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Kerosine (petroleum)

MAK Value Documentation – Translation of the German version from 2020

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Keywords

kerosine (petroleum); CNS; neurotoxicity; irritation; maximum workplace concentration; MAK value; toxicity; hazardous substance; carcinogenicity; developmental toxicity

Abstract

The German Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area has evaluated kerosine (petroleum) [8008-20-6]. The relevant toxicological studies with straight-run kerosine (petroleum) were already included in the documentation and supplements for hydrotreated light petroleum distillates, which are manufactured by hydrotreating straight-run kerosine (petroleum). Therefore, all toxicological end points for kerosine (petroleum) are evaluated by analogy with hydrotreated light petroleum distillates. The maximum concentration at the workplace (MAK value) has been set at 50 ml/m^3 for the vapour fraction and at 5 mg/m^3 for the respirable fraction. As the critical effect of the vapour is central nervous system (CNS) depression and that of the aerosol lung toxicity, Peak Limitation Category II has been assigned with excursion factors of 2 and 4, respectively. Kerosine (petroleum) is not genotoxic but carcinogenic to mouse skin after dermal application and Carcinogen Category 3B has been assigned for skin exposure to kerosine (petroleum). Kerosine (petroleum) is classified in Pregnancy Risk Group C because the NOAEC for developmental toxicity is sufficiently high so that damage to the embryo or foetus is unlikely when the MAK value is not exceeded. Kerosine (petroleum) is not taken up via the skin in amounts that induce systemic effects. There are no data that show that kerosine is a skin or airway sensitizer.

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MAK value (2019)	**50 ml/m³ (ppm) ≙ 350 mg/m³ (vapour)** **5 mg/m³ R (respirable fraction, aerosol)**
Peak limitation (2019)	**Category II, excursion factor 2 (vapour)** **Category II, excursion factor 4 (aerosol)**
Absorption through the skin	–
Sensitization	–
Carcinogenicity (2019)	**Category 3B**[a)]
Prenatal toxicity (2019)	**Pregnancy Risk Group C**
Germ cell mutagenicity	–
BAT value	–
Synonyms	–
Chemical name (IUPAC)	–
CAS number	8008-20-6
Structural formula	aliphatic, alicyclic and aromatic hydrocarbons with carbon numbers predominantly in the range from C9 to C16
Molar mass	about 170 g/mol (for C12 aliphatic substances)
Melting point	–49 °C (pour point; ECHA 2019)
Boiling point at 1013 hPa	146–299 °C (ECHA 2019)
Density at 15 °C	0.77–0.85 g/cm³ (ECHA 2019)
Vapour pressure at 37.8 °C	< 10–37 hPa (ECHA 2019)
log K_{OW}	3.7–8 (calculated; US EPA 2011)
Solubility	10.4 mg/l water (US EPA 2011)
1 ml/m³ (ppm) ≙ 7 mg/m³	**1 mg/m³ ≙ 0.14 ml/m³ (ppm)**
Stability	no data
Production	as a distillation product of petroleum refining
Purity	no data
Impurities	no data
Uses	Kerosine is used in lubricants, greases, adhesives and sealants, polishes, waxes, antifreeze products, detergents and coatings, as well as in metal-working fluids and agrochemicals (ECHA 2019). The main use is most likely its further processing into fuels.

[a)] applies to contact with the skin

Kerosine (petroleum) consists of hydrocarbons obtained by distillation of crude oil with carbon numbers ranging from C9 to C16 and a boiling range of 150 to 290 °C ("straight-run" kerosine). Between 10 and 100 million tonnes of kerosine

are produced in or imported into the EU each year. The content of aromatic hydrocarbons is about 20%. This fraction may also contain small amounts of organic sulfur and nitrogen compounds. The sulfur content can be between 150 and 2400 mg/l (Singh et al. 2016). The average content of benzene in the kerosine fuel Jet Fuel JP-8 is 270 mg/l (Mayfield 1996). The composition and level of impurities depend on the origin of the crude oil.

The relevant studies with untreated kerosine (straight-run kerosine) were already included in the assessment of hydrotreated light petroleum distillates. These are produced from kerosine by hydrogen treatment, which reduces the content of organic sulfur and nitrogen compounds, aromatics and olefins. For hydrotreated light petroleum distillates, documentation and two supplements are available which include studies of straight-run kerosine in addition to studies with other kerosines containing aromatics, such as deodorized kerosine and hydrodesulfurized kerosine, whereby all toxicological end points are covered (Hartwig and MAK Commission 2016, 2017, 2018). The MAK value of 50 ml/m^3 to avoid CNS depression in humans was derived on the basis of studies with C9 to C11 petroleum fractions with an aromatic hydrocarbon content of around 20% and adopted for C9 to C16 fractions with a higher boiling point (Hartwig and MAK Commission 2017, 2018).

