

HAZARD ALERT

1-Bromopropane

1-Bromopropane (1-BP) is a solvent that is used in degreasing, dry cleaning, spray adhesives, and aerosol solvents. Occupational exposure to 1-BP has been linked to neurological illnesses. Animal studies show that 1-BP may also cause cancer and reproductive disorders. Controls and personal protective equipment are available to protect workers from 1-BP exposure.

What is 1-Bromopropane?

1-Bromopropane, also known as n-propyl bromide (nPB), is a solvent (CAS 106-94-5) with several commercial applications. Use of 1-BP has increased in workplaces over the past 20 years. 1-BP is often found in products used in:

- Vapor and immersion degreasing operations for cleaning metals, plastics and electronic and optical components;
- Adhesive spray applications;
- Dry cleaning; and
- Solvent sprays used in operations like asphalt production, aircraft maintenance, and synthetic fiber manufacturing.



Dry cleaning operation

Photo: CDC/NIOSH

Health Effects of 1-BP and How Workers Are Exposed

Exposure to 1-BP can cause irritation (for example, of the eyes, mucous membranes, upper airways and skin) and can damage the nervous system. Neurologic effects can appear as headaches, dizziness, loss of consciousness, slurred speech, confusion, difficulty walking, muscle twitching, and/or loss of feeling in arms and legs [Ichihara et al. 2012]. These effects may continue among affected persons even after exposure to 1-BP has ended [Majersik et al. 2007].

As with many other solvents, workers can be exposed to 1-BP by breathing in vapor or mists of spray. Workers might also be exposed if the chemical touches their skin because it can be absorbed [Hanley et al. 2006; Frasch et al. 2011]. Additionally, the risk of health effects to workers increases the longer they work with or near 1-BP. Impacts on health have been seen in workers after exposures for as little as two days, although symptoms are more commonly associated with longer exposure [Ichihara et al. 2012].

Federal OSHA does not currently have a specific exposure standard for 1-BP; however, employers are required by law to keep their workers safe from this recognized hazard. Degreasing, spray adhesive, aerosol solvent and dry cleaning operations expose workers to air concentrations of 1-BP greater than the limits set by the California Occupational Safety and Health Administration (Cal-OSHA) and the American Conference of Governmental Industrial

Hygienists (ACGIH). California has adopted a 5 ppm (parts per million) time-weighted average PEL (permissible exposure limit) along with a skin notation which means that a worker's skin, eyes and mouth should be protected from any contact with 1-BP; this limit was based on reproductive and developmental toxicity (observed in animal studies) and technological feasibility assessments from industry [CA DIR 2009]. ACGIH currently recommends a 10 ppm time-weighted average threshold limit value but has proposed lowering the value to 0.1 ppm [ACGIH 2013].

Case Study Example [Majersik et al. 2007]

Six foam cushion gluers who were exposed to 1-BP vapors from spray adhesives were seen in a medical clinic for neurotoxicity. The workers had been employed at the facility from 3 months to 3 years. All patients complained of slow onset of lower extremity pain or numbness. Five of six complained of difficulty walking, and on examination had leg spasms, loss of sensation in limbs and muscle twitching. Three patients initially had nausea and headache. Serum bromide concentrations and air samples were obtained to assess exposure. A seven-hour time-weighted average air concentration of 1-BP was found to be 108 ppm (range 92–127 ppm). Two years after exposure, the two most severely affected patients still had trouble with walking and loss of feeling in their legs and they, along with a third patient, continued to feel pain most of the time.

Studies in Experimental Animals

Animal studies suggest that 1-BP exposure is associated with reduced blood cell counts and immunosuppression along with toxicity to the liver and reproductive and nervous systems. Furthermore, the National Toxicology Program (NTP) is considering classifying 1-BP as *reasonably anticipated to be a human carcinogen* [NTP 2013]. This designation was based primarily on increased lung, large intestine and skin cancers seen in rodents that were exposed to 1-BP in the air [NTP 2011].

Providing Training and Education

Under the *Occupational Safety and Health Act of 1970*, employers are responsible for providing safe and healthy working conditions for their workers.

OSHA's Hazard Communication standard (29 CFR 1910.1200) requires employers to give health and safety information and training to their workers who are potentially exposed to hazardous materials, including 1-BP. Employers must make available copies of Safety Data Sheets (SDS) for 1-BP and train workers to use them. 29 CFR 1910.1200(h). The SDS will note health hazards associated with all ingredients in the product. 29 CFR 1910.1200 App. D. The SDS will name 1-BP (or nPB) as an ingredient if it is present in the product at concentrations above 1%. 29 CFR 1910.1200 App. A.1.3.3. Employers must train workers on the health hazards and how to properly use equipment designed to reduce exposures. 29 CFR 1910.1200(h)(3). Employers must give training to workers in a manner and language that the worker understands. OSHA Directive CPL 02-02-038, Inspection Procedures for the Hazard Communication Standard, effective March 20, 1998; OSHA Standard 1910.1200(h) Interpretation Letter to Dr. Richard F. Andree, April 10, 1988, available at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=19651.

