

Evaluation of Occupational Exposures at a Drycleaning Shop Using SolvonK4

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from the managers of a drycleaning shop. The request concerned potential occupational exposures to the drycleaning solvent SolvonK4.

What We Did

- We evaluated the drycleaning shop in May 2014.
- We took air samples for butylal, the main ingredient in SolvonK4. We also took air samples for formaldehyde and butanol. These chemicals can be produced by SolvonK4.
- We measured temperature and relative humidity to learn about the risk for illnesses from the heat.

What We Found

- We found butylal in the personal air samples from employees.
- We did not find formaldehyde or butanol in the personal air samples.
- We saw employees spraying and brushing pretreatment solutions onto fabrics. The employees did not wear gloves or eye protection.
- We saw dust and lint in the shop. This can be a source of fuel if there is a fire.

We evaluated a drycleaning shop because of concerns about occupational exposures to SolvonK4. There are no occupational exposure limits for this chemical. Formaldehyde and butanol, potential byproducts of SolvonK4, were not found in the workplace air. We recommended improvements to work practices, housekeeping, equipment maintenance, and personal protective equipment use.

What Managers Can Do

- Train employees to pour and brush pretreatments onto fabrics instead of spraying.
- Inspect and maintain the drycleaning machine according to the manufacturer's recommendations.
- Clean the shop regularly with a high efficiency particulate air (HEPA) vacuum cleaner or a wet mop.
- Provide eye protection and chemical resistant gloves.

What Employees Can Do

- Wear eye protection and chemical resistant gloves while pretreating fabrics.
- Wash hands or exposed skin with soap and water after contact with chemicals.
- Wash hands after removing gloves.

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
MDC	Minimum detectable concentration
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
PPE	Personal protective equipment
ppm	Parts per million
SDS	Safety data sheet
TLV®	Threshold limit value
TWA	Time-weighted average
WEEL™	Workplace environmental exposure level

Introduction

The Health Hazard Evaluation Program received a request from managers of a drycleaning shop using SolvonK4™. We visited the drycleaning shop in May 2014. We observed work processes and practices and collected personal and area air samples for drycleaning solvents and other chemicals produced or used during drycleaning. We sent the managers and employees the results and preliminary recommendations in June and September 2014. We translated these letters to Korean and Spanish, the first language of the employees.

SolvonK4

The drycleaning SYSTEMK4 developed by Kreussler GmbH uses SolvonK4, a chemical that contains primarily butylal (> 99%), with small amounts of n-butanol (< 0.5%) and formaldehyde (< 0.05%) [Kreussler USA 2011]. Synonyms for butylal include dibutoxymethane, 1-(butoxymethoxy)butane, and formaldehyde dibutyl acetal. The Chemical Abstract Service number is 2568-90-3. With a flash point of 143.6°F, SolvonK4 is a solvent categorized by the National Fire Protection Association as Class IIIA (i.e., flash point at or above 140°F and below 200°F).

Drycleaning Process

The shop had one SolvonK4 drycleaning machine that was operated and maintained by one of the two shop owners. Information on SolvonK4, occupational exposure limits, and known health effects is in Appendix A. The shop also had a commercial washing machine that used water and detergent for laundering fabrics.

Fabrics, including clothes, drapes, and other textiles, were received from customers, labeled, and sorted for cleaning. Prior to drycleaning, some stained fabrics were pre-cleaned or spot cleaned. The shop used several spot-cleaning agents including a custom mixture of 40% SolvonK4, 40% PrenettK4™, and water (Figure 1) or undiluted Greased Lightning® Super Strength cleaning product. The drycleaning machine cleaned fabrics by saturating them with SolvonK4 in enclosed drums. The cleaning cycle was 70 to 80 minutes. Cleaning additives (e.g., ClipK4™ detergent and PrenettK4 spotting agent) were automatically injected into the solvent flow line or into the drum of the drycleaning machine. At the end of the cleaning cycle, the solvent was automatically removed by draining and then heating and tumbling the cleaned fabrics under vacuum to remove any that remained. Employees manually spot-cleaned fabrics that were still stained or soiled after drycleaning with the same products used in precleaning. Employees pressed the cleaned fabrics (Figure 2) and ironed as needed, then hung them on hangers covered with plastic wrapping while awaiting customer pick-up or delivery.



Figure 1. Employee spraying shirts with a SolvonK4 pretreating solution before drycleaning. Photo by NIOSH.



Figure 2. Employee using two pressing machines in series. Photo by NIOSH.