For kerosine (petroleum) as a component in lubricants and metal-working fluids, neither an application concentration nor a skin irritation threshold is given.

1 Toxic Effects and Mode of Action

In all long-term studies in which undiluted kerosines were tested without an initiator, they were found to be carcinogenic to the skin (various skin tumours including squamous cell carcinomas) and irritating to the skin in mice. Kerosine is also a skin irritant in humans. In humans, the most sensitive end point is expected to be CNS depression. With kerosine aerosol, effects on the lungs were observed in mice after inhalation exposure.

For further effects, see Hartwig and MAK Commission (2016, 2017).

2 Mechanism of Action

See Hartwig and MAK Commission (2016, 2017).

3 Toxicokinetics and Metabolism

"White spirit", a hydrocarbon mixture with a lower boiling range than kerosine (petroleum), was absorbed by volunteers in amounts of 55% to 60% after inhalation exposure for 4 hours (Hartwig 2015). A similar proportion can be assumed to be absorbed for kerosine (petroleum).

For the sum of hydrocarbons contained in a kerosine fuel (Jet Fuel JP-8, C7–C17 aliphatics and 18% aromatics), a flux of 20 µg/cm^2 and hour was calculated in a study with rat skin in diffusion cells (Hartwig and MAK Commission 2017; McDougal et al. 2000). This would result in an absorbed amount of 40 mg after the exposure of 2000 cm^2 of skin (area of hands and forearms) for 1 hour.

4 Effects in Humans

In humans, CNS depression is the most sensitive end point; this has been observed in studies after exposure to C9 to C11 petroleum fractions with an aromatic hydrocarbon content of about 20% (Hartwig and MAK Commission 2017, 2018).

Skin irritation after exposure to kerosine in humans is well known. In a study with volunteers investigating the anti-inflammatory effect of steroids, kerosine was used as an irritant, which led to irritation and even blistering. The efficacy of the applied steroids in inhibiting kerosine-induced inflammation differed greatly (Kaidbey and Kligman 1974).

Skin damage was observed by electron microscope in volunteers after the application of kerosine to the skin for 30 or 90 minutes. This was attributed to damage to the lipoproteins in the stratum corneum due to the degreasing effect of kerosine (Lupulescu et al. 1973).

In a study from China, the prevalence of dermatosis in workers exposed to "kerosine" was significantly higher (84%) than in control persons not exposed (less than 1%) (Jee et al. 1986).

There are no data available for the end points reproductive toxicity, genotoxicity and carcinogenicity.

5 Animal Experiments and in vitro Studies

5.1 Acute toxicity

5.1.1 Inhalation

The 4-hour LC_{50} for straight-run kerosine is above 5280 mg/m^3 in rats (ECHA 2019).

5.1.2 Oral administration

The oral LD_{50} for straight-run kerosine is above 5000 mg/kg body weight in rats (ECHA 2019).

5.1.3 Dermal application

The dermal LD_{50} for straight-run kerosine is above 2000 mg/kg body weight in rabbits (ECHA 2019).

5.2 Subacute, subchronic and chronic toxicity

5.2.1 Inhalation

Studies with straight-run kerosine are not available.

For kerosine vapour (Jet Fuel JP-8), the highest concentration tested of 140 ml/m^3 is the NOAEC (no observed adverse effect concentration) for rats after continuous exposure for 13 weeks. Exposure to kerosine aerosol (Jet Fuel JP-8) for 1 hour daily led to lung effects in mice at 50 mg/m^3 and above, detected by electron microscope. Some of these effects are not concentration-dependent and their adversity is difficult to assess. Since no such effects occurred with Jet Fuel JP-8 in vapour form at much higher exposure concentrations, the effects are attributed to the aerosol. However, it is not possible to establish a NOAEC for these effects, as they occurred only after short exposure times, the adversity is unclear, the findings are not consistent and they have not been confirmed by other research groups (Hartwig and MAK Commission 2017).

5.2.2 Oral administration

There are no studies with straight-run kerosine. The systemic LOAEL (lowest observed adverse effect level) in a reproductive toxicity study with Jet Fuel JP-8 in rats was 750 mg/kg body weight and day, based on changes in clinico-chemical parameters, body weights, organ weights and perianal irritation in the males (Hartwig and MAK Commission 2017).

5.2.3 Dermal application

The following unpublished studies were carried out in accordance with OECD Test Guideline 410 in Sprague Dawley rats. Undiluted kerosene, for which the CAS number [8008-20-6] was assigned in the registration dossier, was applied occlusively for 6 hours daily, on 5 days per week for 4 weeks.

