

**A Safety and Health Guide  
for  
1-Bromopropane  
(*n*-Propyl Bromide)**



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**This guide is focused on the chemical hazards associated with the use of 1-bromopropane (*n*-propyl bromide). It is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard should be followed.**

**To obtain additional copies of this guide, or if you have questions about North Carolina occupational safety and health standards or rules, please contact:**

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Additional sources of information are listed on the inside back cover of this guide.

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The projected cost of the NCDOL OSH program for federal fiscal year 2012–2013 is \$18,073,694. Federal funding provides approximately 30.5 percent (\$5,501,500) of this total.



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## Foreword

1-Bromopropane (*n*-propyl bromide, 1-BP) has become a chemical of interest in recent years as a substitute for methylene chloride, trichloroethylene (TCE) and perchloroethylene (“perc”), a chemical commonly used in the dry cleaning of clothes.

Since its introduction and use in North Carolina and other states, an awareness has developed of potential neurological and other health effects that may place workers at risk when exposure to this chemical in the workplace is not controlled. To protect workers from overexposure to 1-bromopropane, employers are required to limit employee exposure to this substance.

*A Safety and Health Guide for 1-Bromopropane* examines the workplace requirements and recommendations for safely working with this chemical. This document also examines the seriousness of the threat that uncontrolled airborne exposure to 1-bromopropane can pose to worker health.

In North Carolina, the N.C. Department of Labor enforces the federal Occupational Safety and Health Act through a state plan approved by the U.S. Department of Labor. NCDOL offers many educational programs to the public and produces publications to help inform people about their rights and responsibilities regarding occupational safety and health.

When reading this guide, please remember the mission of the N.C. Department of Labor is greater than just regulatory enforcement. An equally important goal is to help citizens find ways to create safe workplaces. Everyone profits when managers and employees work together for safety. This booklet, like the other educational materials produced by the N.C. Department of Labor, can help.

Cherie Berry  
Commissioner of Labor

## Note

This guide is intended to provide a generic overview of the standard-related topic and is not intended to alter or determine compliance responsibilities.

Generally speaking, Part 1910 standards apply to general industry, Part 1926 standards apply to the construction industry, and Part 1915 standards apply to shipyards. However, in instances where there are gaps in coverage, standards may apply across boundaries.

This guide discusses the occupational safety and health standards that may be applicable to the use of 1-bromopropane. **It is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard should be followed.** In addition, the use of trade names and commercial sources is for identification only and does not imply endorsement by the N.C. Department of Labor or its divisions.

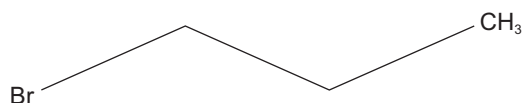
## What Is 1-Bromopropane?

### Background

1-Bromopropane (*n*-propyl bromide) is a type of organic chemical known as an alkyl halide in which a *halogen* atom, in this case bromine, is substituted for one of the hydrogen atoms on the terminal carbon atom of propane, a type of *alkane*. (See Figure 1.) 1-Bromopropane (CAS Registry Number 106-94-5) has the chemical formula C<sub>3</sub>H<sub>7</sub>Br and has been used increasingly as a substitute solvent for ozone-depleting chemicals or suspect carcinogens.

Figure 1

#### Chemical structure of 1-bromopropane



1-Bromopropane is characterized as a liquid at room temperature that has a strong odor and has an appearance that is colorless to a faint yellow color. Some of the chemical properties of 1-bromopropane are listed in Table 1.

Table 1

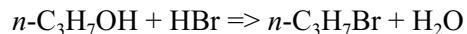
#### Physical and chemical properties of 1-bromopropane

Property	Information
Molecular weight	123.0
Melting point	-110 degrees C
Boiling point	71 degrees C
Vapor pressure (mm Hg)	110.8 at 20 degrees C
Vapor density	4.25
Specific gravity	1.353 at 20 degrees C
Solubility in water	2.45 grams per liter
Conversion factors (1-bromopropane in air) Parts per million (ppm) to $\mu\text{g}/\text{m}^3$ $\mu\text{g}/\text{m}^3$ to parts per million (ppm)	$\mu\text{g}/\text{m}^3 = 5030.7 \times (\text{ppm})$ $\text{ppm} = 1.988 \times 10^{-4} \times \mu\text{g}/\text{m}^3$

### Production and Use

#### Synthesis

1-Bromopropane can be synthesized by reacting *n*-propyl alcohol (*n*-propanol) with excess hydrobromic acid. Water formed as a by-product is quickly removed from the resulting crude product before purification to give the final product. A modification of this reaction procedure involves using bromine with a reducing agent such as sulfur, sulfur dioxide, phosphorus or sodium borohydride. The overall reaction with hydrobromic acid is depicted below.



The prefix *n* (or *normal*) refers to a “straight chain” hydrocarbon component as opposed to a branched hydrocarbon component, such as the isopropyl group in isopropyl alcohol (*i*-propyl alcohol or *i*-propanol) where the hydroxyl (-OH) group is attached to the middle carbon.

Synthesis of 1-bromopropane using this method also produces the structural isomer 2-bromopropane (2-BP or *i*-BP) as a minor impurity. 2-Bromopropane (CAS Registry Number 75-26-3) has been shown to be more hazardous to male and female reproductive systems.

1-Bromopropane can also be produced using a patented process that reacts propene and hydrogen bromide in the presence of an ozonide catalyst. The advantages cited for the use of this procedure are its high efficiency, and it is environmentally friendly and operationally safe.

### **Production and Major Uses**

1-Bromopropane as a commercial chemical is produced in high volumes in the United States. Production in recent years has ranged from 1 million to 10 million pounds.

Previously, 1-bromopropane was used primarily as a solvent for fats, waxes or resins and as an intermediate in the synthesis of other compounds including pharmaceuticals, insecticides, quaternary ammonium compounds, flavors and fragrances in generally well-controlled, closed processes. 1-Bromopropane is now used as a solvent cleaner in vapor and immersion cleaning and degreasing operations for optics, electronics and metals and as a solvent in industries that use spray-applied adhesives. Its use as a solvent substitute for ozone-depleting chlorofluorohydrocarbons (freons) or suspect carcinogens (e.g., trichloroethylene, methylene chloride) has prompted the dry cleaning industry to view it as a replacement for perchloroethylene (“perc”), especially in states that are proposing to ban the use of the latter chemical in dry cleaning.