NIOSH recommends that periodic “refresher” training be offered to workers exposed to hazardous materials in the workplace. The frequency and content of this recurrent training should be determined according to the needs of individual facilities, based on factors such as reports of health effects and changes in work practices and controls.

Increasing Awareness of Healthcare Providers

Workers reporting health effects after being exposed to 1-BP should be referred to a doctor or nurse with occupational or environmental medical expertise.

Doctors, nurses and other public health professionals should be aware of the types of health effects that may occur among workers exposed to 1-BP. A thorough occupational history should always be part of the clinical evaluation of persons who have unexplained symptoms or nonspecific neurologic symptoms that could be caused by one of several medical conditions or occupational exposures. Healthcare providers caring for workers with health effects related to occupational 1-BP exposure should report findings, and their significance, to the affected worker. These healthcare providers should also summarize results on potential work-related health effects, with personal identifiers removed, to the employers.

Reducing Worker Exposure

Evaluating Exposure

Evaluation of exposures in the workplace involves identification of potential hazards followed by characterization or estimates of the level of those hazards. Worker exposures to 1-BP in the air as well as through skin contact should be measured to determine whether the hazard needs to be controlled. Biological monitoring, such as measuring of 1-BP and its metabolites in the urine of exposed workers, may also be a useful tool to evaluate worker exposures. Many of the resources listed at the end of this document have information useful in evaluating worker exposures to 1-BP [Hanley et al. 2010; NIOSH 2002b].

Examples of Sampling Results:

Although exposures may not be found to exceed air concentration levels set by California or ACGIH at every workplace using 1-BP [NIOSH, 2000], overexposures have been found on many occasions. The table below reports selected studies where exposures measured were greater than the recommended levels.

1-BP CONCENTRATIONS – FULL SHIFT MONITORING AT SELECTED WORKSITES			
Operation	1-BP Concentration (Parts per million)*	Number of Samples	Notes
Degreasing [Hanley et al. 2010]	Range 0.08 – 21	44	Workers near degreasers
Adhesive Spray Application [NIOSH 2003]	Range 18-254	16	Foam cushion fabrication workers
Adhesive Spray Application [Hanley et al. 2006]	Range 45-200	26	Foam cushion fabrication workers: sprayers
Adhesive Spray Application [Hanley et al. 2006]	Range 0.6-60	34	Foam cushion fabrication workers: non-sprayers
Dry Cleaning [Blando et al. 2010; NIOSH 2010]	40	1	Machine operator
Dry Cleaning [Blando et al. 2010; NIOSH 2010]	17	1	Cashier

* ACGIH currently recommends a 10 parts per million (ppm) threshold limit value but has proposed lowering the value to 0.1 ppm [ACGIH 2013].

Controlling Exposure

Some types of controls are preferred over others because they are more effective. Based on the principles of general industrial hygiene practice, the following types of controls (listed in order of preference) should be considered to control workplace exposures to 1-BP:

Elimination or Substitution

Eliminating the hazard of concern or substituting the hazardous substance with a less toxic/hazardous process material are the most effective ways to reduce exposures to a potentially hazardous substance. For example, an employer may be able to substitute water-based or acetone-based adhesives for 1-BP based adhesives. Replacement chemicals may also have associated hazards that need to be considered and controlled.

Engineering Controls

Engineering controls to reduce worker exposure to an airborne contaminant, preferably at the point where the contaminant gets into the air, or otherwise isolating the contaminant away from where workers are located, are effective means for reducing exposure. A variety of engineering controls may be considered:

- **Isolation:** Isolation of workplace operations is a proven method of reducing worker exposures. For example, isolating machinery using 1-BP from other work areas can reduce occupational exposure to 1-BP in workers not using the machinery. When isolating 1-BP operations is being considered, it is important to consider whether exhaust ventilation will be necessary to avoid a possible increase in exposure within the isolated work area.
- **Ventilation:** For proper design and installation of ventilation systems, including local exhaust ventilation, it is important to work with persons qualified in these systems. A routine maintenance schedule should be implemented to ensure that ventilation equipment is performing effectively.
- **Other Controls:** Other types of engineering controls may also be helpful, depending on the work activity. For example:
 - Workplaces using vapor degreasing systems should consider controls such as automatically-controlled hoists, sliding or rolling covers, and ensuring the effectiveness of cooling coils.
 - Dry cleaning operators using 1-BP should have a qualified technician manage the conversion

of machines that previously used a different solvent. Machine features helpful in reducing exposure to 1-BP include safety switches, safety interlocks, filtration systems, filling devices, use of gaskets and seals resistant to 1-BP, and process controls. Processes may also need to be performed at different operating conditions such as lower temperatures.