At 0, 0.5, 2 and 5 ml/kg body weight and day, a dose-dependent increase in irritation occurred at the site of application. At 2 ml/kg body weight and day and above, the body weight gains were decreased in the male animals. The erythrocyte count was reduced in both male and female animals, as was the haemoglobin level in male animals. In the high-dose group, the activity of alkaline phosphatase and the concentrations of urea nitrogen and glucose in the blood were increased in both males and females. The body weight gains in female rats were lower than those in the control group, and blood protein and the haematocrit were slightly reduced in the males. The systemic NOAEL (no observed adverse effect level) was 0.5 ml/kg body weight and day (about 400 mg/kg body weight and day) (ECHA 2019).

At 0.01, 0.1 and 1 ml/kg body weight, irritation occurred at the application site that increased in a dose-dependent manner. At 1 ml/kg body weight, the proportion of neutrophils in the blood of the female animals was double the control level. When the study was repeated with 0 and 1 ml/kg body weight and day, again an increased neutrophil count was observed and further haematological and clinico-chemical changes occurred in male and female animals (ECHA 2019).

At 0, 0.01, 0.25 and 0.5 ml/kg body weight and day, there was a dose-dependent increase in irritation at the application site. No adverse systemic effects were observed, not even in the blood. The systemic NOAEL was 0.5 ml/kg body weight and day (about 400 mg/kg body weight and day) (ECHA 2019).

Overall, the systemic NOAEL for dermal application in rats is about 400 mg/kg body weight and day.

5.3 Local effects on skin and mucous membranes

5.3.1 Skin

Undiluted straight-run kerosine is irritating to the skin of rabbits. Tests with dilutions are not available (ECHA 2019).

In an in vivo study in pigs with the application of 8 aliphatic and 6 aromatic main components of Jet Fuel JP-8, tridecane, tetradecane and, with a lower severity, pentadecane produced the most potent irritant effects. The aromatics had no effects. Therefore, it is probably tridecane and tetradecane that are mainly responsible for the irritant effects of Jet Fuel JP-8 (Muhammad et al. 2005).

5.3.2 Eyes

Although undiluted straight-run kerosine is slightly irritating to the rabbit eye, it is not classified as an eye irritant according to the EU classification criteria (ECHA 2019).

5.4 Allergenic effects

5.4.1 Sensitizing effects on the skin

The ECHA database contains negative results from Buehler tests for two low-viscosity straight-run kerosines. The tests deviated from OECD Test Guideline 406 by using only 10 animals. In one of the tests, the substance applied was in undiluted form for induction and in the form of a 25% preparation in mineral oil for the challenge treatment, which resulted in a very weak reaction in 1 of the 10 animals after 24 hours but not after 48 hours. There was no reaction in any of the 4 control animals. The second test preparation was likewise used in undiluted form for induction, and a 50% preparation in mineral oil was used for challenge treatment, which did not produce a reaction in any of the 10 animals (ECHA 2019). For another test substance, for which the CAS number [8008-20-6] is given, the Buehler test results

with 10 guinea pigs were likewise negative. In this test, 75% and 10% preparations of the test substance in paraffinum liquidum were used for induction and challenge treatment, respectively (ECHA 2019).

5.4.2 Sensitizing effects on the airways

There are no data available.

5.5 Reproductive and developmental toxicity

5.5.1 Fertility

Studies with straight-run kerosine are not available.

In a reproductive toxicity study with Jet Fuel JP-8 in rats, the NOAEL for effects on reproduction was the highest dose tested of 3000 mg/kg body weight and day for males and 1500 mg/kg body weight and day for females (Hartwig and MAK Commission 2017).

5.5.2 Developmental toxicity

Pregnant Sprague Dawley rats were exposed to kerosine concentrations of 0, 106 or 364 ml/m^3 for 6 hours daily from days 6 to 15 of gestation. There were no adverse effects in the dams, nor were there any increases in the incidence of malformations, embryotoxicity or foetotoxicity. The gender ratio was unchanged. The NOAEC was therefore 364 ml/m^3 (Hartwig and MAK Commission 2017).

5.6 Genotoxicity

5.6.1 In vitro

The results of genotoxicity studies in vitro with straight-run kerosine were negative. A Salmonella mutagenicity test with straight-run kerosine yielded positive results in the TA98 strain with metabolic activation (Hartwig and MAK Commission 2017). However, in other unpublished Salmonella mutagenicity tests with DMSO extracts of straight-run kerosine, this result could not be reproduced. A TK$^{+/-}$ test with mouse lymphoma cells yielded a positive result without metabolic activation (0.67 to 6.7 nl/ml) and a questionable positive result with metabolic activation (12 to 210 nl/ml, cytotoxic concentration 75 nl/ml). The result of a second TK$^{+/-}$ test was negative. The test was performed without activation using 6 to 130 nl/ml (cytotoxic concentration) and with activation using 4 to 65 nl/ml (ECHA 2019).

