



Case Studies: Simulated 1,1,1 Trichloroethane Exposure during Brake Repair

Dawn Than Column Editor , Amy M. Gitelman & John M. Dement

To cite this article: Dawn Than Column Editor , Amy M. Gitelman & John M. Dement (1996) Case Studies: Simulated 1,1,1 Trichloroethane Exposure during Brake Repair, Applied Occupational and Environmental Hygiene, 11:10, 1177-1179, DOI: [10.1080/1047322X.1996.10389390](https://doi.org/10.1080/1047322X.1996.10389390)

To link to this article: <http://dx.doi.org/10.1080/1047322X.1996.10389390>



Published online: 25 Feb 2011.



Submit your article to this journal [↗](#)



Article views: 10



View related articles [↗](#)



Citing articles: 2 View citing articles [↗](#)

Dawn Tharr, Column Editor

Reported by Amy M. Gitelman and John M. Dement

Introduction

The purpose of this case study is to report the findings from a simulation of an auto mechanic's inhalation exposure to 1,1,1 trichloroethane (TCE) (Chemical Abstract Service number 71-55-6) during brake repair. The 41-year-old auto mechanic had a history of fulminant liver failure with resulting transplantation. Hepatitis A, B, and C antibodies were negative. The auto mechanic had no history of alcohol or drug abuse. He had worked as a general auto mechanic for 20 years repairing brakes, clutches, ignition systems, and fuel systems, as well as conducting general engine overhauls.

Background

The auto mechanic used many solvents, including a parts washer containing petroleum solvents. The parts washer was not equipped with local exhaust ventilation. He also used carburetor cleaners and other products containing nonchlorinated solvents as well as products containing some chlorinated solvents. The auto mechanic wore cotton gloves that became saturated with solvent during work.

The auto mechanic worked in a garage with minimal ventilation. When weather permitted, general dilution ventilation was provided by opening doors and windows. Respiratory protection was not used.

Six months prior to the onset of liver disease, he completed many brake jobs using products containing TCE for cleaning brake assemblies and components. The mechanic used an aerosol industrial solvent degreaser containing >95 percent TCE to clean brakes. Although this product has been discontinued, a comparable product was found with which to conduct the simulation.

TCE, a popular degreaser, was originally produced as a safer replacement for carbon tetrachloride and later for trichloroethylene.⁽¹⁾ TCE, a halogenated hydrocarbon (CH₂CCl₃), is also known as

methyl chloroform. Acute effects of overexposure to TCE vapors by inhalation include mucous membrane irritation of eyes and upper respiratory tract, central nervous system (CNS) depression characterized by dizziness, headache, nausea, cardiac and/or respiratory depression, stupor, unconsciousness, and death in extreme cases. Chronic effects of overexposure to TCE by inhalation or skin absorption include possible liver or kidney damage or damage to the CNS characterized by tingling or numbness in the extremities, blurred vision, or confusion. Repeated dermal exposure can defat the skin and lead to increased susceptibility to skin irritation, infection, and dermatitis.⁽²⁾

Methods

An experienced mechanic repaired front disc brakes in an auto repair garage during nonwork hours. The shop had two large garage doors, one at each end of the building, and two wall-mounted 36-inch-diameter exhaust fans in the middle of the building. There were approximately 16 work bays in the garage (8 on each side). Since sampling was being conducted after business hours, the garage door closest to the parts office was closed. Work bay 1 in the right corner of the building was selected for the simulation mainly due to its availability and accessibility.

An air sampling strategy was devised based on three scenarios: brake cleaning during mechanical ventilation to simulate summer working conditions; brake cleaning during natural ventilation to simulate winter working conditions; and spraying an entire 24-ounce can of degreaser into a catch basin to simulate parts cleaning. During the mechanical ventilation scenario, both fans were operating and one garage door (farthest from the selected work bay) was open. The fans were turned off during the natural ventilation scenario; however, because of the temperature, the garage door was left open. For the final scenario, the fans were operating and both garage doors were open.

During the mechanical ventilation scenario, the front brakes were repaired on a Ford Explorer. During the natural ventilation scenario, the front brakes were repaired on a Chevy Blazer. Each car was placed on a lift during the brake repair so that the wheel well was elevated approximately 5 ft from the ground. Approximately one 24-ounce can of brake cleaner was used for each scenario. A rubber basin was placed on the floor underneath the wheel well to capture any dripping solvent. An entire can of brake cleaner was used during the parts-cleaning simulation.

During each scenario, a direct-reading instrument and air sampling pumps were utilized. The direct-reading instrument provided continuous concentration measurements used to identify tasks associated with peak exposure, whereas the air sampling pumps provided time-weighted average (TWA) concentration measurements. The Foxboro Miran 1A, a direct-reading infrared analyzer instrument, was calibrated prior to sampling using spectral grade TCE. During each scenario, the Foxboro Miran 1A was used to measure background area concentrations before brake cleaning and for continuous measurements of TCE near the breathing zone of the mechanic during brake cleaning and repair. Field notes were taken during sampling to document ongoing operations.