1-Bromopropane is one of several chemicals included in the Environmental Protection Agency’s Significant New Alternatives Policy (SNAP) that has been approved as a substitute for ozone-depleting solvents currently in use in certain applications. Specifically, 1-bromopropane has been approved as an acceptable substitute for CFC-113 (1,1,2-Trichloro-1,2,2-trifluoroethane, Freon 113) and methyl chloroform (1,1,1-trichloroethane) in non-aerosol electronics, metal and precision cleaning.

The principal industry sectors in the United States in which 1-bromopropane has been found are adhesives use; 1-bromopropane manufacturing; aerosol solvents use; vapor degreasing; and dry cleaning. Among the brand names of products that use 1-bromopropane are Abzol, EnSolv and Solvon cleaners; Pow-R-Wash NR Contact Cleaner, Superkleen Flux Remover 2311 and LPS NoFlash NU Electro Contact Cleaner aerosols; and Whisper Spray and Fire Retardant Soft Seam 6460 adhesives; and DrySolv. A discussion of employee exposure levels and types of controls found in some of these industry sectors will follow in Section 3 (Exposure Monitoring and Control).

## Chemical Hazards

### *Physical Hazards*

1-Bromopropane is classified as a Category 2 flammable liquid. It has an autoignition temperature of 914 degrees F and a flash point of less than 72 degrees F. Although a specific upper explosive (flammability) limit has not been determined, it has a lower explosive limit of 4.6 percent by volume in air. 1-Bromopropane decomposes when burned to emit hydrogen bromide (HBr) gas.

### *Health Hazards*

#### **Acute Effects**

Occupational exposure to 1-bromopropane occurs primarily through inhalation and skin contact, although exposure through ingestion and the eyes are other possible routes. Short-term exposure to the chemical can result in irritation of the eyes, nose, throat or respiratory tract.

Chronic (long-term) exposure to 1-bromopropane can adversely affect peripheral nerves and the central nervous system. Symptoms that have been reported include joint pain or leg weakness and pain leading to difficulty standing and walking; muscle twitching or numbness, tingling and prickling in the hands or feet, loss of vibration sense; and anxiety, apathy, insomnia, and difficulties with concentration and memory.

Other health effects that may also occur include dermatitis, nausea and vomiting, diarrhea, difficulty in swallowing, disruption or failure of menstruation, urinary difficulties, anemia or low hematocrit (red blood cell count), liver damage, and lung disease.

#### **Reproductive Hazards**

Animal studies have shown that inhalation exposure to 1-bromopropane can result in decreased fetal weight and skeletal variations. In addition, similar studies in animals have shown 1-bromopropane to cause decreased fertility, decreased prostate weight and effects on sperm quality. Some case studies of female workers occupationally exposed to 1-bromopropane reported altered menstrual periods.

#### **Carcinogenic Activity**

Presently, no epidemiological studies or case reports have been identified that examine the relationship between human cancer and exposure to 1-bromopropane.

#### **Metabolism of 1-Bromopropane**

By identifying, characterizing and measuring the levels of metabolites of 1-bromopropane in humans, it is possible to determine the biological half-life of this chemical in the body. Using this type of information, it may be possible to calculate the level of worker exposure to this chemical even when air sampling results are not available.

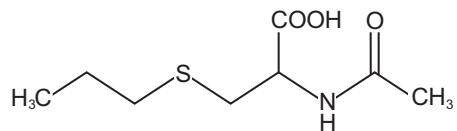
The metabolites of 1-bromopropane identified in humans have been limited thus far to those recovered from the urine of factory workers in Japan following exposure to 1-bromopropane. Metabolism of this chemical in humans results in the removal of the bromine atom from the 1-bromopropane molecule. This is confirmed by the fact that the main metabolite detected in the urine of exposed workers is *N*-acetyl-S-propylcysteine (AcPrCys, *n*-propyl mercapturic acid), which results from reaction of 1-bromopropane with *N*-acetylcysteine in the body. (See Figure 2.)

As expected, levels of this metabolite in the urine increase with increasing exposure to 1-bromopropane in the air. Levels of bromine, which can also be detected in urine, strongly correlate with those for AcPrCys.



**Figure 2**

*N*-acetyl-*S*-propylcysteine



## Exposure Monitoring and Control

### *Exposure Limits*

Currently, there are no OSHA permissible exposure limits (PELs) for 1-bromopropane. The American Conference of Governmental Industrial Hygienists (ACGIH) has recently revised their recommendation that exposure levels be maintained at a threshold limit value (TLV) of 0.1 parts per million as an 8-hour time-weighted average (TWA). The U.S. Environmental Protection Agency (EPA) has previously recommended an exposure level of 25 ppm.

When monitoring employee exposure to 1-bromopropane, the exposure determination must be made without regard to the use of personal protective equipment, such as respiratory protection. This means that employers cannot apply the level of protection that the respirator can provide to determine whether an employee is overexposed to 1-bromopropane vapors present in the workplace environment.

### *Exposure Assessments and Monitoring*

Employers who have a workplace or work operations where 1-bromopropane is used should determine the 8-hour TWA exposure for each employee exposed, or potentially exposed, to this chemical. In so doing, employers should assess all work operations for their potential to generate vapors and mists and the effectiveness of existing engineering and administrative controls. This is done using periodic, or scheduled, monitoring.

### *Scheduled (Periodic) Monitoring*

#### **Initial Monitoring**

Scheduled monitoring is the type of exposure monitoring that has been a traditional requirement in OSHA's substance-specific standards. Using this type of exposure monitoring, employers perform initial monitoring to determine the 8-hour TWA exposure for each employee using a sufficient number of samples collected in the employee breathing zone that fully characterizes their full shift exposure to 1-bromopropane. This should be done for each job classification on every shift where employees may be exposed.

#### ***Does this mean employers must monitor every employee?***

No. Employers are only required to conduct monitoring of selected employees that is representative of other employees in the same job classification working in the same area as the employees monitored.

