

NIOSH Skin Notation Profile

Chlorodiphenyl (54% chlorine)

SKK

ID^{SK}

[SK]

SYS

SK (FATAL)

DIR

DIR (IRR)

DIR (COR)

SEN



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NIOSH Skin Notation Profile

Chlorodiphenyl (54% chlorine)
[CAS No. 11097-69-1]

Naomi L. Hudson

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Foreword

As the largest organ of the body, the skin performs multiple critical functions, such as serving as the primary barrier to the external environment. For this reason, the skin is often exposed to potentially hazardous agents, including chemicals, which may contribute to the onset of a spectrum of adverse health effects ranging from localized damage (such as irritant contact dermatitis and corrosion) to induction of immune-mediated responses (such as allergic contact dermatitis and pulmonary responses), or systemic toxicity (such as neurotoxicity and hepatotoxicity). Understanding the hazards related to skin contact with chemicals is a critical component of modern occupational safety and health programs.

In 2009, the National Institute for Occupational Safety and Health (NIOSH) published *Current Intelligence Bulletin (CIB) 61: A Strategy for Assigning New NIOSH Skin Notations* [NIOSH 2009]. This document provides the scientific rationale and framework for the assignment of multiple hazard-specific skin notations (SK) that clearly distinguish between the systemic effects, direct (localized) effects, and immune-mediated responses caused by skin contact with chemicals. The key step within assignment of the hazard-specific SK is the determination of the hazard potential of the substance, or its potential for causing adverse health effects as a result of skin exposure. This determination entails a health hazard identification process that involves use of the following:

- Scientific data on the physicochemical properties of a chemical
- Data on human exposures and health effects
- Empirical data from *in vivo* and *in vitro* laboratory testing
- Computational techniques, including predictive algorithms and mathematical models that describe a selected process (such as skin permeation) by means of analytical or numerical methods.

This *Skin Notation Profile* provides the SK assignments and supportive data for chlorodiphenyl (54% chlorine). In particular, this document evaluates and summarizes the literature describing the hazard potential of the substance and its assessment according to the scientific rationale and framework outlined in *CIB 61*. In meeting this objective, this *Skin Notation Profile* intends to inform the audience—mostly occupational health practitioners, researchers, policy- and decision-makers, employers, and workers in potentially hazardous workplaces—so that improved risk-management practices may be developed to better protect workers from the risks of skin contact with the chemicals of interest.

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Centers for Disease Control and Prevention

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Contents

Foreword.	iii
Abbreviations.	vi
Glossary	viii
Acknowledgments.	ix
1 Introduction.	1
1.1 General Substance Information	1
1.2 Purpose	1
1.3 Overview of SK Assignment for Chlorodiphenyl (54% chlorine).	1
2 Systemic Toxicity From Skin Exposure (SK:SYS).	2
3 Direct Effects on Skin (SK: DIR).	4
4 Immune-mediated Responses (SK: SEN)	5
5 Summary	5
References.	7

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
ATSDR	Agency for Toxic Substances and Disease Registry
CIB	Current Intelligence Bulletin
cm²	square centimeter(s)
COR	subnotation of SK: DIR indicating the potential for a chemical to be corrosive to the skin following exposure
DIR	skin notation indicating the potential for direct effects to the skin following contact with a chemical
DMBA	7,12-dimethylbenz[a]anthracene
GC	gas chromatographic
GHS	Globally Harmonized System for Classification and Labelling of Chemicals
h	hour(s)
IARC	International Agency for Research on Cancer
ID^{SK}	skin notation indicating that a chemical has been evaluated, but insufficient data exist to accurately assess the hazards of skin exposure
IRR	subnotation of SK: DIR indicating the potential for a chemical to be a skin irritant following exposure to the skin
LD₅₀	dose resulting in 50% mortality in the exposed population
LD_{Lo}	dermal lethal dose
M	molarity
m³	cubic meter(s)
mg	milligram(s)
mg/kg	milligram(s) per kilogram
mg/kg-day	milligram(s) per kilogram per day
MW	molecular weight
NIOSH	National Institute for Occupational Safety and Health
nmol	nanomole(s)
NTP	National Toxicology Program
ODC	ornithine decarboxylase
OEL	occupational exposure limit
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
REL	recommended exposure limit
SEN	skin notation indicating the potential for immune-mediated reactions following exposure of the skin
SK	skin notation
SK	skin notation indicating that the reviewed data did not identify a health risk associated with skin exposure
SYS	skin notation indicating the potential for systemic toxicity following exposure of the skin

TPA	12- <i>O</i> -tetradecanoylphorbol-13-acetate
U.S. EPA	United States Environmental Protection Agency
μg	microgram(s)
μg/cm²	microgram(s) per square centimeter
μL	microliter(s)

Glossary

Absorption—The transport of a chemical from the outer surface of the skin into both the skin and systemic circulation (including penetration, permeation, and resorption).