- Worker exposures to 1-BP should be re-evaluated periodically after engineering controls are installed to be sure that the controls remain effective.



Photo: CDC/NIOSH

Electrical parts degreasing operation

Administrative Controls

Administrative controls are work practices and policies to reduce or prevent exposures to workplace hazards. The following administrative controls should be considered in workplaces using 1-BP:

- Reduce the amount of time that a worker is exposed to 1-BP as well as reducing the number of workers exposed to the chemical.
- Purchase, store, and use the smallest amount of 1-BP possible.
- Keep 1-BP containers closed between uses.
- For dry cleaning operations, avoid:
 - overheating the solvent
 - shortening drying periods

Personal Protective Equipment (PPE)

PPE is used during the interim period when engineering controls are being installed or repaired, when engineering and administrative or work practice controls are not effective in adequately reducing exposure, or when controls are not feasible.

- Respiratory protection:
 - Whenever respirators are needed to protect the health of workers or employers require respirators to be used, the employer must provide the respirators. The employer must also have a written respiratory protection program that meets the requirements of OSHA's Respiratory Protection standard ([29 CFR 1910.134](#)). This program must include a written plan, proper respirator selection and maintenance, fit testing, medical evaluations, cartridge change schedules, a program administrator, and training.
 - If respirators are necessary in atmospheres that are not immediately dangerous to life or health, the workers must use NIOSH-certified air-purifying respirators or NIOSH-approved supplied-air respirators which have the appropriate assigned protection factor. 29 CFR 1910.134(d)(1)(ii), 1910.134(d)(3)(i)(A). Respirators that meet these criteria include air-purifying respirators with organic vapor cartridges.
- Skin protection:
 - 1-BP can be absorbed readily through human skin; therefore, chemical-protective gloves, arm sleeves, aprons, and other appropriate clothing should be worn to reduce skin exposure.
 - 1-BP easily travels through most glove materials. Recommended glove materials for protection against 1-BP are supported polyvinyl alcohol or multiple-layer laminates [Forsberg and Mansdorf 2007].

How Can OSHA and NIOSH Help?

OSHA Consultations: OSHA's On-site Consultation Program offers free and confidential advice to small and medium-sized businesses in all states across the country, with priority given to high-hazard worksites. On-site Consultation services are independent of OSHA enforcement and do not result in penalties or citations. Consultants from state agencies or universities work with employers to identify workplace hazards, provide advice on compliance with OSHA standards, and assist in establishing safety and health management systems. To locate the OSHA On-site Consultation Program nearest you, call 1-800-321-6742 (OSHA) or visit www.osha.gov/dcsp/smallbusiness/index.html.

OSHA-Approved State Plans: Twenty-seven states and U.S. territories operate their own occupational safety and health state plan approved by OSHA. State plans have Hazard Communication standards that are at least as effective as OSHA's standards in providing protection to workers. A list of state plans and more information about each state plan's Hazard Communication standard is available at www.osha.gov/dcsp/osp/index.html.

OSHA Compliance Assistance: OSHA also has compliance assistance specialists throughout the nation who can provide general information about OSHA standards, short education programs on specific hazards or OSHA rights and responsibilities, and additional compliance assistance resources. Contact your local OSHA office for more information by calling 1-800-321-OSHA (6742) or visit OSHA's webpage at www.OSHA.gov.

NIOSH HHE Program: Employees, employee representatives, or employers can ask NIOSH to conduct Health Hazard Evaluations (HHEs) at their workplace. NIOSH may provide assistance and information by phone or in writing, or may visit the workplace to assess employee exposure and health. Based on their findings, NIOSH will recommend ways to reduce hazards and prevent work-related illness. The evaluation is done at no cost to the employees, employee representatives, or employers. For more information about the HHE Program, visit the NIOSH HHE webpage at <http://www.cdc.gov/niosh/hhe/default.html> or contact the HHE program by phone at 513-841-4382. For general information or questions about any hazard or illness, call the NIOSH Information Service: 1-800-CDC-INFO (1-800-232-4636).