#### **Periodic Monitoring**

The results of initial monitoring are used to establish a recommended frequency of exposure monitoring. If initial monitoring shows that employee exposure is below an action level (or one-half of the TLV), then monitoring may be discontinued for the employees that this monitoring represents. If initial monitoring reveals that the represented employees are exposed at or above the action level (or one-half of the TLV) but not above the TLV, monitoring should be repeated every six months. If initial monitoring shows employee exposure is above the TLV, monitoring should be repeated every three months. The recommended schedule for exposure monitoring is summarized in Table 2 below.

**Table 2**

***Recommended Monitoring Frequency for Scheduled Monitoring***

<b>Exposure Scenario</b>	<b>Required Monitoring Activity</b>
Below ½ of TLV (< 0.05 ppm)	No periodic monitoring is recommended for workers represented by this monitoring
At or above ½ of TLV but below the TLV (0.05 ppm to 0.1 ppm)	Monitor every six months
Above the TLV (> 0.1 ppm)	Monitor every three months

**Additional Monitoring**

Additional monitoring should be done whenever a change in the production process, raw materials, equipment, personnel, work practices or control methods may result in new or additional exposures to 1-bromopropane or when the employer believes new or additional exposures may have occurred. This can occur when there are alterations in the production process, raw materials, equipment, personnel, work practices or control methods used in the workplace. The following example demonstrates circumstances in which additional monitoring might be necessary.

*Example.* An employer had conducted initial monitoring of an adhesive spraying operation. However, the employer switched to an adhesive having a higher percentage of 1-bromopropane than initially used. Additional monitoring would be necessary to determine worker exposure to 1-bromopropane and the effectiveness of existing controls for limiting 1-bromopropane exposures at the higher concentration.

***Demarcated (Regulated) Areas***

Although there is no occupational safety and health standard for exposure to 1-bromopropane, employers should establish a demarcated area (“regulated area”) wherever a worker’s exposure to airborne concentrations of 1-bromopropane is, or can be reasonably expected to be, above the TLV. This can be done through the use of warning signs, gates, ropes, barricades, lines, textured flooring or other methods that may be appropriate.

Whatever method is selected should be effective in warning unauthorized workers not to enter the area, thereby reducing the number of employees exposed. Authorized personnel are those employees whose job duties require them to be in the area and may also include maintenance personnel, managers and quality control engineers. In addition, designated worker representatives may enter the regulated area to observe exposure monitoring. All people who enter the regulated area must use proper protective equipment, including respirators when appropriate or necessary.

***Control Measures***

Whenever exposures exceed the TLV, employers should use engineering and administrative controls to reduce and maintain exposures to 1-bromopropane to or below the TLV. When feasible engineering and work practices controls have been used to reduce airborne exposures to 1-bromopropane to the lowest levels achievable but levels are still above the TLV, employers should supplement them with the use of respirators that complies with the Respiratory Protection Standard, 29 CFR 1910.134.

***Engineering controls*** include substitution (using a less toxic material or process that results in lower exposures), isolation (enclosing the source of exposure), and ventilation (such as local exhaust ventilation near the source of the exposure).

***Administrative controls*** are work practice controls and policies dictated by management to reduce or prevent exposures to workplace hazards. The effectiveness of administrative changes in work practices for controlling workplace hazards depends on management commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that control policies and procedures are not circumvented in the name of convenience or production.

## Specific Operations and Processes

**Cold vapor degreasing.** Enclosing a cold vapor degreaser that is used for cleaning electronic parts by immersing parts in a wire mesh basket into 1-bromopropane accompanied by the use of local exhaust ventilation has been shown to maintain airborne concentrations to 4.42 ppm at the degreaser and 1.7 ppm 5 feet away. Improved work practices such as permitting parts to drip dry longer before removing the parts from the enclosed degreaser area can also help reduce 1-bromopropane exposure levels.

**Adhesive spray application.** Enclosing spray booths to minimize the volume of overspray and make better use of local exhaust ventilation, along with improvements in ventilation rates, has been shown to reduce worker exposure to 1-bromopropane when spraying adhesives. In addition, keeping doors to other areas closed will help reduce the migration of this chemical into other areas where employees are working and permit exhaust ventilation to maintain a partial negative pressure in rooms where adhesive spraying is performed.

**Clothes dry cleaning.** Machines using 1-bromopropane should be isolated from other work areas to reduce the exposure of other employees who do not run dry cleaning machines, such as press operators and cashiers. Local exhaust ventilation located at or near the machine door reduces employee exposure during machine loading and unloading and when performing maintenance. Airflow capacity through a retrofitted exhaust hood, measured in cubic feet per minute (cfm), should be no less than 100 times the area of the door opening (i.e., a 4 square foot door opening would require at least 400 cfm air flow). National Institute for Occupational Safety and Health (NIOSH) recommends that general ventilation used to dilute background 1-bromopropane concentrations should be capable of achieving 12 air changes per hour with a minimum make-up air supply of 30 cfm of outside air per person in dry cleaning establishments. Air flow should be from a clean area (customer counter) to one that is less clean (dry cleaning machine).

## Respiratory Protection

Employers are encouraged to provide respirators to employees when engineering and work practice controls are not sufficient to maintain employee exposure to 1-bromopropane at or below the TLV. Respirators should be worn:

- During work operations where engineering and work practice controls are not feasible (e.g., maintenance and repair activities) to maintain employee exposure at or below the TLV.
- Emergencies (i.e., an occurrence that results, or is likely to result, in uncontrolled release of 1-bromopropane that is not an incidental release that can be controlled by employees in the immediate area or by maintenance personnel).
- Where employees are exposed above the TLV for less than 30 days in any 12 consecutive months and the employer has opted not to implement engineering and work practice controls to achieve the TLV.
- Periods necessary to install or implement feasible engineering and work practice controls.
- Operations where all feasible engineering and work practice controls have been implemented but are not sufficient to reduce exposures to or below the TLV.

Where respirator use is required or necessary, the employer is required to establish a respiratory protection program that meets the requirements of the Respiratory Protection Standard, 29 CFR 1910.134. In addition, each employee must be provided with a respirator having an appropriate assigned protection factor. The N.C. Department of Labor has prepared a publication (*Industry Guide #44: A Guide to Respiratory Protection*) to assist employers in understanding and meeting the requirements of this standard. A sample respiratory protection program can be accessed by going to [www.nclabor.com/osha/consult/sample\\_programs.htm](http://www.nclabor.com/osha/consult/sample_programs.htm).