Acute exposure—Contact with a chemical that occurs once or for only a short period of time.

Cancer—Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Contaminant—A chemical that is (1) unintentionally present within a neat substance or mixture at a concentration less than 1.0% or (2) recognized as a potential carcinogen and present within a neat substance or mixture at a concentration less than 0.1%.

Cutaneous (or percutaneous)—Referring to the skin (or through the skin).

Dermal—Referring to the skin.

Dermal contact—Contact with (touching) the skin.

Direct effects—Localized, non-immune-mediated adverse health effects on the skin, including corrosion, primary irritation, changes in skin pigmentation, and reduction/disruption of the skin barrier integrity, occurring at or near the point of contact with chemicals.

Immune-mediated responses—Responses mediated by the immune system, including allergic responses.

Sensitization—A specific immune-mediated response that develops following exposure to a chemical, which, upon re-exposure, can lead to allergic contact dermatitis (ACD) or other immune-mediated diseases such as asthma, depending on the site and route of re-exposure.

Substance—A chemical.

Systemic effects—Systemic toxicity associated with skin absorption of chemicals after exposure of the skin.

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1 Introduction

1.1 General Substance Information

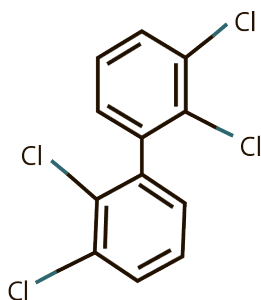
Chemical: Chlorodiphenyl (54% chlorine)

CAS No: 11097-69-1

Molecular weight (MW): 326

Molecular formula: C₆H₃Cl₂C₆H₂Cl₃

Structural formula:



The general substance information was obtained from NIOSH [2007] and the image was obtained from ChemIDplus [NLM, no date].

Synonyms: Aroclor® 1254, PCB, Polychlorinated biphenyl

Uses: Chlorodiphenyl (54% chlorine) has historically been used as a dielectric fluid, hydraulic fluid, and rubber plasticizer. Since 1977, the substance has not been produced or used in the United States [HSDB 2021]. It should be noted that chlorodiphenyl (54% chlorine) may still be present in transformers and capacitors now in use.

1.2 Purpose

This skin notation profile presents (1) a brief summary of epidemiological and toxicological data associated with skin contact with chlorodiphenyl (54% chlorine), a commercial mixture of polychlorinated biphenyl (PCB) compounds, and (2) the rationale behind the hazard-specific skin notation (SK) assignment for chlorodiphenyl (54% chlorine). The SK assignment is based on the scientific rationale and logic outlined in the *Current Intelligence Bulletin (CIB) 61: A Strategy for Assigning New NIOSH Skin Notations* [NIOSH 2009]. The summarized information and health hazard assessment are limited to an evaluation of the potential health effects of dermal exposure to chlorodiphenyl (54% chlorine). A literature search was conducted through March 2021 to identify information on chlorodiphenyl (54% chlorine) dermal absorption, acute toxicity, repeated-dose systemic toxicity, carcinogenicity, biological system/function-specific effects (including reproductive and developmental

effects and immunotoxicity), irritation, and sensitization. Information was considered from studies of humans, animals, or appropriate modeling systems that are relevant to assessing the effects of dermal exposure to these chlorodiphenyl (54% chlorine). The criteria for the search strategy, evaluation, and selection of data are described in Appendix E in the aforementioned CIB 61 [NIOSH 2009].

1.3 Overview of SK Assignment for Chlorodiphenyl (54% chlorine)

Chlorodiphenyl (54% chlorine) is potentially capable of causing numerous adverse health effects following skin contact. A critical review of the available data has resulted in the following SK assignment for chlorodiphenyl (54% chlorine): **SK: SYS-DIR(IRR)**. Table 1 provides an overview of the critical effects and data used to develop the SK assignment for chlorodiphenyl (54% chlorine).

