

PERC Ban among Dry Cleaners Leads to 1-Bromopropane Exposures with Alternative “Green” Solvent

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Background: Regulatory

- NJDEP and several other states consider ban on PERC in dry cleaning
 - Incorporated into plan for compliance with CAA title – Ozone Depleting Substances
 - Air Toxics issue
- Products containing 1-bromopropane are marketed to dry cleaning industry as “green”, “organic”, and “non-hazardous”
- Users assume that “green” means “non-toxic”

Background: 1-BP

- Unregulated chemical
- Non-ozone depleting
 - EPA SNAP program
- Already used in degreasing, metal working, solvent for resins/wax/fats, and spray adhesive operations
- Use increasing, 3% growth per year
 - 4.5 million pounds used in US in 2000
- Estimate that when PERC ban occurs, there will be 1500 dry cleaners in NJ that will convert their machines

Economic Drivers

- 1-BP products are “drain and drop”
- 1-BP is cheapest capital investment alternative if PERC is banned
- 1-BP conversion costs are less than 5 K; whereas a new non-PERC machine is > 40 K capital investment
- 1-BP solvent products are approximately \$45 gallon versus PERC at \$16 gallon (\$6 gallon product plus \$10 disposal)

Background: Health Effects

- Limited health effect testing exists for 1-BP
 - Several animal toxicity studies
 - No epidemiology
 - Several clinical case series exist
- Past studies raised concerns about 2-BP; which lead to substitution with 1-BP.
- Infamous dibromochloropropane (DBCP) cases of male infertility among pesticide production workers in the late 70's

Background: Health Effects

- **Several Case Series**
 - Metal workers, degreasers, 1-BP production, spray adhesive users in furniture making
 - Similar presentation in emergency care:
 - headache, nausea, subacute spastic paraparesis (i.e. weakness) with distal sensory loss, loss of balance, unsteady gait while walking, numbness, and dizziness
 - Long lasting effects including falling, having difficulty walking, pain, and showing signs of permanent nerve damage affecting their lower extremities

Background: Health Effects

- Animal Toxicity Studies
- Inhalation studies
 - Neurological effects including nerve damage, limb weakness
 - Reproductive effects including abnormal sperm and reduced sperm counts
 - NTP reports repro tox studies by WIL Research Labs and Ichihara et al found sperm abnormalities after acute inhalation exposures at ~400 ppm nose only exposure
- Dermal route?

Index Case

- male dry cleaner reports to ED
 - Sx headache, nausea, dizziness, slight tremors, and malaise in February 2008
 - Conversion of PERC machine to 1-BP containing solvents
 - Cleaning machine, manually charging 50 – 60 gallons through front hatch
 - Neglected to change machine settings from PERC
 - Needed Lower steam pressure (1/10th) to evaporator of still
 - Needed higher water flow to condenser
 - Had leaky valve
- Noted degreaser in Pennsylvania also severely and permanently disabled by use of 1-BP

Investigation

- Visited 5 different dry cleaning operators using 1-BP solvents
 - Small shops with 1 – 4 workers
- Collected personal and area samples
- Evaluated ventilation
 - Hot-wire anemometer
 - Smoke tube
- Recorded Video Exposure Monitoring (VEMs) footage
- Data-logged PID measurements for VEM
- Benchmarked against ACGIH TLV of 10 ppm

Air Sampling and Analysis

- **NIOSH method 1025**
 - Sampling at 200 cc/min
 - Media – Solid Sorbent tube (SKC Anasorb CSC 100/50 mg)
 - Analysis by GC-FID; capillary column
 - Method partially validated
 - Modification to separate 1-BP from 2-BP; oven temp was 150°C and programmed temp ramp of 15°C/min
- **Video Exposure Monitoring (VEM)**
synchronizes video with real time TVA
Photo-ionization detector (PID)
 - Calibrated to isobutylene because permeation tube of 1-BP not available

Personal Exposure Data

Shop	Job Title	9/22/08	2/9/09	3/16/09	3/23/09
1	Operator	54.55	42.13	18.77	12.7
	Clerk	12.82	21.85	8.31	11.31
2	Operator	X	41.64	X	X
	Clerk	X	0.65	X	X
3	Operator	X	0.24	ND	0.35
	Seamstress	X	ND	X	X

ND = not detected (<0.002 mg per Anasorb tube)

