RESTORING THE ENVIRONMENT AND MANAGING WASTE THROUGH MINIMIZATION AND AVOIDANCE

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ABSTRACT

The Department of Energy (DOE) has established a national Research, Development, Demonstration, Testing and Evaluation (RDDT&E) Program for pollution prevention and waste minimization at its production plants. During FY 1989/1990 the Office for Environmental Restoration and Waste Management through the Office of Technology Development established comprehensive, waste-minimization technical support programs to demonstrate new, environmentally-conscious technology for production processes. The RDDT&E program now entails collaborative efforts across the DOE. The task underway develops manufacturing technology that not only minimizes waste generation but modernizes manufacturing techniques. The presentation describes the waste minimization plans, successes to-date, and ongoing activities.

The RDDT&E Program realizes that major process modifications, material substitutions, and new technology are required to achieve significant waste reduction at the source. The program focuses on production operations that produce 90% of the DOE waste and involve plutonium, tritium, uranium, electronics, polymers, and other manufacturing operations. Technology is sought that achieves 60% to 80% waste elimination and reduced waste toxicity for radioactive and non-radioactive waste forms.

The waste minimization program includes collaborative efforts within the DOE, and with Federal Agencies, private industry, and universities. Joint-working, joint-funding agreements are in place with the DOE Defense Programs Office, the Air Force, and Boeing Corporation.

INTRODUCTION

Waste minimization is a concern throughout the Department of Energy (DOE), the Department of Defense (DOD), other Federal Agencies, and private industries. As the country has become more environmentally conscious, waste disposal faces stricter rules and regulations which in-turn drive up disposal costs 25% to 50% a year. Clearly, one of the best methods to reduce disposal costs is to reduce disposal quantities through waste minimization.

Some 22.5 billion pounds of toxic chemicals were released into the air, earth, and water in 1987, according to an Environmental Protection Agency (EPA) report. According to the data, 9.7 billion pounds of chemicals were released in streams and other bodies of water: 1.9 billion pounds were sent to municipal wastewater-treatment plants for processing and disposal; 2.7 billion pounds went into the air; 2.4 billion pounds were placed in landfills; and 3.2 billion pounds were injected into underground wells. In addition, 2.6 billion pounds were sent to off-site treatment and disposal facilities.

A source release is volatile organic compounds (VOCs) discharged into the atmosphere. VOCs; in particular, chlorinated hydrocarbons and chlorofluorocarbons (CFCs), are being used in metal cleaning operations including degreasing cleaning, general organic removal, painting, and paint removal processes. The world concern relative to ozone depletion will result in a ban of CFCs in the early 2000.

To address waste minimization the DOE has established a national Research, Development, Demonstration, Testing and Evaluation (RDDT&E) Program for pollution prevention and waste minimization at its production plants. During FY 1989/1990 the Office for Environmental Restoration and Waste Management through the Office of Technology Development established comprehensive, waste-minimization technical support programs to demonstrate new, environmentally-conscious technology for production processes. The RDDT&E program now

entails collaborative efforts across the DOE. The task underway develops manufacturing technology that not only minimizes waste generation but modernizes manufacturing techniques. The presentation describes the waste minimization plans, successes to-date, and ongoing activities.

The DOE production and manufacturing processes create approximately 90% of the hazardous and radioactive waste generated from within the Agency. To eliminate much of the waste sources, the DOE realizes that major process modifications, material substitutions, and new technology are required to achieve waste reduction and hazards reduction at the source that are substantially greater in magnitude than simple administrative change provides. Therefore, the programs focus on assessing whole production processes that manufacture strategic products; e.g. plutonium manufacturing, tritium production, uranium manufacturing, electronics, polymers, and their auxiliary support operations. Technology is sought that achieves 60% to 80% waste elimination and reduced waste toxicity. Affected are sanitary landfills, hazardous, low-level radioactive, mixed, high-level radioactive, and transuranic waste.