**Maximum use concentration (MUC)** means the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected when wearing a respirator. It is determined by the assigned protection factor of the respirator or class of respirators and the exposure limit of the hazardous substance. The MUC can be determined mathematically by multiplying the assigned protection factor specified for a respirator by the required OSHA permissible exposure limit, short-term exposure limit, or ceiling limit. When no OSHA exposure limit is available for a hazardous substance, an employer should determine an MUC on the basis of relevant available information (e.g., ACGIH TLV) and informed professional judgment. For 1-bromopropane, the MUC for a half-face, air-purifying respirator equipped with organic vapor cartridges is 1 ppm, or 5 milligrams per cubic meter (10 times the TLV).

## ***Other Protective Work Clothing and Equipment***

Because 1-bromopropane also produces health effects due to contact with the eyes and skin, the employer must also provide appropriate protective clothing and equipment whenever contact with 1-bromopropane is anticipated. The general requirements for personal protective equipment (PPE) in 29 CFR 1910.132 requires the employer to conduct and document in writing, with signature certification, a job hazard assessment for the purpose of identifying any hazards for which personal protective equipment is necessary. In addition to respiratory protection, some other types of protective clothing and equipment that may be necessary include, but are not limited to, chemical resistant gloves, aprons and goggles. Employers must provide and maintain the clothing and equipment at no cost to the worker. Ordinary street clothing and uniforms or other accessories that do not protect workers from chemical hazards are not considered protective clothing or equipment under the standard.

## ***Hygiene Areas and Practices***

Washing facilities must be provided and must be readily accessible and capable of removing 1-bromopropane or any toxic material from the skin. Washing facilities must comply with the sanitation standard requirements in 29 CFR 1910.141 (for general industry), 29 CFR 1926.51 (for construction) and 29 CFR 1915.88 (for shipyards). The employer must ensure that affected workers use these facilities when necessary. This includes making sure those workers who have skin contact with 1-bromopropane wash their hands and faces at the end of the work shift and prior to eating, drinking, smoking, chewing tobacco or gum, applying cosmetics, or using the toilet.

Eating and drinking areas and surfaces must also conform with the sanitation standard requirements and be maintained as free as practicable of 1-bromopropane whenever employers allow workers to consume food or beverages at a worksite where 1-bromopropane is present. Employers are also required to ensure that workers do not enter eating and drinking areas wearing protective clothing or equipment unless the protective clothing or equipment is properly cleaned beforehand.

## ***Housekeeping***

The sanitation standard for general industry also includes housekeeping measures. Similar requirements are not included in the construction and shipyard standards on housekeeping due to expected difficulties in complying with these requirements in those industry sectors. Proper housekeeping focuses on sources of exposure to 1-bromopropane that engineering controls are not designed to address such as surface contamination, which can lead to skin contact. Therefore, employers are responsible to ensure that all environmental work surfaces are kept as free as practicable of accumulations of toxic materials containing 1-bromopropane. Accordingly, any spills and releases of 1-bromopropane or materials containing 1-bromopropane in the workplace must be promptly cleaned up and disposed of in accordance with environmental regulations for hazardous waste disposal.

## ***Worker Training and Communication***

Employers must inform workers about the hazards associated with exposure to 1-bromopropane and understand the necessary measures they can take to protect themselves. Through a comprehensive hazard communication program, as required by the Hazard Communication Standard (29 CFR 1910.1200), employers must provide employees with the information and training regarding labels and safety data sheets (SDSs) for substances containing this hazardous component.

## Medical Surveillance

Medical surveillance serves several purposes when considering worker exposure to 1-bromopropane. It allows physicians or other healthcare professionals to determine if an individual can be exposed to 1-bromopropane at their workplace without experiencing adverse health effects. It permits appropriate intervention to be taken when adverse health effects related to exposure to 1-bromopropane are identified in an individual. Finally, it determines an employee's fitness to use personal protective equipment, in particular, respirators.

Employers should provide a medical surveillance program for all employees:

- Exposed or may be exposed to 1-bromopropane at concentrations at or above the threshold limit value or other recommended exposure level (as an 8-hour TWA) for 30 or more days per year; or
- Experiencing signs and symptoms of adverse health effects associated with 1-bromopropane exposures; or
- Exposed in an emergency situation (i.e., any occurrence resulting in a uncontrolled release of 1-bromopropane that is not an incidental release that can be controlled by workers in the immediate area or by maintenance personnel).

***What are some signs and symptoms of adverse health effects associated with exposure to 1-bromopropane?***

These include tingling and numbness in extremities. Short term symptoms can also include dizziness and malaise.

A licensed physician should perform or supervise all medical examinations and procedures.

### ***Frequency of Medical Examinations***

Other than required use of a respirator, for which employers must make medical examinations and consultations available to employees at no cost prior to assignment and fit-testing, a recommended frequency of medical surveillance for occupational exposure to 1-bromopropane include:

- Within 30 working days after assignment to a job involving exposure to 1-bromopropane at any level.
- At least annually thereafter.
- Whenever a worker shows signs or symptoms of adverse health effects associated with exposure to 1-bromopropane.
- Within 30 days following exposure during an emergency involving an uncontrolled release of 1-bromopropane.
- At the termination of employment unless the last examination provided was less than six months prior to the date of termination.

### ***Content of Medical Examinations***

Medical examinations should include the following:

- A medical and work history that focuses on:
  - Past, present and anticipated future exposure to 1-bromopropane.
  - Irritation of eyes, nose and throat.
  - History of lightheadedness and dizziness while at work.
  - Current and past history of numbness, weakness or tingling of the lower extremities.
  - A physical examination focusing on the nervous system and skin.
  - Urinalysis for determination of AcPrCys and bromide.
  - Any other examinations or tests suggested by the examining physician.

Employers should provide the following information to the examining physician:

- A copy of safety data sheets for chemicals used.
- A description of the affected employee's former, current and anticipated duties relating to 1-BP exposure.