Table 1. Summary of the SK assignment for chlorodiphenyl (54% chlorine)

Skin notation	Critical target organs or effect	Available data
SK: SYS	Hepatotoxicity; central nervous system effects	Limited human and animal data
SK: DIR(IRR)	Skin irritancy; skin tumor (cancer)	Limited animal data

2 Systemic Toxicity From Skin Exposure (SK:SYS)

No *in vivo* human studies were identified that estimated the degree of absorption of chlorodiphenyl (54% chlorine) following dermal exposure. However, *in vivo* dermal absorption studies in monkeys and guinea pigs and *in vitro* dermal absorption studies in human skin were identified [Wester et al. 1983; Wester et al. 1990; Wester et al. 1993]. Wester et al. [1983] reported the average absorption into skin of three guinea pigs was 55.6% after exposure to 5.2 micrograms per square centimeter ($\mu\text{g}/\text{cm}^2$) of chlorodiphenyl (54% chlorine) applied in 50 microliters (μL) of acetone to 10.1 cm^2 of skin on the back of the ears, which were washed with water and acetone multiple times after 24 hours (h). Approximately 20% of the applied dose was recovered in the skin wash used by Wester et al. [1983] to clean chlorodiphenyl (54% chlorine) from the guinea pig skin. Wester et al. [1990] applied 10 μL of a chlorodiphenyl (54% chlorine) solution to 10 cm^2 area of abdominal skin of four rhesus monkeys at a concentration of 4.8 $\mu\text{g}/\text{cm}^2$ of chlorodiphenyl (54% chlorine) delivered in mineral oil or in trichlorobenzene. The authors reported absorption into the skin over 24 h of 20.8% in the mineral oil solution and 14.6% in the trichlorobenzene solution (corresponding to 1.0 $\mu\text{g}/\text{cm}^2$ and 0.70 $\mu\text{g}/\text{cm}^2$, respectively) [Wester et al. 1990].

In an *in vitro* study in which 1 to 2 $\mu\text{g}/\text{cm}^2$ of chlorodiphenyl (54% chlorine) was applied in a mineral oil or trichlorobenzene solution to cadaver skin for 17 h, Wester et al. [1990] reported absorption out of the skin was less than 1%; the amount in the skin at the end of the skin exposure was not reported. Wester et al. [1993] also reported *in vitro* percutaneous

absorption of chlorodiphenyl (54% chlorine) after 24 h on human cadaver skin from 4 $\mu\text{L}/\text{cm}^2$ of mineral oil and water at unspecified concentrations. The total amount of chlorodiphenyl (54% chlorine) that absorbed into the skin over 24 h was reported to be 6.8% from mineral oil ($6.4 \pm 6.3\%$ [mean \pm standard deviation] and 0.34 $\pm 0.64\%$ was in the skin and receptor solution, respectively). Some of the differences between vehicles probably are related to differences in evaporation of the solvent. Results from the *in vivo* dermal absorption studies show that chlorodiphenyl (54% chlorine) in the skin at the end of the exposure does absorb systemically. Given this, both the *in vitro* and *in vivo* results indicate that chlorodiphenyl (54% chlorine) is absorbed (more than 10% of the applied dose) through the skin following dermal exposure.

No estimate of the human dermal lethal dose (LD_{Lo}) or dermal LD_{50} values (lethal dose in 50% of exposed animal) in animals were identified for chlorodiphenyl (54% chlorine). However, Puhvel et al. [1982] reported that a single application of 50 milligrams (mg), the only dose tested of Aroclor 1254 (i.e., chlorodiphenyl [54% chlorine]) was fatal to hairless mice within 24 h. Lack of dermal LD_{50} values precludes adequate evaluation of the potential of chlorodiphenyl (54% chlorine) to be acutely toxic following dermal exposure.

No chronic or subchronic studies were identified of dermal exposure to chlorodiphenyl (54% chlorine). In a repeat-dose study, Bickers et al. [1974] applied 25 mg/kg per day (mg/kg-day) of chlorodiphenyl (54% chlorine) in acetone to the shaved skin of male rats for 6 days. The authors reported a large increase in liver weight (42% increase over control) and microsomal proteins (44% over control) in addition to a 329% increase in cytochrome P-450 content,

greater than 10- and 7-fold induction of benzo[a]pyrene hydroxylase activity in the liver and skin, respectively, and increases in the activities of other hepatic drug-metabolizing enzymes. The authors also reported that the effects of chlorodiphenyl (54% chlorine) on cytochrome P-450 content and mixed-function oxidase system activities in the liver were similar whether the substance was delivered by intraperitoneal injection or by cutaneous application [Bickers et al. 1974].