WASTE MINIMIZATION PROGRAMS

Currently, the RDDT&E Program has in place two major comprehensive efforts: Depleted Uranium Manufacturing Waste Minimization and Environmentally Conscious Manufacturing. By comprehensive the DOE refers to a complete stem-to-stern look at all manufacturing steps that are integrated to produce a product, rather than assessing individual steps. The goal is to eliminate the number of steps now required to produce a product; and to hopefully, eliminate those that cause high volumes of waste.

The Depleted Uranium Manufacturing effort is moving forward to create new manufacturing technology for uranium of all forms. It modernizes DOE Uranium Manufacturing at the Y-12 Plant in Oak Ridge, Tennessee. The collaborative program includes support research performed at the Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia National Laboratories. In addition, private industry support is ongoing and increasing. In less than one year the program accomplishments include the complete elimination of RCRA* -regulated solvent usage from the Enriched Uranium Recovery Operations in Oak Ridge.

The Environmentally Conscious Manufacturing effort studies elimination and reduction of hazardous chemicals through a joint program between Sandia National Laboratory and the DOE production plants at Kansas City, Mound Laboratory, and the Pinellas Plant along with commercial suppliers. Solvent elimination and substitution, plating and surface finishing, and polymer processing are principal work elements.

URANIUM WASTE MINIMIZATION PROGRAM

The Uranium Waste Minimization Program seeks to modernize the manufacturing process for uranium materials within the DOE. Modernization consists of developing and designing a facility that readily satisfies the DOE health, safety, and environmental directives. Included in the design are fewer process steps that reduce the cost of and the scale of such operations while reducing waste generation by 60% to 80%.

The RDDT&E Program includes work to define the material usage efficiency problems and apply available and new technology that improves material usage efficiency and can be demonstrated. The major production plant waste sources are assessed so the true causes of process waste are correctly targeted. Since uranium is a difficult material to process, the technology has spinoff application on easier-to-process materials including metals and ceramics.

Many metalworking operations are under study. Some of the operations are metal furnaces, casting, metal blank forging, rolling, milling, machining, and chemical treatments. Waste from such operations include casting slag, uranium oxide, cutting fines and abrasives, massive cut-off scrap, machine turnings, many chemical waste, and substandard products. Auxiliary operations such as material pretreatment and post-treatment operations are also under study. Process control and quality control requirements are being re-thought. Materials of construction that contribute to material inefficiencies; e.g. contamination sources and facilities design inefficiencies are important.

No less a concern is the impact of such changes for waste minimization on the quality of the strategic products manufactured by the DOE. Every precaution is taken to assure that change is not at the expense of product quality. Thorough evaluation of material manufacture via the new steps will demonstrate that part tolerances, physical and mechanical properties, and operational performance do not deteriorate.

Despite process hardware changes for greater material usage efficiency, waste will be generated. Therefore, the effort seeks to develop a process that generates only recyclable scrap. The recycle of uranium chips and fragments are particularly difficult. New machining and handling techniques for reactive metals will be developed and demonstrated. The goal is to directly recycle such scrap without sacrificing chemical and physical properties.

Of special note, the Y-12 Plant has had exceptional technical success in substituting non-hazardous coolants

* RCRA-Resource Conservation Recovery Act

and lubricants for traditional materials that are more toxic and not biodegradable. The effort will continue so that non-toxic, biodegradable cutting fluids are available along with manufacturing steps that require little or no hazardous fluids.

Other benefits will be realized through the uranium waste minimization effort. The improved material usage efficiencies with the new process not only reduce waste generation by up to 80%, but also, reduce uranium raw material purchases by 80%. Going beyond studying the changes to the primary uranium process steps, improvements within auxiliary operations can reduce secondary waste by 80%. Such waste includes secondary and tertiary hazardous and contaminated acids, bases, and general manufacturing chemicals. Secondary waste come from process quality control, ventilation, building ingress and egress measures, employee health and protection measures, and other indirect operations. Solvent elimination has already been a success in highly enriched uranium operations and like improvements can be implemented in depleted uranium operations. In each improvement, material usage will decrease and to the extent possible innocuous materials replace hazardous ones.

