

- cardiopulmonary resuscitation and subsequent development of severe brain damage /is described/. [Peer reviewed] [Doring G, Baumeister FA; *Klin Padiatr* 214 (5): 295-298 (2002)]
10. /CASE REPORTS/ A 16 yr old girl was seen for n-butane abuse. She had been inhaling it for a yr, and had collected over 22 canisters (232 ml) which she had inhaled during the previous 3 mo (about 5l total). The patient used the cover of the canister as the mask for the abuse. She suffered from visual hallucinations during initial abuse and became increasingly irritable. School attendance became very irregular and there was a gradual deterioration in social functioning leading to social isolation with very little contact with her peer group. Physical examination was unremarkable. The patient did not cooperate with further hematological and psychological investigations. [Peer reviewed] [Mathew B et al; *Br J Addict* 84 (5): 563-4 (1989)]
 11. /CASE REPORTS/ A 19-yr-old man developed rapidly progressive bilateral pulmonary infiltrates radiologically consistent with hydrocarbon pneumonitis after 'fire breathing.' This practice involved filling his mouth with fumes from a butane lighter and expelling them on an open flame. On at least one occasion he swallowed the fumes. [Peer reviewed] [Ellenhorn, M.J. and D.G. Barceloux. *Medical Toxicology - Diagnosis and Treatment of Human Poisoning*. New York, NY: Elsevier Science Publishing Co., Inc. 1988., p. 967]
 12. /CASE REPORTS/ A newborn infant who suffered intra-uterine anoxia is described, whose mother inhaled butane gas accidentally during the 6th month of pregnancy. The infant was born at 39 weeks. Ultrasonography and neuroradiological studies (CT scan and angiography) showed an almost complete absence of both cerebral hemispheres. The thalamus, brainstem and cerebellum were preserved. These findings were compatible with hydranencephaly. The authors believe that the malformation was due to intra-uterine anoxia occurring during fetal brain-development. [Peer reviewed] [Fernandez F et al; *Dev Med Child Neurol* 28 (3): 361-3 (1986)]
 13. /CASE REPORTS/ An autopsy case of a 14-year-old boy whose death is considered to be a result of cardiac arrhythmia after butane inhalation and sample preservation for butane analysis are reported. The electrocardiogram taken in the ambulance revealed ventricular fibrillation. There were no autopsy findings as to the cause of death. n-Butane, isobutane and propane were identified in the blood, brain and lung of the cadaver ... Based on these results, the cause of death was concluded to be cardiac arrhythmia due to butane inhalation... [Peer reviewed] [Fuke C, Miyazaki T; *Legal Medicine* 4 (2): 134-138 (2002)]
 14. /CASE REPORTS/ Rapidly progressive bilateral pulmonary infiltrates occurred in a 19-yr-old man following an unusual hydrocarbon abuse. The acute illness was the result of a 'trick' known as 'fire-breathing.' Fire-breathing involves filling the oral cavity with butane gas, from an ordinary butane cigarette/cigar lighter, and exhalation of the volatile vapors over an open flame producing a flame-throwing effect. Because of the pulmonary toxic reaction, this activity could have a serious or even fatal outcome. [Peer reviewed] [Cartwright TR, Brown ED; *Arch Intern Med* 143(10): 2007-2008 (1983)]

Non-Human Toxicity Excerpts:

1. /LABORATORY ANIMALS: Acute Exposure/ Butane is an essentially nontoxic petroleum gas that causes no disturbance of the eye, even when injected into the anterior chamber experimentally in rabbits, disappearing spontaneously from the eye in 2 to 4 days. [Peer reviewed] [Grant, W.M. *Toxicology of the Eye*. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986., p. 161]
2. /LABORATORY ANIMALS: Acute Exposure/ ...Concn of 2.1 to 5.6% cause sniffing & chewing movements with rapid rate of breathing /in guinea pigs/, but quick recovery after cessation of exposure. [Peer reviewed] [Clayton, G. D. and F. E. Clayton (eds.). *Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology*. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3182]
3. /LABORATORY ANIMALS: Acute Exposure/ Concns of 5,000 ppm in the anesthetized

- dog may cause hemodynamic changes, such as decreases in cardiac output, left ventricular pressure and stroke volume, myocardial contractility, and aortic pressure. [Peer reviewed] [Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V4 15]
4. /LABORATORY ANIMALS: Acute Exposure/ ...Respiratory exposure of mice to 27% (270,000 ppm) for 2 hr caused death in 40% of the animals and 310,000 ppm for 2 hr caused 60% mortality. In dogs, lethality was observed at concentrations of 200,000-250,000 ppm; anesthesia and relaxation preceded death. ...There was only a small margin of safety between anesthetic and lethal concn. ...n-Butane is somewhat more toxic than isobutane... . [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 270]
 5. /LABORATORY ANIMALS: Acute Exposure/ n-Butane /did not/... cause respiratory... irritation in rabbits. ...Butane appears to be mildly to moderately irritating to the rabbit skin. [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 271]
 6. /LABORATORY ANIMALS: Acute Exposure/ Near the LC50, mice exhibited central nervous system depression, rapid and shallow respiration, and apnea. /isobutane/ [Peer reviewed] [American Conference of Governmental Industrial Hygienists. Documentation of Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2001. Cincinnati, OH. 2001., p. 2]
 7. /LABORATORY ANIMALS: Acute Exposure/ n-Butane is reported to be a weak cardiac sensitizer in the dog, and 5,000 ppm in the anesthetized dog may cause hemodynamic changes, such as decreased cardiac output, decreased left ventricular pressure and stroke volume, and decreased myocardial contractility and aortic pressure. [Peer reviewed] [American Conference of Governmental Industrial Hygienists. Documentation of Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2001. Cincinnati, OH. 2001., p. 1]
 8. /GENOTOXICITY/ The mutagenic potential of n-butane was evaluated in vitro at several concn using Ames Salmonella microsome assay. n-Butane was not mutagenic. [Peer reviewed] [Kirwin CJ et al; J Soc Cosmet Chem 31 (Dec 1980): 367-70 (1980)]

TOXICITY VALUES ▲

Non-Human Toxicity Values:

1. LC50 Rat inhalation 658 mg/l/4 hr [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 270]
2. LC50 Mouse inhalation 680 mg/l/2 hr [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 270]
3. LC50 Rat inhalation 658 g/cu m/4 hr [Peer reviewed] [Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996., p. 541]
4. LC50 Mouse inhalation 680 g/cu m/2 hr [Peer reviewed] [Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996., p. 541]

TSCA Test Submissions:

1. Butadiene Feedstock, a mixture containing 1,3-butadiene (40-69%), 1-butene (11-19%), isobutene (5-20%), and mixed butenes and butane (7-24%), was evaluated for the potential to induce chromosomal damage. CrI:CDR-1(ICR)BR Swiss mice (10/sex/group) were

- exposed to target concentrations of 0, 10,000, 20,000, or 30,000 ppm (actual average concentrations were 0, 10,802, 20,671, or 35,430 ppm, respectively) by inhalation 2 hours/day for 2 consecutive days. A positive control group of 5 males and 5 females received one intraperitoneal injection of cyclophosphamide (75 mg/kg) on each of two days. Animals were sacrificed and bone marrow smears were prepared on days 3 and 4. Expected results were obtained from positive and negative control groups exposed to cyclophosphamide and air-only, respectively. Females at all dose levels showed a significant, dose-related increase in micronucleus formation over controls on both days. Males showed a significant increase only at 35430 ppm on both days. There was a decrease in micronucleated erythrocytes on day 4 in both sexes at all dose levels. [Not reviewed] [Gulf Oil Corp.; Summary of in vitro and in vivo Genotoxicity Studies with Butadiene Feedstock (03/1984); EPA Document No. 88-8400616; OTS0509705]
2. Butadiene Feedstock, a mixture containing 1,3-butadiene (40-69%), 1-butene (11-19%), isobutene (5-20%), and mixed butenes and butane (7-24%), was evaluated for the potential to induce unscheduled DNA synthesis in primary hepatocytes from freshly perfused rat liver. The test compound was injected directly into sealed desiccator chambers. Cell cultures (3/concentration level) were tested at 1000, 5000, 10000, 20000 ppm. Three cultures served as vehicle/negative controls (air-injected), and 3 cultures were exposed to 2-acetylaminofluorene (0.2 mcg/ml) as positive controls. An additional 3 cultures served as system controls: no injections were made into the chamber. The cultures were exposed to the test compound and 3H-thymidine for 18-20 hours. Slides were prepared and dipped in autoradiographic emulsion and were subsequently developed, stained, and coverslipped. The average net nuclear grain count per slide was calculated and the mean net nuclear grain count was determined for each exposure concentration. The positive and negative controls gave expected results for unscheduled DNA synthesis. A weak positive response was observed at 20000 ppm butadiene feedstock when compared to the negative control. This was almost double the response at 1000 ppm. [Not reviewed] [Gulf Oil Corp.; Summary of in vitro and in vivo Genotoxicity Studies with Butadiene Feedstock (03/1984); EPA Document No. 88-8400616; OTS0509705]
 3. Butadiene Feedstock, a mixture containing 1,3-butadiene (40-69%), 1-butene (11-19%), isobutene (5-20%), and mixed butenes and butane (7-24%), was evaluated for the potential to induce mutations in Chinese hamster ovary cell cultures either with or without metabolic activation. Target concentrations of 2,250, 11,250, 22,500, or 45,000 mg/m³ (corresponding to approximately 1,000, 5,000, 10,000, or 20,000 ppm) were injected directly into 4 sealed glass desiccators each with 6 flasks containing cultures of approximately 1 million cells (3 with S9 metabolic activation, 3 without) for 5 hours on culture day 2. The vehicle control group had 12 flasks in all, 6 with S9 activation and 6 without. Control cultures received filtered air, medium, and S9 mix (negative control), or filtered air and 100mcg/ml ethyl methanesulfonate mixed with the growing medium, or filtered air, S9 mix, and 4 mcg/ml of benzo(a)pyrene in the medium (positive control). The control groups gave expected results. There was not a significant difference in the numbers of mutant colonies from cultures treated with butadiene feedstock and those in the vehicle control group. [Not reviewed] [Gulf Oil Corp.; Summary of in vitro and in vivo Genotoxicity Studies with Butadiene Feedstock (03/1984); EPA Document No. 88-8400616; OTS0509705]
 4. The subchronic toxicity of a 50:50 mixture of n-butane:n-pentane was evaluated by inhalation exposure in male and female Fischer 344 rats (20 males and 10 females/group) at concentrations of 1000 and 4500 ppm, while a control group of 40 males and 20 females received filtered air. All groups were exposed for 6 hours/day, 5 days/week. Half the males from each were randomly selected for sacrifice and necropsy after the twentieth exposure; the remaining animals were necropsied after 65 exposures. All animals survived to scheduled sacrifice. Male rats (3/10) exposed to 4500 ppm and male (2/10) and female (1/10) rats exposed to 1000 ppm exhibited hunched posture and/or lethargy which persisted 1 to 3 days following week 6. Both males and females exposed to the hydrocarbon mixtures showed crusted eyes and swollen eyelids, the highest incidence