The drycleaning machine is designed to minimize the release of solvent vapors to ambient air by recycling the solvent in a closed-loop system and automatically evacuating the air in the cleaning chamber before being opened to remove the cleaned fabrics. The machine generates a concentrated waste material called “still bottoms” that contains residual solvent in addition to nonvolatile components, such as detergent, sizing, waxes, oils, and greases. Cleaning of the still bottoms occurs after the drycleaning machine has cooled (usually overnight). The owner used a specially designed rake to transfer the still bottoms to a waste container each week.

Shop Description

The shop was staffed by 10 full-time employees and two owners. The first language of the owners, two pressers, three tailors, and one cashier was Korean. The first language of the remaining four pressers was Spanish. The business operated 7 a.m. to 7 p.m. Monday through Saturday, but drycleaning activities usually started earlier, depending on the forecasted temperature and anticipated workload. The pressers worked from 6 a.m. until they completed pressing for the day. Each presser worked at one of the six pressing stations for the entire shift. The tailors worked from 12 p.m. to approximately 6 p.m. The store was approximately 24 feet × 99 feet × 10 feet. Although the shop had heating and air-conditioning, employees or the owner opened the front and back doors in the shop to provide general dilution ventilation, as needed. The shop had a 60-pound capacity FIRBIMATIC drycleaning machine installed more than 2 years before our visit. The SolvonK4 had not been completely replaced since the drycleaning machine was first installed; however, the owner added SolvonK4 approximately every 3 months. The shop drycleaned 20–40 loads per week. During our visit, five drycleaning loads were cleaned each day.

Methods

The objectives for this evaluation were the following:

1. Assess potential occupational exposures to SolvonK4, formaldehyde, and butanol during drycleaning.
2. Determine whether employees were at risk of heat-related illnesses.
3. Identify other potential health and safety hazards at the shop.

Bulk Analysis

We took a bulk sample of SolvonK4 from the shop and evaluated it for chemical composition using methods described in Table 1. The bulk sample was stored in a 40-milliliter glass vial wrapped in aluminum foil and transported on ice. The bulk sample was analyzed by gas chromatography with a gas chromatography-mass spectrometry detector and gas chromatography-flame ionization detector and compared to a butylal standard (TCI America, Lot# FIE01, purity 98%) using a custom method [NIOSH 2014a] to determine butylal content.

Table 1. Air sampling methods used during the evaluation

Substance	Rationale for sampling	Sampling method
Butylal	Main ingredient in SolvonK4	Custom method, described in [NIOSH 2014a]
Formaldehyde	Potential breakdown product when SolvonK4 is in use	OSHA 52*
Butanol	Potential breakdown product when SolvonK4 is in use	NIOSH 1401†

NIOSH = National Institute for Occupational Safety and Health

OSHA = Occupational Safety and Health Administration

*Following OSHA sampling and analytical method [OSHA 2014a].

†Following NIOSH Manual of Analytical Methods [NIOSH 2014b].

Air Sampling

We took personal and area air samples for butylal, formaldehyde, and butanol using the methods listed in Table 1. Personal air samples were taken on three presser employees and the two owner/operators. We took full-shift personal air samples for butylal, formaldehyde, and butanol, as well as task-based personal air samples for butylal and butanol.

We compared the results for the full-shift personal sampling to occupational exposure limits (OELs), when available (Table 2).

Table 2. Full-shift occupational exposure limits (in ppm) for measured substances in SolvonK4

Substance	NIOSH REL	OSHA PEL	ACGIH TLV
Butylal	None	None	None
Formaldehyde	0.016*	0.75	0.3†
Butanol	50	100	20

ACGIH = American Conference of Governmental Industrial Hygienists

PEL = Permissible exposure limit

ppm = parts per million

REL = Recommended exposure limit

TLV = Threshold limit value

*NIOSH considers formaldehyde to be a potential occupational human carcinogen.

†Ceiling level that should not be exceeded at any time during the workday.

Temperature and Relative Humidity Measurements

We measured air temperature and relative humidity by using HOBO H08-032-IS Pro Series RH/Temperature Data Loggers in the pressing area, the break area at the back of the shop, and near the drycleaning machine. Using these temperature and relative humidity measurements, we calculated a heat index [NOAA 2014] and compared our data with OSHA guidelines for heat illness prevention [OSHA 2014b]. These guidelines group occupational heat exposure risk into the following four categories:

- lower (heat index below 91°F)
- moderate (heat index between 91°F and 103°F)
- high (heat index between 103°F and 115°F)
- very high or extreme (heat index > 115°F).

