IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH) VALUE PROFILE

FOR

IRON PENTACARBONYL

[CAS NO. 13463-40-6]

Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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Foreword

Chemicals are a ubiquitous component of the modern workplace. Occupational exposures to chemicals have the potential to adversely affect the health and lives of workers. Acute or short-term exposures to high concentrations of some airborne chemicals have the ability to quickly overwhelm workers, resulting in a spectrum of undesirable health outcomes that may inhibit the ability to escape from the exposure environment (e.g., irritation of the eyes and respiratory tract or cognitive impairment), cause severe irreversible effects (e.g., damage to the respiratory tract or reproductive toxicity), and in extreme cases, cause death. Airborne concentrations of chemicals capable of causing such adverse health effects or of impeding escape from high-risk conditions may arise from a variety of non-routine workplace situations , including special work procedures (e.g., in confined spaces), industrial accidents (e.g., chemical spills or explosions), and chemical releases into the community (e.g., during transportation incidents or other uncontrolled-release scenarios).

The "immediately dangerous to life or health air concentration values (IDLH values)" developed by the National Institute for Occupational Safety and Health (NIOSH) characterize these high-risk exposure concentrations and conditions [NIOSH 2013]. IDLH values are based on a 30-minute exposure duration and have traditionally served as a key component of the decision logic for the selection of respiratory protection devices [NIOSH 2004]. Occupational health professionals have employed these values beyond their initial purpose as a component of the NIOSH Respirator Selection Logic to assist in developing Risk Management Plans for non-routine work practices governing operations in high-risk environments (e.g., confined spaces) and the development of Emergency Preparedness Plans.

The approach used to derive IDLH values for high priority chemicals is outlined in the NIOSH Current Intelligence Bulletin (CIB) 66: Derivation of Immediately Dangerous to Life or Health Values [NIOSH 2013]. CIB 66 provides 1) an update on the scientific basis and risk assessment methodology used to derive IDLH values, 2) the rationale and derivation process for IDLH values, and 3) a demonstration of the derivation of scientifically credible IDLH values using available data resources.

The purpose of this technical report is to present the IDLH value for iron pentacarbonyl (CAS # 13463-40-6). The scientific basis, toxicologic data and risk assessment approach used to derive the IDLH value are summarized to ensure transparency and scientific credibility.

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1 Centers for Disease Control and Prevention

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Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
AEGL	Acute Exposure Guideline Levels
AIHA	American Industrial Hygiene Association
BMC	benchmark concentration
BMCL	benchmark concentration lower confidence limit
C	ceiling
CAS	chemical abstract service
ERPG	Emergency Response Planning Guidelines
IDLH	immediately dangerous to life or health
LC_{50}	median lethal concentration
LC_{Lo}	lowest concentration of a chemical that caused death in humans or animals
LEL	lower explosive limit
LOAEL	lowest observed adverse effect level
mg/m^3	milligram(s) per cubic meter
NAC	National Advisory Committee
NAS	National Academy of Sciences
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no observed adverse effect level
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
ppm	parts per million
RD_{50}	concentration of a chemical in the air that is estimated to cause a 50% decrease in the respiratory rate
REL	recommended exposure limit
SCP	Standard Completion Program
STEL	short term exposure limit
TLV	threshold limit value
TWA	time weighted average
UEL	upper explosive limit
WEEL	workplace environmental exposure level

Glossary

Acute Exposure: Exposure by the oral, dermal, or inhalation route for 24 hours or less.

Acute Exposure Guideline Levels (AEGLs): Threshold exposure limits for the general public applicable to emergency exposure periods ranging from 10 minutes to 8 hours. AEGL-1, AEGL 2, and AEGL-3 are developed for five exposure periods (10 and 30 minutes, 1 hour, 4 hours, and 8 hours) and are distinguished by varying degrees of severity of toxic effects ranging from transient, reversible effects to life-threatening effects [NAS 2001]. AEGLs are intended to be guideline levels used during rare events or single once-in-a-lifetime exposures to airborne concentrations of acutely toxic, high-priority chemicals [NAS 2001]. The threshold exposure limits are designed to protect the general population, including the elderly, children or other potentially sensitive groups that are generally not considered in the development of workplace exposure recommendations (additional information available at http://www.epa.gov/oppt/aegl/).

Acute Reference Concentration (RfC): An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure for an acute duration (24 hours or less) of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark concentration, with uncertainty factors (UFs) generally applied to reflect limitations of the data used. Generally used in USEPA noncancer health assessments [USEPA 2014].