X = not sampled

Note: results in ppm for 1-BP as 8-hour TWAs

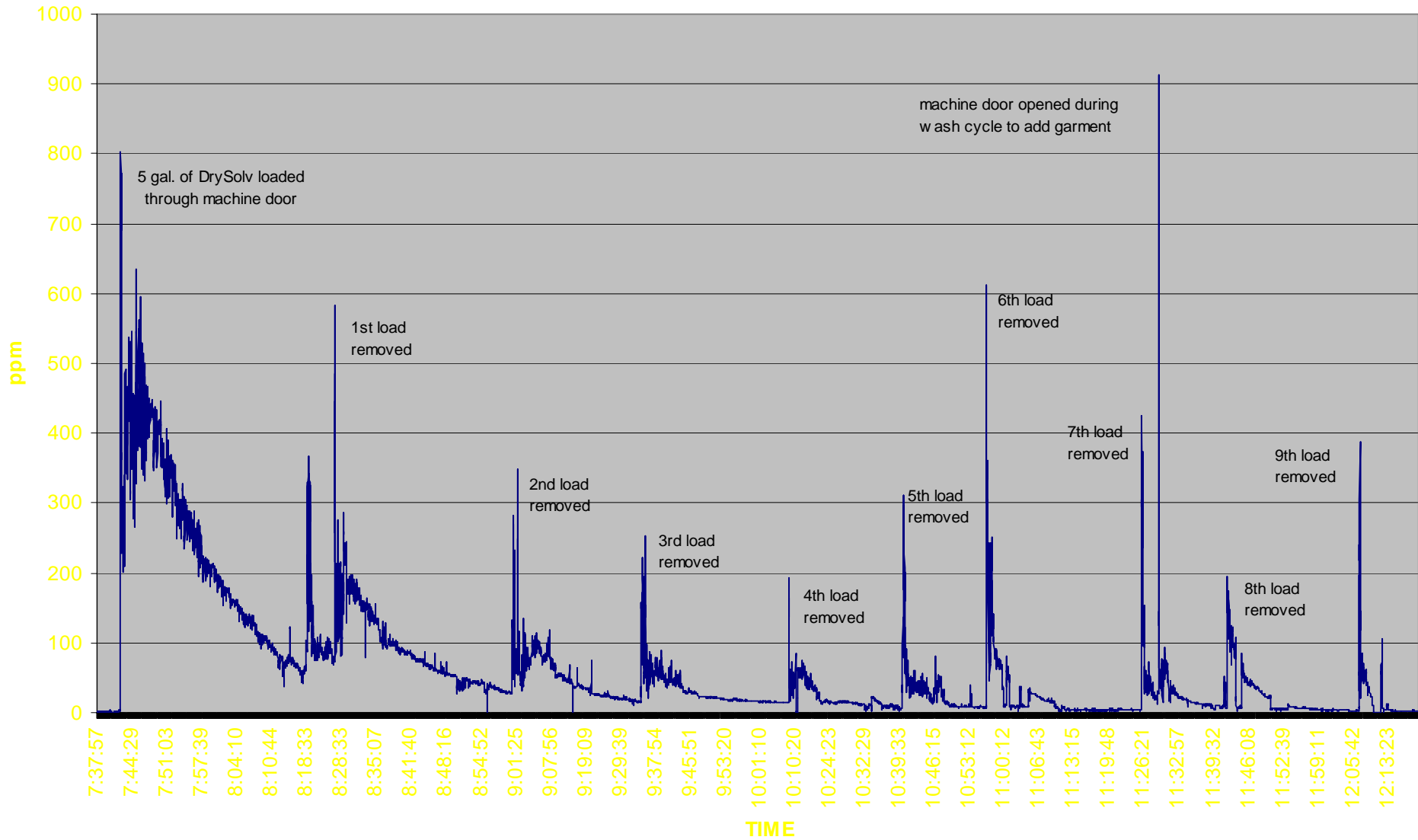
Exposure Results

- ACGIH TLV for 1-BP = 10 ppm
- Exposures to operators ranged from non-detect to 54 ppm for 8 hour time weighted average
- Exposures to clerks ranged from non-detect to 22 ppm for 8 hour time weighted average
- Variable pattern of exposure
 - coefficient of variation
 - personal breathing zone samples (111%)
 - area samples (100%)
 - machine operators (103%)
 - clerks (89%)
- Two factor ANOVA – job title & shop were significant ($p=0.04$); date was not significant

Determinants of Exposure

- Effort and planning to reduce exposures
 - Higher exposures were in more typical shops; lower exposures were recorded in model shop
- Frequency of “cooking” and “charging” machine important determinants of exposure
- % stabilizer important in volatility of solvent
- Gasket types affect leak rates
 - 1-BP damages natural rubber, Viton initially thought to be good but now questioned, Teflon seems to perform the best in the field
- What job tasks result in the worst exposures?

TVA-1000 PID Measurements of Organic Vapor



Task Evaluation

- Solvent loading of machine results in high air levels of 1-BP
- Unloading machine and interrupting machine cycle also causes spikes in air concentrations
 - Our ventilation survey found that Gen3 machines had less than 100 fpm air flow at hatch even with fugitive control fan operating. In some cases, fan stopped when door was opened.
 - NIOSH engineering team looking into LEV for front door hatch
 - NJDEP looking to move operators to Gen4 machines

Additional Concerns

- Education and outreach needed.
 - Many operators think that “green” and “organic” means non-toxic.
 - Many state environmental programs are moving toward wider 1-BP use.
- Literature and index case suggests that there are potential neurological and reproductive hazards.

Current Status

- MMWR published on index dry cleaner case & degreaser case
- Additional publications in progress
- NJDEP grant program to assist dry cleaners in conversion from Gen3 to Gen4 can not be used for machines that will use 1-BP containing solvents.
- PERC ban has been delayed for five years (2014 for co-located; 2025 for stand alone cleaners).
- NIOSH investigating engineering controls

Contact Info

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- MMWR on index dry cleaner case & degreaser case
 - <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5748a2.htm>
- Journal article development will be geared towards Journal of the Air and Waste Management Association