Gilian Dual Mode Low Flow Samplers, air sampling pumps, were calibrated prior to and after sampling using a BIOS flow calibrator as described in National Institute for Occupational Safety and Health (NIOSH) Method 1003 for halogenated hydrocarbons.⁽³⁾ SKC solid sorbent tubes containing coconut shell charcoal (100-mg front section/50-mg back section) were used as the sampling media. Short-term exposure limit (STEL) samples were collected at a flow rate of 0.2 L/min for nearly 15 minutes. Area samplers were collected at a flow rate of 0.1 L/min for nearly 25 minutes. During the mechanical and natural ventilation scenarios, two area pumps were stationed approximately 5 ft off the ground on the

TABLE 1. Direct Reading Air Concentrations of TCE Using the Foxboro Miran 1A

Operation/Sample Location	Absorbance Range	Concentration Range (ppm)
I. Mechanical ventilation scenario		
Spraying on driver's side/mechanic's breathing zone	0.05-0.1	100-201
Spraying on passenger side/mechanic's breathing zone	0.1-0.3	201-603
At ground level near reservoir (container to catch dripping solvent while cleaning calipers and rotors)	0.17-0.23	341-462
II. Natural ventilation scenario		
Spraying on driver's side/mechanic's breathing zone	0.12-0.2	241-402
Spraying on passenger side/mechanic's breathing zone	0.05-0.15	100-301
At ground level near reservoir	0.14-0.55	281-1105
Under wheel well during/after spraying	0.11	221
III. Parts cleaning scenario		
Spraying into bucket/mechanic's breathing zone	0.2->1.2	402->2411
Agitating bucket/mechanic's breathing zone	0.1-0.38	201-763

left and right sides of the vehicle. The mechanic also wore two personal pumps: one for STEL measurements and one for measurements of longer-term concentrations experienced during the entire brake repair process.

Samples were shipped on ice and analyzed by a laboratory accredited by the American Industrial Hygiene Association.

Respirators with organic vapor cartridges were worn during the simulation to minimize inhalation exposures.

Results

Prior to sampling, the ambient garage conditions (91.9°F and 60% relative humidity) were measured using a TSI Velocalc Plus. Air movement patterns were visualized using smoke tubes and velocity was recorded using the TSI. Air

velocity was approximately 10 to 15 ft/min at the level of the car brake assembly on the car lift (approximately 5 ft). Since work bay 1 was located in a corner of the garage, the smoke tended to drift toward the driver's right-hand side and into the corner.

Table 1 provides a range of TCE concentrations measured using the Miran during each scenario. The Miran's probe was held close to the mechanic's breathing zone to simulate inhalation exposures. Background values of TCE prior to brake cleaner spraying were nondetectable using the Miran. While spraying on the vehicle's driver's side, the TCE concentrations were higher during the natural ventilation scenario (241 to 402 ppm) than during the mechanical ventilation scenario (100 to 201 ppm). During

the mechanical ventilation scenario, TCE concentrations ranged from 201 to 603 ppm while spraying on the vehicle's passenger side, whereas the TCE concentrations were lower (100 to 301 ppm) during the natural ventilation scenario. Since the air movement was from the vehicle's driver's side to the passenger side, it is possible that during the mechanical ventilation scenario the air movement lowered the concentrations on the driver's side and increased the concentrations on the passenger side. Additionally, since the passenger side was close to a wall and a corner, TCE vapors could accumulate.

During the natural ventilation scenario, a TCE concentration of 221 ppm was measured underneath the wheel well. The wheel well traps vapors during spraying, especially on a larger car (e.g., Chevy Blazer or Ford Explorer) creating an area with minimal dilution ventilation.

Peak TCE concentrations occurred during the parts-cleaning scenario. While spraying the TCE into a rubber bucket, TCE concentrations ranged from 402 ppm to greater than 2411 ppm. TCE concentrations dropped to 201 from 763 ppm during agitation of the liquid sprayed into the bucket.

Table 2 presents the analytical results of the TCE air samples collected using the air sampling pumps. During each scenario, area air sampling results on the driver's side were lower than area air sampling results on the passenger side. The personal sample collected during brake cleaning on the driver's side and

TABLE 2. Air Sampling Results Using Charcoal Tubes

Sample Number	Personal/Area (Location)	Sample Time (min)	Air Volume Sampled (L)	TCE Concentration (ppm)
I. Mechanical ventilation				
A-1	Personal (driver's side)	14	2.8	86
A-2	Personal (passenger side)	8	1.6	98
B-1	Area (driver's side)	25	2.6	16
B-2	Area (passenger side)	25	2.5	40
B-3	Personal (driver's side and passenger side)	24	2.4	87
II. Natural ventilation				
C-1	Personal (driver's side)	8	1.6	139
C-2	Personal (passenger side)	11	2.1	83
D-1	Area (driver's side)	19	2.0	12
D-2	Area (passenger side)	19	1.9	74
D-3	Personal (driver's side and passenger side)	19	1.8	105
III. Parts cleaning scenario				
Z-1	Personal	13	2.6	367

TABLE 3. TCE Exposure Limits

Organization	TWA (ppm)	STEL (ppm)	Ceiling (ppm)	IDLH (ppm)
NIOSH ⁽⁴⁾			350 ppm	700
ACGIH ⁽⁵⁾	350 (TLV-TWA)	450		
OSHA ⁽⁴⁾	350 (PEL)	450		

passenger side during the mechanical ventilation scenario was lower than the value during the natural ventilation scenario.