5.6.2 In vivo

Genotoxicity studies with straight-run kerosine in vivo (micronucleus and chromosomal aberration tests in rats with intraperitoneal administration) yielded negative results (Hartwig and MAK Commission 2017).

5.7 Carcinogenicity

In an inhalation carcinogenicity study with Jet Fuel JP-4 (mixture of petrol and kerosine) in rats, the tumour incidences were not increased in a substance-related manner (Hartwig and MAK Commission 2017).

Initiation-promotion tests in mice with dermal application revealed that hydrodesulfurized kerosine or jet fuel A were not initiators, but promoters. In all long-term studies in which undiluted kerosine was tested without an initiator, it was found to be carcinogenic to the skin (various skin tumours including squamous cell carcinomas) and irritating to the skin of mice (Hartwig and MAK Commission 2017).

6 Manifesto (MAK value/classification)

The main effects are CNS depression in humans, skin irritation and the possible carcinogenic effect on the skin.

MAK value. The evaluation is based on that for hydrotreated light petroleum distillates, as the prevention of CNS depression covers the other key end points such as irritation and systemic toxicity also for untreated kerosine (Hartwig and MAK Commission 2017). In analogy to that for hydrotreated light petroleum distillates, a MAK value of 50 ml/m^3 for the vapour phase and a MAK value of 5 mg/m^3 R (respirable fraction) for kerosine (petroleum) aerosol has therefore been set for kerosine (petroleum).

The MAK value of 50 ml/m^3 corresponds to a concentration of 10 ml/m^3 for the fraction of 20% aromatics in kerosine. This value is lower than the MAK value for trimethylbenzenes (20 ml/m^3) and as high as that for *n*-butylbenzene. At 5 ml/m^3, the MAK value for diethylbenzenes is lower, but these are contained in kerosine fuels only in amounts of less than one percent (Hartwig and MAK Commission 2019). It can therefore be assumed that the MAK value for kerosine (petroleum) provides protection also against the toxicity of the aromatics it contains.

Some of the studies were conducted with deodorized kerosine. It can therefore be assumed that untreated kerosine has an unpleasant odour, but no studies have been carried out on its annoying effects.

Peak limitation. In analogy to hydrotreated light petroleum distillates, kerosine (petroleum) has been classified in Peak Limitation Category II. By analogy, excursion factors of 2 for the vapour and of 4 for the aerosol have been set.

Prenatal toxicity. In inhalation studies in rats with kerosine or jet fuel, no developmental toxicity and no systemic maternal toxicity were found up to the highest concentrations tested of 364 and 395 ml/m^3 respectively. The actual NAEC (no adverse effect concentration) for developmental toxicity in rats is probably even higher than 395 ml/m^3, the highest concentration used in the inhalation studies. The margin to the MAK value is at least four-fold, when the increased respiratory volume at the workplace (1:2) is taken into account (Hartwig and MAK Commission 2017). The classification of hydrotreated light petroleum distillates in Pregnancy Risk Group C includes possible developmental neurotoxicity, which is considered unlikely (Hartwig and MAK Commission 2018). In analogy to the classification of hydrotreated light petroleum distillates, kerosine is assigned to Pregnancy Risk Group C.

Carcinogenicity. An inhalation carcinogenicity study with a kerosine fuel in rats provided no evidence of a tumorigenic effect. However, straight-run kerosine is a skin carcinogen when applied dermally to mice. Like hydrotreated light petroleum distillates, kerosine (petroleum) is classified in Carcinogen Category 3 B. Classification in Carcinogen Category 3 B refers to skin contact.

Germ cell mutagenicity. Studies with straight-run kerosine did not show any evidence of genotoxic effects in vitro or in vivo. Kerosine (petroleum) is therefore not classified in one of the categories for germ cell mutagens.

Absorption through the skin. The absorbed amount of 40 mg C7–C17 hydrocarbons (including aromatics) estimated from an in vitro study with rat skin after a 1-hour exposure (Section 3) is less than 25% of the amount inhaled if the MAK value for kerosine (petroleum) is observed (about 2100 mg at 60% absorption and a respiratory volume of 10 m^3). Kerosine (petroleum) is therefore not designated with an "H" (for substances which can be absorbed through the skin in toxicologically relevant amounts).

Sensitization. There are no findings of sensitizing effects in humans and no positive results from experimental studies with animals or in vitro studies. Kerosine (petroleum) is therefore not designated with "Sh" or "Sa" (for substances which cause sensitization of the skin or airways).

Notes

Competing interests

The established rules and measures of the Commission to avoid conflicts of interest (www.dfg.de/mak/conflicts_interest) ensure that the content and conclusions of the publication are strictly science-based.

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