HAZMIN R&D AT U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY (USATHAMA)

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Provisions of the Resource Recovery and Conservation Act (RCRA) mandate that HAZMIN be placed high on the list of environmental priorities. The U.S. Army has established a program to reduce its hazardous waste by 50% by the end of fiscal year (FY) 1992 using FY-1985 as the baseline. We have steadily marched to that goal. In 1985, we generated 98 thousand metric tons of hazardous wastes. In 1990, we generated 83 thousand metric tons of waste. This figure includes RCRA closures, the new TCLP wastes, and the increase from Desert Shield/Desert Storm.

The Army generates hazardous waste from five different sources: spills, motor pool operations, surface treatment operations (painting, electroplating, etc.), ammunition disposal, and energetics production. These have been listed from the lowest quantity to the highest. This paper will only describe the R&D efforts relating to the second and third sources. Because of specific military requirements, the problems encountered with HAZMIN for surface treatment operations are more difficult to solve than might otherwise be thought in comparison to private industry. For instance, the Army uses chemical agent resistant coating (CARC) on its vehicles. This coating is much harder to remove than ordinary paint.

The hazardous wastes from the above sources can be classifies into three categories: propellants/explosives/pyrotechnics (PEP), organic solvents, and heavy metals. Organic solvents and heavy metals can come from any of the operations while PEP wastes only come from munitions production and disposal. The organic solvents used in maintenance operations are usually chlorinated hydrocarbons.

The challenge of HAZMIN is to reduce or eliminate generation of hazardous wastes by material substitution, byproduct recovery/reuse, or operational changes and simultaneously reduce operating costs while maintaining or improving product quality. We can meet this challenge by selectively developing HAZMIN technologies that address the appropriate situations. At some later time, we may have to achieve HAZMIN at the expense of increased operating costs or loss of quality. Since the categories of wastes generated come from several different uses, no one solution can always be applied. For instance, one can replace an organic solvent for paint stripping with a biodegradable surfactant; but, that surfactant most likely cannot be used in propellant production where the very same organic solvent was used.

The role of R&D in the Army's HAZMIN program is to apply existing technologies to new situations, to meet Army specific requirements, and to fit existing processes. R&D personnel also must develop innovative technologies. This includes new processes for old products while making sure that new products are made such that their manufacturing processes generate a minimum amount of waste. The job would not be complete unless these technologies are implemented. Therefore, a major concern is that any R&D efforts address only those solutions that have a high probability of being workable and cost effective. The R&D efforts must include plans to implement successful technologies.

With the background discussion complete, we can look at some specific technologies in relation to the waste generating operations. We will look at tactical vehicle maintenance (motor pool operations). Maintenance operations that generate hazardous wastes include painting, depainting, degreasing, cleaning, and electroplating. These operations generate sludge containing excess paint (from either water filtering or dry filtering of the spray booth air), stripped paint (from either chemical stripping or blasting operations), and industrial wastewater treatment plant (IWTP) sludge. Air emissions of concern from these operations are volatile organic compounds (VOCs). Liquid wastes include rinse water (containing oils, grease, and heavy metals), spent stripper solutions (containing VOCs, heavy metals, corrosives, and possibly other toxic organics), and spent plating baths (containing chromium and other heavy metals).

New HAZMIN technologies for tactical equipment maintenance involve recover/reuse process changes and material substitution. Recovery/reuse technologies include electrodialysis of chromic acid solutions, and filtration of paint stripper baths. The process changes include aluminum ion vapor deposition (AIVD) as an alternative to electroplating, plastic media blasting (PMB) for paint stripping, fluidized bed paint stripping for small parts, more efficient paint application techniques, and ultrasonic cleaning. For material substitution, we are looking at alternate chemical paint stripper formulations, alternate paint formulations, and solvent substitution.

Electrodialysis of chromic acid solutions has the potential for increasing the life span of chromic acid solutions used in plating operations. This will reduce the generation of hazardous wastes, reduce costs associated with treatment or disposal, and reduce material costs. This demonstration was carried out at Corpus Christi Army Depot. The final report concludes: "The system was successful in removing a significant quantity of metals from the chromic acid solutions, and it may have been successful in oxidizing trivalent to hexavalent chromium. In the batch rejuvenation of chromic acid stripping solution, however, the leakage of sulfates into the solutions through a membrane hole resulted in damaged parts when the solution was used on an operation tank."[a] The quotation suggests partial success; further information can be obtained from the report.