Epidemiological studies and clinical surveys of PCB-exposed workers have reported hepatic effects including increased serum-levels of liver-related enzymes [ATSDR 2000]. Several occupational studies were also identified that reported systemic effects in workers who had some occupational exposure to chlorodiphenyl (54% chlorine), and where sequential or concurrent exposure to other chlorodiphenyl mixtures nearly always occurred [ATSDR 2000]. For example, Fischbein et al. [1979] reported central nervous system (CNS) effects (i.e., headache, nervousness, fatigue) as some of the most prevalent symptoms among 326 capacitor workers employed at two capacitor manufacturing facilities. At the facilities, dielectric fluids containing various mixtures of PCBs (i.e., Aroclor 1254, 1242, and others) were extensively used for approximately 30 years, and about 40% of the workers were employed for 20 years or longer. There was a low prevalence of abnormal liver findings in

these workers. Although these epidemiological and occupational exposure studies involved inhalation and dermal routes for which the relative contribution by each route was unknown, humans are known to absorb PCBs by the ingestion, inhalation, and dermal routes of exposure, after which the PCBs are transported similarly through the systemic circulation [ATSDR 2000]. Due to this similarity in the mode of transport, PCBs are expected to produce similar systemic effects from different routes of exposure. Therefore, the potential exists for chlorodiphenyl (54% chlorine) to cause CNS effects, among others, following dermal exposure.

No standard toxicity or specialty studies were identified that evaluated the biological system/function specific effects (including reproductive and developmental effects and immunotoxicity) following dermal exposure to chlorodiphenyl (54% chlorine). No epidemiological studies or animal bioassays were identified that specifically evaluated the potential for chlorodiphenyl (54% chlorine) to be carcinogenic in humans or animals following dermal exposure. Other organizations or agencies have evaluated the carcinogenic potential of chlorodiphenyl (54% chlorine) or PCBs following other routes of exposure. Table 2 summarizes the carcinogenic designations for chlorodiphenyl (54% chlorine) from governmental and nongovernmental agencies.

Table 2. Summary of the carcinogenic designations for chlorodiphenyl (54% chlorine) by numerous governmental and nongovernmental organizations

Organization	Carcinogenic designation
NIOSH [2007]	Potential occupational carcinogen
NTP [2016]	No designation
U.S. EPA [2021]	No designation
ECHA [2021]	No designation
IARC [2012]	Group 2B: Possibly carcinogenic to humans
ACGIH* [2018]	A3: Confirmed animal carcinogen with unknown relevance to humans

ACGIH* = American Conference of Governmental Industrial Hygienists; ECHA = European Chemicals Agency; IARC = International Agency for Research on Cancer; NIOSH = National Institute for Occupational Safety and Health; NTP = National Toxicology Program; U.S. EPA = United States Environmental Protection Agency.

Evidence from *in vivo* and *in vitro* dermal absorption studies [Wester et al. 1983; Wester et al. 1990; Wester et al. 1993] indicates that chlorodiphenyl (54% chlorine) has the potential to be absorbed through the skin following dermal exposure. No acute dermal toxicity studies that estimated the LD₅₀ of the chemical were identified. However, chlorodiphenyl (54% chlorine) was reported to cause hepatotoxicity in a repeat-dose dermal toxicity study in rats [Bickers et al. 1974].* Occupational exposure studies involving PCBs or such studies involving chlorodiphenyl (54% chlorine) nearly always occurred with sequential or concurrent exposure to other chlorodiphenyl mixtures [ATSDR 2000], and these exposures likely involved both dermal and inhalation routes. The occupational exposure data including Fischbein et al. [1979] indicate the potential for PCBs to cause CNS effects. This assessment concludes that the limited data in humans and animals indicate that chlorodiphenyl (54% chlorine) has the potential to cause systemic toxicity including liver and CNS effects. Therefore, chlorodiphenyl (54% chlorine) is assigned a SK: SYS notation.

