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CD Aero Eliminates Use of nPB, Gains Production Capacity

Changes over to Aqueous Cleaner

CDE CD Aero
A Division of Cornell Dubilier Electronics, Inc.

Summary

A leading manufacturer of electronic capacitors globally, CD Aero (formally known as Aerovox) has been in business for over 100 years. Located in New Bedford, Massachusetts, the company employs 80 people and manufactures intelligent capacitor solutions for industries such as the medical, military, health and beauty sectors. CD Aero's capacitors are supplied to original equipment manufacturers and end up in products such as defibrillators and laser hair removal devices.

After a change in ownership, CD Aero worked with the Toxics Use Reduction Institute (TURI) and the Massachusetts Office of Technical Assistance (OTA) to find a safer alternative cleaning process to the use of n-propyl bromide (nPB). With a new aqueous cleaning process, the company is now saving $46,000 per year, protecting health and safety and reducing its regulatory obligations.

Drivers for Change

During the manufacturing process, the capacitors are placed into baskets and filled with oil by a controlled vacuum impregnation process. Then, to clean the capacitors, CD Aero used a vapor degreaser with nPB as the cleaning solvent to remove oils and particulates from the capacitor surfaces, both aluminum and tin-plate steel. The degreaser was outdated and very large, occupying over 2,000 square feet of manufacturing space and requiring 10,000 pounds of solvent to operate, generating annual fugitive emissions of 5,000 pounds.

Capacitor

The new owners of CD Aero established replacing nPB with an aqueous alternative as a priority in an effort to improve the overall work environment and protect the natural environment. The environmental health and safety concerns associated with using nPB and the need for a more sustainable piece of cleaning equipment that uses a safer product were major drivers that helped move this project forward.

Search for New Equipment

Over several years, CD Aero researched a new cleaning process to replace the outdated degreaser and nPB. They evaluated different kinds of washers from several different vendors, settling on automated pass-through conveyor parts washers as the preferred type of equipment. That type of equipment is also more economical because it is automated.

CD Aero selected equipment manufactured by JenFab, which consists of a conveyor belt and high-pressure spray nozzles to apply the cleaner, as the best option. This new equipment allows CD Aero to wash, rinse, and dry parts more quickly than in the competing new equipment options; despite a longer time in each of the cleaning, rinsing, and drying zones, the conveyor runs at a faster linear speed, allowing more parts to be cleaned per hour than in the competing systems.

TURI Lab Testing of Potential Alternatives

Using TURI's Cleaner Solutions database, the TURI lab identified a number of aqueous products that could be suitable for CD Aero's process. The first step was to test the cleaners against various oils on aluminum and ceramic surfaces and calculate the average percent removal to determine the overall effectiveness. After CD Aero identified its preferred equipment, the lab adjusted the process and narrowed the search to three low-foam cleaners.

Aluminum and ceramic coupons were immersed into the selected cleaners with increased heat for only one minute to mimic the contact time based on the likely speed of the conveyor belt on the new equipment. The final results are displayed in the table below.

Performance Testing of CD Aero's Alternatives to nPB

Product (% Dilution)	Contaminant	Overall Effectiveness: Aluminum	Overall Effectiveness: Ceramic
Aquaease PL 732 (100%)	Canola Oil	34%	96%
	Epoxidized Soybean Oil	6%	77%
	SAS-60E	96%	88%
SC Aircraft & Metal Cleaner (10%)	Canola Oil	90%	93%
	Epoxidized Soybean Oil	83%	94%
	SAS-60E	91%	96%
LF 2100 (5%)	Canola Oil	93%	97%
	Epoxidized Soybean Oil	55%	97%
	SAS-60E	90%	96%
Aquavantage 3800 GD (5%)	Canola Oil	76%	73%
	Epoxidized Soybean Oil	56%	71%
	SAS-60E	97%	89%

LF2100 and Aquavantage 3800 GD had lesser overall averages and a greater variation in results due to their lack of performance on the epoxidized soybean oil. SC Aircraft & Metal Cleaner had results that were more consistent across the different substrates and soils. It is important to note that without the equipment to simulate a high-pressure spray application, the Lab's capability to replicate this process was limited.

