



# Pollution Prevention (P2) Factsheet

## Case Studies on Safer Alternatives for Solvent Degreasing Applications

The transition to sustainable manufacturing is best accomplished by using pollution prevention (P2) approaches. This paper summarizes a number of case studies that highlight the P2 approach of switching to aqueous and less toxic metal cleaners to reduce health risks and manufacturing costs. EPA compiled these case studies as a supplement to “Pollution Prevention (P2) Spotlight: Reducing Trichloroethylene (TCE) Waste in the Fabricated Metals Sector.” [www.epa.gov/toxics-release-inventory-tri-program/reducing-trichloroethylene-tce-waste-fabricated-metals-sector](http://www.epa.gov/toxics-release-inventory-tri-program/reducing-trichloroethylene-tce-waste-fabricated-metals-sector)

### Featured Solvents

- Trichloroethylene (TCE)
- Methyl chloroform (TCA)
- Dichloromethane (DCM, methylene chloride)

### What are cleaning solvents and how are they used?

Cleaning solvents are used to remove oil, grease, solder flux, and other contaminants. Facilities that produce metal products often use solvents and other chemicals as degreasers to clean metal parts in preparation for further finishing operations, like painting or welding.

Common examples of solvents include:

**Trichloroethylene (TCE):** used as a solvent for metal degreasing, as well as a refrigerant and in dry cleaning fluid. TCE is a volatile organic compound (VOC) that poses a human health hazard to the central nervous system, kidney, liver, immune system, reproductive system, and to the developing fetus. TCE is also characterized by U.S. Environmental Protection Agency (EPA) as carcinogenic to humans by all routes of exposure (i.e., by inhalation, ingestion, and dermal exposure).

### Trends in the reduced use of TCE reported by the fabricated metals sector to EPA’s Toxic Release Inventory (TRI) database:

- Quantity of TCE releases to air decreased from 3 million lbs in 2001 to 0.6 million lbs. in 2012.
- The number of fabricated metal facilities reporting TCE decreased to 44 from 141, suggesting many facilities have eliminated TCE use entirely or reduced its use below the 10,000 pound reporting threshold.

Learn more about TCE: [www.epa.gov/assessing-and-managing-chemicals-under-tsca/trichloroethylene-tce](http://www.epa.gov/assessing-and-managing-chemicals-under-tsca/trichloroethylene-tce).

**Methyl chloroform (TCA):** used as a solvent and in some consumer products. Exposure to TCA can result in mild motor impairment (e.g., increased reaction time), lightheadedness, impaired balance, and lack of muscle control in acutely exposed humans. Cardiac arrhythmia and respiratory arrest may result from the depression of the central nervous system.

**Dichloromethane (DCM, methylene chloride):** used as a solvent in paint strippers, a process solvent in the manufacture of pharmaceuticals and film coatings, a propellant in aerosols, and a solvent for metal cleaning and finishing in electronics manufacturing. Effects of short-term (acute) exposures to workers and consumers, including bystanders, can result in harm to the central nervous system, or neurotoxicity. Effects of longer periods of exposure (chronic) for workers includes liver toxicity, liver cancer, and lung cancer.

Learn more about DCM: [www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-methylene-chloride-or-dichloromethane-dcm](http://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-methylene-chloride-or-dichloromethane-dcm).

### Case Studies:

1. **Schick** (formerly American Safety Razor) in Verona, Virginia, manufactures a variety of blades and tools from steel stock. TCE was used as a cleaning solvent in both liquid and vapor cleaning/degreasing operations at a newly acquired facility. Schick's prior experience with TCE as a potential environmental contaminant,



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combined with increasing costs associated with its distillation and waste disposal and higher regulatory risk, made TCE elimination a priority.

Schick installed aqueous “wash boxes” on production lines to replace TCE-based cleaning processes, and also used an alcohol-based vapor degreaser as an effective substitute. TCE use has been completely eliminated at this plant. In addition to risk reduction, **these P2 measures have resulted in an estimated cost reduction of \$250,000 a year from reduced energy, material and hazardous waste disposal costs.**

Learn more: [www.epa.gov/p2/pollution-prevention-accomplishments-schick-manufacturing-verona-virginia](http://www.epa.gov/p2/pollution-prevention-accomplishments-schick-manufacturing-verona-virginia)

**2. Lightolier** in Fall River, Massachusetts, fabricates aluminum reflectors for lighting product lines. The facility was using large amounts of TCE and acids annually. Only 10 percent of the used TCE was captured for recycling. In addition, the company became aware of hidden costs such as liability, worker safety, and opportunities for increased productivity.

Furthermore, Lightolier’s degreasing systems were old and required increasing maintenance. The company replaced the TCE degreasers with an aqueous degreaser and a powder coat degreaser. In addition, switching from pure petroleum lubricants to water-soluble coolants would eliminate the generation of oily parts in the first place.