- The employee's representative current exposure level and anticipated 1-BP exposure levels.
- A description of any personal protective equipment and respiratory equipment used, including when and for how long this equipment has been worn.
- Information from previous medical examinations not otherwise available, currently within control of the employer.

It is the employer's responsibility to obtain the physician's written opinion as soon as possible following completion of the medical examination. The physician's written opinion should contain:

- The physician or other licensed health care provider's (PLHCP) opinion regarding whether the worker has any detected medical condition(s) that would place the worker at increased risk of material impairment to health from future exposure to 1-bromopropane.
- Any recommended limitations on the employee's exposure to 1-bromopropane or the use of any personal protective equipment, such as respirators.
- A statement that the employee has been provided an explanation of the results of the medical examination and has been informed of any medical conditions resulting from exposure to 1-bromopropane that require further evaluation or treatment, and any special provisions for the use of protective clothing or equipment.

The physician must not reveal any specific findings or diagnoses in the written opinion that are unrelated to workplace exposure to 1-bromopropane. Similar to the requirements of existing substance-specific standards, the employer should provide a copy of the physician's written opinion to the affected employee as soon as possible after receiving it.

## Recordkeeping

### *Why do employers need to maintain records regarding occupational exposure to 1-bromopropane?*

Accurate records can verify employer efforts to control employee exposure to 1-bromopropane and can assist in diagnosing and identifying workplace-related illnesses. Therefore, employers are required by 1910.1020 to maintain records of worker 1-bromopropane exposures (including air monitoring data, historical monitoring data and objective data) and medical surveillance records.

### *Air Monitoring Data*

Employers must keep records of all employee exposure monitoring used to comply with the standard for 30 years. The record must indicate:

- The date of measurement for each sample taken.
- The operation involving exposure to 1-bromopropane that was monitored.
- Sampling and analytical methods used and evidence of their accuracy.
- The number, duration and results of samples taken.
- The type of protective devices used (e.g., type of respirators worn).
- The name and job classification of all workers represented by the monitoring and specifying which employees were actually monitored.

### *Historical Monitoring Data*

When an employer relies on historical monitoring data to determine worker exposure to 1-bromopropane, an accurate record of the historical monitoring data must be maintained as part of the exposure monitoring record. The record should indicate:

- The data was collected using methods that meet the accuracy requirements of the standard.
- That the processes and work practices, characteristics of the 1-bromopropane containing material, and environmental conditions at the time the data was obtained were essentially the same as those of the job for which current exposure is being determined.
- Any other relevant data regarding operations, materials, processes or work exposures.

### *Objective Data Records*

Where employers use objective data to demonstrate compliance with the 1-bromopropane TLV, they must keep an accurate record for as long as it is relied upon. The record must include:

- The 1-bromopropane-containing material in question.
- The source of the objective data.
- The testing protocol, test results and analysis of the material for release of 1-bromopropane.
- A description of the process, operation or activity and how the data support the determination.
- Other data relevant to operations, materials, processes or employee exposures.

Employers must make exposure records available when requested by affected employees, former employees, their designated representatives, and the commissioner of labor or her designee.



## ***Medical Surveillance Records***

Employers must keep all medical surveillance records for the duration of the employee's employment plus 30 years, including:

- The employee's name and unique identifier (e.g., Social Security number).
- The employee's medical examination results, including the medical history, questionnaires (including medical questionnaires for respirator use), responses, test results and physician's recommendations.
- The written opinions of the PLHCP.
- Any employee medical complaints related to 1-bromopropane exposure.
- A copy of the information provided to the examining PLHCP (i.e., a description of the worker's duties as they relate to occupational exposure to 1-bromopropane; worker's 1-BP exposure levels; a description of PPE used by the worker; and information from previous employment-related medical examinations).

Employee medical surveillance records must be available to the subject employee, anyone having specific written consent of that employee, and the commissioner of labor or her designee.

## Standards Applicable to 1-Bromopropane

### *General Industry*

29 CFR 1904	Recordkeeping
29 CFR 1910.106	Flammable liquids
29 CFR 1910.107	Spray finishing using flammable and combustible materials
29 CFR 1910.119	Process safety management of highly hazardous chemicals
29 CFR 1910.132–138	Personal protective equipment
29 CFR 1910.132	General requirements—including job hazard analysis
29 CFR 1910.133	Eye and face protection
29 CFR 1910.134	Respiratory protection
29 CFR 1910.138	Hand protection
29 CFR 1910.141	Sanitation
29 CFR 1910.145	Accident prevention signs and tags
29 CFR 1910.151	Medical services and first aid (requirement to have eyewash)
29 CFR 1910.1020	Access to employee exposure and medical records
29 CFR 1910.1200	Hazard communication
29 CFR 1910.1450	Occupational exposure to hazardous chemicals in laboratories
N.C. Gen. Stat. 95-129(1)	General Duty Clause of OSHANC

### *Construction*

29 CFR 1904	Recordkeeping
29 CFR 1926.21	Safety training and education
29 CFR 1926.24	Fire protection and prevention
29 CFR 1926.25	Housekeeping
29 CFR 1926.25(b)	(requirement to remove combustible scrap and debris)
29 CFR 1926.50	Medical services and first aid
29 CFR 1926.51	Sanitation
29 CFR 1926.59	Hazard communication
29 CFR 1926.95–106	Personal protective equipment (including extremities)
29 CFR 1926.102	Eye and face protection
29 CFR 1926.103	Respiratory protection
29 CFR 1926.200	Accident prevention signs and tags
29 CFR 1910.1020	Access to employee exposure and medical records
N.C. Gen. Stat. 95-129(1)	General Duty Clause of OSHANC

# Glossary

The following terms are used in this document but are not elsewhere defined:

*Aliphatic (hydrocarbon):* “Straight-chain” hydrocarbon.

*Alkane or paraffin:* A saturated hydrocarbon. Alkanes consist only of hydrogen and carbon atoms, all bonds are single bonds, and the carbon atoms are not joined in cyclic structures but instead form an open chain. They have the general chemical formula  $C_nH_{2n+2}$ .

*Alkyl halide (Haloalkane):* A compound containing carbon, one or more halogens, and hydrogen.

*Assigned protection factor (APF):* The workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by the respiratory protection standard.

