Using Benchmarking to Minimize Common DOE Waste Streams

Volume III. Aqueous Cutting Fluid Waste

Prepared for
U.S. Department of Energy
Office of Waste Management
Environmental Management
Waste Minimization Division

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Abstract

Finding innovative ways to reduce waste streams generated at U.S. Department of Energy (DOE) sites by 50% by the year 2000 is a challenge for DOE's waste minimization efforts. A team composed of members from several DOE facilities used the quality tool benchmarking to improve waste minimization efforts. First the team examined aqueous cutting fluid generation and handling processes at their sites. Then team members developed telephone and written questionnaires to help identify potential "best-in-class" industry partners willing to share information about their waste minimization techniques and technologies. The team identified two partners, Halliburton Energy Services in Duncan, Oklahoma, and Lockheed Martin Aeronautical Systems in Marietta, Georgia. Recently, both companies introduced new coolant management programs. As a result of the changes, both companies have reduced purchases of new cutting fluid concentrate, the labor required to maintain cutting fluid and sumps, the cutting

fluid waste stream, and the cost of coolant waste disposal. For both companies, change was dependent on management support and change in management approaches; increased worker involvement in the coolant process; technology improvements; and market drivers requiring companies to downsize, increase efficiency, and cut costs to be competitive.

ACKNOWLEDGMENTS

This report represents the efforts of many participants who shared their talents, time, and resources to further DOE's waste minimization efforts. We thank the following for their contributions:

Industry partners and their representatives:

- Halliburton Energy Services, Duncan, Oklahoma; Anthony Chandler, environmental technician; Kelly Haggard, manufacturing engineer; Dan Jones, manufacturing engineer; Chris Marshall, manufacturing engineer; Jason Smith, coolant coordinator; Chris Taylor, assistant to the coolant coordinator.
- Lockheed Martin Aeronautical Systems, Marietta, Georgia; Harold Hollingshed, maintenance supervisor.

DOE sponsors

- Kent Hancock and Ker-Chi Chang at DOE EM-334, and Oren Critchfield at DOE/AL

DOE aqueous cutting fluid process experts

- Karl Arnold, Staff Process Specialist Engineer, AlliedSignal Aerospace, Inc., Kansas City Division (KCD), Kansas City, Missouri
- Andy Cardiel, Manufacturing Consultant, Sandia National Laboratories/California, Livermore, California
- Gary Graham, Journeyman Machinist/Supervisor of machine repair section in charge of coolant recycling, Sandia National Laboratories/New Mexico, Albuquerque, New Mexico
- Art Jens, Machine Maintenance Supervisor, Brookhaven National Laboratory, Upton, New York
- Mary Martinez, Special Materials Fabrication Team Leader, Los Alamos National Laboratory, Los Alamos, New Mexico
- James Wright, Senior Supervisor of Craft Services, Battelle Pacific Northwest Laboratories, Richland, Washington

Executive Summary

Mission

Recent Executive Orders are challenging U.S. Department of Energy (DOE) facilities to prevent pollution at its source and to use recycled products. DOE continues to seek innovative ways to reduce waste streams generated at DOE sites by 50% by the year 2000.

Project Focus

Sponsored by the DOE's Waste Minimization Division (EM-334), the Benchmarking for Waste Minimization project (1) examines waste minimization techniques and technologies that have been used successfully to minimize aqueous cutting fluid and (2) provides this information to affected sites within DOE. Benchmarking was the methodology used for analyzing the internal processes and seeking partners that have successfully improved their waste minimization procedures.

This report describes the team findings of the best waste minimization practices for aqueous cutting fluid.

Benchmarking Definition

Benchmarking is the continuous process of improving products, services, and practices by identifying and understanding the current process, exchanging information with recognized leaders in the field, and implementing meaningful improvements.

Benchmarking is used by a variety of companies and organizations as a quality improvement tool. For this project, the following 12-step benchmarking process was used:

1. Identify process to be benchmarked
2. Establish management commitment
3. Identify and establish benchmarking team
4. Define and understand the process to be benchmarked
5. Identify metrics
6. Evaluate current performance
7. Identify potential benchmarking partners
8. Collect process data from potential partners
9. Analyze potential partners' data and choose partners
10. Conduct site visits
11. Communicate results
12. Continue to benchmark the process

Benchmarking Team

A benchmarking team evaluated the current internal processes used at several DOE facilities for aqueous cutting fluid. The team created a process flow chart and defined process metrics. Using telephone surveys and written questionnaires, the team searched for industry partners with similar working environments that had addressed the problems that the team was investigating. The team found a variety of potential partners, and made two site visits.

Site Visit Results

The team visited Halliburton Energy Services in Duncan, Oklahoma, and Lockheed Martin Aeronautical Systems (LMAS) in Marietta, Georgia, to learn about their waste minimization practices. Recently, both companies introduced new coolant management programs. As a result of the changes, both companies have reduced:

- purchases of new cutting fluid concentrate,
- the labor required to maintain cutting fluid and sumps,
- the cutting fluid waste stream, and
- the cost of coolant waste disposal.

Factors for Change

For both companies, change was dependent on these major factors:

- management support and change in management approaches,
- increased worker involvement in the coolant process,
- technological improvements, and
- market drivers requiring companies to downsize, increase efficiency, and cut costs to be competitive.

Changes at Halliburton Energy Services

Changes at Halliburton that enhanced the waste minimization effort included the following:

- Changed coolants from a water-soluble to a biostatic semisynthetic. This change reduced coolant usage by 50%.
- Adopted a new coolant management system that uses portable filtration at the sump to keep cutting fluid clean and prevent deterioration. Coolant personnel test the cutting fluid daily for concentration levels and periodically for bacteria growth and pH level. They treat the fluid with stabilizer to inhibit bacteria growth and add cutting fluid concentrate or water as needed to maintain proper concentration.
- Designed and built an evaporator to remove water and diminish coolant waste to its lowest possible volume.
- Defined focus factories within the facility to increase worker process ownership, accountability for expenses, and improve quality.