Filtration of paint stripping baths has the potential for extending the life span of paint stripping baths. The process contains a bag filter in the bath recirculation line. The final report of tests run at Letterkenny Army Depot says that "... Despite these problems, some operational experience and data were collected. Four rounds of samples were analyzed for solids content and particle size distribution. Two operating modes for the equipment were developed: continuous removal of suspended solids and periodic removal settled sludge. Both monofilament and mesh filter bags were tested, and it was determined that the monofilament bags could collect a greater quantity of sludge material per weight of filter bag material, and that they could be reused, whereas the mesh bags had to be disposed of after each use.

Based on observations during the test program, the filter system should increase agitation and circulation in the paint stripping tank (which will aid dissolution of the solid chemical used to make up a fresh solution), reduce the amount of suspended solids and sludge formation in the tank bottom, reduce sodium hydroxide usage (but not sodium gluconate usage), increase bath life,

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a. U.S. Army, 1991, *Evaluation of Electrodialysis for Chromic Acid Recovery and Purification at Corpus Christi Army Depot*; U.S. Army Toxic and Hazardous Materials Report Number CETHA-TS-CR-91032, July 1991, page 7-1.

decrease hazardous waste, and reduce the labor required to remove manually the sludge periodically."[b]

The objective of the AIVD project is to prove that AIVD is an alternative to cadmium corrosion protection. This will reduce the generation of wastes resulting from cadmium plating operations. Anniston Army Depot purchased and installed a unit. Four hundred parts have been plated. About 90% appear to be candidates for further action. The major stumbling blocks are the specifications. Many of them specifically call for cadmium plating. A performance specification for corrosion protection should be used instead. Anniston estimates that AIVD will save about $91,000 a year.

PMB reduces hazardous waste generation by eliminating the use of chemical strippers, and with the ability for large percentage recycle, reduces the amount of waste generated compared to other media blasting. Less abrasives in the removed paint means less hazardous waste for disposal. Initial studies showed that there would be labor reductions and cost benefits as well as processing a greater variety of parts. Developed operating parameters must be adhered to. Higher pressures that would decrease the time required to strip a part will destroy the media so that it cannot be recycled.

Fluidized bed paint removal contains a heated bed of fluidized aluminum oxide for the removal of grease and paints from parts at Army depots. It has been determined that the method works well for steel parts. It does not work for heat treated aluminum parts since the heat in the bed adversely affects their structural integrity. This technology will reduce the generation of hazardous waste and provide a better working environment.

The personnel running the high-efficiency paint application project have evaluated three different paint application systems that might have increased transfer efficiency thus reducing hazardous waste generation and VOC emissions. The tests analyzed the transfer efficiency, rate of application, and ability to meet coating specifications as well as provided guidance for full-scale implementation. Six conclusions were drawn in the final report:

1. None of the three low-cost [high volume, low pressure (HVLP)] paint spray guns clearly outperformed the other with respect to transfer efficiency or coating finish. Small variations in measured transfer efficiency were probable due to the paint operator rather than the paint spray equipment.

2. For the particular model tested, the use of heated air had no major effect on improving the transfer efficiency or the coating finish.

3. None of the HVLP equipment tested at Sacramento Army Depot (SAAD) on small sized parts with one-component polyurethane CARC or two-component polyurethane enamel alternative achieved a measured transfer efficiency ≥65%. The transfer efficiency averages ranged from 16.1 to 36.6%.

a. U.S. Army, 1991, *Evaluation of a Particulate Filtration System for an Alkaline Paint Stripper at Letterkenny Army Depot*, U.S. Army Toxic and Hazardous Materials Agency Report Number CETHA-TS-CR-91033, July 1991, page i.

4. With the exception of the Can-Am turbine, none of the HVLP equipment tested at SAAD on medium-sized parts with one-component polyurethane CARC or two-component polyurethane enamel alternative achieved a measured transfer efficiency ≥65%. The transfer efficiency averages for the low-cost HVLP equipment ranged from 49.4 to 58.2%. The average transfer efficiencies for the turvine HVLP equipment ranged from 60.6% to 64.4%. It should be noted, however, that different parts and a different paint spray booth were used in the testing of the low-cost HVLP guns.

5. The conventional paint spray gun tested at SAAD achieved paint transfer efficiencies approaching those of the HVLP types for both small- and medium-sized parts when operated at low outlet pressures (i.e., approximately 20 psi).