CD Aero was initially interested in the product Aquaease PL 732 after a recommendation from their preferred vendor. Aquaease PL 732 was effective on ceramic for canola oil and SAS-60E, and it was effective on aluminum with SAS-60E. Although the overall effectiveness of the cleaner was less than 100%, CD Aero was confident that the high-pressure spray would increase overall contaminant removal.

After testing in the lab, CD Aero worked with the equipment vendor to verify that the new equipment and the selected cleaner, the Aquaease product, would perform as effectively as nPB on the capacitors. CD Aero was also required to conduct internal qualification testing of their new cleaning process to ensure it would satisfy customer needs. As a global supplier of products to the military and medical industries, CD Aero must meet certain industry standards and requirements.

Choosing an Alternative Cleaner

Using TURI's hazard assessment tool, the Pollution Prevention Options Analysis System (P2OASys), TURI staff compared CD Aero's original solvent to the alternative cleaners studied to make sure that the cleaners would improve health and safety. P2OASys evaluates chemicals on eight primary categories of environmental health and safety endpoints; a summary score is generated ranging from 2 to 10, 2 meaning of "Low" concern (coded green) and 10 meaning of "Very High" concern (coded red). Each of the eight main categories is scored in this same way so the user can see what specific hazards are driving the overall score.

The table below summarizes the environmental health and safety comparison of CD Aero's original solvent, nPB, to the alternatives identified. Only six of the eight main categories are shown here, because process and life cycle factors were considered separately during the evaluation of new equipment and because there is no significant difference in process conditions between the four aqueous alternatives.

The scores and resulting ratings for the aqueous alternatives are based on information about ingredients using key Globally Harmonized System (GHS) hazard phrases provided on Safety Data Sheets (SDSs) and TURI's list of additional resources. In some cases, there is no information about ingredients; in others they are described generically with the specific chemicals claimed as proprietary information. Therefore, while they all offer a meaningful improvement over nPB, the differences shown below between the aqueous alternatives may not be significant, and companies are encouraged to request additional information from manufacturers.

Environmental Health and Safety Comparison of nPB and Alternatives

Category	Original Solvent: n-propyl bromide	Identified Alternative: Aquaease PL 732	SC Aircraft & Metal Cleaner	LF 2100	Aquavantage 3800 GD
Acute Human Effects	VH	H	H	M	H
Chronic Human Effects	VH	L	M	M	L
Ecological Hazards	H	M	M	L	M
Environmental Fate & Transport	VH	M	L	M	M
Atmospheric Hazard	H	L	L	M	M
Physical Properties	VH	M	M	M	M

Key: L = Low M = Medium H = High VH = Very High

n-Propyl Bromide (nPB)

CD Aero was aware of the hazards associated with nPB, and this was a major reason they wanted to remove it from their facility. The most significant concerns associated with long-term exposure to nPB are cancer risk and adverse effects on the nervous, reproductive, and immune system. nPB is considered a hazardous air pollutant by EPA and is harmful to the environment and wildlife.[1]

The Alternatives

All the alternatives identified were aqueous cleaners, which offer significantly improved environmental health and safety profiles over nPB. The primary hazards associated with the alternatives studied were dermal and eye irritation associated with the concentrated formulations. The alternative that CD Aero selected, Aquaease PL 732, is an alkaline

[1]USEPA issued an Advanced Notice of Proposed Rulemaking in June 2021 in the process toward implementing the addition of 1-bromopropane (1-BP) to the Clean Air Act's list of hazardous air pollutants (HAP). EPA intends to add 1-BP to the HAP list by the end of 2021.

aqueous phosphate-based cleaner. The only significant health hazard associated with it is mild skin and eye irritation. High levels of phosphates discharged into water bodies can cause eutrophication.