Changes at LMAS

Changes at LMAS that enhanced the waste minimization effort included the following:

- Instituted a coolant management program.
- Consolidated machine shops by product type.
- Used a contractor to recycle coolant on site.
- Made machine modifications that cut down on leaks, stagnant spots in supply lines, and other places that could contribute to bacteria growth.
- Used a pressure spray to clean machines more thoroughly, which leaves fewer bacteria to contaminate fresh coolant.
- Maintained fluid quality and consistency through fluid monitoring, better controls on concentration levels, and computer tracking.
- Trained employees extensively to increase employee and management awareness and expertise in coolant management.

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Acronyms and Definitions

BMP	Best Management Practices
DOE	U.S. Department of Energy
ES&H	Environment, Safety and Health
KCD	Kansas City Division
LMAS	Lockheed Martin Aeronautical Systems
MMES	Martin Marietta Energy Systems
Oilers	Workers responsible for the lubrication and maintenance of machine shop equipment.
SNL/CA	Sandia National Laboratories, California
SNL/NM	Sandia National Laboratories, New Mexico
Soluble oil	Oil that has been treated with emulsifying agents to become soluble in water
WMin	Waste Minimization
WWTF	Waste Water Treatment Facility

1.0 Introduction

1.1 Background

Executive Orders

Executive Orders signed by President Clinton require federal government agencies to prevent pollution and to use recycled products. Executive Order 12856 states that "It is the national policy of the United States that whenever feasible, pollution should be prevented or reduced at the source." On October 20, 1993, President Clinton signed Executive Order 12873, which focuses on federal acquisition, recycling, and waste prevention and is intended "to strengthen the role of the Federal Government as an enlightened, environmentally conscious and concerned consumer."

DOE Waste Minimization Mission

The U.S. Department of Energy (DOE) has placed a high priority on waste minimization and pollution prevention, encouraging waste generators to develop programs and request adequate resources to effect long-term savings. To provide a strategy for meeting these priorities, the DOE created the Waste Minimization/Pollution Prevention Crosscut Plan (DOE, 1994). The plan states that DOE's waste minimization (WMin) mission is

> "To reduce generation and release of DOE multi-media wastes and pollutants by implementing cost-effective waste minimization and pollution prevention technologies, practices, and policies, with partners in government and industry while conducting the Department's operations in compliance with applicable environmental requirements."

DOE Objective

This benchmarking project helps to accomplish one of the major DOE Crosscut Plan Strategic Objectives, which is "to identify and develop technologies and exchange information." The DOE can enhance the effectiveness of WMin efforts by exchanging applicable technologies and information with companies or organizations that are already successful in their WMin/Pollution Prevention approach. A secondary DOE objective is to work closer with U.S. industry.

Waste streams that are common in the DOE complex are logical targets for evaluation because the results can be shared across the complex.

Sponsor

The sponsor of this project is the DOE Waste Minimization Division, EM-334. The division's mission is to plan, coordinate, and develop a DOE-wide Waste Minimization and Pollution Prevention Program that results in a decrease in the amount of wastes produced by the DOE.

Benchmarking Approach

Benchmarking was chosen as the project approach because it

- has proven capabilities as a quality improvement tool,
- provides flexibility,
- may be applied to many different processes, and
- increases ties with U.S. industry.

For a complete definition of benchmarking and an explanation of the process, refer to *Using Benchmarking to Minimize Common DOE Waste Streams, Volume I, Methodology and Liquid Photographic Waste*, SAND93-3992, April 1994.

1.2 Purpose

Project Purpose

The project's purpose is to

- identify common waste streams throughout the DOE,
- provide a forum for the waste generators who produce the same waste stream at different DOE facilities,
- partner with private industry to learn the best waste minimization technologies that have been applied successfully to these waste streams, and
- provide this information to the DOE.

Benchmarking (a quality tool) provided the methodology for analyzing internal DOE site processes and for seeking industry partners that have successfully improved their own waste minimization efforts.

Report Purpose

This report describes the results of the benchmarking effort to identify the best waste minimization practices for managing aqueous cutting fluid.

1.3 Report Structure

This document is Volume III in a series of waste minimization benchmarking project reports. Volume I includes the background, full project scope, benchmarking methodology, project details such as training and survey techniques, and results of the liquid photographic waste case study. Volume II includes the results of the used motor oil case study. The results of the aqueous cutting fluid team are included in this report. Additional volumes will be added as other waste streams are studied.

Continued on the next page...

1.3 Report Structure, continued

The following table describes the report structure:

Report Section	Description
1	Project background and purpose.
2	The generic 12-step benchmarking methodology.
3	Project details and results. **See Sections 3.10 and 3.11 for waste minimization practices, techniques, and recommendations.**

2.0 Benchmarking Methodology

Introduction

This section is a brief overview of the generic process of benchmarking, as defined by Sandia's Process Improvement/Benchmarking Team.

Benchmarking Definition

Benchmarking is the continuous process of improving products, services, and practices by

- identifying and understanding customer requirements and process performance,
- exchanging information with recognized leaders (internal and external to the organization),
- implementing meaningful improvements, and
- recalibrating the process by assessing the progress and monitoring trends and results.

Author Robert Camp has defined benchmarking as "the search for industry `best practices' that lead to superior performance" (Camp, 1989).

Benchmarking Steps

Figure 2-1 is a flow chart of the 12-step benchmarking methodology used at Sandia.