Discussion

Several organizations have established exposure limits for TCE. Table 3 provides a summary of these values. The most stringent exposure level for TCE is 350 ppm ceiling limit, NIOSH's recommended exposure limit (REL). Both the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have 450 ppm STELs.

Many of the Miran's peak measurements (Table 1) exceeded NIOSH's ceiling REL of 350 ppm, especially during spraying and near the reservoir (a container placed on the floor to catch dripping solvent while cleaning calipers and rotors). The NIOSH immediately dangerous to life or health concentration was also exceeded, particularly during the parts-cleaning scenario, while spraying an entire can of degreaser into a bucket and agitating its contents.

Concentrations of TCE were higher while spraying on the passenger side of the vehicle during the mechanical ventilation scenario than during the natural ventilation scenario. This was probably due to the tendency of the air to flow toward the corner of work bay 1, as demonstrated by the smoke tubes during fan operation. A reverse trend occurred while spraying on the driver's side. The reduction of air movement achieved by turning off the exhaust fans may have contributed to these results. While spraying, a bucket was underneath the wheel well to collect residual TCE. Concentrations at the bucket ranged from 281 to 1105 ppm. The highest concentration

was obtained by placing the Miran probe as close as possible to the surface of the reservoir. The Miran results indicate that higher exposures to TCE occur during spraying and when the mechanic is near the reservoir. Exposures would be enhanced if the air flow was blowing into the mechanic's face while spraying. When the Miran probe was placed underneath the wheel well, concentrations increased due to the entrapment of vapors beneath the wheel well.

The air sampling results (Table 2) for scenarios 1 and 2 were within established exposure limits. During the third scenario, a TWA concentration of 367 ppm was measured. This concentration, although below the ACGIH STEL of 450 ppm, is above the NIOSH REL 350 ppm ceiling value. This indicates that excessive exposures are likely, especially during parts cleaning. The Miran results also demonstrate breathing zone values in excess of the NIOSH ceiling value of 350 ppm while spraying brake components.

The contribution of dermal exposures was not assessed during this experiment. Additionally, during normal garage operations, other mechanics would also be contributing to an individual's overall solvent exposure by their use of solvents and cleaners in nearby work bays.

The medical literature has several articles associating TCE exposure with fulminant liver disease. McIntyre and Long⁽⁶⁾ describe the case of a 17-year-old abuser of butane aerosols who developed fulminant hepatic failure after inhaling a proprietary engine or carburetor cleaner. Halevy *et al.*⁽⁷⁾ describe a case of transient liver and renal damage in an electronics technician following acute overexposure to TCE. The technician had been spraying TCE for 4 hours in a small room with the door open. Cohen and Frank⁽⁸⁾ reported a case of liver disease in a screen

printer following occupational exposure to TCE. The screen printer sprayed an adhesive containing 65 percent TCE several hours each day for nearly 4 years without respiratory protection. The results of our study provide additional data demonstrating elevated exposures to TCE while using spray aerosols and demonstrate the need for more appropriate measures to reduce worker exposures.

References

1. Agency for Toxic Substances and Disease Registry: Case Studies in Environmental Medicine: 1,1,1-Trichloroethane. U.S. Department of Health and Human Services, Atlanta, GA (1993).
2. Agency for Toxic Substances and Disease Registry: Toxicological Profile for 1,1,1 Trichloroethane, Draft for Public Comment, Update. U.S. Department of Health and Human Services, Washington, DC (1994).
3. National Institute for Occupational Safety and Health: Method #1003 for Halogenated Hydrocarbons. In: Manual of Analytical Methods, 4th ed. NIOSH, Cincinnati, OH (1994).
4. National Institute for Occupational Safety and Health: Pocket Guide to Chemical Hazards. NIOSH, Cincinnati, OH (1994).
5. American Conference of Governmental Industrial Hygienists: 1995-1996 Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs). ACGIH, Cincinnati, OH (1995).
6. McIntyre, A.S.; Long, R.G.: Fatal Fulminant Hepatic Failure in a 'Solvent Abuser.' *Postgraduate Medical Journal* 68:29-30 (1992).
7. Halevy, J.; Pitlik, S.; Rosenfeld, J.: 1,1,1 Trichloroethane Intoxication: A Case Report with Transient Liver and Renal Damage. *Review of the Literature. Clinical Toxicology* 16(4):467-472 (1980).
8. Cohen, C.; Frank, A.L.: Liver Disease Following Occupational Exposure to 1,1,1-Trichloroethane: A Case Report. *American Journal of Industrial Medicine* 26:237-241 (1994).

EDITORIAL NOTE: Amy M. Gitelman and John M. Dement are with the Division of Occupational and Environmental Medicine, Department of Community and Family Medicine, Duke University Medical Center, Durham, North Carolina 27710; telephone: (919) 286-3232.