3 Direct Effects on Skin (SK: DIR)

No human or animal *in vivo* studies on corrosivity of 2,4-TDI or 2,6-TDI or *in vitro* tests for corrosivity using human skin models or *in vitro* tests of skin integrity using cadaver skin were identified. Occupational exposure studies or case reports were not identified that investigated direct skin effects of the chemical alone following dermal exposure. However, Fischbein et al. [1979] examined the dermatological effects among 326 capacitor-manufacturing workers handling various mixtures of PCBs [including chlorodiphenyl (54% chlorine)] at two facilities. The overall prevalence of dermatological symptoms was high, with 76 (45%) of male workers and 87 (55%) of female workers

reporting a history of dermatologic complaints. Skin rash, the most prevalent symptom, was reported by 128 workers (39.3%), a burning sensation by 81 workers (24.8%), acne by 35 workers (10.7%), while pigmentation disturbances (darkening) was reported by 2.5% of workers, thickening of the skin by 3.7% of workers, and discoloration of the nails were reported by 2.5% of the workers. Exposures at these facilities likely involved both dermal and inhalation routes.

Fischbein and Wolff [1987] presented two case reports of two transformer maintenance workers who handled dielectric fluid containing PCBs and who had frequent skin contact with the dielectric fluid. One of these cases reported “smelling and tasting the chemical in his food,” which indicates that the worker may have also been exposed through ingestion. Acneiform lesions developed on both thighs of one worker and on the legs and upper arms of the other worker [Fischbein and Wolff 1987]. Serum and adipose PCB concentrations in these workers were reportedly high, while gas chromatographic (GC) patterns of PCB in the serum were found to correspond to Aroclor 1254 (i.e., chlorodiphenyl, 54% chlorine) rather than Aroclor 1260 (i.e., chlorodiphenyl, 60% chlorine) [Fischbein and Wolff 1987]. The wives of these workers were not occupationally exposed to PCBs but were reported to launder the work clothes of their husbands. Examination of the wives revealed no clinical abnormalities or increase in the serum and adipose tissue concentrations of PCBs. However, the wives of the workers had GC patterns of PCBs that corresponded to chlorodiphenyl (54% chlorine) as observed in their husbands [Fischbein and Wolff 1987].

Puhvel et al. [1982] evaluated the potential for chlorodiphenyl (54% chlorine) to cause chloracne (an acne-like eruption of blackheads, cysts, and pustules associated with over-exposure to certain halogenated aromatic compounds, such as chlorinated dioxins and dibenzofurans) in the hairless mouse model. Application of 1 or 3 mg of Aroclor 1254 (i.e., chlorodiphenyl

*References in **bold** text indicate studies that serve as the basis of the SK assignments.

[54% chlorine]) in acetone or acetone:mineral oil (4:1) emulsions to the skin of three hairless mice 4 days per week over 6 weeks did not induce any observable changes, either grossly or histologically [Puhvel et al. 1982].

Studies in animals have examined the potential for chlorodiphenyl (54% chlorine) to cause skin tumor or direct skin effects. In a study in mice, Dwivedi and Sitzman [1998] applied 600 micrograms (μg) chlorodiphenyl (54% chlorine) in 100 μL acetone or 2.5–5 nanomoles (nmol) of 12-*O*-tetradecanoylphorbol-13-acetate (TPA) in 100 μL acetone to the shaved skin of mice for 5 h. Epidermal ornithine decarboxylase (ODC) activity—a prominent feature among the various biochemical changes observed during tumor promotion—was not detectable following dermal exposure to chlorodiphenyl (54% chlorine), indicating a lack of potential for tumor development in the skin [Dwivedi and Sitzman 1998].

DiGiovanni et al. [1977] investigated the skin tumor-initiating potential of chlorodiphenyl (54% chlorine) and the effect of simultaneous administration of chlorodiphenyl (54% chlorine) and 7,12-dimethylbez[a]anthracene (DMBA) in the mouse. In this study, mice were topically treated with (a) 2.56 μg DMBA and promoted with 5 μg TPA for 32 weeks; (b) 100 μg of chlorodiphenyl (54% chlorine) and promoted with 5 μg TPA for 32 weeks; and (c) 2.56 μg DMBA and 100 μg of chlorodiphenyl (54% chlorine) and promoted for 32 weeks with 5 μg TPA. Chlorodiphenyl (54% chlorine) at 100 μg displayed a weak skin tumor-initiating capacity after promoting with TPA for 32 weeks (0.2 papillomas/mouse, 10% of survivors with papillomas) [DiGiovanni et al. 1977]. However, when chlorodiphenyl (54% chlorine) was administered concurrently with DMBA, a slight decrease in the number of tumors at 32 weeks (1.7 papillomas/mouse, 42% of survivors with papillomas) was reported when compared with the effects of DMBA applied alone [DiGiovanni et al. 1977]. Based on the results, DiGiovanni et al. [1977] concluded that chlorodiphenyl (54% chlorine) was a weak initiator, and that when

given concurrently with the known carcinogen DMBA, chlorodiphenyl (54% chlorine) was capable of modifying the response only slightly.