Figure 2-1. 12-Step Benchmarking Methodology

2.1 Defining the Benchmarking Process

Benchmarking Process

The following table shows the steps that comprise the benchmarking process. Steps 1 through 6 reflect internal process improvement. Steps 7 through 12 reflect external activities.

Step	Activity
1	**Identify Process to be Benchmarked** The process selected must be narrow enough in scope that it is manageable. The process must be important to the work or business function and be customer-focused because a substantial amount of resources (i.e., personnel, time, and funds) are required to conduct the benchmarking study. The result must improve the process and add value.
2	**Establish Management Commitment** Management is defined as the person(s) who has the authority to allocate resources (personnel, time, and funds) and who is ultimately responsible for the outcome of the benchmarking activity. Management • has the responsibility to make the effort to understand the fundamentals of benchmarking and to demonstrate a willingness to implement the results; • needs to support the team and its recommendations with resources, encouragement, and commitment; and • has the right to expect frequent updates from the benchmarking team (e.g., verbal reports, meeting minutes, reports, periodic presentations).
3	**Identify and Establish Benchmarking Team** The benchmarking team members include • **process experts** who have extensive knowledge of the process through their daily jobs (these are the people impacted by any changes), • **resource personnel** such as facilitators, trainers, quality or benchmarking consultants, information specialists, technical writers, and statisticians, and • a **project leader** who guides the benchmarking process. The team may need training in benchmarking techniques, including process definition, the benchmarking process, quality tools, questionnaire design, and interviewing techniques. The team members must understand their roles and responsibilities and commit to a common team purpose or goal. The members must attend and participate in all meetings and complete their assignments. *Continued on the next page...*

Step	Activity
4	**Define and Understand the Process to be Benchmarked** The team defines the process through an understanding of important process elements: inputs, outputs, suppliers, and customers. The customer drives the business, and therefore, the team needs to understand the customers' wants, needs, and expectations. The team's final output for this step includes a process flow chart depicting the work flow and the relationships between people and organizations. The output from this step lays the foundation for the remainder of the benchmarking activity.
5	**Identify Metrics** The metrics must be meaningful to the process. Example metrics include customer requirements, cost, cycle time, and quality. Metrics, when possible, should be consistent with established standards (i.e., industrial, national, international). The process metrics aid in evaluating and assessing the current process. Strength and weakness trends developed from the metrics can identify areas for improvement and provide guidance and direction for selecting improvements to be implemented. Effective metrics provide guidance for developing survey tools for benchmarking partners.
6	**Evaluate Current Performance** The metrics help to identify the process areas to be improved and the nature of the improvements. The team may need to develop a decision matrix for ranking the improvements. A cost/benefit or return-on-investment analysis may be required to evaluate whether the benchmarking process should be continued. If the recommendation for implementation of the appropriate process improvements is made, it is necessary to monitor the trends and results. Benchmarking does not automatically assume that outside partners are required.
7	**Identify Potential Benchmarking Partners** Based on the metrics collected from the internal process, the team needs to identify and establish criteria for "best in class" partner selection criteria. The team can identify potential partners through numerous resources: database searches and contacts with external organizations, knowledgeable individuals, suppliers, and customers. The team needs to identify a sufficient pool of partners to determine the few they will visit. Partners that have better processes are not always easily found. A team may discover that their own processes are better than those of the potential partners. *Continued on the next page...*

Step	Activity
8	**Collect Process Data from Potential Partners** The team develops surveys to obtain preliminary information from potential partners. Surveys may consist of questionnaires, telephone interviews, or face-to-face interviews. (Normally, site interviews are reserved for Step 10.) The survey questions are based on the process metrics and criteria established for selecting partners. Up-front planning on how to analyze the quantitative and qualitative data is essential for developing good surveys.
9	**Analyze Data and Choose Partners** The preliminary data are used to select partners for site visits and interviews. The project leader compares the data gathered from the potential partners to the metrics and criteria set by the team. The final partner(s) must have a process that is applicable (in this study) to various DOE sites. The project leader should make direct comparisons of the data, process parameters, and constraints. The team analyzes the data and determines weighting and ranking criteria in order to select the final partners. If the team cannot find a partner that can provide substantial process improvements, the team needs to rethink the project. The team may decide • to repeat several steps, which includes revising the criteria, expanding the pool of potential partners, collecting new process data, and re-analyzing the data in the search to find appropriate partners; or • to conduct an internal evaluation; or • to terminate the benchmarking effort.
10	**Conduct Site Visits and Reanalyze Data** To gain the maximum benefit from partner site visits, careful and thorough preparation is essential. Preparation includes, but is not limited to, determining appropriate interviewees, assigning team interviewing roles, developing a list of questions and a meeting agenda, and determining how to handle the interview data. The site visit is an opportunity for two-way communication between the benchmarking team and each partner. During the site visit, the team conducts an in-depth interview. It is essential that the team develop an effective interview guide for each partner before the site visit. After all partners' information is collected, the quantitative and qualitative data are analyzed. A decision matrix may be used to identify and select the partners' practices to be incorporated. *Continued on the next page...*

Step	Activity
11	**Communicate Results** The team reports results to upper management and all involved parties and develops an action plan that describes the team's recommendations, methods for implementation, and implementation costs and schedule. The findings need to be adaptable to the process and the organization's culture and constraints. The improvements need to be monitored and evaluated.
12	**Continue to Conduct Benchmarking of Process** The best process today may not be the best process tomorrow. Depending on the amount of change in the process, customer requirements, competition, technological advances, and changing business practices, it is important to revisit the process, or specific aspects of the process, periodically.