was observed in females receiving 4500 ppm. Body weights were significantly decreased in males and females at both exposure levels compared to controls by weeks 3 and 4. Female body weights remained depressed throughout the course of the study, while males seemed to recover during week 11. There was no apparent dose-relationship, however. Liver and kidney weights from all treated rats were comparable to those of the controls at both 4 and 13 weeks. Gross lesions observed during necropsy were considered unrelated to treatment. [Not reviewed] [IIT Research Institute; Thirteen-Week Inhalation Toxicity Study of C4/C5 Hydrocarbon Blends in Rats; EPA Document No. FYI-AX-0385-0332; OTS00000332-1]

Populations at Special Risk:

The possibility of increased susceptibility to hepatotoxins after enzyme induction by abuse of volatile agents is discussed. [Peer reviewed] [McIntyre AS, Long RG; Postgrad Med J 68(794): p 29-30 (1992)]

PHARMACOKINETICS ▲

Absorption, Distribution and Excretion:

1. Inhalation studies ... in which rats and mice were exposed to lethal concn (27.8-29%) revealed that n-butane is absorbed and distributed to various tissues. After 4 hr of respiratory exposure, surviving rats were sacrificed ... concn of butane were ... highest in perinephric fat (2086 ppm), then brain (750 ppm), spleen (522 ppm), liver (492 ppm), and kidney (441 ppm). In mice exposed to 2 hr of butane vapors, the brain levels of n-butane were found to be 779 ppm. In both rats and mice the brain levels of n-butane correlated with the degree of CNS depression ... Dermal absorption of n-butane vapors has not been reported. However, dermal penetration of butane would not be expected to occur to any large extent since skin contact is transient because of volatility. [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 269]
2. Because of its volatile nature, elimination of butane by exhalation can be anticipated. [Peer reviewed] [Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V4 15]

Metabolism/Metabolites:

1. Microsomal enzyme systems have been found that oxidize butane to its parent alcohol. [Peer reviewed] [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3183]
2. Hydroxylation of butane ... /occurs/ in rat liver microsomes to yield 2-butanol as the major metabolite. n-Butane is the lowest molecular weight alkane ... demonstrated to substrate-bind with cytochrome p450. ... If 2-butanol is the major metabolite formed in mammals, it would be expected to be eliminated in expired air. ... 2-Butanol may also be conjugated with glucuronic acid or be oxidized to methyl ethyl ketone which in turn is expired. [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 269]

Biological Half-Life:

1. Based on kinetic studies ... with ethane and n-pentane, the elimination half-life of n-butane can be expected to be closer to that of n-pentane (half life= 0.13 hr, at nonsaturating concn). [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New

York - Oxford: Elsevier, 1987., p. 269]

2. Its elimination half-life is 0.13 hr at nonsaturating concns. [Peer reviewed] [Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V4 15]

Interactions:

1. ... Mixing butane and isobutylene produced an additive ... /CNS depressant/ effect in 2 of 12 mice and a potentiating effect in the remaining 10 animals. In rats, the butane-isobutylene mixture showed a summation of effects in 9 of 12 animals and a potentiation of effects in the remaining animals. [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 270]
2. ... Exposure of dogs to 1-20% n-butane for ... 2 min to 2 hr hypersensitized the heart to ventricular fibrillation induced by epinephrine. /In a separate study/ ... exposure of dogs to concn of 15-90% for 10 min caused the heart to be sensitized to epinephrine-induced arrhythmias. [Peer reviewed] [Snyder, R. (ed.) Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume 1: Hydrocarbons. Amsterdam - New York - Oxford: Elsevier, 1987., p. 270]

7.0 ENVIRONMENTAL FATE/EXPOSURE POTENTIAL

SUMMARY ▲

Environmental Fate/Exposure Summary:

n-Butane is released to the environment through various waste streams via the manufacture, use, and disposal of many products associated with the petroleum and natural gas industries. Extensive data show the release of n-butane into the environment from hazardous waste disposal sites, landfills, waste incinerators and the combustion of gasoline-fueled engines. n-Butane is also a highly-volatile constituent in the paraffin fraction of crude oil and natural gas. If released to air, a vapor pressure of 1820 mm Hg at 25 deg C indicates n-butane will exist solely as a gas in the ambient atmosphere. Gas-phase n-butane will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 6.3 days. Data also suggest that nighttime reactions with radical species and nitrogen oxides may contribute to the atmospheric transformation of n-butane. If released to soil, n-butane is expected to have low mobility based upon an estimated Koc of 900. Volatilization from moist soil surfaces is expected to be an important fate process based upon an estimated Henry's Law constant of 0.95 atm-cu m/mole. n-Butane is expected to volatilize from dry soil surfaces based upon its vapor pressure. While volatilization is expected to be the dominant fate process in both soil and water, n-butane is also susceptible to biodegradation processes. In one soil study, a biodegradation rate of 1.8 mgC/day/kg dry soil was reported for n-butane. In a screening study, complete biodegradation of n-butane was reported in 34 days. If released into water, n-butane may adsorb to suspended solids and sediment based upon the estimated Koc. Volatilization from water surfaces is expected to be an important fate process based upon this compound's estimated Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 2.2 hours and 3.0 days, respectively. An estimated BCF of 33 suggests the potential for bioconcentration in aquatic organisms is moderate. Hydrolysis is not expected to be an important environmental fate process since n-butane lacks functional groups that hydrolyze under environmental conditions. Occupational exposure to n-butane may occur

through inhalation and dermal contact with this compound at workplaces where n-butane, or petroleum and natural gas containing n-butane, are produced or used. Monitoring data indicate that the most probable route of exposure of n-butane to the general population is by inhalation of ambient air; in addition, ingestion of food and drinking water, and dermal contact with this compound in liquids such as crude oil and gasoline and other liquid products containing n-butane may result in exposure. Extensive monitoring data indicates n-butane is a widely occurring atmospheric pollutant. (SRC) [Peer reviewed]

POLLUTION SOURCES ▲

Natural Occurring Sources:

1. RAW NATURAL GAS /CONTAINS AVG/ 0.30 MOL% N-BUTANE [Peer reviewed] [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984., p. 12(80) 911]
2. n-Butane is a constituent in the paraffin fraction of crude oil and natural gas. [Peer reviewed] [USEPA; Drinking water Criteria Document for Gasoline ECAO-CIN-D006, 8006- 61-9 (1986)]

Artificial Sources:

n-Butane's production and use in many products associated with the petroleum (1,2,14-16) and natural gas industries(2) may result in its release to the environment through various waste streams(SRC). In addition, the combustion of gasoline is a major mechanism for the release of n-butane into the atmosphere(3-9,14). Waste incinerators(10), hazardous waste disposal sites(11) and landfills(12,13) also release n-butane into the environment. [Peer reviewed] [(1) Sauer TC Jr; Org Geochem 7: 1-16 (1981) (2) Arnts RR, Meeks SA; Atmos Environ 15: 1643-51 (1981) (3) Hampton CV et al; Environ Sci Technol 16: 287-98 (1982) (4) Nelson PF, Quigley SM; Atmos Environ 18: 79-87 (1984) (5) Neligan RE; Arch Environ Health 5: 581-91 (1962) (6) Sigsby JE et al; Environ Sci Technol 21: 466-75 (1987) (7) Stump FD et al; Atmos Environ 23: 307-20 (1989) (8) Zweidinger RB et al; Environ Sci Tech 22: 956-62 (1988) (9) Altwicker ER, Whitby RA; Atmos Environ 12: 1289-96 (1978) (10) Carotti AA, Kaiser ER; J Air Pollut Contr Assoc 22: 224-53 (1972) (11) LaRegina J et al; Environ Prog 5: 18-27 (1986) (12) Young P, Parker A; Vapors Odors and Toxic Gases from Landfills ASTM Spec Tech Publ 851: 24-41 (1984) (13) Sawhney BL, Raabe JA; Ground Water Contamination Mvmt Org Pollut in Granby Landfill, Bull 833 p 9 (1986) (14) Sawyer RF; Environ Hlth Perspect Suppl 101: 5-12 (1993) (15) McLaren R et al; Environ Sci Technol 30: 3001-9 (1996) (16) Ostermark U, Petersson G; Chemosphere 25: 763-8 (1992)]

