

Company description

Spirit AeroSystems, Inc., is an aerostructures manufacturer headquartered in Wichita, Kansas. It is one of the world's largest first-tier aerostructures manufacturers responsible for supplying commercial airplanes, business/regional jets and defense platforms. Spirit manufactures several structural components for airlines, including fuselages, integrated wings/wing components, pylons and nacelles. With 13,000 total employees worldwide in 2023, this company has several facilities within the United States as well as in the United Kingdom, Scotland, Northern Ireland, France, Malaysia and Morocco. It is currently a primary supplier for Boeing aircraft. Additional customers include Airbus, Rolls-Royce, Mitsubishi Aircraft Corporation, Bombardier, Lockheed Martin and Northrop Grumman. Spirit is also listed as a member of the Fortune 500, making it one of the 500 most profitable industrial corporations in the United States.

Incentives to change

Spirit has demonstrated a strong commitment to protecting human health and the environment. According to its published social responsibility statement, it is its policy to conduct and manage business in a manner that protects the environment and promotes the health, safety and well-being of its employees, customers and surrounding community. In addition, Spirit has published greenhouse gas reduction, or GHG, goals, targeting a 30% absolute reduction in Scope 1 and 2 emissions from 2019-2030. Although impacted by the pandemic slow down, this solvent reduction project, recently added to their ISO 14001 plan, will help Spirit reduce hazardous materials, hazardous waste, costs and air emissions as well as minimize associated health risks to employees and the community. This project is especially important to Spirit because the company is located in an environmental justice area. These are areas that, historically, are disproportionately impacted by environmental hazards and often lack the resources to address these factors. Funded through a grant from Region 7 of the Environmental Protection Agency, or EPA, Spirit partnered with K-State's Pollution Prevention Institute, or PPI, to host the solvent reduction project. The multi-year project goals are to reduce toxic solvents, hazardous waste and emissions by 10% per freight on board or FOB built, using 2019 as the baseline. The project targeted the use of two solvents, BMS 11-7 and methyl propyl ketone, or MPK, however, opportunities were also found to reduce the usage of 50:50 isopropyl alcohol/water, Naphtha, and pure isopropyl alcohol. Originally, this project was intended to last two years, but it was extended to a third year. This case study covers the work completed during the three-year project, with most hands-on technical work being completed through the PPI intern program. The following goals form the basis of the original grant proposal.

1. Establish an internal solvent-use advisory board.
2. Investigate and study high solvent-use areas and practices to document measurable solvent reduction opportunities.
3. Evaluate and publish training videos and a comprehensive case study.
4. Increase awareness through Spirit-hosted internal trainings and case study presentations.

PROJECTS

Project 1. Solvent-use advisory board

Working in partnership with PPI, Spirit established an advisory board to create a multidisciplinary solvent reduction team. The purpose of the advisory board is to create a diverse group of individuals who can help implement practical solvent reduction solutions throughout the Wichita Spirit facility by making experience-based recommendations for process, material or technology modifications or by implementing and raising awareness to the cause. Members include PPI staff, the Spirit environment health and safety manager and team, PPI interns, several members in management from safety, the paint training supervisor, iSi waste management and the integration manager. Some meetings included only key management staff and others included the full advisory board. Meeting topics covered solutions to solvent waste issues, best practices, how to raise awareness in respective departments and the opportunity to propose new ideas for minimizing solvent waste. The smaller subcommittee of the board has met at least 10 times, while the larger formal advisory board has met four times.

PROJECTS, CONTINUED

Project 2. Investigate, study and identify solvent reduction opportunities

Hand-wipe cleaning represents about 50% of the various solvent use processes at Spirit and was the focus of most of the solvent reduction opportunities. Operators use solvent dispensed onto hand wipes to remove contamination from a part prior to sealing, primer application, riveting and touch-up processes. The hand-wipe cleaning process was selected because it is one of the most solvent-use intense processes and includes various sub-processes related to bottle filling and bottle returns. In the painting areas, a solvent distillation process for spent gun and line washing MPK solvent was also studied and implementation was initiated in 2023. Throughout the three years of study, interns were able to build on the previous year's source reduction work. In total, interns researched and investigated five solvent-use reduction projects detailed below.