Since removing the degreasers and making other improvements such as installing still-rinse tanks, implementing countercurrent rinsing, and increasing the drip time to reduce acid discharges, the company has eliminated approximately 1.25 million lbs of TCE and saved an estimated \$170,000. **Volatile organic compound (VOC) emissions have dropped 90 percent from 125,000 to 12,000 lbs per year, also significantly reducing air compliance costs.**

Lightolier found that 10 percent of one employee’s time was spent monitoring the TCE degreasers and manifesting the used TCE sent to a recycler, a week’s worth of labor was dedicated to Emergency Planning and Community Right-to-Know Act (EPCRA) reporting for TCE, and 40 percent was spent on Right-to-Know training strictly for TCE.

[Elimination of Trichloroethylene and Reduction of VOC Emissions at Lightolier \(PDF\)](#)

Learn more: [www.turi.org/TURI\\_Publications/Case\\_Studies/Process\\_Efficiency/](http://www.turi.org/TURI_Publications/Case_Studies/Process_Efficiency/)

**3. V.H. Blackinton & Co., Inc** in North Attleboro, MA, is a large manufacturing operation -- blanking, stamping, punching and machining raw stock prior to cleaning, enameling, brazing, polishing, plating and refinishing -- of metal plated items. The facility had used ozone-depleting Freon, as well as TCE and other VOCs and ammonia but was able to eliminate them.

Blackinton eliminated the use of Freon by replacing the existing finished work dryer with one that uses a deionized water rinse and hot air. The TCE cleaning operations were replaced with an aqueous cleaning system. Approximately 45 gallons of water-based cleaner is used annually, achieved by carefully monitoring the bath chemistry and ultra-filtering the cleaner weekly for reuse. In addition, a small in-tank filter, an oil skimmer, and conversion to compatible water-based pressing and stamping oils, made the new aqueous cleaning system more efficient.

More recently, new brazing furnaces with belts twice as wide as those in the old furnaces were installed, doubling the process capacity. The new furnaces use a 25 percent hydrogen and 75 percent nitrogen mix, eliminating over 20,000 lbs a year of disassociated anhydrous ammonia used in the old furnaces. The cost of the new system and quality of the finished product is the same or better. **A close looped cooling water system that**



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reuses water for the furnaces conserves 5000 gallons per day and additional water conservation activities eliminate the use of more than 25,000 gallons per day.

Learn more: [www.turi.org/Our\\_Work/Business/Industry\\_Sectors/Metal\\_Finishing/May-20-2004-Metal-Finishing-Forum/Handouts/Case-Studies/Case-Study-V.-H.-Blackington-Company](http://www.turi.org/Our_Work/Business/Industry_Sectors/Metal_Finishing/May-20-2004-Metal-Finishing-Forum/Handouts/Case-Studies/Case-Study-V.-H.-Blackington-Company)

4. **Danfoss Chatleff LLC** in Buda, Texas, manufactures refrigeration and air conditioning components, and had been using a TCE-based degreaser to remove machine oil from metal parts. The facility replaced TCE with an aqueous degreaser/parts washer and evaporator eliminating 9,900 lbs of hazardous waste per year and saving the facility \$36,000/year. **The new cleaning process requires less operator time, estimated to be worth \$25,000/year. By eliminating the use of TCE, Danfoss also significantly reduced future environmental risk/liability associated with the shipping, storage, and use of a hazardous chemical.** (Danfoss also estimates saving approximately \$10,000 per year in disposal costs and \$1,000 in training and reporting costs.)

Learn more: [www.zerowastenetwork.org/success/story.cfm?StoryID=1155&RegionalCenter](http://www.zerowastenetwork.org/success/story.cfm?StoryID=1155&RegionalCenter)

5. **Perkins Products Inc.** in Chicago, Illinois, was using mineral spirits for parts cleaning to remove straight cutting oil from metal work pieces in the milling department. The company replaced these solvents with aqueous detergents. The detergent was found to be safer for employees, better for the environment, less expensive and compatible with current production process. A total of 1,600 gallons of solvent were eliminated, **10,400 lbs of VOCs were avoided, and \$500 saved per year, with only a one-year return on investment period.**

Learn more: [www.istc.illinois.edu/info/library\\_docs/TN/TN15-116.pdf](http://www.istc.illinois.edu/info/library_docs/TN/TN15-116.pdf)

6. **Marathon** in Ashland, Minnesota, had been using a terpene-based cleaner and petroleum distillate for external cleaning of large equipment. The terpene solvent was suspected to be impairing the biological processes of the refinery's wastewater treatment plant. During testing, two aqueous cleaners were applied as a foam that adhered to vertical surfaces for several minutes -- enough time for the cleaner to work -- then rinsed off with hot water. The refinery staff using one of the foaming agents **described the result as "requiring less chemical, less time and less water, while providing better results" compared to the terpene-based cleaner.**

Learn more: [www.mntap.umn.edu/industries/facility/machine/resources/marathon/](http://www.mntap.umn.edu/industries/facility/machine/resources/marathon/)

7. **Lockheed Martin Defense Systems** in Pittsfield, Minnesota, used 125 tons each year of 1,1,1-trichloroethane (trichlor, 1,1,1-TCA, methyl chloroform) and chloroflourocarbon-113 (CFC-113, Freon) in 39 vapor degreasers to clean precision products, emitting 70 tons of these chemicals each year into the air.