Contact OSHA

For questions or to get information or advice, to report an emergency, report a fatality or catastrophe, file a confidential complaint, order publications, or to request OSHA's free on-site consultation service, contact your nearest OSHA office, visit www.osha.gov, or call OSHA at 1-800-321-OSHA (6742), TTY 1-877-889-5627.

Contact NIOSH

To receive documents or more information about occupational safety and health topics, contact NIOSH at 1-800-CDC-INFO (1-800-232-4636), TTY 1-888-232-6348, email cdcinfo@cdc.gov, or visit the NIOSH website at www.cdc.gov/niosh.

Worker Rights

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
- Receive information and training (in a language and vocabulary the worker understands) about workplace hazards, methods to prevent them, and the OSHA standards that apply to their workplace.
- Review records of work-related injuries and illnesses.
- Get copies of test results that find and measure hazards.
- File a complaint asking OSHA to inspect their workplace if they believe there is a serious hazard or that their employer is not following OSHA's rules. OSHA will keep all identities confidential.
- Exercise their rights under the law without retaliation or discrimination

For more information, see [OSHA's workers page](#).

Disclaimer

This Hazard Alert is not a standard or regulation, and it creates no new legal obligations. It contains recommendations as well as descriptions of mandatory safety and health standards [and other regulatory requirements]. The recommendations are advisory in nature, informational in content, and are intended to assist employers in providing a safe and healthful workplace. The Occupational Safety and Health Act requires employers to comply with safety and health standards and regulations promulgated by OSHA or by a state with an OSHA-approved state plan. In addition, the Act's General Duty Clause, Section 5(a)(1), requires employers to provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. The mention of any non-governmental organization or link to its website in this Hazard Alert does not constitute an endorsement by OSHA or NIOSH of that organization or its products, services, or website.

References and Resources

Federal

CDC (Centers for Disease Control and Prevention) [2008]. Neurologic illness associated with occupational exposure to the solvent 1-Bromopropane—New Jersey and Pennsylvania (2007–2008). *MMWR* 57(48):1300-1302.

NIOSH [2000]. NIOSH health hazard evaluation report: Trilithic, Inc.; Indianapolis, IN. National Institute for Occupational Safety and Health, HETA No. 2000-0233-2845 [<http://www.cdc.gov/niosh/hhe/reports/pdfs/2000-0233-2845.pdf>]. Date accessed: May 29, 2013.

NIOSH [2002a]. NIOSH health hazard evaluation report: Custom Products, Inc.; Mooresville, NC. National Institute for Occupational Safety and Health, HETA No. 98-0153-2883 [<http://www.cdc.gov/niosh/hhe/reports/pdfs/1998-0153-2883.pdf>]. Date accessed: May 29, 2013.

NIOSH [2002b]. NIOSH health hazard evaluation report: STN Cushion Company; Thomasville, NC. National Institute for Occupational Safety and Health, HETA No. 2000-0410-2891 [<http://www.cdc.gov/niosh/hhe/reports/pdfs/2000-0410-2891.pdf>]. Date accessed: May 29, 2013.

NIOSH [2003]. NIOSH health hazard evaluation report: Marx Industries, Inc.; Sawmills, NC. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA Report No. 99-0260-2906 [<http://www.cdc.gov/niosh/hhe/reports/pdfs/1999-0260-2906.pdf>]. Date accessed: May 29, 2013.

NIOSH [2004]. NIOSH Respirator Selection Logic 2004. By Bollinger, Nancy. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH_ Publication NO. 2005-100 [<http://www.cdc.gov/niosh/docs/2005-100/pdfs/2005-100.pdf>]. Date accessed: July 11, 2013.

NIOSH [2010]. Health hazard evaluation report: Evaluation of 1-bromopropane use in four New Jersey commercial dry cleaning facilities. By Eisenberg J. Ramsey J. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational

Safety and Health, HETA No. 2008-0175-3111 [<http://www.cdc.gov/niosh/hhe/reports/pdfs/2008-0175-3111.pdf>]. Date accessed: May 29, 2013.

NTP [2011]. NTP technical report on the toxicology and carcinogenesis studies of 1-bromopropane in F344/N rats and B6C3F1 Mice. Research Triangle Park, NC: Department of Health and Human Services, National Institute of Health, NIH Publication No. 11-5906 [http://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/TR564.pdf]. Date accessed: April 10, 2013.

NTP [2013]. Revised Draft Report on Carcinogens - Monograph for 1-Bromopropane; May 14 2013. Office of the Report on Carcinogens, Division of the National Toxicology Program, National Institute of Environmental Health Sciences, U.S. Department of Health and Human Services. [http://ntp.niehs.nih.gov/NTP/roc/thirteenth/Monograph_Drafts/RevisedDraftRoC1BP_monograph_508.pdf]. Date accessed: May 29, 2013.