A. Hand Wipe Cleaning- Overflow Solvent Reduction

Spirit decants solvent from 55-gallon drums into 16-ounce hand-held bottles for employees via an electronic liquid-filling machine. The employees use those bottles to dispense solvent onto a hand wipe. The machine-filling process often overflows the solvent, resulting in loss of raw materials that must be disposed of as hazardous waste. Using a 55-gallon drum gauge, the 2021 intern was able to calculate overflow quantities to determine annual costs. The 2021 intern researched alternative options and recommended purchasing a new solvent-filling machine. This new machine is currently in the capital approval process, so the overflow solvent is still being produced, captured and disposed of as hazardous waste. The 2022 intern identified that the use of solvent bottles with larger openings may be another option for reducing solvent overflow; however, the sample bottles did not entirely align with the solvent-filling machine specifications. As a result, it was determined that the best course of action would be to replace the machine as recommended.

The current solvent-filling machine has been in use since 1992. In 2021, the new machine cost provided by a vendor was \$20,000. Using 2019 baseline production rates, prevention of raw material loss and hazardous waste by upgrading to a new standard base model would result in annual cost savings of \$48,000. With a capital cost for the new machine of \$20,000, the simple payback period of this project is estimated to be less than six months. Eliminating this waste reduces the amount of raw material needed by 3,300 gallons, reducing not just hazardous material, but also a reduction of 11.53 tons/yr. of VOCs, 2.71 tons/yr. of HAPs, and 3,300 gallons of hazardous waste. In addition, it would also improve the overall health and safety of the workplace. The following image shows what the current electronic liquid filling machine looks like.



Figure 1- Spirit's electronic liquid filling machine

The room that this machine is stored in is classified as a Class 1 Division 1 hazardous storage area. Replacing the current machine could reduce that classification and would save Spirit money on the necessary ventilation and safety requirements that come with a Class 1 Division 1 rating. These savings were not calculated.

B. Hand Wipe Cleaning- Returned Solvent Waste Reduction

Pre-filled hand-held solvent bottles are reused throughout Spirit's facility to facilitate ease of application and reduce unnecessary waste. These bottles are refilled when empty and redistributed. The 2021 intern found that, due to lack of employee accountability or training, poor tool crib organization, improper or confusing signage, and other reasons, the bottles were not always returned empty. Figure 2 shows what these bottles look like. This returned solvent is classified as waste because it is returned with various solid and liquid contaminations or could not be confirmed as the solvent on the label. At the time of this case study, an option for reuse for a dirtier process was not identified. Therefore, the leftover solvent is disposed of as hazardous waste and is a loss of raw material.

PROJECTS, CONTINUED

The 2021 intern was able to use a 55-gallon drum gauge to quantify this waste and the intern estimated annual costs. The 2022 intern researched and initiated implementing various employee outreach initiatives that increased employee attentiveness to the proper disposal of solvent and ensured that full and partially full bottles get reused. These initiatives include improving solvent storage signs, changing chemical color labels to distinguish chemicals easier, improving solvent storage organization by putting shelves in flammable cabinets and removing totes from the flammable cabinets. Improving solvent storage signs will make it easier for employees to determine where to place full/partially full and empty bottles. Changing chemical color labels will help prevent employees from placing the wrong chemical in the wrong tote, which will reduce time spent sorting the bottles. Putting shelves in the flammable cabinets will create more space and make it easier for employees to reuse bottles. The highest user of pint-sized solvent bottles is the Plant 2 tool crib, which was reorganized to allow easier access to flammable cabinets.