ENVIRONMENTALLY CONSCIOUS MANUFACTURING

The Environmentally Conscious Manufacturing effort seeks to minimize and prevent the generation of solid and liquid waste and gaseous emissions through substitution of materials and modification or replacement of processes. The effort improves the electronics and plastics manufacturing operations at the DOE non-nuclear production sites located at Kansas City, Mound Laboratory, the Pinellas Plant, and commercial suppliers. Important within these operations is the effort to eliminate or greatly reduce the use of hazardous solvents. As in the uranium program the waste minimization philosophy to streamline the production operations and reduce production steps is studied to reduce production emissions by 60% to 80% and create less toxic waste. The new processes must be demonstrated and satisfy the DOE health, safety, and environmental directives.

The current focus of the effort is solvent replacement. Chlorofluorocarbons (CFC) and chlorinated hydrocarbons have been used extensively in the manufacture of electronics and electrochemically plated parts. Although solvent reductions have been ongoing within the DOE since the mid-1980's, the current goal is elimination for CFC and CHC solvents by 1993.

The program is also addressing individual process steps. Electrochemical metal plating and polymers processing must be improved for hazardous waste reduction. Operating changes are under study. In addition, new surface finishing techniques; e.g. laser plating and fluxless soldering, are being researched to eliminate or greatly reduce hazardous waste from these operations.

As in the uranium program the process changes can not compromise product quality. Therefore, a thorough part testing and qualification program is included for each alternate solvent application. The tests include part aging and compatibility, cleanliness measure, and functionality of the final products. On line monitoring and process control instrumentation will be developed to complement the future quality control program.

The effort includes collaboration with other companies who manufacture electronics and polymers and supply such materials to the DOE sites. Within the framework of the collaboration is a working relation with the National Center for Manufacturing Sciences located in Ann Arbor, Michigan. Besides working with the many member companies within the Center, Cooperative Research and Development Agreements (CRADA) can be implemented with these and other companies, as needed, to provide joint funding and work sharing.

DEFENSE PROGRAMS, RDDT&E, AND OTHER COLLABORATIONS

The DOE Office for Defense Programs (DP) and the Office of Technology Development have created a collaborative effort through a Memorandum of Agreement through which other complementary, waste minimization programs are jointly funded. Commencing in FY 1990 the program is coordinated by the Albuquerque Operations Office for Environmental Programs headed by Kathy Carlson.

The DP waste minimization program structure studies specific processes and waste streams. Included are plutonium, uranium, tritium and other radioactive materials, mixed waste, solvents, plating, polymers, and miscellaneous processes not covered by the programs mentioned above. Waste Stream Managers are responsible for program coordination and program strategy planning. National laboratory and production plant representatives constitute the waste stream committee membership so the source of the waste is intimately involved in planning and controlling that eventually impacts their operations.

The DP/EM collaborative plan has a Fiscal Year 1991 budget of $42 million for research and development support. To date the work has:

1. Completed project plans for two strategic weapons programs,
2. Chlorofluorocarbon and chlorinated hydrocarbon elimination on schedule to satisfy the Montreal protocol,
3. A collaborative agreement signed between Sandia Laboratories and the Electroplaters and Surface Finishers Society for research at universities,

4. Completed surveys of DOE electroplating facilities for waste minimization options,
5. Established a program for plating waste minimization for energy conservation in a Northern California middle school.

Expansion of the RDDT&E successes are being implemented through other joint-working agreements. Collaborative agreements have been signed with the Air Force, EPA, NIST, NASA, and Boeing Corporation. The Air Force-DOE agreement jointly funds research support for hazardous solvent replacement and recycle. The EPA agreement with the EPA Office for Research and Development includes waste assessment and research planning exchanges. The Boeing agreement includes a CRADA through which Boeing and the DOE jointly fund research for alternative technologies that produce less hazardous waste.