Acute Toxicity: Any poisonous effect produced within a short period of time following an exposure, usually 24 to 96 hours.

Adverse Effect: A substance-related biochemical change, functional impairment, or pathologic lesion that affects the performance of an organ or system or alters the ability to respond to additional environmental challenges.

Benchmark Dose/Concentration (BMD/BMC): A dose or concentration that produces a predetermined change in response rate of an effect (called the benchmark response, or BMR) compared to background [USEPA 2014] (additional information available at http://www.epa.gov/ncea/bmds/).

Benchmark Response (BMR): A predetermined change in response rate of an effect. Common defaults for the BMR are 10% or 5%, reflecting study design, data variability, and sensitivity limits used.

BMCL: A statistical lower confidence limit on the concentration at the BMC [USEPA 2014].

Bolus Exposure: A single, relatively large dose.

Ceiling Value ("C"): U.S. term in occupational exposure indicating the airborne concentration of a potentially toxic substance that should never be exceeded in a worker's breathing zone.

Chronic Exposure: Repeated exposure for an extended period of time. Typically exposures are more than approximately 10% of life span for humans and >90 days to 2 years for laboratory species.

Critical Study: The study that contributes most significantly to the qualitative and quantitative assessment of risk [USEPA 2014].

Dose: The amount of a substance available for interactions with metabolic processes or biologically significant receptors after crossing the outer boundary of an organism [USEPA 2014].

ECt_{50}: A combination of the effective concentration of a substance in the air and the exposure duration that is predicted to cause an effect in 50% (one half) of the experimental test subjects.

Emergency Response Planning Guidelines (ERPGs): Maximum airborne concentrations below which nearly all individuals can be exposed without experiencing health effects for 1-hour exposure. ERPGs are presented in a tiered fashion with health effects ranging from mild or transient to serious, irreversible, or life threatening (depending on the tier). ERPGs are developed by the American Industrial Hygiene Association [AIHA 2006].

Endpoint: An observable or measurable biological event or sign of toxicity ranging from biomarkers of initial response to gross manifestations of clinical toxicity.

Exposure: Contact made between a chemical, physical, or biological agent and the outer boundary of an organism. Exposure is quantified as the amount of an agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut).

Extrapolation: An estimate of the response at a point outside the range of the experimental data, generally through the use of a mathematical model, although qualitative extrapolation may also be conducted. The model may then be used to extrapolate to response levels that cannot be directly observed.

Hazard: A potential source of harm. Hazard is distinguished from risk, which is the probability of harm under specific exposure conditions.

Immediately Dangerous to Life or Health (IDLH) condition: A situation that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment [NIOSH 2004, 2013].

IDLH value: A maximum (airborne concentration) level above which only a highly reliable breathing apparatus providing maximum worker protection is permitted [NIOSH 2004, 2013]. IDLH values are based on a 30-minute exposure duration.

LC_{01}: The statistically determined concentration of a substance in the air that is estimated to cause death in 1% of the test animals.

LC_{50}: The statistically determined concentration of a substance in the air that is estimated to cause death in 50% (one half) of the test animals; median lethal concentration.

LC_{LO}: The lowest lethal concentration of a substance in the air reported to cause death, usually for a small percentage of the test animals.

LD_{50}: The statistically determined lethal dose of a substance that is estimated to cause death in 50% (one half) of the test animals; median lethal concentration.

LD_{LO}: The lowest dose of a substance that causes death, usually for a small percentage of the test animals.

LEL: The minimum concentration of a gas or vapor in air, below which propagation of a flame does not occur in the presence of an ignition source.

Lethality: Pertaining to or causing death; fatal; referring to the deaths resulting from acute toxicity studies. May also be used in lethality threshold to describe the point of sufficient substance concentration to begin to cause death.

Lowest Observed Adverse Effect Level (LOAEL): The lowest tested dose or concentration of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Mode of Action: The sequence of significant events and processes that describes how a substance causes a toxic outcome. Mode of action is distinguished from the more detailed mechanism of action, which implies a more detailed understanding on a molecular level.

No Observed Adverse Effect Level (NOAEL): The highest tested dose or concentration of a substance that has been reported to cause no harmful (adverse) health effects in people or animals.

Occupational Exposure Limit (OEL): Workplace exposure recommendations developed by governmental agencies and non-governmental organizations. OELs are intended to represent the maximum airborne concentrations of a chemical substance below which workplace exposures should not cause adverse health effects. OELs may apply to ceiling, short-term (STELs), or time-weighted average (TWA) limits.