Other Measurements and Observations

We toured the drycleaning shop and observed work processes, practices, and use of personal protective equipment (PPE). We checked the shop's ventilation with a TSI Model 8386 VelociCalc® Multi-Function Ventilation Meter. We did not observe or sample during the still bottom cleaning during our visit.

Results and Discussion

Bulk Sample

Bulk analysis of SolvonK4 revealed that this solvent contained more than 99% butylal, 0.05% butanol, and less than 0.00045% formaldehyde. These results were consistent with the information reported by the manufacturer [Kreussler USA 2010, 2011].

Air Sampling

Results of our personal air sampling for butylal are shown in Tables 3 and 4.

Table 3. Full-shift personal breathing zone air sample results for butylal, May 2014

Day	Employee	Sample duration (minutes)*	Main work tasks	Concentration (ppm)
1	1	418	Pressing	0.23
	2	408	Pressing	0.14
	3	464	Loading, unloading, and prespotting†	0.67
	4	346	Pressing	0.14
	5	330	Pressing	0.34
2	1	426	Prespotting‡, pressing and hanging	0.32
	2	528	Pressing	0.15
	3	615	Loading, unloading, and prespotting†	0.83
	5	411	Pressing	0.15

*Sample durations varied because employees left as soon as they finished the tasks for the day.

†Employee used SolvonK4-based prespotting solution.

‡Employee used Greased Lightning prespotting solution.

Table 4. Task-based personal breathing zone air sample results for butylal, May 2014

Day	Employee	Task duration (minutes)	Work task	Concentration (ppm)
1	3	23	Unloading, loading, prespotting*	0.57
2	1	23	Hanging and pressing	1.8
	1	20	Hanging and pressing	0.42
	3	21	Pouring SolvonK4, loading, unloading	0.81
	3	21	Unloading, loading, and prespotting*	1.9
	3	21	Unloading, loading, and prespotting*	1.1

*Employee used SolvonK4-based prespotting solution.

Butylal concentrations ranged from 0.14 to 0.83 ppm in the full-shift personal breathing zone air samples (Table 3) and from 0.42 to 1.9 ppm in the task-based breathing zone air samples (Table 4). The highest butylal concentrations in full-shift samples were found for the employee unloading and loading fabrics into and from the drycleaning machine and for spraying and brushing a SolvonK4 containing prespotting solution onto fabrics.

We did not detect formaldehyde or butanol in full-shift personal air samples. For full-shift samples, the minimum detectable concentrations (MDCs) ranged from 0.007 to 0.01 ppm for formaldehyde and from 0.003 to 0.008 ppm for butanol. We did not detect butanol in task-based personal air samples.

Kreussler reports that SolvonK4 is chemically stable in conditions ranging from very acidic (pH 4) to very basic (pH 14). However, this solvent may react with water in the presence of heat and acid to release formaldehyde and butanol [Kreussler USA 2011]. The shop owner added an acid neutralizer to the still after removing the still bottoms waste. On the basis of our air sample results this neutralizer likely helped prevent SolvonK4 from releasing butanol and formaldehyde.

Table 5 shows the area air concentrations of butylal, n-butanol, and formaldehyde. We found measureable butylal concentrations throughout the shop. We did not find n-butanol or formaldehyde in area air samples.

Table 5. Full-shift area air sample results, May 2014

Day	Area	Butylal concentration (ppm)	n-Butanol concentration (ppm)	Formaldehyde concentration (ppm)
1	Front desk	NS	NS	NS
2		0.18	ND	ND
1	Press area	0.21	ND	ND
2		0.12	ND	ND
1	Dry cleaner	0.19	ND	ND
2		0.19	ND	ND

NS = not sampled

ND = not detected (below the MDC of 0.005 ppm for n-butanol and 0.008 ppm for formaldehyde).

Temperature and Relative Humidity Measurements

During the 2 days of our visit, the temperatures inside the shop ranged from 78°F to 104°F and the relative humidity ranged from 21%–57%. It was warmest in the pressing areas of the shop. Comparing the heat indices we calculated at the sampling locations to the OSHA guidelines for heat illness prevention, we noted that the risk of heat-related illness varied throughout the work day. The risk was low in the morning and high in the early and late afternoon, but for only a few hours.

Cool drinking water was available at all times from a dispenser in the break area. We saw employees drinking water during breaks and at lunch. The owners did not specify what type of clothing employees could wear at work and during our visit employees in the pressing area wore shorts and light-weight short-sleeved shirts. On days forecasted to be warm employees started their shift early and the air-conditioning was turned on when the drycleaning machine was not operating to reduce the risk for heat-related illness.

