OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR DICYCLOPENTADIENYL IRON

INTRODUCTION

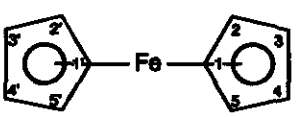
This guideline summarizes pertinent information about dicyclopentadienyl iron for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

- **Formula**

  $(C_5H_5)_2Fe$

- **Structure**



- **Synonyms**

  Ferrotsen; ferrocene; biscyclopentadienyl iron; di-2,4-cyclopentadien-1-yl iron; iron bis(cyclopentadiene); iron bis(cyclopentadienide); iron dicyclopentadienyl; bis(eta(5)-2,4-cyclopentadien-1-yl)-iron

- **Identifiers**

  1. CAS No.: 102-54-5
  2. RTECS No.: LK0700000
  3. DOT UN: None
  4. DOT label: None

- **Appearance and odor**

  Dicyclopentadienyl iron is a flammable, bright orange, crystalline solid with a camphor-like odor.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

  1. Molecular weight: 186.05
  2. Boiling point (760 mm Hg): 249°C (408.2°F) (sublimes above 100°C (212°F))
  3. Specific gravity: Data not available
  4. Vapor density: Data not available
  5. Melting point: 173°-174°C (343°-345°F)
  6. Vapor pressure at 20°C (68°F): Data not available
  7. Solubility: Insoluble in water; soluble in alcohol, ether, and benzene
  8. Evaporation rate: Data not available

- **Reactivity**

  1. Conditions contributing to instability: Heat, sparks, open flame, and steam
  2. Incompatibilities: Contact of dicyclopentadienyl iron

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with tetranitromethane may lead to violent explosions. This substance also reacts violently with ammonium perchlorate and mercury (II) nitrate.

3. Hazardous decomposition products: Thermal oxidative decomposition of dicyclopentadienyl iron can produce acrid smoke and irritating fumes.

4. Special precautions: None reported

- **Flammability**

The National Fire Protection Association has not assigned a flammability rating to dicyclopentadienyl iron. Other sources rate dicyclopentadienyl iron as a moderate fire risk.

1. Flash point: Data not available

2. Autoignition temperature: Data not available

3. Flammable limits in air: Data not available

4. Extinguishant: No information is available on the proper extinguishant for fires involving dicyclopentadienyl iron.

Fires involving dicyclopentadienyl iron should be fought upwind from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Containers of dicyclopentadienyl iron may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving dicyclopentadienyl iron.

EXPOSURE LIMITS

- **OSHA PEL**

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for dicyclopentadienyl iron is 15 mg/m^3 (total dust) and 5 mg/m^3 (respirable fraction) as 8-hr time-weighted average (TWA) concentrations [29 CFR 1910.1000, Table Z-1].

- **NIOSH REL**

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) of 10 mg/m^3 (total dust) and 5 mg/m^3 (respirable fraction) as a TWA for up to a 10-hr workday and a 40-hr workweek [NIOSH 1992].

- **ACGIH TLV**

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned dicyclopentadienyl iron a threshold limit value (TLV) of 10 mg/m^3 as a TWA for a normal 8-hr workday and a 40-hr workweek [ACGIH 1993].

- **Rationale for limits**

The OSHA and NIOSH limits are based on the risk of mutagenicity associated with exposure to dicyclopentadienyl iron [54 Fed. Reg. 2592; NIOSH 1992].

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Exposure to dicyclopentadienyl iron can occur through inhalation, ingestion, and eye or skin contact.

- **Summary of toxicology**

1. *Effects on Animals:* Exposure to dicyclopentadienyl iron may cause liver, red blood cell, and testicular changes in experimental animals. The LC_{50} for an unspecified period of time in rats is greater than 150 mg/m^3 [Hathaway et al. 1991]. The oral LD_{50} is 1,320 mg/kg in rats and 832 mg/kg in mice [NIOSH 1993]. Ten 200 mg/kg oral doses of dicyclopentadienyl iron administered over a 2-week period caused no fatalities in rats [Hathaway et al. 1991]. In a 6-month subchronic study in dogs, oral doses of 30 to 300 mg/kg/day dicyclopentadienyl iron caused hemosiderosis (iron deposits) in the liver [Hathaway et al. 1991; ACGIH 1991]. Dogs exposed to a 300-mg/kg/day dose of dicyclopentadienyl iron for an unspecified period of time developed cirrhosis of the liver; reversible decreases in hemoglobin, packed red cell volume, and red cell count were also seen in these animals within the first 4 weeks of exposure on this regimen [Hathaway et al. 1991]. Testicular hypoplasia developed in dogs given oral dicyclopentadienyl iron doses of 100 mg/kg/day for 6 months [Hathaway et al. 1991; ACGIH 1991]. Dicyclopentadienyl iron is mutagenic in mouse lymphoma test systems [NLM 1992].

2. *Effects on Humans:* No data are available on the

effects of exposure to dicyclopentadienyl iron in humans.

- **Signs and symptoms of exposure**

1. *Acute exposure:* No signs or symptoms of acute exposure to dicyclopentadienyl iron have been reported in humans.

2. *Chronic exposure:* Based on effects seen in animals, chronic exposure to dicyclopentadienyl iron may cause liver, red blood cell, or testicular damage.

- **Emergency procedures**

> **WARNING!**
>
> **Seek immediate medical attention for severely affected victims or for victims with signs and symptoms of toxicity or irritation!**

Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. Initiate the following emergency procedures:

1. *Eye exposure:* Irritation may result. ***Immediately and thoroughly*** flush the eyes with large amounts of water, occasionally lifting the upper and lower eyelids.

