel) are non-genotoxic carcinogens [43-46].

In the most recent study of tumorigenic potential, rats were administered diesel by oral gavage (in olive oil) four times per week for 104 weeks [47]. The authors surmised that there was a non-dose dependent increase in the incidence of total malignant tumours (which may be of limited relevance) and an increase in uterus-vaginal malignant tumours (which was described as dose related). No further details are available.

Reproductive and developmental toxicity

No teratogenic (developmental) effects were observed in rats subject to inhalation of diesel vapour between gestational days 6 and 15 (6h day^{-1}; 100 & 400 ppm) ([48] as reviewed in [9]).

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Annex I: Categories of Diesel Additives.

Category	Concentration Range	Example(s)	Notes
Antioxidants	9 – 25 ppm	Hindered phenols (e.g. 2,4-dimethyl-6-tert-butylphenol).	Prevent “gum-forming” reactions
Stabilisers	25 - 200 ppm	Polymethacrylate, polyisobutane	Prevent sediment formation if diesel product is prepared from craked components.
Metal deactivators	~10 ppm	N,N’-disalicylidene-1,2-propanediamine	Chelate metal ions
Cetane improvers	200 – 800 ppm	2-ethyl hexyl nitrate	Decrease time between injection of ignition in combustion chamber.
Combustion improvers	0.2% v/v	Historically include barium, manganese and copper.	Catalytic effect on combustion. No longer in common use.
Flow improvers	500 ppm	Ethylene acetate / vinyl acetate polymers	
Detergents	100 - 200	Amines, amides, imidazolines	Prevent “gummy deposits”.
Corrosion inhibitors	5 ppm	Surfactants based on esters or amine salts of alkenyl succinic acids, alkyl orthophosphoric acids an014d aryl sulphonic acids.	Primarily to protect pipelines during transport.
Antistatic additives (Static Displacement Additives)	1 – 5 ppm	Toluene, alkyl benzene sulphonate, mono and di-alkyl salicylic and dodecyl sulphosuccinic acid (Cr and Ca salts).	Added to prevent build-up of charge during bulk transfer under fast pumping rates.
Dehazers and demulsifiers	5 – 20 ppm	Quaternary ammonium salts.	Added to storage tanks on an ad hoc basis to remove water contamination.
Lubricity additives	0.03 w/w%	Phosphate ester amides.	Improve lubricity caused by hydrotreatment (to remove sulphur).
Anti-icers	Up to 30 ppm	Alcohols / glycols.	Added to delivery tanks.
Biocides	200 ppm	Thiazine derivatives.	Prevent bacterial spoilage on storage in fuel tanks.
Antifoamants	10 – 20 ppm	Silicone additives.	Prevent foaming, allowing more more complete filling of engine.
Odour masks and odorants	10 – 20 ppm		Neutralise or mask smell.
Drag reducers	50 ppm	High molecular weight, oil-soluble polymers.	Reduce drag through pipelines to increase throughput.

Table A1: summary of common additives used to improve burn, storage or transport characteristics of diesel [1].

Annex II: UK Classification of Fuel Oils.

Category	Crude Fraction	Primary Application
A1	Middle distillate	Automotive diesel fuel.
A2		Agricultural engine fuel.
C1	Paraffin	Flue-less heating appliances.
C2	Kerosene	Vaporising or atomising domestic heating appliances.
D	Middle distillate	Atomising burners for domestic, commercial or industrial applications.
E - H	Residual distillate	Atomising burners for boilers or certain industrial engines which may require pre-treatment or additives.

Table A2: Classification of various grades of fuel oil according to crude distillate fraction ("crude fraction") and application. Source: Annex A to BS 2869:1998.

Annex III: UK Physicochemical Standards for Diesel

Property	Minimum	Maximum
Cetane №.	51	-
Density at 15 °C (kg m^{-3})	820	845
Viscosity at 40 °C (mm^2 s^{-1})	2.0	4.5
Flash point (°C)	> 55	-
Polycyclic aromatic hydrocarbons (% w/w)	-	11
Sulphur content (mg kg^{-1})	-	50
Water content (mg kg^{-1})	-	200
Ash content (% w/w)	-	0.01
Fatty acid methyl ester content (% v/v)	-	5

Table A3: Summary of standard physicochemical properties of diesel (BS EN 560:2004).

This document will be reviewed not later than 3 years or sooner if substantive evidence becomes available.