Reference

This section is an adaptation of Section 2 of the report, *Benchmarking the Property Inventory Process at Sandia National Laboratories*, SAND92-2565 (Ramirez and Hill, 1993). It describes the generic process of benchmarking, as defined by Sandia's Process Improvement/Benchmarking Department.

Benchmarking Details

For details on the benchmarking methodology used for this project, refer to *Volume I, Methodology and Liquid Photographic Waste*, SAND93-3992, April 1994. For a copy of Volume I, contact the author at (505) 844-8956 or through the Environmentally Conscious Life Cycle Systems Department, Sandia National Laboratories, Albuquerque, New Mexico, 87185.

3.0 Aqueous Cutting Fluid Benchmarking Results

Adaptation of Benchmarking Methodology

The 12 steps of the benchmarking methodology listed in Section 2 provide the framework for this project.

Benchmarking is a flexible process that lets each team adapt the standard procedure to the unique needs of the project.

The following section describes how the aqueous cutting fluid team used the benchmarking process to collect information on Best Management Practices and other techniques and technologies for minimizing aqueous cutting fluid waste within DOE.

3.1 Step 1: Identify Process to be Benchmarked

DOE's Waste-Generating Activities

Figure 3-1 illustrates four major types of waste-generating activities within the DOE, including:

- mission related,
- waste management,
- environmental remediation, and
- infrastructure related.

Infrastructure-related activities are the DOE's "landlord" activities as shown in the lower portion of Figure 3-1. Infrastructure-related activities were chosen because they have not yet received the same DOE-wide attention as the other three waste-generating activities. These activities produce DOE-wide waste streams that are also produced in outside industry. Therefore, they are ideal activities for benchmarking because appropriate industry partners should be easy to identify and locate.

Figure 3-1. Waste-Generating Activities in DOE

Identification of Common Waste Streams

Initial activities centered on collecting information on as many DOE waste streams as possible. Refer to Volume I for the detailed rationale for selecting aqueous cutting fluid waste as one of the waste streams for benchmarking.

Aqueous cutting fluid was chosen for benchmarking because it is both common and widely used through DOE. For some DOE sites, cutting fluid waste is the single largest constituent of their hazardous waste streams.

☞ OUTCOME OF BENCHMARKING STEP 1:

Process chosen for benchmarking:

- Aqueous cutting fluid waste

3.2 Step 2: Establish Management Commitment

Strong DOE Commitment

Because of DOE's emphasis on waste minimization, management commitment was a positive element in this project. The DOE sponsor for this project is the Waste Minimization Division, EM-334. Management support included the following:

- Headquarters provided project funding and guidance.
- The Albuquerque Field Office provided support through the WMin coordinator.
- Site management allowed the process experts time to participate.
- Sandia management provided benchmarking expertise and trainers.

☞ OUTCOME OF BENCHMARKING STEP 2:
DOE management committed resources at national, regional, and local levels.

3.3 Step 3: Identify and Establish Benchmarking Team

Team Members

A benchmarking team usually consists of a project leader, process experts, management, and support personnel. Not all team members are required to participate at all times. Some team members may perform more than one role, as needed, for the team at large and smaller subteams.

Finding Team Members

The project leader used the following sources to find benchmarking team members:

- Contacts within the DOE
- Proceedings from waste minimization conferences
- Discussions with site waste minimization coordinators

Roles and Responsibilities

The following table outlines suggested roles and responsibilities needed for a benchmarking effort.

Role	Responsibilities
Project Leader	Plan, organize, assign tasks, and oversee the benchmarking project.
Process Experts	Provide professional expertise on the target process during the workshops, contact industry partners, and conduct site interviews.
DOE Management	Set policy and provide support, personnel, time, and funding.
Trainers/Facilitators	Teach participants benchmarking techniques and lead workshops and work sessions to accomplish goals.
Information Specialist	Aid the search for potential benchmarking partners through database searches.
Writer/Recorder	Document the benchmarking process by recording workshop activities and provide support for project leader, as needed.

Continued on the next page...

Team Roster

The following table lists the aqueous cutting fluid team members:

Team Member	Title	Location
Karl Arnold	Staff Process Specialist Engineer	Allied Signal Aerospace, Inc., Kansas City, Missouri
Andy Cardiel	Manufacturing Consultant	Sandia National Laboratories/California, Livermore, California
Gary Graham	Journeyman Machinist	Sandia National Laboratories/New Mexico, Albuquerque, New Mexico
Art Jens	Machine Maintenance Supervisor	Brookhaven National Laboratory, Upton, New York
Diane Leek	Technical Writer	Tech Reps, Inc., Albuquerque, New Mexico
Victoria Levin	Project Leader, Environmentally Conscious Life Cycles Systems	Sandia National Laboratories/New Mexico, Albuquerque, New Mexico
Mary Martinez	Special Materials Fabrication Team Leader	Los Alamos National Laboratory, Los Alamos, New Mexico
James Wright	Senior Supervisor of Craft Services	Battelle Pacific NW Laboratories, Richland, Washington

☞

OUTCOME OF BENCHMARKING STEP 3:
Planning team, benchmarking team, and interview team successfully assembled.

3.4 Step 4: Define and Understand the Process to be Benchmarked

Process Foundation

Step 4 lays the foundation for all future activity. The team must define and understand the existing process before examining another's process. This step establishes the baseline from which to measure performance gaps.

Workshop Goals and Activities

The project leader, process experts, and support staff attended a workshop that provided training and a work session for the entire team, covering several benchmarking steps.

The **goals** of the first workshop were to

- Define and understand the process to be benchmarked (Step 4),
- Create a flow chart of the generic process (Step 4),
- Define the metrics of the process (Step 5), and
- Define the criteria for choosing potential partners (Step 7).