2. *Skin exposure:* Irritation may result. ***Immediately and thoroughly*** wash contaminated skin with soap and water.

3. *Inhalation exposure:* Move the victim to fresh air ***immediately.*** Have the victim blow his or her nose, or use a soft tissue to remove particulates or residues from the nostrils.

   If the victim is not breathing, clean any chemical contamination from the victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Ingestion exposure:* Take the following steps if dicyclopentadienyl iron or any material containing it is ingested:

   —Have the victim rinse the contaminated mouth cavity several times with a fluid such as water.

   —Have the victim drink a glass (8 oz) of fluid such as water.

   —Induce vomiting by giving syrup of ipecac as directed on the package. If ipecac is unavailable, have the victim touch the back of the throat with a finger until productive vomiting ceases.

   —Do ***not*** force an unconscious or convulsing person to drink fluid or to vomit.

5. *Rescue:* Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures, the location and proper use of emergency equipment, and methods of protecting themselves during rescue operations.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve dicyclopentadienyl iron and lead to worker exposures to this substance:

—Use as an additive in oil and gasoline fuel to improve efficiency of combustion and eliminate smoke

—Manufacture of rubber, silicone resins, and high-temperature polymers

—Use as coating for missiles and satellites

—Use as a combustion catalyst

The following methods are effective in controlling worker exposures to dicyclopentadienyl iron, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information on control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

  Before a worker is placed in a job with a potential for exposure to dicyclopentadienyl iron, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the blood and liver.

  A preplacement medical evaluation is recommended to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to dicyclopentadienyl iron at or below the prescribed exposure limit. The examining health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the blood or liver.

- **Periodic medical examinations and biological monitoring**

  Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to dicyclopentadienyl iron exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of dicyclopentadienyl iron on the blood or liver. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

  Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. No biological monitoring test acceptable for routine use has yet been developed for dicyclopentadienyl iron.

- **Medical examinations recommended at the time of job transfer or termination**

  The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

WORKPLACE MONITORING AND MEASUREMENT

Determination of a worker's exposure to airborne dicyclopentadienyl iron is made using a mixed cellulose ester filter (MCEF) with a 0.8-micron pore size. Samples are collected at a maximum flow rate of 2.0 liters/min until a

maximum air volume of 960 liters is collected. Analysis is conducted by atomic absorption spectroscopy (or by inductively coupled argon plasma atomic emission spectroscopy). This method has a sampling and analytical error of 0.16 and is described in OSHA Methods No. ID-121 and No. ID-125G in the OSHA Computerized Information System [OSHA 1992] and the *OSHA Analytical Methods Manual* [OSHA 1985].

PERSONAL HYGIENE

If dicyclopentadienyl iron contacts the skin, workers should flush the affected areas immediately with plenty of water for 15 minutes, and then wash with soap and water.

Clothing contaminated with dicyclopentadienyl iron should be removed immediately, and provisions should be made for the safe removal of the chemical from the clothing. Persons laundering the clothes should be informed of the hazardous properties of dicyclopentadienyl iron.

A worker who handles dicyclopentadienyl iron should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, or applying cosmetics.

Workers should not eat, drink, use tobacco products, or apply cosmetics in areas where dicyclopentadienyl iron is handled, processed, or stored.

STORAGE

Dicyclopentadienyl iron should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Containers of dicyclopentadienyl iron should be protected from physical damage and should be stored separately from ammonium perchlorate, tetranitromethane, mercury (II) nitrate, heat, sparks, and open flame. To prevent static sparks, containers should be grounded and bonded for transfers. Because containers that formerly contained dicyclopentadienyl iron may still hold product residues, they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving dicyclopentadienyl iron, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup has been completed. The following steps should be undertaken following a spill or leak:

1. Do not touch the spilled material.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate the area of the spill or leak.
5. For small dry spills, use a clean shovel and gently place the material into a clean, dry container, creating as little dust as possible; cover and remove the container from the spill area.
6. For small liquid spills, take up with activated carbon or other noncombustible absorbent material and place into closed containers for later disposal.
7. For large liquid spills, build dikes far ahead of the spill to contain the dicyclopentadienyl iron for later reclamation or disposal.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

- **Emergency planning requirements**

  Dicyclopentadienyl iron is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022].

- **Reportable quantity requirements for hazardous releases**

  Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the National Response Center of an accidental release of dicyclopentadienyl iron; there is no reportable quantity for this substance.

- **Community right-to-know requirements**

  Employers are not required by Section 313 of SARA to submit a Toxic Chemical Release Inventory form (Form R) to EPA reporting the amount of dicyclopentadienyl iron emitted or released from their facility annually.

- **Hazardous waste management requirements**

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity, as defined in 40 CFR 261.21-261.24. Although dicyclopentadienyl iron is not specifically listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA requires employers to treat any waste as hazardous if it exhibits any of the characteristics discussed above.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information about their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

- **Conditions for respirator use**

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of dicyclopentadienyl iron exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information about the selection and use of respirators and about the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing (gloves, boots, aprons, and gauntlets, as necessary) should be worn to prevent skin contact with dicyclopentadienyl iron. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materials to dicyclopentadienyl iron permeation. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to dicyclopentadienyl iron.

If dicyclopentadienyl iron is dissolved in an organic solvent, the permeation properties of both the solvent and the mixture must be considered when selecting personal protective equipment and clothing.

Safety glasses, goggles, or face shields should be worn during operations in which dicyclopentadienyl iron might contact the eyes (e.g., through dust particles or splashes of solution). Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with dicyclopentadienyl iron. Contact lenses should not be worn if the potential exists for dicyclopentadienyl iron exposure.

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