Peak Concentration: Highest concentration of a substance recorded during a certain period of observation.

Permissible Exposure Limit (PEL): Occupational exposure limits developed by OSHA (29 CFR 1910.1000) or MSHA (30 CFR 57.5001) for allowable occupational airborne exposure concentrations. PELs are legally enforceable and may be designated as ceiling, STEL, or TWA limits.

Point of Departure (POD): The point on the dose–response curve from which dose extrapolation is initiated. This point can be the lower bound on dose for an estimated incidence or a change in response level from a concentration-response model (BMC), or it can be a NOAEL or LOAEL for an observed effect selected from a dose evaluated in a health effects or toxicology study.

RD_{50}: The statistically determined concentration of a substance in the air that is estimated to cause a 50% (one half) decrease in the respiratory rate.

Recommended Exposure Limit (REL): Recommended maximum exposure limit to prevent adverse health effects based on human and animal studies and established for occupational (up to 10-hour shift, 40-hour week) inhalation exposure by NIOSH. RELs may be designated as ceiling, STEL, or TWA limits.

Short-Term Exposure Limit (STEL): A worker's 15-minute time-weighted average exposure concentration that shall not be exceeded at any time during a work day.

Target Organ: Organ in which the toxic injury manifests in terms of dysfunction or overt disease.

Threshold Limit Values (TLVs®): Recommended guidelines for occupational exposure to airborne contaminants, published by the American Conference of Governmental Industrial Hygienists (ACGIH). TLVs refer to airborne concentrations of chemical substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, over a working lifetime, without adverse effects. TLVs may be designated as ceiling, short-term (STELs), or 8-hr TWA limits.

Time-Weighted Average (TWA): A worker's 8-hour (or up to 10-hour) time-weighted average exposure concentration that shall not be exceeded during an 8-hour (or up to 10-hour) work shift of a 40-hour week. The average concentration is weighted to take into account the duration of different exposure concentrations.

Toxicity: The degree to which a substance is able to cause an adverse effect on an exposed organism.

Uncertainty Factors (UFs): Mathematical adjustments applied to the POD when developing IDLH values. The UFs for IDLH value derivation are determined by considering the study and effect used for the POD, with further modification based on the overall database.

Workplace Environmental Exposure Levels (WEELs): Exposure levels developed by the American Industrial Hygiene Association (AIHA) that provide guidance for protecting most workers from adverse health effects related to occupational chemical exposures expressed as a TWA or ceiling limit.

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1.0 Introduction

1.1 Overview of the IDLH Value for Iron Pentacarbonyl

IDLH Value: 0.4 ppm

Basis for IDLH Value: The IDLH value is based on a rat non-lethality concentration of 5.2 ppm in the 4-hour Biodynamics [1988] study, which corresponds to a concentration of 10.4 ppm after a 30-minute duration adjustment. Reported effects at this concentration included lacrimation and nasal discharge, which are classified as potentially escape-impairing. Applying a composite uncertainty factor of 30 to account for adjusting from a LOAEL to NOAEL, steep exposure-response relationship, interspecies differences and human variability yields an IDLH value of **0.4 ppm**.

1.2 Purpose

This *IDLH Value Profile* presents (1) a brief summary of technical data associated with acute inhalation exposures to iron pentacarbonyl and (2) the rationale behind the Immediately Dangerous to Life or Health (IDLH) value for iron pentacarbonyl. IDLH values are developed based on the scientific rationale and logic outlined in the NIOSH Current Intelligence Bulletin (CIB) 66: Derivation of Immediately Dangerous to Life or Health (IDLH) values [NIOSH 2013]. As described in CIB 66, NIOSH performs in-depth literature searches to ensure that all relevant data from human and animal studies with acute exposures to the substance are identified. Information included in CIB 66 on the literature search includes pertinent databases, key terms, and guides for evaluating data quality and relevance for the establishment of an IDLH value. The information that is identified in the in-depth literature search is evaluated with general considerations that include description of studies (i.e., species, study protocol, exposure concentration and duration), health endpoint evaluated, and critical effect levels (e.g., NOAELs, LOAELs, LC_{50} values). For iron pentacarbonyl, the in-depth literature search was conducted through February 2014.