ENVIRONMENTAL FATE ▲

1. TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 900 (SRC), determined from a log Kow of 2.89(2) and a regression-derived equation(3), indicates that n-butane is expected to have low mobility in soil(SRC). Volatilization of n-butane from moist soil surfaces is expected to be an important fate process(SRC) given an estimated Henry's Law constant of 0.95 atm-cu m/mole(SRC), derived from its vapor pressure, 1820 mm Hg(4) and water solubility, 61.2 mg/l(5). The potential for volatilization of n-butane from dry soil surfaces may exist(SRC) based upon its vapor pressure(4). While volatilization from soil surfaces is expected to be the predominant fate process of n-butane released to soil(SRC), this compound is also susceptible to biodegradation. In

one soil, a biodegradation rate of 1.8 mgC/day/kg dry soil was reported(6). [Peer reviewed] [(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 10 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (4) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification, Techniques of Chemistry 4th ed., NY, NY: Wiley-Interscience Vol 2, p. 78-80 (1986) (5) McAuliffe C; Nature 200: 1092-3 (1963) (6) Toccalino PL et al; Appl Environ Microbiol 59: 2977-83 (1993)]

2. **AQUATIC FATE:** Based on a classification scheme(1), an estimated Koc value of 900 (SRC), determined from a log Kow of 2.89(2) and a regression-derived equation(3), indicates that n-butane may adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(3) based upon an estimated Henry's Law constant of 0.95 atm-cu m/mole(SRC), derived from its vapor pressure, 1820 mm Hg(4) and water solubility, 61.2 mg/l(5). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 2.2 hours and 3 days, respectively(SRC). According to a classification scheme(6), an estimated BCF of 33(SRC), from its log Kow(2) and a regression-derived equation(7), suggests the potential for bioconcentration in aquatic organisms is moderate(SRC). While volatilization from water surfaces is expected to be the major fate process for n-butane released to water, biodegradation of this compound is also expected to occur. In a screening study, complete biodegradation was reported in 34 days(8). In a second study using a defined microbial culture, it was reported that n-butane was degraded to 2-butanone(9,10) and 2-butanol (10, 11). Photolysis or hydrolysis(3) of n-butane in aquatic systems is not expected to be important. [Peer reviewed] [(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 10 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 7-4 to 7-5, 15-1 to 15-29 (1990) (4) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification, Techniques of Chemistry 4th ed., NY, NY: Wiley-Interscience Vol 2, p. 78-80 (1986) (5) McAuliffe C; Nature 200: 1092-3 (1963) (6) Franke C et al; Chemosphere 29: 1501-14 (1994) (7) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (8) Solano-Serena F et al; Appl Microbiol Biotechnol 54: 121-5 (2000) (9) Patel RN et al; Appl Environ Microbiol 39: 727-33 (1980) (10) Hou CT et al; Appl Environ Microbiol 46: 178-84 (1983) (11) Patel RN et al; Appl Environ Microbiol 39: 720-6 (1980)]
3. **ATMOSPHERIC FATE:** According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), n-butane, which has a vapor pressure of 1820 mm Hg at 25 deg C(2), is expected to exist solely as a gas in the ambient atmosphere. Gas-phase n-butane is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 6.3 days(SRC), calculated from its rate constant of 2.54×10^{-12} cu cm/molecule-sec at 25 deg(3). Based on data for iso-octane and n-hexane(4), n-butane is not expected to absorb UV light in the environmentally significant range, >290 nm(SRC) and probably will not undergo direct photolysis in the atmosphere. Experimental data showed that 7.7% of the n-butane fraction in a dark chamber reacted with nitrogen oxide to form the corresponding alkyl nitrate(5,6), suggesting nighttime reactions with radical species and nitrogen oxides may contribute to the atmospheric transformation of n-butane(SRC). [Peer reviewed] [(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification, Techniques of Chemistry 4th ed., NY, NY: Wiley-Interscience Vol 2, p. 78-80 (1986) (3) Atkinson R; J Phys Chem Ref Data, Monograph 2, (1994) (4) Silverstein RM, Bassler GC; pp. 148-169 in Spectrometric Id of Org Cmpd, J Wiley and Sons Inc (1963) (5) Atkinson R et al; J Phys Chem 86: 4563-9 (1982) (6) Atkinson R et al; Preprints Div Environ Chem 23: 173-6 (1983)]

ENVIRONMENTAL TRANSFORMATIONS ▲

Biodegradation:

1. ... *Mycobacterium crassa* & *M. phlei* grow on butane. In combination with various concn of oxygen, butane supports the growth of *Neurospora crassa*, as well as the germination of *N. ascospores* & growth of *Escherichia coli* strains B & Sd4, thus rendering butane potentially biodegradable. [Peer reviewed] [Clayton, G. D. and F. E. Clayton (eds.). *Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology*. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3183]
2. Incubation with natural flora in the groundwater in presence of the other components of high octane gasoline (100 ul/l): biodegradation: 0% after 192 hr @ 13 deg C (initial concn 0.63 ul/l). [Peer reviewed] [Verschueren, K. *Handbook of Environmental Data of Organic Chemicals*. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 298]
3. The degradation of n-alkanes by microorganisms is similar to the degradation of fatty acids. The terminal methyl group is enzymatically oxidized by incorporation of molecular oxygen by a monooxygenase producing a primary alcohol with further oxidation to an acid group, although involvement of a dioxygenase is also postulated. Once the fatty acid is produced, it is degraded into 2-carbon units via the beta-oxidation pathway. ... Another pathway for n-alkane degradation that is encountered less often is the oxidation of both terminal carbons to form a dioic acid with subsequent beta-oxidation. Subterminal oxidation of the 2-carbon atom is seen mainly in C3-C6 alkanes. ... A dehydrogenation of the n-alkane may also occur yielding an alkene which is then converted to an alcohol, although there is little evidence for this theory. Some microorganisms have been shown to have both terminal and subterminal oxidation, each having very different rates of activity. /In a study comparing/ ... growth on long and short chain alkanes by some bacteria ... the initial oxygenase had a broad specificity and would oxidize C1-C8 alkanes ... /but/ cells grown on C4-C8 alkanes did not oxidize the shorter chain alkanes to a significant extent. ... /n-Alkanes/ [Peer reviewed] [Parr, J.F., P.B. Marsh, and J.M. Kla (eds.). *Land Treatment of Hazardous Wastes*. Park Ridge, New Jersey: Noyes Data Corporation, 1983., p. 327]
4. Within 24 hr, n-butane was oxidized to its corresponding methyl ketone, 2-butanone(1,3), and the corresponding alcohol, 2-butanol(2,3), by cell suspensions of over 20 methyltrophic organisms isolated from lake water and soil samples(1-3). After 192 hr, the concn of n-butane contained in gasoline was reduced from 0.63 to 0.37 ul/l for both a sterile control and a mixed culture sample collected from ground water contaminated with gasoline; these data indicate that n-butane was not biodegraded over the study period(4). The biodegradation of n-butane in a Columbia River soil was measured over 50 days; a degradation rate of 1.8 mgC/day/kg dry soil was reported without the addition of nitrogen (5). When nitrogen at 0.15 mg per bottle was added, the degradation rate increased to 11.4 mgC/day/kg dry soil(5). 100% of the initially added n-butane (32.9 mg/l) was biodegraded over 34 days in a screening study using an activated sludge inoculum(6). [Peer reviewed] [(1) Patel RN et al; *Appl Environ Microbiol* 39: 727-33 (1980) (2) Patel RN et al; *Appl Environ Microbiol* 39: 720-6 (1980) (3) Hou CT et al; *Appl Environ Microbiol* 46: 178-84 (1983) (4) Jamison VW et al; pp. 187-96 in *Proc Int Biodeg Symp 3rd Sharpley JM, Kaplan AM, eds. Essex Eng (1976)* (5) Toccalino PL et al; *Appl Environ Microbiol* 59: 2977-83 (1993) (6) Solano-Serena F et al; *Appl Microbiol Biotechnol* 54: 121-5 (2000)]

Abiotic Degradation:

1. A detailed mechanism is presented for reactions occurring during irradiation of ppm concn of propene and/or n-butane and oxides of nitrogen in air. A smog chamber solar simulator facility designed for providing data suitable for quantitative model validation was used to elucidate several unknown or uncertain kinetic parameters and details of the reaction mechanism. Products of the photooxidation in the presence of NOx included 2-butyl