The table below summarizes the **workshop activities**. A detailed description of the activities follows the table.

Stage	Activity
1	Workshop facilitators directed team-building exercises to integrate the team into a cooperative, working unit.
2	Workshop facilitators trained the team in the benchmarking methodology so that team members understood the group process, the task, the commitment, and the work involved to complete the project.

Stage 1 — Team Building

Team Building

The team-building exercise resulted in a team name, motto, logo (Figure 3-2), and mission statement.

Team Name	The Eliminators
Motto	We Reduce Waste.

Figure 3-2 Logo for the Eliminators

Stage 2 — Train the Process Experts

The process experts were chosen for their knowledge of their fields and the tasks they perform in their daily jobs. However, they needed training in the benchmarking process.

Stage 3 — Create a Consensus Flow Chart

Process Flow Chart

The process experts came from a variety of sites that had different procedures to accomplish similar tasks. Regardless of the site, the team members produced machined parts for their customers. The team needed to create a flow chart that expressed the process "big picture." The facilitator helped the group define the process parameters.

Process Parameters

All processes have the following common parameters:

- Inputs
- Suppliers
- Outputs
- Customers

The team used the parameters above to help them define the particular process that produces the aqueous cutting fluid waste stream. For each parameter, the team listed ideas, and then evaluated each component to confirm that it was directly related to the aqueous cutting fluid waste stream. The final lists are shown below.

Inputs

Inputs for the aqueous cutting fluid waste stream include:

- Tramp oil
- Aqueous cutting fluid concentrate
- Water hardness
- Cutting fines
- Bacteria
- Machines using coolant
- Labor
- Preventative maintenance systems
- Housekeeping
- Routine sump maintenance
- pH
- Coolant concentration
- Bactericide or bacteriostat
- Aeration
- Skimming
- Alternate cutting lubrications
- Waste minimization policy

Suppliers

Suppliers for the aqueous cutting fluid waste stream include:

- Product manufacturers
- Labor force
- Maintenance crews
- Machines
- Stock or raw materials
- Bacteria
- Environment, Safety, and Health (ES&H) organization
- Regulators
- DOE
- Water company

Customers

Customers of the aqueous cutting fluid waste stream include:

- Machinists
- DOE
- ES&H organization
- Reclamation personnel or contractors
- Facility management
- Treatment, storage, or disposal personnel or contractors
- Taxpayers
- Environment
- Product customers

Continued on the next page...

Outputs

Outputs of the aqueous cutting fluid waste stream include:

- Cutting fluid waste
- Waste water
- Finished part
- Machine residue
- Part residue
- Chips
- Oily rags
- Used protective clothing

Flow Chart

After the lists were finalized, the team created a flow chart (Figure 3-3) that diagrams the aqueous cutting fluid generation and handling process.

☞ OUTCOME OF BENCHMARKING STEP 4:

Aqueous cutting fluid process inputs, outputs, customers, and suppliers were identified. A flow chart of the process was completed.

Figure 3-3. Aqueous Cutting Fluid Generation and Handling Process

3.5 Step 5: Identify Metrics

Definition

Metrics are the measures of the internal process. Metrics allow evaluation and assessment of existing performance and provide points of contrast after the lessons learned from the benchmarking activity have been applied.

Metrics

After the process flow chart was created (see Step 4), the facilitator led the team through a discussion of the metrics.

The group decided that the following metrics were relevant:

- Number of independent sump systems
- Ratio used to mix water and cutting fluid concentrate
- Volume of cutting fluid mix used/yr
- Sampling frequency (pH & concentration)
- Sampling cost for pH & concentration
- Average sump capacity
- Number of cutting fluid changes/yr/machine
- Length of time between cutting fluid changes
- Volume of new concentrate added during the year
- Volume of actual waste/yr
- Volume of recycled cutting fluid
- Estimated man hours for cutting fluid maintenance per machine using cutting fluids
- Unit cost of cutting fluid
- Cost of treatment/gallon
- Cost of storage/pound
- Cost of disposal/pound
- Cost of transportation/pound
- Cost of testing for waste characterization
  - Tolerance
  - Water hardness

NOTE: Not all the metrics are easily obtainable within DOE.

☞ OUTCOME OF BENCHMARKING STEP 5:
The team defined aqueous cutting fluid process metrics that provide the measures of the internal process.

3.6 Step 6: Evaluate Current Performance

Information Exchange

The team performed an informal evaluation of each site's performance by exchanging information and comparing activities and processes. Each process expert had the opportunity to discuss and explain his or her site process during the first workshop. Refer to Table 3.6.1 for a summary of DOE machine shop processes and profiles.

Value of Workshop

The participants identified how the workshop helped them to:

- learn new ideas through hearing about other sites' processes.
- gain a networking opportunity for sharing ideas.
- understand differences among state environmental laws and regulations. For example, a practice that was followed in one state might not be allowed in another state.

☞ OUTCOME OF BENCHMARKING STEP 6:

- Individual team members shared information on each site's process and established network contacts for future problem solving.

3.7 Step 7: Identify Potential Benchmarking Partners

Search Parameters

"Criteria" are defined as standards on which a judgment or decision may be based (Webster's, 1985). The team developed criteria to be used to identify appropriate potential partners. Defining criteria limited the search to partners that fit the team's needs.

Criteria

The aqueous cutting fluid team defined the following criteria for potential partners, who must have:

- a willingness to participate.
- a cutting fluid program.
- a variety of machines.
- a recycling or treatment system.
- a waste minimization program.
- management commitment for waste minimization.
- a preventative maintenance program.
- more than one shop.
- small batch, complex parts capability.
- a variety of products.
- a willingness to provide metrics.
- a variety of materials machined in the shop.