1.3 General Substance Information

Chemical: Iron pentacarbonyl

CAS No: 13463-40-6

Synonyms: Iron carbonyl; Pentacarbonyliron[*]

Chemical category: Iron compounds; metal carbonyls[†]

Structural formula:

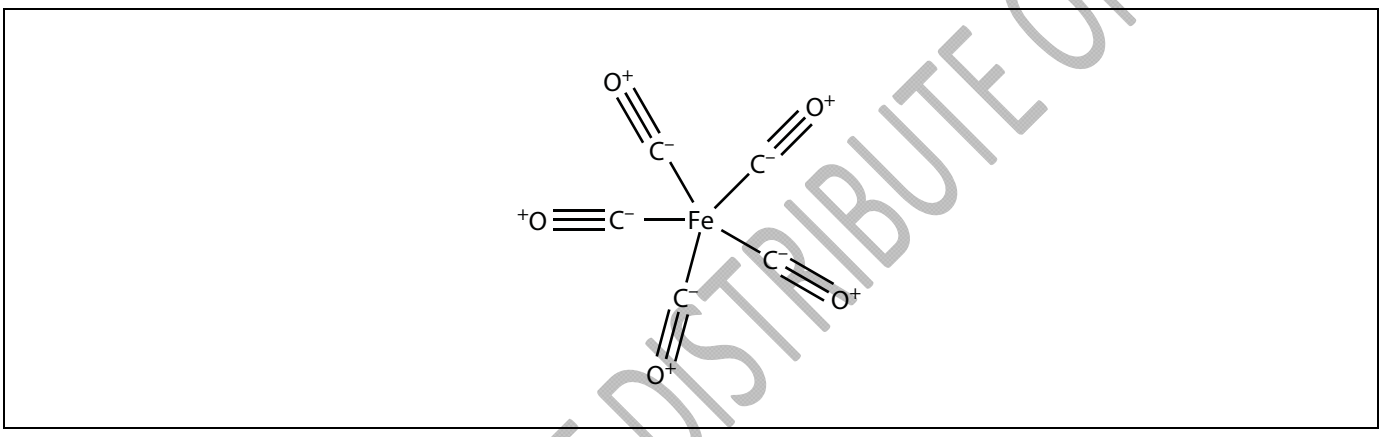

Table 1 highlights selected physiochemical properties of iron pentacarbonyl relevant to IDLH conditions. Table 2 provides alternative exposure guidelines for iron pentacarbonyl. Table 3 summarizes the Acute Exposure Guidelines Level (AEGL) values for iron pentacarbonyl.

Table 1: Physiochemical Properties of Iron Pentacarbonyl

Property	Value
Molecular weight	195.99[‡]
Chemical formula	C_5FeO_5
Description	Colorless to yellow to dark red, oily liquid
Odor	Moldy, musty
Odor Threshold	Not available
UEL	12.5[†]
LEL	3.7[†]
Vapor pressure	40 mmHg at 30.56°C (87°F)[§]
Flash point	-15°C (5°F)[‡]
Ignition temperature	320°C (608°F)[‡]
Solubility	Very slightly soluble in water[†]

Abbreviation: °C – Celsius; °F – Fahrenheit; mmHg – millimeter mercury; LEL – lower explosive limit; UEL – upper explosive limit

[*] NLM [2014]

[†] IFA [2014]

‡ HSDB [2014]
§ OSHA [1989]

Table 2: Alternative Exposure Guidelines for Iron Pentacarbonyl

Organization	Value
Original (SCP) IDLH value [NIOSH 2014]	None
NIOSH REL [2014]	Not available
OSHA PEL [2014]	0.1 ppm TWA; 0.2 ppm STEL
ACGIH TLV [2014]	Not available
AIHA ERPG [2013]	Not available
AIHA WEEL [2013]	Not available

Abbreviation: ACGIH – American Conference of Governmental Industrial Hygienists; AIHA – American Industrial Hygiene Association; ERPG – Emergency Response Preparedness Guidelines; IDLH – immediately dangerous to life or health; NIOSH – National Institute for Occupational Safety and Health; OSHA – Occupational Safety and Health Administration; PEL – permissible exposure limit; REL – recommended exposure limit; SCP – Standards Completion Program; WEEL – workplace environmental exposure level

Table 3: AEGL Values for Iron Pentacarbonyl

Classification	10-min	30-min	1-hour	4-hour	8-hour	Endpoint [reference]
AEGL-1	NR	NR	NR	NR	NR	Not recommended; insufficient data
AEGL-2	0.077 ppm 0.61 mg/m^3	0.077 ppm 0.61 mg/m^3	0.060 ppm 0.48 mg/m^3	0.037 ppm 0.30 mg/m^3	0.025 ppm 0.20 mg/m^3	Based on a 3-fold reduction in the AEGL-3 values.
AEGL-3	0.23 ppm 1.8 mg/m^3	0.23 ppm 1.8 mg/m^3	0.18 ppm 1.4 mg/m^3	0.11 ppm 0.88 mg/m^3	0.075 ppm 0.60 mg/m^3	Estimated lethality threshold in rats (1.0 ppm determined by BMD analysis [BASF 1995]. n = 1 or 3; uncertainty factor = 10 (3 for both interspecies variability, and individual variability).