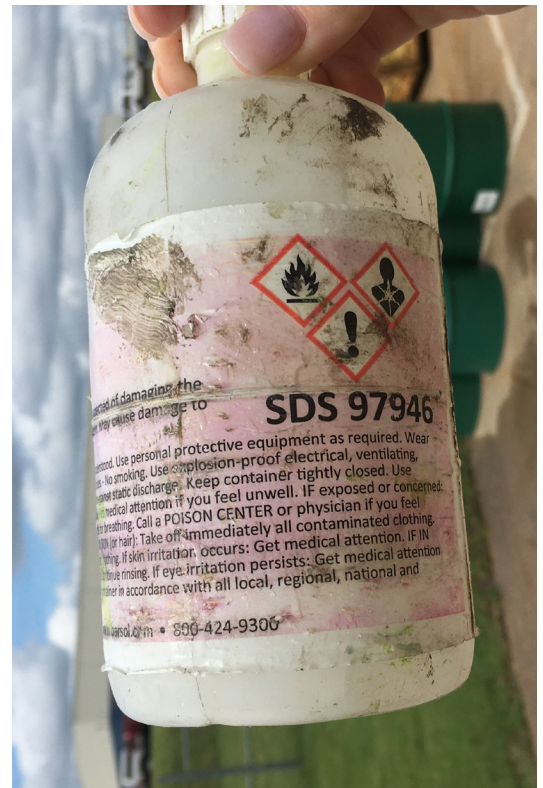


Figure 2- BMS 11-7 solvent bottle

The 2023 intern also worked with Spirit and PPI to create a training video that addresses the importance of proper solvent usage and storage. A “Spirit Learning Solutions,” or SLS training script, and presentation were drafted and are undergoing an approval process to become integrated into the Spirit employee trainings. The video will include information about the health and environmental risks associated with improper solvent usage, best practices to implement when using solvents, and information on the new solvent distillation units as described below. This training specifically instructs solvent users to return pint bottles to proper locations and explains the waste produced as the result of the solvent bottle return process. The 2023 intern also included solvent bottle return waste estimates and training as part of the 2023 Solvent Advisory Board meeting agenda in an effort to continue to raise awareness about the issue and seek solutions.

To update 2021 waste solvent estimates, the 2023 intern observed over 5,000 bottles and found that about 2,300 gallons of waste are produced annually from solvent returned to Master Mix in pint bottles during typical production rates. These changes are estimated to reduce hazardous waste by 50%, decreasing VOC and HAP emissions by 3.9 tons and 1.9 tons per year, respectively, as well as reduce hazardous waste generation by over 1,000 gallons. This reduction is estimated to produce about \$14,000 in raw material savings and waste savings.

C. Hand Wipe Cleaning- Fuselage Integration Solvent Reduction

Fuselage integration is the department with the highest solvent usage in the hand-cleaning process at Spirit. Fuselage integration alone used an estimated 20,000 gallons of solvent in 2019. One of the identified waste streams stems from ear bud waste. Employees soak ear buds in a 50:50 mix of isopropyl alcohol and water that they use to remove excess sealant from the fuselage. It was noticed that the amount of solvent that the ear buds are soaking in is more than necessary. The solvent used to soak the ear buds wastes an estimated 850 gallons per year in fuselage integration based on the assumption that the full volume of the container contains waste. It is resulting in an estimated \$5,000 in raw material costs and bulk hazardous waste disposal costs.

It is important to note that the proposed solutions for fuselage integration solvent reduction as well as the employee outreach initiatives can be applied campus wide. Solutions to reducing solvent usage include providing employees with a solvent guide, as well as getting standardized containers for ear bud processes. The standardized container has three different aspects to it; it would be a smaller container than the one that is currently being used, it would have a lid to prevent IPA evaporation into the air, and it would also contain a swab that would replace the ear buds as a solvent applicator. It would be available to be distributed to employees through the tool crib. Another solution to reducing solvent usage would be the use of a solvent guide. The solvent guide is a document that would be available at each employee’s workstation that details what kind of solvent

PROJECTS, CONTINUED

employees should use depending on the material they are cleaning, as well as reiterating techniques employees should pay attention to when cleaning. Essentially, it is simply providing reminders from training available at their workstation for how to clean a material.

In fuselage integration, this is estimated to reduce VOCs and HAPs emissions by 12.5 tons and 3.3 tons per year, respectively, as well as reduce solvent usage by 3,600 gallons and save about \$40,000 in raw material savings and hazardous waste reduction during a normal production year. Using a standardized container to replace the ear bud process is estimated to save 2.8 tons of VOCs, 730 gallons of hazardous waste, and over \$4,000 in raw material and hazardous waste generation on an annual basis.

D. Paint Gun Cleaning Solvent Replacement

Paint gun cleaning solvent reduction was a project that the 2021 intern researched. Spirit mainly uses MPK solvent to clean its paint guns. MPK is an effective paint gun cleaner but requires a large amount of solvent to clean the gun, which is ultimately disposed of as hazardous waste. The 2021 intern calculated solvent usage for this process for a typical production year to evaluate costs and find feasible solutions. Based on calculations and discussions with the vendor, an aqueous paint gun cleaning system was recommended, which is also compatible with solvent in case the aqueous solution does not clean sufficiently. If the aqueous cleaner can be used consistently, the recommended unit would eliminate the need for solvent and eliminate the hazardous waste created. If fully implemented, this unit could save an estimated \$144,000 annually as well as result in the annual reduction of 34 tons of VOC emissions, nine tons of HAPs emissions, and 7,500 gallons of hazardous waste for the company. As of 2023, this project is not currently being considered for implementation due to a more feasible means of solvent reduction being implemented.