NTP [2013]. Topic Page: 1-Bromopropane. [<http://ntp.niehs.nih.gov/go/37896>]. Date accessed June 16, 2013.

U.S. Environmental Protection Agency [2007]. SNAP Regulations: Rule 12. [<http://www.epa.gov/ozone/snap/regulations.html#rule12>]. Date accessed June 10, 2013.

States

California Department of Industrial Relations (CA DIR) [2009]. Airborne Contaminants. [http://www.dir.ca.gov/oshsb/airborne_contaminants09.html]. Date accessed May 30, 2013.

CDPH [2003]. Health Hazard Alert: 1-Bromopropane (n-Propyl Bromide). California Department of Health Services and the California Department of Industrial Relations [<http://www.cdph.ca.gov/programs/hesis/Documents/bpropane.pdf>]. Date accessed: April 10, 2013.

Safety and Health Assessment and Research for Prevention [2009]. Safety and Health Alert: 1-Bromopropane (also known as 1-BP, n-propyl Bromide, nPB). Washington State Department of Labor and Industries [<http://www.lni.wa.gov/Safety/Research/Files/BromopropaneFactSheet.pdf>]. Date accessed: April 10, 2013.

Others

ACGIH [2013]. TLVs® and BEIs®: Threshold limit values for chemical substances and physical agents & biological exposure indices. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Anderson SE, Munson AE, Butterworth LF, et al. [2010]. Whole-body inhalation exposure to 1-bromopropane suppresses the IgM response to sheep red blood cells in female B6C3F1 mice and Fisher 344/N rats. *Inhalation Toxicology* 22(2):125-132.

Blando JD, Schill DP, De La Cruz MP, Zhang L, Zhang J [2010]. Preliminary study of propyl bromide exposure among New Jersey dry cleaners as a result of a pending ban on perchloroethylene. *J Air Waste Manag Assoc* 60(9):1049-1056.

Forsberg K, Mansdorf SZ [2007]. Quick selection guide to chemical protective clothing, 5th Ed. John Wiley and Sons, Hoboken NJ. Page 116.

Frasch HF, Dotson GS, Barbero AM [2011]. In vitro human epidermal penetration of 1-bromopropane. *J Toxicol Environ Health A* 74(19): 1249-1260.

Hanley KW, Petersen M, Curwin BD, Sanderson WT [2006]. Urinary Bromide and Breathing Zone Concentrations of 1-Bromopropane from Workers Exposed to Flexible Foam Spray Adhesives. *Ann Occup Hyg* 50(6):599-607.

Hanley KW, Petersen MR, Cheever KL, Lian L [2009]. N-Acetyl-S-(n-Propyl)-L-Cysteine in Urine from Workers Exposed to 1-Bromopropane in Foam Cushion Spray Adhesives. *Ann Occup Hyg* 53(7):759-769.

Hanley KW, Petersen MR, Cheever KL, Luo J [2010]. Bromide and N-acetyl-S-(n-propyl)-L-cysteine in urine from workers exposed to 1-bromopropane solvents from vapor degreasing or adhesive manufacturing. *Int Arch Occup Environ Health* 83:571-584.

Ichihara G, Kito J, Li W, Ding X, Ichihara S, Takeuchi Y [2012]. Neurotoxicity of 1-bromopropane: evidence from animal experiments and human studies. *J Ad Res* 3(2):91-98.

Kim HY, Chung YH, Jeong JH, Lee TM, Sur GS, Kang JK [1999]. Acute and repeated inhalation toxicity of 1-bromopropane in SD rats. *J Occup Health* 41(2):121-128.

Li W, Shibata E, Zhou Z, et al [2010]. Dose-dependent neurologic abnormalities in workers exposed to 1-Bromopropane. *J Occ Env Med* 52(8):769-777.

Majersik JJ, Caravati EM, Steffens JD [2007]. Severe neurotoxicity associated with exposure to the solvent 1-bromopropane (n-propyl bromide). *Clin Toxicol* 45(3):270-276.

Mirzaa T, Ge'rin M, Be'gina D, Daniel D [2000]. A Study on the Substitution of Trichloroethylene as a Spot Remover in the Textile Industry. *AIHAJ* 61(3): 431-438.

Raymond LW, Ford MD [2007]. Severe illness in furniture makers using a new glue: 1-bromopropane toxicity confounded by arsenic. *J Occup Environ Med* 49:1009-1019.



DTSEM 07/2013