Abbreviation: AEGL – acute exposure guideline levels; mg/m^3 – milligrams per cubic meter; min – minute; NR – not recommended due to insufficient data; ppm – parts per million
*__References__: NAS [2010]

2.0 Animal Toxicity Data

The majority of acute studies for iron pentacarbonyl provided data on lethality, with little additional information to assess potential escape-impairing effects. Using a dynamic exposure chamber without analytical monitoring, Gage [1970] reported that a single 5.5 hour exposure to 33 ppm was lethal to 3 of 8 rats, but no effects were seen in rats exposed for eighteen 5.5 hour periods at 7 ppm. Postmortem examination of the rats that died showed pulmonary edema, indicating that lung effects are a critical target for this chemical. Sunderman et al. [1959] conducted lethality studies with mice and rats with reported 30-minute LC50 values of 273 ppm and 114 ppm, respectively. Biodynamics [1988] reported that rats exposed to 5.2 ppm of iron pentacarbonyl for 4 hours showed effects 1 to 2 hours post exposure, but essentially no toxicity during exposure. The observed effects included lacrimation and nasal discharge at a slightly higher incidence than controls. Necropsy of these rats revealed red lungs in some of the rats, but the actual number was not reported, and the observation was considered of equivocal significance on the basis of gross pathology only. Together, the studies of Gage [1970] and Biodynamics [1988] show minimal irritant effects in the range of 5 to 7 ppm of iron pentacarbonyl even for single acute exposure periods significantly longer than 30-minutes. BASF [1995] reported 1 of 10 rats died following a single 6-hour exposure to 2.91 ppm of iron pentacarbonyl. A total of 5/10 rats died within 4 days after receiving two 6-hour exposures. Because of the delayed mortality seen in this and other studies, it is not known whether additional rats would have died following the single exposure if there had been additional post-exposure monitoring. NAS [2010] calculated an LC_{01} value of 1.9 ppm and a $BMCL_{05}$ for lethality of 0.8 ppm, assuming that a single exposure would have killed 5/10 animals, as a worst case scenario in light of the delayed deaths. However, rats exposed to 1.0 ppm for 5 days/week for 1 month did not exhibit any clinical signs, suggesting a steep exposure-response curve, and that 1.0 ppm is a very conservative estimate of the lethality threshold from a single exposure.

The acute toxicity studies show a significant difference in lethal concentrations in rats across the available studies. It is convenient that the study by Sunderman et al. [1959] was for the duration of interest and included sufficient information to calculate an LC_{50} value, but a static exposure scenario was used, leading to significant uncertainty in the actual exposure levels. The Biodynamics [1988] and BASF [1995] studies were conducted using modern exposure methods and identified much lower effect levels, but involved greater time extrapolation, and the BASF [1995] study includes the additional uncertainties due to the multiple exposures and inadequate information on

post-exposure deaths following a single exposure. Thus, the appropriate IDLH value derivation would yield a value generally near this exposure range.

Table 4 summarizes the LC data identified in animal studies and provides 30-minute equivalent derived values for iron pentacarbonyl. Table 5 provides non-lethal data reported in animal studies with 30-minute equivalent derived values. Information in these tables includes species of test animals, toxicological metrics (i.e., LC, NOAEL, LOAEL), adjusted 30-minute concentration, and the justification for the composite uncertainty factors applied to calculate the derived values.