- nitrate, butyraldehyde, 1-butyl nitrate, methyl nitrate, peroxyacetyl nitrate, propene oxide, propionaldehyde, formaldehyde, and acetaldehyde. [Peer reviewed] [Carter W PL et al; Int J Chem Kinet 11 (1): 45-102 (1979)]
2. Estimated lifetime under photochemical smog conditions in SE England: 15 hr. [Peer reviewed] [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 297]
 3. The rate constant for the gas-phase reaction of n-butane with photochemically-produced hydroxyl radicals is 2.54×10^{-12} cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 6.3 days(SRC) at an atmospheric concentration of 5×10^5 hydroxyl radicals per cu cm(8). Experimental data showed that 7.7% of the n-butane fraction in a dark chamber reacted with nitrogen oxide to form the corresponding alkyl nitrate(2,3); this suggests that nighttime reactions with radical species and nitrogen oxides may contribute to the atmospheric transformation of n-butane. The rate constant for the gas-phase reaction of n-butane with photochemically-produced nitrate radicals is 4.59×10^{-17} cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 1.9 years(SRC) at an atmospheric concentration of 5×10^8 nitrate radicals per cu cm(7). n-Butane is not expected to undergo hydrolysis in the environment due to the lack of hydrolyzable functional groups(3). Based on data for iso-octane and n-hexane(5), n-butane is not expected to absorb UV light in the environmentally-significant range, >290 nm and therefore is not expected to directly photolyze(SRC). The n-butane concentration of an air sample, initially 286 ppbC, was reduced by 14% within 6 hrs of irradiation by natural sunlight in downtown Los Angeles, CA(6). [Peer reviewed] [(1) Atkinson R; J Phys Chem Ref Data, Monograph 2, (1994) (2) Atkinson R et al; J Phys Chem 86: 4563-9 (1982) (3) Atkinson R et al; Preprints Div Environ Chem 23: 173-6 (1983) (4) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5 (1990) (5) Silverstein RM, Bassler GC; Spectrometric Id of Org Compd, J Wiley and Sons Inc p 148-169 (1963) (6) Kopczynski SL et al; Environ Sci Technol 6: 342-7 (1972) (7) Atkinson R; Atmos Environ 34: 2063-101 (2000) (8) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993)]
 4. The photooxidation rates for n-butane in air and water with ozone and peroxy radicals were 3.1×10^{-14} cu cm/molecule-sec(1) and 3.0×10^{-4} L/molecule-sec(2) at 30 and 28 deg C, respectively. Neither reaction is expected to be environmentally important(SRC). [Peer reviewed] [(1) Atkinson R, Pitts JN Jr; J Phys Chem 78: 1780-4 (1974) (2) Hendry DG et al; J Phys Chem Ref Data 3: 944-78 (1974)]

ENVIRONMENTAL TRANSPORT ▲

Bioconcentration:

An estimated BCF of 33 was calculated for n-butane(SRC), using a log Kow of 2.89 (1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is moderate(SRC). [Peer reviewed] [(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 10 (1995) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)]

Soil Adsorption/Mobility:

The Koc of n-butane is estimated as 900(SRC), using a measured log Kow of 2.89(1) and a regression-derived equation(2). According to a classification scheme(3), this estimated Koc value suggests that n-butane is expected to have low mobility in soil. [Peer reviewed] [(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and

Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 10 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (3) Swann RL et al; Res Rev 85: 17-28 (1983)]

Volatilization from Soil/Water:

The Henry's Law constant for n-butane is estimated as 0.95 atm-cu m/mole(SRC) based upon its vapor pressure, 1820 mm Hg(1), and water solubility, 61.2 mg/l(2). This Henry's Law constant indicates that n-butane is expected to volatilize rapidly from water surfaces(3). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(3) is estimated as 2.2 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(3) is estimated as 3.0 days (SRC). n-Butane's Henry's Law constant(1,2) indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of n-butane from dry soil surfaces may exist(SRC) based upon its vapor pressure(1). [Peer reviewed] [(1) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification, Techniques of Chemistry 4th ed., NY, NY: Wiley-Interscience Vol 2, p. 78-80 (1986) (2) McAuliffe C; Nature, 200: 1092-3 (1963) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY, NY: McGraw-Hill p. 15-15 to 15-29 (1982)]

ENVIRONMENTAL CONCENTRATIONS ▲

Water Concentrations:

1. GROUNDWATER: One of 11 groundwater monitoring wells near the Granby Landfill, CT contained n-butane at a concn of 20 ppb. [Peer reviewed] [Sawhney BL, Raabe JA; Ground Water Contamination Mvmt Org Pollut in Granby Landfill, Bull 833 p. 9 (1986)]
2. DRINKING WATER: n-Butane was listed as one of the many organic chemicals identified in drinking water in the USA as of 1974(1-3). [Peer reviewed] [(1) Abrams EF et al; Identification of Organic Compounds in Effluents from Industrial Sources USEPA-560/3-75-002 (1975) (2) Kool HJ et al; Crit Rev Env Control 12: 307-57 (1982) (3) Kopfler FC et al; Adv Environ Sci Technol 8: 419-33 (1977)]
3. SURFACE WATER: n-Butane was listed as a contaminant present in the waters of Lake Ontario(1). The Inner Harbor Navigation Canal of Lake Pontchartrain at New Orleans, LA was found to contain n-butane at an average concn for 8 samples of 2.4 ppb on May 6, 1980(2). [Peer reviewed] [(1) Great Lakes Water Quality Board; Inventory Chem Subst Id Great Lakes Ecos p 195 (1983) (2) McFall JA et al; Chemosphere 14: 1253-65 (1985)]
4. SEAWATER: All 8 near-surface seawater samples from the intertropical Indian Ocean contained n-butane at a mean value of 52 pMol/l(1). n-Butane was measured in surface seawater collected from the mid-Atlantic Ocean in September/October 1988 at mean concentrations for each transect ranging from 2.8 to 32 pMol/l(2). n-Butane was measured in seawater at 0.21 and 0.3 nl/l(3). [Peer reviewed] [(1) Bonsang B et al; J Atmos Chem 6: 3-20 (1988) (2) Plass C et al; J Atmos Chem 15: 235-51 (1992) (3) Singh HB, Zimmerman PB; Adv Environ Sci Technol 24: 177-235 (1992)]

Effluents Concentrations:

1. It has been measured as exhaust from diesel engines at 22 ppm. [Peer reviewed] [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3182]
2. In flue gas of municipal incinerator: < 0.4 ppm; exhaust gas of diesel engine: 5.3% of emitted hydrocarbons; in combustion gas of household central heating: approx 50 ppm at

- 7% carbon dioxide system on gasoil, 3.3 g/kg gasoil at 6% carbon dioxide, 1.6 g/kg gasoil at 7% carbon dioxide; in gasoline: 4.31–5.02 vol %; in auto exhaust (gasoline engine): 62 car survey, 5.3 vol % of total exhaust hydrocarbons; 15 fuel study, 4 vol % of total exhaust hydrocarbons; engine variable study, 2.3 vol % of total exhaust hydrocarbons; evaporation from gasoline fuel tank: 16.5–48.5 vol % of total evaporated hydrocarbons; evaporation from carburetor: 9.1–23.0 vol % of total evaporated hydrocarbons. [Peer reviewed] [Verschuieren, K. *Handbook of Environmental Data of Organic Chemicals*. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 297]
3. Flue gases emitted from a waste incinerator at Babylon, Long Island, NY contained n-butane at concn generally less than 0.4 ppm(1). Two of five Hazardous waste sites listed on the National Priorities List emitted gaseous n-butane with a 75 to 100% frequency of occurrence(2). Landfills also release n-butane into the environment(3). One of 11 groundwater monitoring wells near the Granby Landfill, CT contained trace quantities of n-butane(4). A landfill gas sample collected from a U.K. waste disposal facility in 1994 contained unreported quantities of butane(5). n-Butane was present at 0.006% volume in landfill gas collected during the anaerobic decomposition stage at a Palos Verdes, CA municipal landfill site(6). n-Butane was detected in landfill gas samples collected from the Fresh Kills municipal solid-waste landfill at an average concentration of 3.80 ppmv (n=250) (7). [Peer reviewed] [(1) Carotti AA, Kaiser ER; *J Air Pollut Contr Assoc* 22: 224–53 (1972) (2) LaRegina J et al; *Environ Prog* 5: 18–27 (1986) (3) Young P, Parker A; *Vapors Odors and Toxic Gases from Landfills ASTM Spec Tech Publ* 851: 24–41 (1984) (4) Sawhney BL, Raabe JA; *Ground Water Contamination Mvmt Org Pollut in Granby Landfill, Bull* 833 p. 9 (1986) (5) Allen MR et al; *Environ Sci Technol* 31: 1054–61 (1997) (6) Brosseau J, Heitz M; *Atmos Environ* 28: 285–93 (1994) (7) Eklund B et al; *Environ Sci Technol* 32: 2233–37 (1998)]
 4. A Texaco refinery located in Tulsa OK was attributed with emissions to the surrounding atmosphere; n-butane concn were measured as 175.2 and 342.7 ppbC for two min before and after 1:33 PM(1). The n-butane content of the air downwind of a Mobil natural gas facility in Rio Blanco CO was 56.0 ppbC(1). Underwater hydrocarbon vent discharges from offshore oil production platforms were found to contain n-butane concn in the vapor phase at 740 umol/l of gas(2). n-Butane was emitted to the air from a Swedish catalyst-cracking petroleum refinery; air samples collected 100 m downwind from the fluid catalytic cracking unit contained n-butane ranging from 3.3 to 9.8% by weight(3). [Peer reviewed] [(1) Arnts RR, Meeks SA; *Atmos Environ* 15: 1643–51 (1981) (2) Sauer TC Jr; *Org Geochem* 7: 1–16 (1981) (3) Ostermark U; *Chemosphere* 30: 1813–17 (1995)]
 5. n-Butane is a product of gasoline combustion(6–8). Data from Sept 2 1979 identified n-butane as a gaseous emission of the vehicle traffic through the Allegheny Mountain Tunnel of the Pennsylvania Turnpike(1). The average exhaust from 67 gasoline-fueled vehicles was found to contain n-butane at a concn 2.2% by weight(2). An average weight percent of 4.39 was reported for n-butane emitted in vehicle exhaust in the Cassiar Connector(a twin-bore highway tunnel, Vancouver, BC) in August 1995(3). An emission rate of 146 mg/l was reported for n-Butane based on measurements made both inside and outside the Van Nuys tunnel in September 1993(4). Light-duty vehicle emissions measured at the Caldecott Tunnel in August(low oxygenate fuel sold) and October(high oxygenate fuel sold) 1994 contained n-butane at 1.8 and 1.9 weight% of total VOCs, respectively(5). Emission rates of n-butane from light-duty and heavy-duty vehicles in the Fort McHenry tunnel(Baltimore, MD; collected June 1992) were measured as 10.4 and 3.9 mg/vehicle-mile, respectively; air concentrations at the east portal ranged from 6.8 to 96.8 ppbC(6). Emission rates of n-butane from light-duty and heavy-duty vehicles in the Tuscarora tunnel(Pennsylvania; collected September 1992) were measured as 8.1 and 9.4 mg/vehicle-mile, respectively; air concentrations ranged from 2.4 to 21.2 ppbC(6). [Peer reviewed] [(1) Hampton CV et al; *Environ Sci Technol* 16: 287–98 (1982) (2) Nelson PF, Quigley SM; *Atmos Environ* 18: 79–87 (1984) (3) McLaren R et al; *Environ Sci Technol* 30: 3001–9 (1996) (4) Fraser MP et al; *Environ Sci Technol* 32: 2051–60 (1998) (5) Kirchstetter TW et al; *Environ Sci Technol* 30: 661–70 (1996) (6) Zielinska B et al; *Atmos*