The company evaluated alternative cleaners for economic and technical feasibility and potential worker health and safety impact. Ultimately, seven aqueous systems and two semi-aqueous systems replaced 36 of the 39 degreasers and **reduced facility solvent use to less than 2 tons per year, and air emissions to less than 1 ton per year.** Cost savings included: \$497,000 in solvent procurement; \$17,500 in waste disposal and \$65,000 in permitting and record keeping. The company incorporated a "closed loop" aqueous cleaning system in the transmission assembly and repair process. The system included a variety of substrates (steel, stainless steel, aluminum, cast iron, and bronze) and contaminants (plastic and oil, grease, wax and metal, plastic or rubber shavings) requiring removal. **This process reduced consumption of 2,000,000 gallons of water per year and saved \$3,450 in water and sewer costs.**

Learn more: [www.turi.org/content/download/931/4573/file/AqueousCleaning.pdf](http://www.turi.org/content/download/931/4573/file/AqueousCleaning.pdf)



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8. **Dayton Rogers** metal stamping facility in Minneapolis, Minnesota, was using TCA as a vapor degreaser to remove forming lubricant oil from parts prior to dry-sander deburring. The solvent was eliminated by upgrading its deburring operation to deburr and clean parts simultaneously. The company modified the vibratory tumbling machines to increase throughput, added a wet sander and switched to a water-based lubricant so that removing the forming lubricants would be easier in the water-based deburring system. **This resulted in saving \$26,575 per year and a payback period for the equipment of approximately three months.** This approach would be suitable in stamping and machining operation where deburring is done, but precision cleaning is not necessary.

Learn more: [www.mntap.umn.edu/industries/facility/machine/pretreat/](http://www.mntap.umn.edu/industries/facility/machine/pretreat/)

9. **Rosemount Aerospace Inc.** in Burnsville, Minnesota, used TCA during sensor cleaning at a large manufacturer of aircraft data instrumentation. After sensor assembly, the TCA comes in contact with silicone oil during testing to remove the oil before a soldering process. Aqueous cleaners tested on the sensors **removed light oils and fingerprints at least as well as the existing vapor degreasing system and eliminated worker exposure to TCA.**

Learn more: [www.mntap.umn.edu/industries/facility/machine/resources/aqueous/](http://www.mntap.umn.edu/industries/facility/machine/resources/aqueous/)

10. **APS Materials Inc.**, a small metal finishing company in Dayton, Ohio, used TCA and methanol in its degreasing operation to clean orthopedic implants such as those used for metal knee and hip replacements. A dilute limonene solution was tested as replacement cleaner. This dilute terpene-based cleaner adequately cleaned metal parts without adversely affecting the performance of the plasma-arc coating application. **The replacement cleaner resulted in a cost savings of \$4,800 per year and a payback period of 4.5 months.** Elimination of the disposal problems associated with methanol and TCA, coupled with the maintenance of plasma-arc coating quality, makes the use of terpene-based cleaners attractive to other plasma spray coating processes as well as other metal cleaning/coating operations.

Learn more: [citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.405.5454&rep=rep1&type=pdf](http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.405.5454&rep=rep1&type=pdf)

11. **Roberts Automatic Products**, a third generation family-owned precision production machining company in Chanhassen, Minnesota specializes in precise and complex computer numeric control (CNC) machining and screw machine parts. Roberts used DCM as a degreasing solvent to clean its parts and reported to TRI as much as 40,000 pounds a year of DCM wastes that were released or treated by the plant.

Roberts purchased the Serec closed-loop vacuum degreasing unit in 2011 and put it into service in 2012. Roberts **reduced its DCM waste to 13,636 pounds from more than 44,000 pounds the previous year.** The facility is no longer required to file TRI reports for DCM and has eliminated DCM as a source of toxic waste and a hazardous air pollutant.

Learn more: [www.epa.gov/toxics-release-inventory-tri-program/reducing-dichloromethane-waste](http://www.epa.gov/toxics-release-inventory-tri-program/reducing-dichloromethane-waste)

According to an EPA analysis of TRI data, in 2013, 61 out of 280 facilities reporting the use of DCM in the U.S. reported newly implemented source reduction activities. Two examples include:

- An organic chemical manufacturer that previously used DCM to clean equipment when changing from one process to another, switched to a less hazardous cleaning solution of water and limonene; and,
- An optical instrument manufacturer started using aqueous cleaning solutions instead of DCM.

[www.epa.gov/toxics-release-inventory-tri-program/reducing-dichloromethane-waste](http://www.epa.gov/toxics-release-inventory-tri-program/reducing-dichloromethane-waste)