TURI developed the Pollution Prevention Options Analysis System (P2OASys) tool to help companies determine whether the toxics use reduction (TUR) options they are considering improve upon their existing process when looking at environmental, health and safety endpoints.P2OASys can help identify potentially negative environmental, worker or public health impacts and avoid making regrettable substitutions.

Potential hazards are compared using data endpoints for eight main categories that encompass chemical, physical, workplace and environmental hazards. Scores range from 2 to 10 with the lower score being more desirable. Those scores have been translated to a ranking as noted in the table key.

Added Benefits

CD Aero was motivated to enhance their environmental health and safety program and did not expect to receive all the added benefits that have resulted from its toxics use reduction efforts. These benefits include:

- Removing the old degreaser freed up 1,920 square feet on the shop floor, which can now be used for manufacturing space. This equates to an additional $16,000/year cost benefit.
- The new equipment eliminated the need for a carbon adsorption system as CD Aero no longer has to control potentially hazardous air emissions.
- The workers appreciate the health and safety improvements in their work environment.
- The newer equipment is significantly easier to use, and labor time was reduced from cleaning on all three shifts to cleaning on fewer than two shifts.
- The equipment manufacturer wants to use the CD Aero site to demonstrate its equipment because it is operating so well.

Cost Analysis

Replacing nPB at CD Aero's manufacturing facility not only created a safer work environment, but the owners predict that it will result in major operational cost savings and increased overall productivity.

Operating and Maintenance Cost Comparison of CD Aero's Old and New Systems

Item	Old nPB System: Annual Costs	New JenFab/Aquaease System: Annual Costs	Cost Savings
Cleaning solution	$15,000	$15,000	--
Electricity	$56,500*	$35,500	$21,000
Steam	$25,500	$11,250	$14,250
Water	$0	$1,000	($1,000)
Impregnation oil disposal	$600	$600	--
Regulatory reporting (TURA fee)	$1,200	$0	$1,200
Maintenance Costs	$11,000	$0	$11,000
Total	**$109,800**	**$63,350**	**$46,450**

*Electricity costs of equipment, carbon absorption, and chiller.

In addition to over $46,000 in annual savings due to the changes in operating costs, the facility has had to conduct minimal training, and has seen an increased throughput of 68% and a 33% reduction in maintenance labor (see below).

Productivity Increases Between CD Aero's Old and New Systems

Item	Old nPB System	New JenFab/Aquaease System	Comments
Training	Several weeks of training many years ago	Approximately 30 minutes for each of 3 operators	Minimal training was needed to learn the new system
Throughput	Up to 40.5 baskets per hour	Over 68 baskets per hour	68% increase in throughput
Maintenance Labor	Approx. 3 hours per week	Under 2 hours per week to wash down tanks and replenish system	33% reduction in maintenance labor

At a capital cost of $260,000, the facility will see a payback on their investment in just over 5.5 years. That payback period is reduced to just over 4 years when adding in an additional cost benefit of $16,000 per year due to added manufacturing space gained by removing the old, large equipment. The facility also has seen the benefits of not having to worry about maintaining a carbon absorption system in the new unit, and the workers are very happy with it as it is simple and safer to use.

Conclusion

CD Aero successfully eliminated the use of nPB at their facility, which significantly reduced worker exposure to hazardous chemicals, reduced operating costs, and resulted in many unexpected added benefits as well. The collaboration between CD Aero, TURI, OTA, and trusted vendors resulted in a safer and effective alternative cleaning process, and successful implementation.

The Toxics Use Reduction Institute (TURI) at UMass Lowell *provides the resources and tools to help Massachusetts companies and communities make the Commonwealth a safer place to live and work. TURI awards grants to businesses, community organizations, and researchers to discover new opportunities to reduce the use of toxic chemicals and to demonstrate technologies to peers. For more information, visit http://www.turi.org or contact Joy Onasch (joy@turi.org, 978-934-4343).*