[Environ 30: 2269-86 \(1996\)\]](#)

6. Hot soak (n-butane=33.04 weight%) and cold-start (n-butane=12.23 weight%) emission profiles of an integrated sample of vehicles and ages were measured inside a parking garage in Chicago during March 1990; hot-soak emissions were monitored after the morning rush hour while cold-start emissions were measured when the vehicles left for the evening rush hour(1). n-Butane was present in gasoline engine exhaust for light-duty vehicles at 1.3 and 4.4% by weight of total organic gas emissions (non-catalyst and catalyst-equipped vehicles, respectively)(2). n-Butane was measured in vehicle exhaust samples from light-duty vehicles at 2.84 and 6.44 weight% of non-methane hydrocarbons in two different studies(3). Emissions of n-butane from light-duty vehicles(current fleet, 1989) under incremental cold start, stabilized, and hot start conditions were 3.75, 19.57, and 7.59 weight% non-methane hydrocarbons, respectively; emissions of n-butane from an older fleet of cars (1983-1985) were 7.80 weight%(3). n-Butane concentrations were measured in the exhaust of 30 vehicles driven under a variety of conditions; emissions of 130.08, 66.73, 35.96, 17.95, and 18.17 mg/km were measured for driving under urban (average speed 21.38 km/hr), suburban (average speed 41.73 km/hr), rural (average speed 54.53 km/hr), motorway1 (average speed 90.72 km/hr) and motorway2 (average speed 111.36 km/hr) conditions, respectively(4). Emissions from current vehicles versus several low emission vehicles were monitored over a suburban drive at 40 km/hr; n-butane emissions were 66.7 (mean), 32, 19, 1.4, and 6.1 mg/km for the current vehicles, a lean burn vehicle, and vehicles equipped with either an oxidation catalyst, a 3-way catalyst, and a second 3-way catalyst, respectively(4). Emissions from nine popular late-model 4-cylinder motor vehicles were characterized at three test temperatures (75, 90, and 105 deg F) in order to simulate summer driving conditions(5). Diurnal evaporative emissions contained n-butane at an average weight% of 14.60-18.39 (throttle body fuel injection-port fuel injection), 25.24-25.15, 39.92-42.24 at temperatures of 60-84, 72-96, and 84-108 deg F, respectively(5). Hot soak evaporative emissions contained n-butane at 3.46-2.86, 5.08-3.57, 8.27-0.68 weight% at temperatures of 75, 90, and 105 deg F, respectively (5). Tailpipe emissions in this study contained n-butane at 1.01-0.92, 1.64-1.41, and 3.33-2.39 weight% at 75, 90, and 105 deg F, respectively(5). [\[Peer reviewed\]](#) [(1) [Doskey PV et al; J Air Waste Manage Assoc 42: 1437-45 \(1992\)](#) (2) [Harley RA et al; Environ Sci Technol 26: 2395-408 \(1992\)](#) (3) [Fujita EM et al; Environ Sci Technol 28: 1633-49 \(1994\)](#) (4) [Bailey JC et al; Sci Total Environ 93: 199- 206 \(1990\)](#) (5) [Stump FD et al; J Air Waste Manage Assoc 42: 1328-35 \(1992\)\]](#)
7. n-Butane from car exhaust ranged in concn from 0.12 to 0.28 ppmV with an average for 8 samples of 0.18 ppmV(1). The average concn of n-butane in the exhaust of 46 automobiles was 4.8, 23.2 and 4.9 weight% of total hydrocarbons according to the federal test procedure, hot soak test and the New York City cycle, respectively(2). A mean concentration of 2.61 ppmv was determined from exhaust samples taken from 6 different cars(3). Tailpipe emissions from a late-model medium duty diesel truck were obtained using the hot-start Federal Test Procedure urban driving cycle on a transient chassis dynamometer; an n-butane emission of 3830 ug/kg was measured(6). Emissions from two passenger ferries (medium speed, four-stroke diesel main engines) operating in Sweden were measured during July and August 1995; average concentrations and emissions were <0.02 mg/nm3 and <0.1 mg/kW-hr(4). An emission rate of 66.7 tons/day has been determined for the California South Coast Air Basin(5). [\[Peer reviewed\]](#) [(1) [Neligan RE; Arch Environ Health 5: 581-91 \(1962\)](#) (2) [Sigsby JE et al; Environ Sci Technol 21: 466-75 \(1987\)](#) (3) [Blake NJ et al; J Geophys Res 98: 2851-64 \(1993\)](#) (4) [Cooper DA et al; Atmos Environ. 30: 2463-73 \(1996\)](#) (5) [Grosjean D et al; Environ Sci Technol 27: 110-21 \(1993\)](#) (6) [Schauer JJ et al; Environ Sci Technol 33: 1578-87 \(1999\)](#)]

Sediment/Soil Concentrations:

n-Butane was detected in 10 of 10 sediment samples from Walvis Bay of the Namibian shelf of SW Africa at concn of 2.2, 0.45, 2.2, 1.5, 0.31, 0.24, 0.01, 0.22, 0.52,

and 0.27 ng/g(1). Sediments from the Bering Sea contained n-butane gas at concn ranging from 4 to 43 nl/l(2). [Peer reviewed] [(1) Whelan JK et al; *Geochim Cosmochim Acta* 44: 1767-85 (1980) (2) Kvenvolden KA, Redden GD; *Geochimica et Cosmochimica Acta* 44: 1145-50 (1980)]

Atmospheric Concentrations:

1. Ground level concn at Point Barrow, AK, Sept 1967: 0.03-0.19 ppb; at downtown Los Angeles, 1967: 10th percentile 20 ppb, average 46 ppb, 90th percentile 80 ppb; expected ground level concn in USA urban air: 0.05-0.45 ppm. [Peer reviewed] [Verschueren, K. *Handbook of Environmental Data of Organic Chemicals*. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 297]
2. URBAN: The average n-butane concn for 2 samples per 4 sites in Tulsa, OK was 102.0 ppbC with a range of 16.5 to 342.7 ppbC(1). The n-butane concn for 6 sites in Rio Blanco, CO averaged 10.3 ppbC with a range from 0.7 to 56.0(1). n-Butane was detected in 21 of 21 air samples from Houston, TX ranging in concn from 11.5 to 1604.1 ppm with an average of 316.1 ppm(5). According to the Total Exposure Assessment Methodology (TEAM) conducted in New Jersey, 4 of 12 air samples contained n-butane(2). Roadway air samples collected during the summer of 1990 along a heavily used road in the Atlanta metropolitan area contained n-butane at 4.11 ppbC(3). Air samples collected within Atlanta's airport on August 27, 1990 contained n-butane at 2.89 ppbC(3). Urban air samples collected in Southern California over September 8-9, 1993 during a severe Los Angeles area photochemical smog episode contained n-butane (average, 16.45 ug/cu m; range, 7.10-45.10 ug/cu m; n=36)(4). Air samples collected over 15 days between July and September 1987 in downtown Chicago contained n-butane at average concentrations of 5.96 and 8.44 ug/m³(4 and 20 hour sample times, respectively)(6). n-Butane was measured in 100% of air samples collected from 6 locations in Columbus, OH at mean and maximum concentrations of 2.75 and 10.01 ppbv, respectively(7). [Peer reviewed] [(1) Arnts RR, Meeks SA; *Atmos Environ* 15: 1643-51 (1981) (2) Wallace LA et al; *Environ Res* 35: 293-319 (1984) (3) Conner TL et al; *J Air Waste Manage Assoc* 45: 383-94 (1995) (4) Fraser MP et al; *Environ Sci Technol* 31: 2356-67 (1997) (5) Lonneman WA et al; *Hydrocarbons in Houston Air USEPA-600/3-79/018* p. 44 (1979) (6) Scheff PA, Wadden RA; *Environ Sci Technol* 27: 617-25 (1993) (7) Spicer CW et al; *Atmos Environ* 30: 3443-56 (1996)]
3. URBAN: The average n-butane concn in the air at the 6th floor of the Cooper Union Building in New York City NY was 43, 48 and 38 ppbC for 19, 12 and 10 samples taken at 6:00-9:00 AM, 9:00-11:00 AM and 1:00-3:00 PM, respectively, in July 1978(1). The average n-butane concn in the air at the 82nd floor of the Empire State Building in New York City NY was 17, 27 and 19 ppbC for 18, 21 and 17 samples taken at 6:00-9:00 AM, 9:00-11:00 AM and 1:00-3:00 PM, respectively, in July 1978(1). At street level at the Empire State and World Trade Buildings in Manhattan, NY the average n-butane concn of 4 samples was 72 ppbC in July 1978(1). In 1975 the average n-butane concn of 14 air samples taken between 05:30-08:30 and 12:30-15:30 at the World Trade Center in New York City NY were 36 and 30 ppbC, respectively(1). In 1975 the average n-butane concn of 11 and 8 air samples taken between 5:30-8:30 AM and 12:30-3:30 PM at the Interstate Sanitation Commission in New York City, NY were 64 and 97 ppbC, respectively(1). n-Butane was detected at an average concn of 27.4 ug/cu m for 5 samples collected at the 82nd floor of the World Trade Center in New York City between 5:00 AM - 5:30 PM Aug 23, 1977(2). [Peer reviewed] [(1) Altwicker ER et al; *J Geophys Res* 85: 7475-87 (1980) (2) Altwicker ER, Whitby RA; *Sampling, Sample Prep and Measurement of Specific Non-methane Hydrocarbons* 72 Ann Meet Air Pollut Contr Assn (1979)]
4. URBAN: The ground level atmospheric concn of n-butane was 29 ppb at 13:25 and 165 ppb at 08:00 for Huntington Park, CA(1). At 1500 ft the n-butane concn was 8 ppb at 07:43 and at a height of 2,200 ft the n-butane concn was 3 ppb at 8:07(1). The n-butane concn ranged from 21 to 70 ppb of volume at a downtown Los Angeles location for the Fall of 1981(2). The n-butane concn at 1100 ft just east of Antioch, CA was 13.5 ug/cu

- m, at 1000 ft near Pittsburg, CA was 21.0 ug/cu m, at 1100 ft over Carquinez Strait, CA was 2.5 ug/cu m and at 1000 ft over San Pablo Bay, CA was 0.5 ug/ cu m(3). According to the National Ambient Volatile Organic Compounds (VOCs) Database, the median urban atmospheric concn of n-butane is 9.174 ppb of volume for 546 samples(4). 87.5% of air samples collected from Washington DC from March 1990 to March 1991 during the Chemical Manufacturers Association Urban Baseline VOC Measurement Program contained n-butane at a mean concentration of 4.29 ppbv (median=3.3 ppbv; max=30 ppbv)(5). A median n-butane concentration of 40.3 ppbC was determined based on measurements of air samples from 39 U.S. cities from 1984 to 1985 (range=4.5–5448 ppbC)(6). [Peer reviewed] [(1) Scott Research Labs Inc; Atmospheric Reaction Studies in the Los Angeles Basin, NTIS PB-194-058 p. 86 (1969) (2) Grosjean D, Fung K; J Air Pollut Control Assoc 34: 537-43 (1984) (3) Sexton K, Westberg H; Environ Sci Tech 14: 329-32 (1980) (4) Shah JJ, Heyerdahl EK; National Ambient VOC Database Update USEPA 600/3-88/010 (1988) (5) Hendler AH, Crow WL; Preliminary Results of the Chemical Manufacturers Association Urban Baseline VOC Measurement Program, In: Proc. Annu. Meeting - Air Waste Manage Assoc, 85th (Vol 2B), 92/75.05 (1992)(6) Singh HB, Zimmerman PB; Adv Environ Sci Technol 24: 177-235 (1992)]
5. URBAN: n-Butane was detected in the atmospheres of Pretoria, Johannesburg and Durban, South Africa(1). n-Butane was identified in the ambient air of Sydney Australia(2) ranging in concn from 0.8 to 52.0 ppb of volume with an average concn of 9.5 ppb of volume(3). n-Butane was detected at an average concn of 121.61 ppbC in the atmosphere over the British Columbia Research Council Laboratory at the University of British Columbia(4). The average n-butane concn in the air over Tokyo, Japan in 1980 and 1981 were 1.9 and 2.4 ppb for 66 and 192 samples, respectively(5). At Deuselbach, Hunsruck in Germany, the atmospheric n-butane concn was 0.54 ppb for October 23, 1983(6). n-Butane was detected in the atmospheres of 6 industrialized cities of the USSR ranging in size of population from 0.4 to 4.5 million people(7,8). The minimum, maximum and average n-butane concn in the ambient air of Bombay, India were 0.6, 145.0 and 21.2 ppb, respectively(9). Concentrations of n-butane were followed for over one year (July 1991 to September 1992) at a location in London, England; concentrations ranged from 6.8 to 36.7 ppbv with the higher concentrations reported in the winter months(10). [Peer reviewed] [(1) Louw CW et al; Atmos Environ 11: 703-17 (1977) (2) Mulcahy MFR et al; Paper IV p 17 in Occurrence Contr Photochem Pollut, Proc Symp Workshop Sess (1976) (3) Nelson PF, Quigley SM; Environ Sci Technol 16: 650-5 (1982) (4) Stump FD, Dropkin DL; Anal Chem 57: 2629-34 (1985) (5) Uno I et al; Atmos Environ 19: 1283-93 (1985) (6) Rudolph J, Khedim A; Int J Environ Anal Chem 290: 265-82 (1985) (7) Ioffe BV et al; Dokl Akad Nauk Sssr 243: 1186-9 (1978) (8) Ioffe BV et al; Environ Sci Technol 13: 864-8 (1979) (9) Mohan Rao AM, Panditt GG; Atmos Environ 2: 395-401 (1988) (10) Field RA et al; Environ Technol 15: 931-44 (1994)]
 6. URBAN: Air samples, collected from downtown Cairo, Egypt and at the Sheraton Tunnel, Egypt, in June 1997 contained n-butane at 0.94% by weight(1). The mean concentration of n-butane measured at downtown Porto Alegre, Brazil locations over a one-year period (March 1996-April 1997) was 11.9 mg/cu m(2). The arithmetic mean concentration of n-butane in air samples collected in Vienna during May 1987 was 19.5 ppbC(3). Air samples collected from an inner-city residential location and a downtown site in Berlin during June through August 1996, contained n-butane at an average concentration of 4.43 and 7.40 ug/cu m, respectively(4). Air samples collected from the Taipei metropolitan area in August 1998 contained n-butane at a median concentration of 716.6 pptv (range of 103.9-3912.6 pptv)(5). The arithmetic and geometric means were 16.6 and 11.3 ppbC, respectively, for the atmospheric n-butane content at urban locations in Lancaster, England(6). An air sample collected on a London street contained n-butane at 78 ppbv(7). Concentrations of n-butane measured in a London photochemical plume study (July 12, 1988) averaged 2871 and 1915 ppbv in two separate flights; concentrations out-of-the-plume ranged from 342 to 1339 ppbv(7). A mean concentration of 397.2 ug/cu m n-butane (range=37.8 to 738.2 ug/cu m; median of 421 ug/cu m) was measured in air samples

collected in London during a pollution event in 1991; prior to this pollution event, the mean n-butane concentration was 109.7 ug/cu m (range=18.9–372.3 ug/cu m; median=91.5 ug/cu m)(8). A median concentration of 12.86 ug/cu m was reported for 212 samples collected between December 1991 to November 1993 at a downtown station in Edmonton, Alberta(9). n-Butane was measured at an annual average of 30.8 and 6.3 ug/m³ in polluted and baseline air samples, respectively, from the Rhine-Ruhr area in Germany(10). [Peer reviewed] [(1) Doskey PV et al; J Air Waste Manage Assoc 49: 814–22 (1999) (2) Grosjean E et al; Environ Sci Technol 32: 2061–9 (1998) (3) Lanzerstorfer C, Puxbum H; Water Air Soil Pollut 51: 345–55 (1990) (4) Thijssse TR et al; J Air Waste Manage Assoc 49: 1394–1404 (1999) (5) Wang JL et al; Environ Sci Technol 34: 2243–48 (2000) (6) Colbeck I, Harrison RM; Atmos Environ 19: 1899–904 (1985) (7) Blake NJ et al; J Geophys Res 98: 2851–64 (1993) (8) Field RA et al; Environ Technol 13: 391–408 (1992) (9) Cheng L et al; Atmos Environ 31: 239–46 (1997) (10) Luxenhofer O, Ballschmiter, K; Fresenius J Anal Chem 350: 395–402 (1994)]