*Boiling point:* The temperature of a liquid at which its vapor pressure is equal to or very slightly greater than atmospheric pressure.

*Chemical Abstracts Service (CAS) Registry Number:* Each CAS Registry Number (often referred to as a CAS Number) is a unique numeric identifier that designates only one substance, has no chemical significance and is a link to a wealth of information about a specific chemical substance. The CAS Registry is the most authoritative collection of disclosed chemical substance information, containing more than 71 million organic and inorganic substances and 64 million sequences.

*Exposure or occupational exposure:* Exposure to airborne 1-bromopropane that would occur if the employee were not using a respirator.

*Flash point:* The temperature at which a liquid or volatile solid gives off sufficient vapor to form an ignitable mixture with air near the surface of the liquid.

*Halogen:* One of the electronegative elements of Group VII A of the periodic table (fluorine, chlorine, bromine, iodine and astatine).

*Historical monitoring data:* Data from 1-bromopropane monitoring conducted within the previous 12 months during work operations conducted under workplace conditions closely resembling the processes, types of material, control methods, work practices and environmental conditions in the employer’s current operations.

*Hydrocarbon:* An organic compound consisting exclusively of the elements hydrogen and carbon.

*Isomer:* One of multiple molecules having the same number and kind of atoms and therefore the same molecular formula and molecular weight, but differing with respect to the arrangement or configuration of the atoms.

*Lower explosive limit:* Lowest concentration (percentage) of a gas or vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). Concentrations lower than LEL are “too lean” to burn. Also called lower flammable limit (LFL).

*Melting point:* The temperature at which the crystals of a pure substances are in equilibrium with the liquid phase at atmospheric pressure.

*Metabolism:* The transformation(s) of chemical substances that occur within an organism following entry.

*Metabolite:* An intermediate material produced and used in the processes of a living cell or organism.

*Molecular weight:* The sum of the atomic weights of the atoms in a molecule.

*Objective data:* Information that demonstrates the expected worker exposure to 1-bromopropane associated with a particular product or material or a specific process, operation or activity. Information that can serve as objective data includes, but is not limited to, air monitoring data from an industry-wide survey; data collected by a trade association from its members; or calculations based on the composition or chemical and physical properties of a material. The data must reflect workplace conditions closely resembling the processes, types of material, control methods, work practices and environmental conditions in the employer’s current operations.

*Peripheral nervous system (PNS):* The main function of the PNS is to connect the central nervous system (CNS) to the limbs and organs. Unlike the CNS, the PNS is not protected by the bone of spine and skull, or by the blood–brain barrier, leaving it exposed to toxins and mechanical injuries.

*Peripheral neuropathy:* Damage to nerves of the peripheral nervous system, which may be caused either by diseases of or trauma to the nerve or the side effects of systemic illness.

*Permissible exposure limit (PEL):* An exposure limit that is published and enforced by OSHA as a legal standard.

*Respirator:* Any device designed to provide the wearer with respiratory protection against inhalation of a hazardous atmosphere. Respirators used in addition to engineering and work practice controls to protect employees from overexposure to chemical substances must be NIOSH certified.

*Specific gravity:* The ratio of the density of a substance compared to the density (mass of the same unit volume) of a reference substance. *Apparent specific gravity* is the ratio of the weight of a volume of the substance to the weight of an equal volume of the reference substance. The reference substance is nearly always water for liquids or air for gases.

*Threshold limit value (TLV):* The level of a chemical substance to which a worker can be exposed day after day for a working lifetime without adverse health effects. TLV is a reserved term of the American Conference of Governmental Industrial Hygienists (ACGIH).

*Time weighted average (TWA):* The average exposure level determined from samples, taken for different time periods, throughout a workday. The TWA is determined by multiplying each sample by the time the sample was taken, adding these results and dividing this sum by the total sampling time. Where the TWA is compared to an 8-hour PEL (or AL) to TLV, the sum is divided by eight hours or 480 minutes, depending on the units of time used.

*Vapor density:* The relative density of a gas or vapor as compared with some specific standard (as hydrogen or air). The vapor density of air is generally set as one.

*Vapor pressure:* The vapor pressure of a liquid is the equilibrium pressure of a vapor above its liquid (or solid); that is, the pressure of the vapor resulting from evaporation of a liquid (or solid) above a sample of the liquid (or solid) in a closed container.

## References

- American Conference of Environmental Industrial Hygienists, 2014. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.
- Environmental Protection Agency, *Federal Register*, Volume 72, Pages 30141–67.  
Available: <http://www.epa.gov/fedrgstr/EPA-AIR/2007/May/Day-30/a9707.pdf>
- Environmental Protection Agency, *Federal Register*, Volume 72, Pages 30168–207.  
Available: <http://www.epa.gov/fedrgstr/EPA-AIR/2007/May/Day-30/a9706.pdf>
- Environmental Protection Agency. Substitutes for Non-Aerosol Solvent Cleaning Under SNAP as of August 10, 2012.  
Available: <http://www.epa.gov/ozone/snap/solvents/solvents.pdf>
- Environmental Protection Agency, *Federal Register*, Volume 68, Pages 33284–316 (2003).  
Available: <http://www.gpo.gov/fdsys/pkg/FR-2003-06-03/pdf/FR-2003-06-03.pdf>
- National Institute for Occupational Safety and Health, 2003. Hazard evaluation and technical assistance report: Marx Industries, Sawmill, NC. DHHS (NIOSH) Publication No. 99-0260-2906.  
Available: <http://www.cdc.gov/niosh/hhe/reports/pdfs/1999-0260-2906.pdf>
- National Institute for Occupational Safety and Health (NIOSH), 2002. Hazard evaluation and technical assistance report: STN Cushion Company, Thomasville, NC. DHHS (NIOSH) Publication No. 2000-0410-2891.  
Available: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2000-0410-2891.pdf>
- National Institute for Occupational Safety and Health (NIOSH), 2002. Hazard evaluation and technical assistance report: Custom Products, Inc., Mooresville, NC. DHHS (NIOSH) Publication No. 98-0153-2883.  
Available: <http://www.cdc.gov/niosh/hhe/reports/pdfs/1998-0153-2883.pdf>
- National Institute for Occupational Safety and Health (NIOSH), 2010. Hazard evaluation and technical assistance report: Evaluation of 1-Bromopropane Use in Four New Jersey Commercial Dry Cleaning Facilities. DHHS (NIOSH) Publication No. 2008-0175-3111.  
Available: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2008-0175-3111.pdf>
- Department of Health and Human Services, National Institutes of Health, U.S. National Library of Medicine, Hazardous Substances Data Bank.