Table 4: Lethal Concentration Data for Iron Pentacarbonyl

Reference	Species	LC_{50} (ppm)	LC_{Lo} (ppm)	Time (min)	Adjusted 30-minute Concentration* (ppm)	Composite Uncertainty Factor	Derived Value (ppm)†
Sunderman et al. [1959]	Mouse	273273	--	30	273273	30‡	9.11
Armit [1980]	Rabbit	250	--	45	286	30‡	9.5
Sunderman et al. [1959]	Rat	118	--	30	118	30‡	3.9
Biodynamics [1988]	Rat	10	--	240	20	30‡	0.7
BASF [1995]	Rat	3±	--	720	9	30‡	0.3
BASF [1995]	Rat	--	3§	360	7	10^	0.7
BASF [1995]	Rat	--	1**	360	2.3	10^	0.2

Abbreviation: LC – lethal concentration; LC_{50} – median lethal concentration; LC_{Lo} – lowest concentration of a chemical that caused death in humans or animals; min – minute; ppm – parts per million

* For exposures greater than 30 minutes the ten Berge et al. [1986] relationship is used for adjustment (C^n x t = k); empirically estimated n values were not available, therefore the default values were used, n = 3 for exposures greater than 30 minutes and n = 1 for exposures less than 30 minutes.

† The derived value is the result of the adjusted 30-minute concentration divided by the composite uncertainty factor.

‡ Composite uncertainty factor to account for adjustment of LC_{50} values to LC_{01} values, use of lethal concentration threshold in animals, interspecies differences and human variability.

± 5/10 rats died within 4 days after receiving two 6-hour exposures

§ 1/10 rats died after a single 6-hour exposure

^ Composite uncertainty factor to account for lethal concentration threshold in animals, interspecies differences and human variability.

** Modified $BMCL_{05}$ for lethality after a single 6-hour exposure

Table 5: Non-lethal Concentration Data for Iron Pentacarbonyl

Reference	Species	NOAEL (ppm)	LOAEL (ppm)	Time (min)	Adjusted 30-minute Concentration* (ppm)	Composite Uncertainty Factor	Derived Value (ppm)†
Biodynamics [1988] [+]	**Rat**	**--**	**5.2**	**240**	**10.4**	**30** [±]	**0.4**

Abbreviation: NOAEL – no observed adverse effect level; min – minute; LOAEL – lowest observed adverse effect level; ppm – parts per million

[*] For exposures greater than 30 minutes the ten Berge et al. [1986] relationship is used for adjustment (C^n x t = k); empirically estimated n values were not available, therefore the default values were used, n = 3 for exposures greater than 30 minutes and n = 1 for exposures less than 30 minutes.

[†] The derived value is the result of the adjusted 30-minute concentration divided by the composite uncertainty factor.

[+] Identified study is the primary basis of the IDLH value for iron pentacarbonyl.

[±] Composite uncertainty factor assigned to account for adjusting from a LOAEL to NOAEL, steep exposure-response relationship, interspecies differences and human variability

3.0 Human Data

No information was identified that provided adequate estimates of observed effects following exposure in humans. Stokinger [1981] reported that the effects of human exposure to iron pentacarbonyl are similar to those of nickel carbonyl exposure. Such effects are giddiness and headache, dyspnea, and vomiting that was alleviated after removal from exposure. Symptoms such as fever, cyanosis and coughing lasting up 36 hours after exposure have also been reported. Death may occur several days after exposure.

4.0 Summary

The assembled data on iron pentacarbonyl reveal a steep exposure-response relationship and a small gap between concentrations associated with severe non-lethal effects and death in test animals. Reported effects of concern include delayed onset of death following acute exposure. The IDLH value for iron pentacarbonyl is based on a rat non-lethality concentration of 5.2 ppm in the 4-hour Biodynamics [1988] study, which corresponds to a concentration of 10.4 ppm after a 30-minute duration adjustment. Reported effects at this concentration included lacrimation and nasal discharge, which are classified as potentially escape impairing. Applying a composite uncertainty factor of 30 to account for extrapolation from a LOAEL to a NOAEL, severe effects in animals (i.e., steep exposure-response relationship), interspecies differences and human variability, results in an IDLH value of **0.4 ppm**.

It should be noted that the IDLH value for iron pentacarbonyl differs by more than an order of magnitude from the AEGL-2 30-minute value, which is intended to represent an airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape [NAS 2001]. Data to calculate an AEGL-2 value for iron pentacarbonyl were deemed insufficient resulting in the establishment of an AEGL-2 equal to 1/3 of the calculated AEGL-3 value, which is intended to represent an airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death [NAS 2001, 2010]. The AEGL-3 value for 30-minutes was set at 0.23 ppm and was based on lethal threshold estimates in rats reported in BASF [1995]. NIOSH used non-lethality data reported in Biodynamics [1988] as the basis of the IDLH value of 0.4 ppm for iron pentacarbonyl.

The small difference between the AEGL-3 value and IDLH value are caused by alternative primary data, selection of the endpoints and duration adjustments.

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