7. **SUBURBAN:** According to the National Ambient Volatile Organic Compounds (VOCs) Database, the median suburban atmospheric concn of n-butane is 8.832 ppb of volume for 226 samples(1). The n-butane concn was 6.0, 2.5 and 2.0 ug/cu m at 10, 15 and 40 mi downwind of Janesville, WI 8–14–78(2). Air samples collected over 15 days between July and September 1987 in a suburban location of Chicago contained n-butane at an average concentration of 3.85 ug/cu m (4- and 20-hour sample times, respectively)(3). [Peer reviewed] [(1) Shah JJ, Heyerdahl EK; National Ambient VOC Database Update USEPA 600/3–88/010 (1988) (2) Sexton K; Environ Sci Technol 17: 402–7 (1983) (3) Scheff PA, Wadden RA; Environ Sci Technol 27: 617–25 (1993)]
8. **RURAL:** The respective median, minimum and maximum atmospheric concn of n-butane for 5 rural locations in NC ranged from 1.1 to 33.6, 0.2 to 14.8, and 2.5 to 47.5 ppb(2). The atmospheric concn of n-butane for Jones State Forest, TX ranged from 12.0 to 49.6 ppb with an average of 24.1 ppb for 10 samples(3). According to the National Ambient Volatile Organic Compounds (VOCs) Database, the median rural atmospheric concn of n-butane is 0.779 ppb of volume for 36 samples(4). The arithmetic and geometric means were 1.1 and 1.3 ppbC, respectively, for the atmospheric n-butane content at rural locations in NW England(5). At a rural site near Duren, Germany, the atmospheric n-butane concn was 5.5 ppb for March 1984(1). At a rural location outside of Berlin (Frohnau Funkturm) during June through August 1996, air samples contained n-butane at an average concentration of 1.0 ug/cu m(9). n-Butane concentrations were measured at four rural locations in Canada: Saturna Island, BC(range of 0.09 to 1.42 ppbv from June to December 1991, n=62), Kejimbujik National Park, Nova Scotia (range of 0.08 to 0.88 ppbv from November 1990 to December 1991, n=124), Lac la Flamme, Montmorency Forest, Quebec (range of 0.01 to 0.93 ppbv, n=100), Egbert, Ontario (range of 0.12 to 1.62 ppbv, n=116)(6). n-Butane was measured at 1.75 ppbv at a rural location in Egbert, Ontario in April 1990(8). Concentrations of n-butane measured in air sampled along the coast of south Norway from May 1987 to May 1988 ranged from 20 to 3020 parts per trillion(7). [Peer reviewed] [(1) Rudolph J, Khedim A; Int J Environ Anal Chem 290: 265–82 (1985) (2) Seila RL et al; Atmospheric Volatile Hydrocarbon Composition at Five Remote Sites in NW NC, USEPA–600/D–84–092 (1984) (3) Seila RL; Non-urban Hydrocarbons Concn in Ambient Air No of Houston TX USEPA–500/3–79–010 p38 (1979) (4) Shah JJ, Heyerdahl EK; National Ambient VOC Database Update USEPA 600/3–88/010 (1988) (5) Colbeck I, Harrison RM; Atmos Environ 19: 1899–904 (1985) (6) Bottenheim JW, Shepherd MF; Atmos Environ 29: 647–64 (1995) (7) Hov O et al; Atmos Environ 25A: 1981–99 (1991) (8) Shepson PB et al; Atmos Environ 27A: 749–57 (1993) (9) Thijssse TR et al; J Air Waste Manage Assoc 49: 1394–1404 (1999)]
9. **REMOTE:** According to the National Ambient Volatile Organic Compounds(VOCs) Database, the median remote atmospheric concn of n-butane is 0.510 ppb of volume for 7 samples(1). For 9 samples collected over a 30 hour period, the average n-butane concn in the Smokey Mountains, NC was 4.8 ppbC with a range from 3.6 to 7.6 ppbC(2). On Aug 27, 1976, the average n-butane concn for air over Lake Michigan at altitudes of 2000, 2500

and 3000 ft was 5.9 ppb of volume(3). On Aug 28, 1976, the average n-butane concn for air over Lake Michigan at altitudes of 1000 and 1500 ft was 1.5 ppb of volume(3). The air over the Norwegian Arctic had an average n-butane concn for 5 samples from Bear Island, 2 from Hopen and 2 from Spitsbergen of less than 0.02 ppb of volume in July 1982 and 0.805 ppb of volume in the spring of 1983(4). All 27 air samples from the intertropical Indian Ocean contained n-butane at concn ranging from 0.03 to 0.70 ppb of volume(5). Air samples collected from the haze over the Arctic during March 1984 and April 1983 contained n-butane at 415 parts per trillion volume (range of 150 to 590 parts per trillion volume)(6). The average n-butane concentration measured during an aerial study in the Arctic (Alert, NWT, Canada, May 1989) was 344 parts per trillion volume; ground samples collected in Alert in April 1989 contained an average n-butane concentration of 459 parts per trillion volume(7). [Peer reviewed] [(1) Shah JJ, Heyerdahl EK; National Ambient VOC Database Update USEPA 600/3-88/010 (1988) (2) Arnts RR, Meeks SA; Atmos Environ 15: 1643-51 (1981) (3) Miller MM, Alkezweeny AJ; Ann NY Acad Sci 338: 219-32 (1980) (4) Hov O et al; Geophys Res Lett 11: 425-8 (1984) (5) Bonsang B et al; J Atmos Chem 6: 3-20 (1988) (6) Khalil MAK, Rasmussen RA; Geophys Res Letters 11: 437-40 (1984) (7) Kieser BN et al; Atmos Environ 27A: 2979-88 (1993)]

10. **SOURCE DOMINATED:** According to the National Ambient Volatile Organic Compounds (VOCs) Database, the median source-dominated atmospheric concn of n-butane is 9.500 ppb of volume for 53 samples(1). Emissions from a Texaco refinery located in Tulsa, OK contained n-butane at 175.2 and 342.7 ppbC for two min before and after 1:33 PM(2). The n-butane content of the air downwind of a Mobil natural gas facility in Rio Blanco, CO was 56.0 ppbC(2). The arithmetic and geometric means were 7.3 and 3.4 ppbC, respectively, for the atmospheric n-butane content at polluted rural locations in northwest England(3). n-Butane was detected in the ambient air over 1 of 5 National Priorities List (NPL) hazardous waste sites and one industrial/municipal landfill in New Jersey(4). The frequency of occurrence for n-butane at both sites was between 75 and 100%(4). n-Butane was detected in the air of the Lincoln Tunnel at an average concn of 198.1 ppbC (5). Air over the roadway outside the tunnel had an average n-butane concn of 16.42 ug/cu m(5). Air samples from the Caldecott tunnel, collected in June 1991, contained n-butane at a mean concentration of 72.94 ppbC(7). Oil field emission samples were collected from the Tulsa, OK area; concentrations of n-butane ranged from 4.8 to 25.2% weight composition. In addition, n-butane emissions from well head, gathering tanks, pipeline tanks, terminal tanks, and refinery tanks were 17.4 to 21.8, 21.4, 14.0, 11.4, and 23.5% weight composition(6). [Peer reviewed] [(1) Shah JJ, Heyerdahl EK; National Ambient VOC Database Update USEPA 600/3-88/010 (1988) (2) Arnts RR, Meeks SA; Atmos Environ 15: 1643-51 (1981) (3) Colbeck I, Harrison RM; Atmos Environ 19: 1899-904 (1985) (4) LaRegina J et al; Environ Proc 5: 18-27 (1986) (5) Scheff PA et al; JAPCA 37A: 469-78 (1989) (6) Viswanath RS; J Air Waste Manage Assoc 44: 989-94 (1994) (7) Zielinska B, Fung KK; Sci Total Environ 146/147: 281-8 (1994)]
11. **SOURCE DOMINATED:** Emissions from a petroleum refinery, lead smelter (using a heavy oil as fuel), and cast iron factory (using coal as a fuel) were sampled in Cairo, Egypt; n-butane was measured at 36.85, 25.60, and 18.07% by weight, respectively(1). Petroleum refinery emissions measured one mile downwind of a major refinery in Romeoville, IL in 1990 contained n-butane at 15.26 weight %(2). Air samples collected over 15 days between July and September 1987 from an industrial location on the southeast side of Chicago contained n-butane at an average concentration of 10.8 ug/cu m (4- and 20-hour sample times, respectively)(3). Butane was reported at an average concentration of 24 ug/cu m in air samples collected from the Craeybeckx highway tunnel in Antwerp-Belgium during April 1991; background concentrations were 4.1 ug/cu m(4). [Peer reviewed] [(1) Doskey PV et al; J Air Waste Manage Assoc 49: 814-22 (1999) (2) Doskey PV et al; J Air Waste Manage Assoc 42: 1437-45 (1992) (3) Scheff PA, Wadden RA; Environ Sci Technol 27: 617-25 (1993) (4) De Fre R et al; Environ Hlth Perspect 4: 31-37 (1994)]
12. n-Butane was detected at concentrations of 0.08 to 0.4 ppbv in interstitial air from within

the snow pack on an ice floe in the Arctic Ocean (collected April 1994)(1). [Peer reviewed] [(1) Ariya PA et al; J Atmos Chem 34: 55-64 (1999)]

13. INDOOR: Indoor air samples collected in a carpeted administrative office with no VOC-emitting office equipment located one floor above a copy center and in a carpeted hallway approximately 40 feet from the entrance to a copy center contained n-butane at 9.5 and 23.5 ppbv, respectively(1). The in-vehicle median concentration of n-butane, measured in 2 4-door sedans in Raleigh, NC in 1988, was 36.1 ug/cu m (mean of 54.3 ug/m³; range of 3.9 to 588.4 ug/cu m)(2). The median concentrations of n-butane measured inside two vehicles driven under urban, interstate, and rural conditions were 57.3, 27.8, and 8.4 ug/cu m, respectively(2). [Peer reviewed] [(1) Stefaniak AB et al; Environ Res 83: 162-73 (2000) (2) Chan CC et al; Environ Sci Technol 25: 964-72 (1991)]