# Additional Resources

## ***Standards***

Respiratory Protection Standard 29 CFR 1910.134

[http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=12716](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716))

Respiratory Protection Standard—Appendix A (Fit Test Procedures)

[http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=9780](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9780))

Hazard Communication Standard 29 CFR 1910.1200

[http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=10099](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099)

Sanitation Standard (General Industry) 29 CFR 1910.141

[http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=9790](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9790)

## ***Sample Programs***

Hazard Communication

[http://www.nclabor.com/osha/consult/sample\\_programs.htm](http://www.nclabor.com/osha/consult/sample_programs.htm)

Respiratory Protection

[http://www.nclabor.com/osha/consult/sample\\_programs.htm](http://www.nclabor.com/osha/consult/sample_programs.htm)

## ***Operating Documents***

Inspection Procedures for the Respiratory Protection Standard CPL 02-00-120

[http://www.osha.gov/OshDoc/Directive\\_pdf/CPL\\_2-0\\_120.pdf](http://www.osha.gov/OshDoc/Directive_pdf/CPL_2-0_120.pdf)

Recordkeeping Policies and Procedures Manual CPL 02-00-135

[http://www.osha.gov/OshDoc/Directive\\_pdf/CPL\\_02-00-135.pdf](http://www.osha.gov/OshDoc/Directive_pdf/CPL_02-00-135.pdf)

Inspection Procedures for the Hazard Communication Standard CPL 02-02-038

[http://www.osha.gov/OshDoc/Directive\\_pdf/CPL\\_2-2\\_38D.pdf](http://www.osha.gov/OshDoc/Directive_pdf/CPL_2-2_38D.pdf)

## ***Publications***

Hazard Alert: 1-Bromopropane

[http://www.nclabor.com/osha/etta/hazard\\_alerts/1-Bromopropane.pdf](http://www.nclabor.com/osha/etta/hazard_alerts/1-Bromopropane.pdf)

## ***Other Agency Information***

NIOSH Respiratory Protection Subject Index Page

<http://www.cdc.gov/niosh/npptl/topics/respirators/>

Environmental Protection Agency Significant New Alternatives Policy (SNAP)

<http://www.epa.gov/ozone/snap>

# Appendix A

## Sample Safety and Health Program for the Occupational Exposure to 1-Bromopropane

This program has been implemented to ensure employees are not overexposed to 1-bromopropane. It will be reviewed annually and updated to reflect changes to the company's procedures and policies.

1-Bromopropane (1-BP) can harm the reproductive system and the nervous system. It can damage the nerves, causing weakness, pain, numbness, and paralysis. 1-BP is a colorless solvent with a sweet smell. It can be in liquid or spray form and is used in dry cleaning, vapor decreasing, auto parts cleaning, spray adhesive applications, and electronic parts manufacturing.

### *Engineering Controls and Work Practices*

The following engineering controls and work practices have been implemented:

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### *Regulated Areas, Signs and Labels*

We will regulate the work areas where 1-BP is used. These regulated areas will be limited to authorized employees only and will be marked with signage. The signs will bear the following legend:

**DANGER  
1-BROMOPROPANE  
PROTECTIVE CLOTHING IS REQUIRED IN  
THIS AREA  
AUTHORIZED PERSONNEL ONLY**

All 1-BP containers and pipes will have labels. Safety data sheets will be available in the work area.

### *Preventive Maintenance*

Preventive maintenance will be conducted on the ventilation systems as recommended by the manufacturer. This schedule is as follows:

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Air filters will be replaced on the following schedule:

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## ***Personal Protective Equipment***

Employees will be provided with appropriate personal protective equipment (PPE), which will include:

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All employees will be required to wear the appropriate PPE in the regulated area. The PPE will be cleaned and inspected daily and before each use. Any equipment found to be defective will be turned in to the supervisor for repair or disposal and new equipment will be provided. All employees will be trained on the use of PPE.

Employees required to wear respirators will be trained and fit-tested initially and annually per the respirator program. Refer to the respirator program for specific requirements.

## ***Signs and Symptoms of Overexposure***

- Irritated eyes, nose, throat or respiratory tract.
- Confusion, dizziness, tiredness, an irregular heart rate.
- Poor coordination, trouble walking or talking.
- Numb hands or feet.

## ***First Aid and Emergency Response***

### **Eye Contact**

- Immediately flush with large amounts of water for at least 15 minutes, lifting upper and lower lids. Remove contact lenses, if worn, when rinsing.

### **Skin Contact**

- Remove contaminated clothing and wash contaminated skin with soap and water.

### **Inhalation**

- Remove the person from exposure.
- If properly trained, begin rescue breathing (using universal precautions) if breathing has stopped and CPR if heart action has stopped.
- Transfer promptly to medical facility.

### **Spills**

- Call 911 and HazMat.
- Immediately evacuate all personnel.
- Secure and control entrance to facility.
- Eliminate nearby ignition sources.

### **Emergency Numbers**

Poison Control: 1-800-222-1222

CHEMTREC: 1-800-424-9300

National Response Center: 1-800-424-8802

## ***Exposure Monitoring***

1-BP is currently an unregulated chemical. However, to help ensure that our employees are not overexposed to 1-BP, we will conduct initial and periodic monitoring to determine employee exposure. Determination of employee exposure will be made from breathing zone air samples that are representative of the 8-hour TWA and 15-minute short-term exposures of each employee.



Employees will be provided the monitoring results within 15 working days after receipt of results. If requested, employees will be allowed to observe exposure monitoring.

As a reference for exposure levels, we will follow the guidance provided by the American Conference of Governmental Industrial Hygienists (ACGIH), which recommends the following over an 8-hour workshift:

- 0.1 parts per million (PPM) threshold limit value (TLV)
- 0.5 mg/m<sup>3</sup> time-weighted average (TWA)

Please note that the Environmental Protection Agency (EPA) recommends an 8-hour time weighted average (TWA) of 25 PPM.