Greater sharing of waste minimization technology among U.S. businesses and Agencies is planned. At the Idaho National Engineering Laboratory a national effort for technology exchange is underway that brings together the DOE, the DoD, private industry, and other agencies to share the ever-burgeoning waste minimization information. In December the International Workshop on Solvent Substitution was held in Phoenix and revealed the rapid progress toward RCRA solvent elimination within the U.S. The Idaho effort hopes to build on this initial success and form national waste minimization working groups with memberships from across the Federal and private sectors. The goal is to realize serious waste minimization progress through new technology by the year 2000.

THE IDAHO PROGRAM INITIATIVE

A major waste minimization initiative sponsored by the RDDT&E program, the Air Force, and private industry is currently underway at the Idaho National Engineering Laboratory. The FY 1990 collaborative effort in solvent substitution at INEL consists of research in the areas of:

- Solvent Handbook
- Volatile Organic Compounds
- Alternative Paint Strippers
- CFC's Substitution and Replacement
- High VOC Primers, Topcoats and other Replacements
- Chlorinated Solvent Replacements
- Spray Forming

A complete description of these projects along with others will be presented at this conference. The basic objectives of these 7 research projects are:

SOLVENT HANDBOOK (INEL)

The purpose of the Solvent Utilization Handbook is to provide guidelines for substitute solvent selection. Information in this book includes cleaning performance, corrosion and solvent treatability, recycle/recovery, volatile organic compound emission, flash point, toxicity, specific hazards, safety considerations, possible enhancement techniques, and possible volatile organic compound emission controls. The handbook will include all test methodologies and conditions.

VOLATILE ORGANIC COMPOUNDS (INEL)

The objective of the Volatile Organic Compound (VOC) task is to identify and measure the potential VOC emissions from the solvent substitutes used in production and maintenance operations. Relative to the present rules, regulations, and probable future changes, it appears that the VOC emissions from all government facilities will be regulated.

ALTERNATIVE PAINT STRIPPERS (INEL)

The focus of the Alternative Paint Stripper task is to test and select low toxicity, environmentally compliant solvents for paint stripping operations.

CFCs SUBSTITUTES AND REPLACEMENTS (BOEING)

The program to replace CFCs includes investigating alternate lubricants for machining and drilling operations, substitute solvents for vapor degreasing and cleaning, and replacement of present CFC-based release agents with other materials. There are a total of seventeen separate programs addressing the issue of CFCs.

HIGH VOC PRIMERS, TOPCOATS AND OTHER REPLACEMENTS (BOEING)

The objective is to find low VOC coatings which conform to southcoast Rule 1124 to support fabrication of hardware facilities. Screening and evaluation to establish performance requirements, and qualification of successful materials will be conducted. The specific areas of activity include waterborne interior primers, waterborne low VOC exterior primers, low VOC fuel tank primers, low VOC primers to conform to military specifications, low VOC adhesive primers, low VOC topcoats that utilize high solids content or powder coating, low VOC protective enamel, low VOC interior urethane coating, and low VOC coatings for fasteners, dry film lubricants, water-based maskants, and conformal coatings.

CHLORINATED SOLVENT REPLACEMENTS (BOEING)

The development efforts to find replacements for chlorinated solvents cover three basic areas: alternative vapor degreaser fluids, paint strippers, cleaning for super critical clean requirements and for printed wiring boards.

SPRAY FORMING (INEL)

The objective of the Spray Forming task is to investigate the replacement of chromium electroplates with sprayed chromium or high performance chrome bearing alloys. In the process, molten metal droplets are sprayed on a base metal, consolidating them into a highly dense coating. No liquid waste is generated and no airborne particulates are emitted. The collaborative effort includes 17 other research projects in the area of metal finishing.

CONCLUSION

The DOE RDDT&E Program is a major indication of progress and a commitment within the DOE to provide waste minimization technology for the DOE production plants. In addition, the ambitious technical goals for waste minimization are indicative of a DOE that is becoming a leader in this arena and preparing for new, modern operations. Through technology transfer the DOE plans to provide such modernization technology to other agencies and U.S. industry. Likewise, the DOE looks to private industry to offer new waste minimization technology for use within the Agency. With continued teaming the RDDT&E program expects significant progress towards waste minimization implementation.