Food Survey Values:

Butane, not specified as n-butane, was detected in beef volatiles at an unreported concentration(1). n-Butane emission rates from hamburger meat charbroiling over a natural gas-fired grill was 107,000 ug/kg of meat cooked(2). [Peer reviewed] [(1) Shahidi F et al; CRC Crit Rev Food Sci Nature 24: 141-243 (1986) (2) Schauer JJ et al; Environ Sci Technol 33: 1566-77 (1999)]

Milk Concentrations:

n-Butane was detected in 6 of 12 samples of mothers breast milk from the cities of Bayonne NJ, Jersey City NJ, Bridgeville PA and Baton Rouge LA(1). [Peer reviewed] [(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982)]

Other Environmental Concentrations:

An air sample taken near an oil fire was found to contain n-butane and n-butene at a combined concn of 1.63 mg/cu m(1). The background measurements utilized as a set of controls for air expired from humans contained n-butane in 8 of 20 samples collected over 18 mo(2). [Peer reviewed] [(1) Perry R; Mass Spectroscopy in the Detection and Identification of Air Pollutants, Int Symp Ident Meas Environ Pollut p. 130-7 (1971) (2) Krotoszynski BK et al; J Anal Toxicol 3: 225-34 (1979)]

HUMAN EXPOSURE ▲

Probable Routes of Human Exposure:

NIOSH (NOHS Survey 1972-1974) has estimated that 71,296 workers are potentially exposed to n-butane in the USA(1). NIOSH (NOES Survey 1981-1983) has statistically estimated that 422,474 workers(68,683 of these are female) are potentially exposed to n-butane in the US(2). Occupational exposure to n-butane may occur through inhalation and dermal contact with this compound at workplaces where n-butane, or petroleum and natural gas containing n-butane, are produced or used(SRC). A 1984 study showed n-butane was emitted from gasoline exposing outside operators at the refineries to an average air concn of 3.437 mg/cu m; n-butane was detected in 54 of 56 samples(3). Transport drivers were exposed to n-butane at atmospheric concn of 9.701 mg/cu m and n-butane was detected in 49 of 49 samples(3). Gas station attendants were exposed to n-butane at atmospheric concn of 21.605 mg/cu m and n-butane was detected in 49 of 49 samples(3). Attendants at a high volume service station in eastern PA were exposed to levels of n-butane ranging from 0.1 to 0.3 ppm for 18 of 18 air samples(4). Workers at

separate gasoline bulk handling facilities were exposed to vapors that contained n-butane at concn of 33.7% by weight, 21.2% by weight and 38.1% by volume(5) of total hydrocarbons. Exposures to total hydrocarbons at one of the facilities exceeded 240 ppm for 5% of the sampling time(5). n-Butane is a highly volatile compound and monitoring data indicate that it is a widely occurring atmospheric pollutant(SRC). These data indicate that the general population may be exposed to n-butane via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with this compound in liquids such as crude oil and gasoline and other liquid products containing n-butane(SRC). [Peer reviewed] [(1) NIOSH; National Occupational Hazard Survey (NOHS) (1974) (2) NIOSH; National Occupational Exposure Survey (NOES) (1983) (3) Rappaport SM et al; Appl Ind Hyg 2: 148-54 (1987) (4) Kearney CA, Dunham DB; Am Ind Hyg Assoc J 47: 535-9 (1986) (5) Halder CA et al; Am Ind Hyg Assoc J 47: 164-72 (1986)]

Average Daily Intake:

According to the National Ambient Volatile Organic Compounds (VOCs) Database, the median urban atmospheric concn of n-butane is 9.174 ppbV for 546 samples(1). Based upon this figure and the value for average daily inhalation by a human adult of 20 cu m of air, the average daily intake of n-butane via air is 183 mg. [Peer reviewed] [(1) Shah JJ, Heyerdahl EK; National Ambient VOC Database Update USEPA 600/3-88/010 (1988)]

Body Burdens:

n-Butane was detected in 6 of 12 samples of mothers breast milk from the cities of Bayonne NJ, Jersey City NJ, Bridgeville PA and Baton Rouge LA(1). According to the Total Exposure Assessment Methodology (TEAM) conducted in New Jersey, 2 of 12 personal breath samples contained n-butane(2). The background measurements utilized as a set of controls for air expired from humans contained n-butane in 8 of 20 samples collected over 18 mo(3). Butane was detected in human breath samples at concentrations between 1 to 10 ppb(4). [Peer reviewed] [(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Wallace LA et al; Environ Res 35: 293-319 (1984) (3) Krotoszynski BK et al; J Anal Toxicol 3: 225-34 (1979) (4) Fenske JD, Paulson SE; J Air Waste Manage Assoc 49: 594-98 (1999)]

8.0 EXPOSURE STANDARDS AND REGULATIONS

STANDARDS AND REGULATIONS ▲

Allowable Tolerances:

1. Residues of butane are exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest. [Peer reviewed] [40 CFR 180.1001(c); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from: <http://www.gpoaccess.gov/ecfr/> as of January 6, 2003]
2. Butane is exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to animals. [Peer reviewed] [40 CFR 180.1001(e); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from: <http://www.gpoaccess.gov/ecfr/> as of January 6, 2003]

OCCUPATIONAL PERMISSIBLE LEVELS ▲**OSHA Standards:**

Vacated 1989 OSHA PEL TWA 800 ppm (1900 mg/cu m) is still enforced in some states. [Peer reviewed] [NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997., p. 360]

NIOSH Recommendations: Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 800 ppm (1900 mg/cu m). [Peer reviewed] [NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases. U.S. Department of Health & Human Services, Public Health Service, Center for Disease Control & Prevention. DHHS (NIOSH) Publication No. 2001-145 (CD-ROM) August 2001., p.]

Threshold Limit Values:

1. 8 hr Time Weighted Avg (TWA): 1,000 ppm /Aliphatic hydrocarbon gases, Alkane [C1-C4]/ [QC reviewed] [American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH, 2005, p. 15]
2. Excursion Limit Recommendation: Excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a work day, and under no circumstances should they exceed 5 times the TLV-TWA, provided that the TLV-TWA is not exceeded. /Aliphatic hydrocarbon gases, Alkane [C1-C4]/ [QC reviewed] [American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH, 2005, p. 5]

Other Occupational Permissible Levels:

1. Australia, Belgium, Finland, France, India, Switzerland: TWA 800 ppm (1900 mg/cu m). [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V8 1168]
2. Austria, Germany, Germany (DFG MAK): TWA 1000 ppm. [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V8 1168]
3. Denmark, Japan (JSOH), Russia: TWA 500 ppm (1200 mg/cu m). [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V8 1168]
4. Ireland, The Netherlands, United Kingdom (HSE OES): TWA 600 ppm. [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V8 1168]
5. Hungary TWA 300 mg/cu m; STEL 900 mg/cu m. [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V8 1168]
6. Poland TWA 1900 mg/cu m; STEL 3000 mg/cu m. [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V8 1168]
7. Russia: STEL 300 mg/cu m. [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V8 1168]
8. Ireland: STEL 750 ppm (1780 mg/cu m). [Peer reviewed] [Bingham, E.; Cohnsen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y.

(2001), p. V8 1168]

9. Finland: STEL 1,000 ppm (2,350 mg/cu m). [Peer reviewed] [Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001), p. V8 1168]

OTHER STANDARDS AND REGULATIONS ▲

FIFRA Requirements:

1. Residues of butane are exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest. [Peer reviewed] [40 CFR 180.1001(c); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from: <http://www.gpoaccess.gov/ecfr/> as of January 6, 2003]
2. Butane is exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to animals. [Peer reviewed] [40 CFR 180.1001(e); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from: <http://www.gpoaccess.gov/ecfr/> as of January 6, 2003]

FDA Requirements:

1. Substance added directly to human food affirmed as generally recognized as safe (GRAS). [Peer reviewed] [21 CFR 184.1165; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from: <http://www.gpoaccess.gov/ecfr/> as of January 6, 2003]
2. Butane is generally recognized as safe when used in accordance with good manufacturing or feeding practice. [Peer reviewed] [21 CFR 582.1165; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from: <http://www.gpoaccess.gov/ecfr/> as of January 6, 2003]

9.0 MONITORING AND ANALYSIS METHODS

Analytical Laboratory Methods:

1. OSHA Method PV2010; analyte: n-butane; matrix: air; procedure: gas chromatography and flame ionization detector (FID); The detection limit of the analytical procedure, including a 15:1 split ratio, is 0.333 ng per injection. [Peer reviewed] [U.S. Department of Labor/Occupational Safety and Health Administration's Index of Sampling and Analytical Methods. Available from: <http://www.osha.gov/dts/sltc/methods/toc.html> on n-butane (106-97-8) as of January 14, 2003]
2. NIOSH Method 3800; analyte: n-hexane; matrix: ambient air and combustion gas mixtures; procedure: extractive fourier transform infrared (FTIR) spectrometry; estimated limit of detection: 0.10 at 10-meter absorption pathlength. [Peer reviewed] [NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases. U.S. Department of Health & Human Services, Public Health Service, Center for Disease Control & Prevention. DHHS (NIOSH) Publication No. 2001-145 (CD-ROM) August 2001., p.]