E. Line Flushing and Paint Gun Cleaning Solvent Reduction

The last project includes solvent distillation, now accepted as P2 by the EPA. It yields considerable raw material savings. The 2021 and 2023 interns evaluated implementing a solvent recycling system to recover the solvent used to flush and clean paint lines in one of the company's paint booths. The interns researched and evaluated the suggested options. Based on trial runs completed by the 2023 intern, the process is estimated to be 70-90% efficient, allowing the recycled solvent to be reused instead of raw material. Furthermore, this process produces bulk hazardous waste in the form of a dried paint puck which weighs significantly less than the gallons of liquid hazardous waste and therefore reduces disposal quantities and costs.

A five-gallon capacity solvent recovery unit is currently being leased and is installed in the Strut/Nacelle building where it will be integrated into the paint training program. The amount of solvent used for the training program is still unknown, but based on 2022 usage in the Strut Nacelle East building, the 2023 intern estimates the machine could result in a net annual savings of \$14,700 by saving 970 gallons in raw materials and 1,200 gallons in hazardous waste. Estimates are based on an 80% return rate determined by trials collected from 2021 and 2023 interns, as well as the assumption that all MPK ordered is used for line flushing and gun cleaning. After everyday use of the solvent distillation unit is integrated into paint training, similar solvent distillation units (of capacities varying from 5-48 gallons) could be installed in paint booths across the Spirit facility. This level of implementation is estimated to save \$620,000 in the first year, based on 2019 HAZMAT orders of 55-gallon MPK drums. Because this estimate incorporates the cost of purchasing the machines, it can be noted that the second-year cost savings are estimated to be around \$720,000. Based on an 80% return rate, facility-wide solvent distillation implementation would result in reducing VOC and HAP emission by 160 tons and 16 tons, respectively.

RESULTS

Table 1 shows a summary of all the solvent source reduction projects and their estimated impacts. The total estimated annual savings from implementing the overflow, returned solvent, fuselage integration and facility-wide distillation projects would be 150 tons of VOCs, 26 tons of HAPs, over 40,000 gallons of hazardous waste and economic savings of about \$700,000. BMS 11-7 and MPK are the two target solvents in this study. Overall, the three-year project proposes potential reductions of 10.8% for BMS 11-7, and 64.6% for MPK per FOB excluding the facility-wide solvent reclamation unit, the remaining projects resulted in at least a 10% reduction for BMS 11-7, and 2.4% for MPK. As compared to the overall project goals for solvent reduction, continuing the implementation of solvent distillation machines proves necessary to achieve the goal of reducing solvent by 10% per FOB by 2030.

TABLE 1 – SUMMARY OF ALL PROJECTS

Reductions	Annual Estimated Environmental Impact	Estimated cost savings (\$/year)	Status
Overflow solvent reduction-machine replacement	11.5 tons VOCs 2.71 tons HAPs 3,300-gal hazardous material and hazardous waste reduced	\$48,000	Recommended
Returned solvent waste reduction	3.9 tons VOCs 1.9 tons HAPs 1,100 gal of hazardous material and hazardous waste reduced	\$14,000	Implemented
Fuselage integration solvent reduction	12.5 tons VOCs 3.3 tons HAPs 3600-gal of hazardous material and hazardous waste reduced	\$42,500	Implemented
Strut Nacelle East distillation unit	4 tons VOCs 0.4 tons HAPs 970 gallons of hazardous material 1,200 gallons hazardous waste	\$14,000	Implemented
Facility-wide distillation units	160 tons VOCs 16 tons HAPs 38,000 gallons hazardous material 47,000 gallons hazardous waste reduced	\$620,000	Recommended
Total	190 tons VOCs 24 tons HAPs 46,000 hazardous material reduced 55,000 gallons hazardous waste reduced	\$724,000	<i>Project status updated 5/2024</i>

References

[1] S. Aerosystems, 2022. [Online]. Available: <https://www.spiritaero.com/pages/release/spirit-aerosystems-reports-fourth-quarter-and-full-year-2021-results/>.