### ***Medical Surveillance***

If an employee is exposed to 1-BP at or above the TLV or TWA action level, they will be provided with medical examinations and consultations at no expense to the employee. The examinations will be provided prior to an assignment where exposure will occur and annually thereafter. If required by a physician, the examinations may occur more frequently.

The following tests should be conducted and information collected initially and annually:

- History of exposure to 1-BP
- Presence of tingling or numbness in extremities
- Liver function tests
- Urinalysis

If symptoms develop or overexposure is suspected, the following should be conducted:

- Detailed examination of the nervous system

The physician will provide a written opinion containing the results of the medical examination and any recommended limitations on the employee or on the use of PPE. No specific findings or diagnoses unrelated to 1-BP exposure will be given in the written opinion. The employee will be provided with a copy of the written opinion within 15 days of its receipt.

### ***Training and Information***

Employees will be trained at the time of their initial assignment and annually thereafter. Training will include:

- Recommended exposure limits for 1-BP
- Operations where 1-BP is present
- Safe work practices
- Medical surveillance
- PPE
- Physical and health hazards
- Methods and observations
- Emergency procedures
- Hazard communication

### ***Recordkeeping***

Medical and exposure records will be maintained per 29 CFR 1910.1020. Exposure records will be maintained for 30 years. Medical surveillance records will be maintained for the duration of employment plus 30 years. Employees will be provided these records upon request.

# Appendix B

## Sampling Information

### ***Laboratory Sampling/Analytical Method:***

**Sampling media:** Coconut shell charcoal (CSC) tube (6-mm o.d., 100/50-mg sections)

**Analytical solvent:** (99:1) Carbon disulfide (CS<sub>2</sub>): Dimethylformide (DMF)

**Maximum volume:** 12 Liters

**Maximum flow rate:** 0.1 L/min

**Maximum time:** 120 Minutes

**Current analytical method:** Gas chromatography; GC/FID

**Method reference:** OSHA Analytical Method (OSHA PV2061)

**Method classification:** Partially Validated

## **OSH Publications**

We provide a variety of OSH publications. These include general industry and construction regulations, industry guides that cover different OSH topics, quick cards, fact sheets and brochures that cover a wide variety of serious safety and health workplace hazards. Workplace labor law posters are available free of charge. To obtain publications, call toll free at 1-800-NC-LABOR (1-800-625-2267) or direct at 919-807-2875. You may view the list of publications and also download many of them at **[www.nclabor.com/pubs.htm](http://www.nclabor.com/pubs.htm)**.

# Occupational Safety and Health (OSH)

## Sources of Information

You may call 1-800-NC-LABOR (1-800-625-2267) to reach any division of the N.C. Department of Labor; or visit the NCDOL home page on the World Wide Web: <http://www.nclabor.com>.

### Occupational Safety and Health Division

Mailing Address:  
1101 Mail Service Center  
Raleigh, NC 27699-1101  
Local Telephone: 919-807-2900 Fax: 919-807-2856

Physical Location:  
111 Hillsborough St.  
(Old Revenue Building, 3rd Floor)

*For information concerning education, training, interpretations of occupational safety and health standards, and OSH recognition programs contact:*

### Education, Training and Technical Assistance Bureau

Mailing Address:  
1101 Mail Service Center  
Raleigh, NC 27699-1101  
Telephone: 919-807-2875 Fax: 919-807-2876

Physical Location:  
111 Hillsborough St.  
(Old Revenue Building, 4th Floor)

*For information concerning occupational safety and health consultative services contact:*

### Consultative Services Bureau

Mailing Address:  
1101 Mail Service Center  
Raleigh, NC 27699-1101  
Telephone: 919-807-2899 Fax: 919-807-2902

Physical Location:  
111 Hillsborough St.  
(Old Revenue Building, 3rd Floor)

*For information concerning migrant housing inspections and other related activities contact:*

### Agricultural Safety and Health Bureau

Mailing Address:  
1101 Mail Service Center  
Raleigh, NC 27699-1101  
Telephone: 919-807-2923 Fax: 919-807-2924

Physical Location:  
111 Hillsborough St.  
(Old Revenue Building, 2nd Floor)

*For information concerning occupational safety and health compliance contact:*

### Safety and Health Compliance District Offices

**Raleigh District Office** (3801 Lake Boone Trail, Suite 300, Raleigh, NC 27607)  
Telephone: 919-779-8570 Fax: 919-420-7966

**Asheville District Office** (204 Charlotte Highway, Suite B, Asheville, NC 28803-8681)  
Telephone: 828-299-8232 Fax: 828-299-8266

**Charlotte District Office** (901 Blairhill Road, Suite 200, Charlotte, NC 28217-1578)  
Telephone: 704-665-4341 Fax: 704-665-4342

**Winston-Salem District Office** (4964 University Parkway, Suite 202, Winston-Salem, NC 27106-2800)  
Telephone: 336-776-4420 Fax: 336-767-3989

**Wilmington District Office** (1200 N. 23rd St., Suite 205, Wilmington, NC 28405-1824)  
Telephone: 910-251-2678 Fax: 910-251-2654

\*\*\*To make an OSH Complaint, **OSH Complaint Desk:** 919-807-2796\*\*\*

*For statistical information concerning program activities contact:*

### Planning, Statistics and Information Management Bureau

Mailing Address:  
1101 Mail Service Center  
Raleigh, NC 27699-1101  
Telephone: 919-807-2950 Fax: 919-807-2951

Physical Location:  
111 Hillsborough St.  
(Old Revenue Building, 2nd Floor)

*For information about books, periodicals, vertical files, videos, films, audio/slide sets and computer databases contact:*

### N.C. Department of Labor Library

Mailing Address:  
1101 Mail Service Center  
Raleigh, NC 27699-1101  
Telephone: 919-807-2850 Fax: 919-807-2849

Physical Location:  
111 Hillsborough St.  
(Old Revenue Building, 5th Floor)

### N.C. Department of Labor (Other than OSH)

1101 Mail Service Center  
Raleigh, NC 27699-1101  
Telephone: 919-733-7166 Fax: 919-733-6197