On the basis of our measurements and observations, we suggest that employees and employers be aware of signs and symptoms of heat-related illness and continue to take steps to prevent heat illness. This is especially true on days forecasted to have a heat index of greater than 91°F, when the risk of heat-related illness is considered to be high. Because we visited the shop in mid-spring when the outdoor temperatures and relative humidities were mild, we expect that the risk for heat-related illness would be higher in the hotter summer months.

Observations

We observed the owner/operator spraying the SolvonK4-based spotting cleaner from an unlabeled bottle onto fabrics without wearing gloves and safety glasses. After spraying the

spot cleaner he brushed the fabric and blew compressed air onto the treated area. According to the safety data sheet (SDS) for SolvonK4, employees should wear eye protection and polyvinyl chloride or polyethylene gloves [Kreussler USA 2010, 2011] when spraying this product. Because SolvonK4 is a combustible liquid [Kreussler USA 2011], spraying may create a fire hazard. The shop did not have an emergency eyewash station in case of accidental exposure to the eye.

Employees used other spot cleaners without appropriate personal protective equipment. According to the SDS for the Greased Lightning product, employees should wear eye protection and rubber protective gloves [HomeCare Labs 2014] because this product can cause burns and irritation of the eyes and skin.

For loading and unloading clothes, the operator wore a latex-free Kimberly-Clark Tecnol Procedure mask that was reused throughout the day. During the day the operator hung the mask on the drycleaning machine between loading and unloading tasks. The owner explained that the mask was worn for protection from dust released when unloading clothes. We did not see any other employees wearing masks.

We saw accumulated dust in the shop that could contain fabric lint containing organic material. Lint can be a source of fuel if a fire is present [OSHA 2014c]. The owners stated that the floors were cleaned weekly with a vacuum that was not equipped with a high efficiency particulate air filter.

The recirculating heating and air-conditioning system was a residential style air-handling system and was about 2 years old. While the drycleaning machine was operating, the thermostat was set to “fan only” and shop doors were opened to provide additional ventilation. When the drycleaning machine was turned off the owner turned the air-conditioning system on and closed the shop doors for the remainder of the work day.

We noted a SolvonK4 odor near the operating drycleaning machine. Employees told us that the odor was stronger during the first months of operation, but lessened after the drycleaning machine underwent its first routine maintenance.

Conclusions

We measured the highest full-shift air concentrations of butylal, the main ingredient of SolvonK4, on the operator unloading and loading the drycleaning machine and spraying and brushing the fabric with a SolvonK4-based prespotting solution. There are no occupational exposure limits for butylal. We saw potential for skin exposure to employees spraying and brushing SolvonK4-based prespotting agents. The long-term human health effects of SolvonK4 are unknown. Formaldehyde and butanol, potential breakdown products, were not found in the personal air samples.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the shop to use a labor-management health and safety committee or working group to discuss

our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation. We encourage the shops to contact the state's occupational safety and health consultation group if assistance is needed in implementing these recommendations.

Our recommendations are based on an approach known as the hierarchy of controls. This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and PPE may be needed.

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Install an emergency eyewash station.
2. Pour and brush the pre-spotting mixture onto fabric instead of spraying it on the fabric.

Administrative Controls

The term administrative controls refer to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Label containers used for storing chemicals. OSHA requires all containers to be labeled with their contents.
2. When the heat index is high, follow the guidance in the OSHA Fact Sheet: Protecting Employees from the Effects of Heat.

http://www.osha.gov/OshDoc/data_Hurricane_Facts/heat_stress.pdf

Additional recommendations to prevent heat-related illness (English, Spanish, and Korean) can be found at:

<http://www.cdc.gov/niosh/docs/2010-114/pdfs/2010-114.pdf>

<http://www.osha.gov/SLTC/heatillness/index.html>

http://www.cdc.gov/spanish/niosh/docs/2010-114_sp/

http://www.osha.gov/SLTC/heatillness/spanish/index_sp.html

http://www.bepreparedcalifornia.ca.gov/ResourcesAndLinks/Languages/Documents/Korean/KO_HeatIllness.pdf

3. Use a vacuum equipped with a high efficiency particulate air filter or use wet methods to clean the shop. Avoid dry sweeping.
4. Inspect and maintain the drycleaning machine regularly per the manufacturer's recommendations.