6. The conventional paint spray gun tested at SAAD achieved proper paint atomization (i.e., proper coating lay) for both coatings (i.e., one-component polyurethane CARC and two-component polyurethane enamel alternative) while operating at low outlet air pressures (approximately 20 psi).[c]

The Oak Ridge National Laboratory (ORNL) has significantly reduced its use of VOCs and chlorofluorocarbons (CFCs) in its industrial operations. A technology used is ultrasonic cleaning. We have initiated a contract for the ORNL project engineer to review U.S. Army operations and where applicable to help institute ultrasonic cleaning at U.S. Army installations.

The personnel conducting the project on the use of alternate chemical strippers will identify and evaluate commercially available strippers to replace current formulations containing methylene chloride. A successful stripper must contain no toxic chemicals, effectively strip a variety of coatings and substrates within two hours, and meet operational, health, and safety requirements. To date, no one formulation meets all requirements for all coatings.

Alternate paint formulations is a project that we will be picking up from the U.S. Army Construction Engineering Research Laboratory. This project is trying to develop new paint formulations that do not exceed the VOC limits imposed by regulations.

As mentioned above in the paragraph on ultrasonic cleaning, ORNL has reduced its use of VOCs and CFCs. One way it achieved the reduction was to use an alternate solvent. Again, we have started a contract to have ORNL identify where we could use this solvent and help us implement its use.

In conclusion, the U.S. Army has many environmental challenges. It has met them with existing technology and is looking for more cost-effective technologies, many of which are near implementation. The next generation of technologies for addressing environmental problems is at the pilot or laboratory scale and looks very promising. It appears that no single technology can solve all problems associated with a single industrial operation such as paint stripping.

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a. U.S. Army, 1991, *Evaluation of a Particulate Filtration System for an Alkaline Paint Stripper at Letterkenny Army Depot*, U.S. Army Toxic and Hazardous Materials Agency Report Number CETHA-TS-CR-91033, July 1991, page i.

THE ARMY'S

HAZARDOUS WASTE MINIMIZATION

R & D Program

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Army HAZMIN Goal

To reduce hazardous waste generation by 50% by the end of 1992 using FY 1985 total as baseline

HAZMIN Challenge

Eliminate hazardous waste while increasing efficiency

ROLE OF R&D IN HAZMIN

APPLICATION OF EXISTING TECHNOLOGIES

To new situations
To meet Army-specific requirements
To fit into existing processes

↓

INNOVATIVE TECHNOLOGY DEVELOPMENT

New processes

↓

IMPLEMENTATION

METHODS

Material Substitution
Operational Changes
By-Product Recovery/Reuse

DEPOT HAZMIN TECHS UNDER DEVELOPMENT

RECOVERY/REUSE

√ Electrodialysis of Chromic Acid Solutions
√ Filtration of Paint Stripper Solutions

PROCESS CHANGE

√ Aluminum Ion Deposition as an Alternative to Electroplating
√ Plastic Media Blasting for Paint Stripping
√ Fluidized Bed Paint Stripping for Small Parts
√ More Effective Paint Application Techniques
√ Ultrasonic Cleaning

MATERIALS SUBSTITUTION

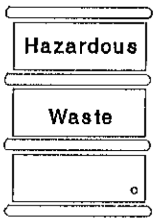
√ Alternate Chemical Paint Stripper Formulations
√ Alternate Paint Formulations
√ Solvent Substitution

Electrodialysis of Chromic Acid Baths

Objective: To reduce or eliminate HW from chromic acid baths

Process: Uses an electrical charge and a semi- permeable membrane to separate impurities and regenerate chromic acid

Tasks	Milestones
Receive final report	Aug 91
Assist depots with implementation	FY 92



Results

√ Removed metals from baths
√ Leaking membrane clouded results
√ Possible solutions have been recommended

FILTRATION OF PAINT STRIPPING BATHS

OBJECTIVE

Demonstrate the potential for extending the life span of paint stripping baths by filtration

METHOD

Filtration unit was purchased and installed at Letterkenny AD. Testing and demonstration was conducted to determine feasibility, effectiveness, cost and to develop guidelines for system implementation wherever appropriate

RESULTS

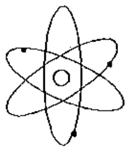
✓ Will reduce suspended solids and sludge formation
✓ Will reduce sodium hydroxide usage
✓ Will increase bath life
✓ Will decrease hazardous waste and labor usage

Aluminum Ion Vapor Deposition

Objective: To determine the effectiveness of using aluminum ion vapor deposition to replace cadmium coatings

Process: The parts to be treated are placed in a vacuum and an electric charge is placed on the parts. Then aluminum wire is melted in a crucible in the bottom