Information Sources for Identifying Potential Partners

A variety of methods and sources for identifying potential partners, including the following, were used:

- Literature search by an information specialist
- Process experts' suggestions
- Contacts through customers or suppliers
- Trade associations or publications

☞ OUTCOME OF BENCHMARKING STEP 7:
A list of 58 potential partners was identified.

3.8 Step 8: Collect Process Data from Potential Partners

Data Collection Methods

In benchmarking, the main tool for gathering initial process data from potential partners is a questionnaire, either oral or written. Both types were used for this project.

Questionnaire Development Training

The benchmarking team learned questionnaire development techniques and how to define the questions to pose to potential partners.

Refer to Volume I, Appendix B, for an abbreviated training guide on questionnaire development techniques. Refer to Appendix A in this volume for the final telephone and written questionnaires used in this project for aqueous cutting fluid.

Questionnaire Development Process

The group discussed questions that would help them find benchmarking partners. The group needed two questionnaires:

- a telephone questionnaire to act as a filter to determine industry partner interest and broad suitability and
- a written questionnaire that would elicit detailed information to help determine the final candidates for site visits.

Results

Of the 58 initial contacts made by the aqueous cutting fluid team by telephone, 20 of the companies

- had processes that were appropriate for comparison to the DOE's process defined by the process experts and
- were willing to participate.

Written questionnaires were sent to these companies. Of the 20 written questionnaires sent, 12 were returned. (This return rate of 60% meets the average return rate of 30-60% for prescreened written questionnaires.)

☞ OUTCOME OF BENCHMARKING STEP 8:

1) The telephone questionnaire "qualified" 20 potential partners. Written questionnaires were sent to these respondents.
2) Twelve potential partners returned written questionnaires.

3.9 Step 9: Analyze Potential Partners' Data and Choose Partners

Choosing Benchmarking Partners

The questionnaires were evaluated. Each final partner:

- had processes similar to those at the DOE sites.
- was not a manufacturer, but a user of cutting fluids.
- machined a variety of parts and materials.
- provided a comparison of dollar savings before and after implementation.
- showed a major decrease in disposal volume after implementation of the new process.
- had ideas or technology that provided new insights/techniques for minimizing aqueous cutting fluid wastes.
- had extended the life of the coolant between coolant changes.
- was willing to participate.

☞ OUTCOME OF BENCHMARKING STEP 9:
The team evaluated the written questionnaires returned by the potential partners and chose its final partners:

- Halliburton Energy Services in Duncan, Oklahoma
- Lockheed Martin Aeronautical Systems in Marietta, Georgia

3.10 Step 10: Conduct Site Visits

Team Visits Partners

The interview team, a subset of the benchmarking team, received training on interview techniques, rules of conduct, and agenda development skills. The interview team visited Halliburton Energy Services in Duncan, Oklahoma, and Lockheed Martin Aeronautical Systems (LMAS) in Marietta, Georgia, to gather information on best management practices and processing techniques for aqueous cutting fluid.

- For an abbreviated training guide for on-site interviewing techniques, refer to Volume I, Appendix D.
- For the aqueous cutting fluid team's final interview question set, refer to Appendix B of this document.

Results of Coolant Management

Recently, both companies introduced new coolant management programs (LMAS in 1992, Halliburton in 1994). As a result of the changes, both companies have reduced

- purchases of new cutting fluid concentrate,
- the labor required to maintain cutting fluids and sumps,
- the cutting fluid waste stream, and
- the cost of coolant waste disposal.

Both companies have prolonged the coolant life in the sump, resulting in fewer sump changes, which requires less new coolant and less labor to pump and fill sumps and, in turn, produces less waste.

Since 1992, LMAS has recycled over 500,000 gal of fluid. Since 1992, the coolant management program has generated $62,705 in savings.

Halliburton reduced spent coolant disposal costs by $450,000/year between 1992 and 1994.

NOTE: The main reason for the difference in savings is that LMAS has an on-site Waste Water Treatment Facility (WWTF) and Halliburton uses a contractor to remove and dispose of spent coolant. Reducing the coolant waste stream had a larger economic impact at Halliburton than at LMAS.

Common Factors for Change

The methods used to achieve these reductions are different for each facility. The two companies are radically different in the work that they do and the physical characteristics and requirements of their plants. However, for both companies, change was dependent on the following major factors:

1) Management support and change in management approaches
2) Increased worker involvement in the coolant process
3) Technology improvements
4) Market drivers requiring companies to downsize, increase efficiency, and cut costs to be competitive

3.10.1 Halliburton Energy Services Site Visit

Company Introduction

The team visited Halliburton Energy Services in Duncan, Oklahoma. Halliburton Company provides a broad range of energy services and products, industrial and marine engineering and construction services, and property and casualty insurance services. The machine shops at the Duncan plant produce components for facilitating oil or gas production.

New Program Adopted

In 1994, Halliburton began a new coolant management program. The change in the coolant management program was approved by management after the manufacturing engineers in charge of coolant presented a plan that described how the company could reduce coolant costs by 80% with a $20,000 investment. The results were better than anticipated. Sump life increased from 6 weeks to 4 months, and coolant disposal costs were cut by over 90%.

Current System

In 1994, the Halliburton Duncan plant implemented its current coolant management system.

Approximately 250 machines are in use, including lathes, mills, saws, drills, machining centers, and grinders. All the machines have individual sumps, with an average capacity of 100 gallons. The grinders use a synthetic coolant. Semisynthetics are used in the lathes and mills and represent 95% of the coolant volume. The coolant management efforts concentrate on the semisynthetics. A disk skimmer system is installed on most sumps to remove tramp oil.