Personal Protective Equipment

PPE is the least effective means for controlling hazardous exposures. Proper use of PPE requires a comprehensive program and a high level of employee involvement and commitment. The right PPE must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment may be needed. PPE should not be the sole method for controlling hazardous exposures. PPE should be used until effective engineering and administrative controls are in place.

1. Wear gloves and eye protection (safety glasses or safety goggles) when using spot cleaners. When using spot cleaners containing SolvonK4 wear a long sleeve shirt and polyvinyl chloride or polyethylene gloves. For other chemicals refer to the manufacturer's SDS.
2. Do not use a surgical mask to protect against inhaling dust in the air. Surgical or procedure masks are not considered respiratory protection because they do not provide a tight seal to the face. Dust particles can easily move through the gaps in the mask. If protection against dust particles is desired, employers may allow employees to voluntarily use NIOSH-approved respirators when they are not required by OSHA. This includes the use of N95 filtering facepiece respirators that provide protection against dust particles. If the employer allows voluntary respirator use, the OSHA requirements for voluntary use of respirators in 29 CFR 1910.134 must be followed, including the provision of Appendix D to employees who voluntarily use the respirators (<https://www.osha.gov/SLTC/etools/respiratory/voluntaryuses.html>).

Appendix A: Occupational Exposure Limits and Health Effects

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a time-weighted average (TWA) exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limit or ceiling values. Unless otherwise noted, the short-term exposure limit is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH recommended exposure limits are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2014c]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Other OELs commonly used and cited in the United States include the TLVs, which are recommended by ACGIH, a professional organization, and the workplace environmental exposure levels (WEELs), which are recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. These OELs are not consensus standards. TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others

trained in this discipline “to assist in the control of health hazards” [ACGIH 2014]. WEELs have been established for some chemicals “when no other legal or authoritative limits exist” [AIHA 2014].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at <http://www.dguv.de/ifa/Gefahrstoffdatenbanken/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp>, contains international limits for more than 1,500 hazardous substances and is updated periodically.

OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91–596, sec. 5(a)(1))]. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) PPE (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health. Control banding focuses on how broad categories of risk should be managed. Information on control banding is available at <http://www.cdc.gov/niosh/topics/ctrlbanding/>. This approach can be applied in situations where OELs have not been established or can be used to supplement existing OELs.

SolvonK4

Little toxicity information is available for butylal [NYSDEC 2011], the main ingredient in SolvonK4. Only acute toxicity studies focused on dermal and oral exposures have been published [NYSDEC 2011]. In an assessment of safer alternatives to perchloroethylene in drycleaning, the Toxics Use Reduction Institute concluded that toxicological data are lacking for some of the alternatives – particularly the new acetal-based system like SolvonK4 – making the human health assessment incomplete [TURI 2012].

Kreussler GmbH reported low toxicity of butylal on the basis of studies in which animals were exposed via ingestion and through the skin [Kreussler USA 2011]. Kreussler suggests that the risk for airborne exposure to butylal at drycleaning shops should be low because this solvent has a low vapor pressure, meaning that it does not quickly evaporate at room

temperature [Kreussler USA 2011]. In a long-term inhalation study researchers observed no adverse effects in rats after exposing them to 478 ppm butylal over 13 weeks [REACH 2014]. We are not aware of any studies that have evaluated respiratory sensitization or long-term inhalation exposures to butylal in humans. No toxicological data are available to characterize central nervous system effects or other target organ effects, reproductive or developmental toxicity, or other chronic health effects.

Kreussler states that butylal is not a skin sensitizer or skin or eye irritant from short-term exposures [Kreussler USA 2011]. We are not aware of any studies that have evaluated longer duration exposures from ingestion or through skin contact. The Local Hazardous Waste Management Program in King County, Washington (LHWMP) determined that SolvonK4 exhibited lower toxicity to fish than perchloroethylene [LHWMP 2013]. The European Union has not classified butylal in the Registration, Evaluation, Authorization and Restriction of Chemicals program. However, the European Chemical Agency has listed butylal as causing skin irritation [ECHA 2013].

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Keywords: North American Industry Classification System 812320 (Drycleaning and Laundry Services [except Coin-Operated]), Virginia, drycleaning solvents, alternative drycleaning solvents, SolvonK4, butylal, Chemical Abstract Service 2568-90-3, butanol, formaldehyde, Hispanic employees, Korean, Spanish, ventilation, thermal comfort

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Availability of Report

Copies of this report have been sent to the employer and employees at the facility. The state and local health department and the Occupational Safety and Health Administration Regional Office have also received a copy. This report is not copyrighted and may be freely reproduced.

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