Tasks	Milestones
Final report	Aug 91
Assist depots with implementation	FY 92



PLASTIC MEDIA BLASTING DEMONSTRATION

Benefits Realized from Replacement of Obsolete Equipment with State-of-the-Art Plastic Media Blasting Booth

WASTE REDUCTION

✓ High Efficiency Recycle System and Pressure Control Reduces Waste Generation by *70%* (Annual Waste Production is Reduced by 93,000 lbs) , Minimizes CFCs

LABOR REDUCTION

✓ Automatic Floor Recovery Reduces Labor Requirements by *25%* (1250 Manhours per Year)

OTHER CONCLUSIONS

✓ PMB has high operating costs, slow removal of CARC
✓ Does not effectively remove deep corrosion
✓ Operators need to keep operating at optimum conditions
✓ Automated systems may significantly improve costs

Fluidized Bed Paint Stripping

Objective: To show the effectiveness of fluidized bed paint stripping on Army parts and paints

Process: Uses a hot fluidized bed of aluminum oxide to heat (pyrolyze) paint on metal parts

Tasks	Milestones
Final report	Aug 91

Results

✓ Works with regular steel parts
✓ Removes temper from Aluminum parts
✓ Need to remove Aluminum Oxide from parts
✓ Could have a dusting problem
✓ Bed material becomes a hazardous waste

High Volume/Low Pressure Paint Application

Objective: To determine the transfer efficiency of HVLP systems for Army depot operations

Process: The system uses specially modified paint guns to produce less overspray and cut down on the amount of paint used

Tasks	Milestones
Receive final report	Aug 91
Assist depots with implementation	FY 92

RESULTS

- √ None of the guns outperformed the others
- √ Heated air had no effect
- √ None of the guns reached the 65% TE on small parts
- √ Only the CAN-AM turbine approcahed 65% on medium parts
- √ Conventional units approached the HVLP unit at low P
- √ Conventional units had proper atomization at low P

ALTERNATE CHEMICAL STRIPPER IDENTIFICATION AND EVALUATION

OBJECTIVE

Identify and evaluate commercially-available strippers to replace current formulations containing methylene chloride

SUCCESSFUL STRIPPER MUST:

- √ Reduce TTO contributions
- √ Effectively strip a variety of coating/substrate combinations within 2 hours
- √ Meet operational, health, and safety requirements

STATUS

To date no alternate stripper meets requirements
Project is continuing

ALTERNATE PAINT FORMULATIONS

OBJECTIVE

To develop paints that reduce or eliminate VOC emissions while maintaining an effective coating.

VALUE

Reduce VOC emissions so that activities can continue to operate without violating environmental regulations

STATUS

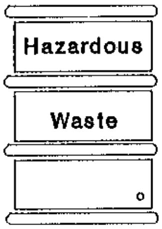
Working with CERL will pick up project for demo

Solvent Reduction

Objective: To demonstrate the use of the Oak Ridge National Laboratory's CFC reduction strategy at an Army Depot

Process: Use Solvent 140 to substitute for cold cleaning operations and ultrasonic cleaning for hot cleaning operations

Tasks	Milestones
Send out MIPR	Jul 91
Review Army operations	Dec 92
Submit Demo Plan	Feb 92
Begin Demonstration	Jun 92
Complete Demonstration	Jan 93
Submit Final Report	Mar 93



ARMY HAZMIN PROGRAM

GOAL - Reduce Generation of Waste 50% by 1992
(1985 Base Year)

STATUS

Tracked Waste (1000 Metric Tons)

1985	1986	1987	1988	1989	1990	1991	1992
98	126	60	59	112*	83**	⟶	*49*

* Includes 60,000 metric tons of waste generated during two RCRA closures

** Includes RCRA waste, TCLP, and Desert Storm production

SUMMARY

✓ Three primary means to reduce the generation of hazardous wastes:

- *Recovery/Reuse*
- *Process Changes*
- *Material Substitutions*

✓ Opportunities currently exist to reduce hazardous waste generation in ways that will reduce operating costs and at least maintain, or improve, product quality

✓ Current emerging technologies can be adapted to site/application-specific operations to accomplish the above

SUMMARY

(CONTINUED)

- ✓ As more HAZMIN measures are implemented, more innovation will be required to accomplish the above

- ✓ In the absence of future innovation, more HAZMIN can be expected to require higher operating costs

- ✓ An interface of real substance must be established between user and developer in order to effectively benefit from new HAZMIN technology