Coolant Control and Distribution

A coolant coordinator and an assistant are responsible for all coolant management. Coolant concentrate is mixed automatically with reverse osmosis (RO) water in a 19 to 1 ratio using positive displacement in a 250-gal tank. Pre-mixed coolant is placed in 55-gal drums on wheels and distributed by contractor "sweepers."

Coolant Monitoring

Sweepers perform daily concentration checks on the machines and work with the coolant coordinator to maintain coolant. The bacteria count is checked on each machine every one or two weeks, with results available within 15 minutes. The sweepers perform some area housekeeping. Stabilizer is added as needed and a biocide is added as a last resort. (Only the coolant coordinator has access to biocide.) Make-up coolant is used to replace coolant sprayed out or carried off on parts. The coolant tends to lose water quicker than coolant concentrate is lost. If needed, tap water is used to dilute the coolant in the sumps.

Spent Coolant Removal

Two propane-powered sump trucks are used to remove exhausted coolant from the sump. The coolant coordinator's assistant and a sweeper clean the sumps and refill them from the mobile 55-gal drums.

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3.10.1 Halliburton Energy Services Site Visit, continued

Management Changes

The new coolant management program was part of a larger effort to be competitive and cut costs, which caused radical change in management beliefs and corporate structure.

Focus Factories

A major change was the creation of "focus factories" as the primary work structure. At Halliburton, a focus factory is a group of machines and personnel dedicated to producing one main product, such as pumps, drillable tools, service tools, or flow meters. (In the past, machinists might work on flow meters one day and ball valves the next.) The aim of the focus factory is to build expertise, ensure consistency, and create accountability for the products.

Each factory tries to be self-sustaining, with a minimum of shared resources. Support staff such as programmers, manufacturing engineers, and design maintenance engineers work for one focus factory, instead of all product lines. In some cases, one individual's time may be allocated to several focus factories, with costs allocated accordingly. Focus factories still have some shared assets, such as warehouse space.

Accountability for Expenses

As many expenses as possible are tied to the focus factory based on real costs, not an overhead charge based on square footage. (For example, precise coolant purchases can be tracked for each focus factory, but heating costs cannot.) By knowing the real costs, and being responsible for expenses, employee efforts to minimize expenses have a direct effect on the financial performance of the focus factory.

Expense information is posted on bulletin boards, so workers know the costs associated with production. In the past, only the shop foreman had that information, and it was not shared with the workers. Before implementation of the new system, the costs of coolant and waste disposal were part of the overhead. There was no incentive for workers to keep costs down. Now, if a person makes an effort to cut costs, it affects the focus factory directly.

Ownership of the coolant resides in each of the factories. Machinists are more aware of coolant concentration and condition. Knowledge of coolant management has increased on the floor.

Focus Factory Advantages

The advantages of the focus factory are that

- If problems arise, manufacturing problems can be traced back to a specific machine or process step.
- Engineers and workers gain in-depth knowledge of their product.
- Workers, engineers, supervisors, and management have more access to each other for better communication.
- An individual's efforts can make a measurable difference.

3.10.1 Halliburton Energy Services Site Visit, continued

Technology Changes

Major technology changes occurred in Halliburton's technical approach to coolant management. The company

- changed coolants from a water-soluble to a biostatic semisynthetic. This change reduced coolant usage by 50%.
- adopted a new coolant management system in 1994.
- designed and built an evaporator to remove water and diminish coolant waste to its lowest possible volume.

Coolant Management System

The Duncan plant adopted the "0" or "Zero" Waste System developed by Biotech International, Inc. The system calls for

- filtering machining fines at the sump to keep cutting fluid clean and prevent deterioration,
- testing the cutting fluid daily for concentration levels and periodically for bacteria growth and pH level,
- treating the fluid with stabilizer to inhibit bacteria growth and adding cutting fluid concentrate or water as needed to maintain proper concentration, and
- keeping records to track trends.

Advantages:

- Filtration is accomplished with portable filtration units. Halliburton has five filtration units for approximately 250 machines. The units are moved every 2 or 3 hours and perform filtration while the machine is operating. The filters run unattended and have automatic shut-offs so they can run overnight. There is no machine down-time during filtration.
- The decision to dump and replace cutting fluid is verified by testing. The decision to change or not change fluid is defendable because cutting fluid tests provide data rather than an intuitive feeling.
- Costs for coolant concentrate, biocide, and the labor required to pump and fill sumps have decreased.
- Biocide is used as a last resort, because biocides cause potential safety hazards if not used properly.

Evaporator

Once the decision is made to dump cutting fluid, spent cutting fluid is moved via propane-powered sump trucks to a 10,000-gal holding tank. Fluid is fed from the holding tank to an evaporator. The evaporator almost totally dehydrates the waste. The dehydrated sludge is stored in 55-gal drums until a contractor removes and disposes of the sludge.

The evaporator began as a creative idea from an employee in the plating shop. Using scrap parts and existing materials, Halliburton designed and built the evaporator for $1,500.

Continued on the next page...

3.10.1 Halliburton Energy Services Site Visit, concluded

Evaporator, continued

Evaporator technical features:

- Maintains the temperature at 212°F (water's boiling point).
- Uses an air sparger to bubble air from within the cutting fluid. Halliburton found that the air is just as important as the heat is. (Air flow at the surface was not beneficial.)
- Has a flat carbon steel heat exchanger.
- Uses steam supplied from an existing plant heating boiler.
- Has secondary containment for environmental safety.

The evaporator has two safety devices. The heat cuts off automatically if

- the temperature becomes greater than 212°F or
- the level of coolant gets too low

Evaporator Advantages:

- The disposal cost per pound of waste has increased because the waste is concentrated into a sludge that contains metals. However, the overall cost of waste disposal has decreased because of the 95% reduction in volume.
- Evaporates 35 gal per hour.