Limited data from occupational exposure studies or case reports that likely involved both dermal and inhalation routes [Fischbein and Wolff 1987; Fischbein et al. 1979] indicate chlorodiphenyl (54% chlorine) and other PCB mixtures may cause direct skin effects, including rash, burning sensations, discoloration, thickening of the skin, and acneiform lesions in humans following dermal exposure. However, data in mice indicate that chlorodiphenyl (54% chlorine) is not likely to cause chloracne [Puhvel et al. 1982]. Limited data available in mice indicate that chlorodiphenyl (54% chlorine) is a weak tumor initiator [DiGiovanni et al. 1977]. Therefore, chlorodiphenyl (54% chlorine) is assigned a skin notation of **SK: DIR(IRR)**.

4 Immune-mediated Responses (SK: SEN)

No occupational exposure studies that investigated the skin sensitization potential of chlorodiphenyl (54% chlorine) were identified. No diagnostic (human patch) tests or predictive tests in animals such as guinea pig maximization tests, Buehler tests, murine local lymph node assays, mouse ear swelling tests, or any other studies that evaluated the potential of the substance to cause skin sensitization were identified. Due to the paucity of data, chlorodiphenyl (54% chlorine) is not assigned a SK: SEN notation.

5 Summary

In vivo dermal absorption studies in monkeys and guinea pigs [Wester et al. 1983; Wester et al. 1993] and *in vitro* dermal absorption studies in human skin [Wester et al. 1993] indicate that chlorodiphenyl (54% chlorine) has the potential to be absorbed through the skin following dermal exposure. No acute dermal toxicity studies that

estimated the LD₅₀ of the chemical were identified. However, chlorodiphenyl (54% chlorine) was reported to cause hepatotoxicity in a repeat-dose dermal toxicity study in rats [Bickers et al. 1974]. Occupational exposure studies involving PCBs or such studies involving chlorodiphenyl (54% chlorine) nearly always occurred with sequential or concurrent exposure to other chlorodiphenyl mixtures [ATSDR 2000], and these exposures likely involved both dermal and inhalation routes. The occupational exposure data including Fischbein et al. [1979] indicate the potential for PCBs to cause CNS effects. Limited data from occupational exposure studies or case reports that likely involved both dermal and inhalation routes [Fischbein and Wolff 1987; Fischbein et al. 1979] indicate chlorodiphenyl (54% chlorine) and other PCB mixtures may cause direct skin effects, including rash, burning sensations, discoloration, thickening of the skin, and acneiform lesions in humans

following dermal exposure. However, data in mice indicate that chlorodiphenyl (54% chlorine) is not likely to cause chloracne [Puhvel et al. 1982]. Limited data available in mice indicate that chlorodiphenyl (54% chlorine) is a weak tumor initiator [DiGiovanni 1977]. No diagnostic (human patch) tests or predictive tests in animals were identified that evaluated the potential for chlorodiphenyl (54% chlorine) to cause skin sensitization. Based on the available data, chlorodiphenyl (54% chlorine) is assigned a composite **SK: SYS-DIR(IRR)** notation.

Table 3 summarizes the skin hazard designations for chlorodiphenyl (54% chlorine) previously issued by NIOSH and other organizations. There were no equivalent dermal designations for chlorodiphenyl (54% chlorine) according to the Globally Harmonized System (GHS) of classification and labelling of chemicals [European Parliament 2008].

Table 3. Summary of previous issued skin hazard designations for Chlorodiphenyl (54% chlorine)

Organization	Skin hazard designation
NIOSH [2007]	No designation
OSHA [2019]*	[Skin]: Potential for dermal absorption
ACGIH® [2018]	[Skin]: based on the liver toxicity reported among animals treated dermally with Aroclor 1254

ACGIH® = American Conference of Governmental Industrial Hygienists; NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration.

*Date accessed.

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Note: Asterisks (*) denote sources cited in text; daggers (†) denote additional resources.

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