Coolant

The plant currently uses a biostatic semisynthetic coolant to discourage bacteria growth and avoid the greasy spots around the machines that are the result of using a soluble oil coolant. In the past, coolant was removed due to spoilage before it could absorb enough oil to cause problems. Now, with longer coolant life, oil absorption has become a problem because the oil-saturated coolant leaves a greasy residue on the finished parts. (Oil on machined parts potentially causes problems for plating and other manufacturing processes.) Halliburton is working currently with several coolant vendors either to develop a custom coolant or select a better coolant that meets the needs of machining processes and rejects oil more completely than the current coolant.

Recycling

In the past, Halliburton used a centrifuge to clean and recycle cutting fluid. However, the centrifuge use has been discontinued because of high expenses for maintenance and centrifuge down time. The portable filtration units are cheaper, require less maintenance, and do not require coolant transport to the centrifuge.

Continued on the next page...

3.10.2 Lockheed Martin Aeronautical Systems (LMAS) Site Visit

Company Introduction

The team visited Lockheed Martin Aeronautical Systems (LMAS) in Marietta, Georgia. LMAS is a full-service design, development, and production facility that manufactures a variety of aircraft, including cargo airlifters such as the C-130 Hercules, fighter aircraft such as the F-22, and maritime patrol aircraft such as the P-3 Orion.

New Program Adopted

In 1991, LMAS management sponsored a major study of all waste streams at the plant. The recommendations for the machine shop area were to

1) consolidate machine shops by product type and
2) adopt a coolant program.

In 1992, LMAS began to implement a five-year coolant waste minimization program. Recycling and filtering cutting fluid has reduced purchases of new concentrate and resulted in less spent fluid sent to the on-site waste water treatment plant. Sump life has been extended from approximately five to six weeks to two or three months.

Enablers

Several factors contributed to the success of the program:

- Management supported and pursued suggested changes from the study.
- Extensive training increased employee awareness and expertise in coolant management.
- Machine modifications, fluid monitoring, and computer tracking have helped maintain fluid quality and consistency.

Current System

Approximately 200 machines are used, with sump capacities ranging from 10 to 50 gal for small machines to 3,000 gal for large mills. The larger sumps are in-ground, beneath the machines. Smaller machines use internal sumps or tray sumps. LMAS currently uses a soluble oil coolant. Some machines are equipped with rope or belt systems to remove tramp oil. Most tramp oil is removed during the recycling process.

Coolant Supervision

In the past, oilers mixed the coolant with no standardization and dumped it when it developed odors. Now, maintenance oilers monitor coolant concentration daily with a refractometer and perform make-up operations as needed. Every week, the oilers check the pH and the bacteria count. The pH results are available immediately, and the bacteria results are available within 24 hours. The oilers are responsible for more than coolant distribution and monitoring: they also perform preventive maintenance on the machines.

3.10.2 Lockheed Martin Aeronautical Systems (LMAS) Site Visit, continued

Coolant Distribution

Coolant concentrate is mixed automatically at several locations in the facility. Some large sumps have a mixing station on a panel that contains a filter, a water meter, a level control, and a Unimix mixing device. LMAS uses a 20 to 1 ratio using positive displacement. For other sumps, pre-mixed coolant is placed in 350-gal coolant dispensing carts and distributed, using air pumps and flex hoses.

Recycling

Results of weekly monitoring informs the maintenance oilers when to move fluid to the outdoor recycling farm. Air pumps and hoses or sump suckers are used to remove coolant from machines and transport it to one of three 3,000-gal holding tanks for periodic recycling. A recycling contractor trucks a mobile recycling unit to the site and recycles the coolant using a centrifuge and pasteurization unit. Recycling is performed at least once a week, or as needed. LMAS has seven outdoor holding tanks: three for fluid waiting for recycling, three for recycled fluid, and one 1,500-gal tank for recovered tramp oil.

The recycled coolant, with the addition of a small quantity of new coolant, is used for makeup and coolant changes. The contractor adds biocide during the recycling process. The contractor is also responsible for maintaining biocide in the sump, if needed, as indicated by the weekly bacteria checks.

The contractor supplies a statement of work stating the number of gallons recycled, gallons of tramp oil recovered, amount of new coolant added to the recycled coolant, amount of biocide added, and the pH reading before and after recycling. The contractor recycles 3,000 gal in approximately eight hours. Recovered tramp oil is placed in a holding tank and removed by a local vendor.

LMAS decided to use a contractor because of the expense of buying recycling equipment. Eventually, LMAS plans to perform in-house recycling as funds for capital equipment purchases become available.

Filtration

LMAS also has Henry filtration on eight centralized coolant systems that serve 24 different types of machines. These filters remove chips and fines. Individual sumps do not have filtration.

Spent Coolant Removal

If the coolant becomes contaminated or the bacteria is not controllable, the coolant can no longer be recycled. At that point, oilers remove the sump covers, pump out the sump, change the filters, and pressure spray the machines. The pressure spray provides better cleaning and leaves fewer bacteria to contaminate fresh coolant.

3.10.2 Lockheed Martin Aeronautical Systems (LMAS) Site Visit, concluded

Spent Coolant Removal, continued

LMAS has its own Waste Water Treatment Facility (WWTF) on site. Oily waste drain lines are piped directly to the WWTF. From various locations throughout the LMAS complex, spent coolant is pumped from machine sumps to the WWTF. The cost of waste disposal is not charged back to the machine shop; it is part of the operating overhead expense. The internal cost to process spent coolant is approximately 10 cents a gallon, far below the industry standard for contractor removal of spent coolant.

The advantages of a waste disposal treatment facility on site are as follows:

- No storage of exhausted coolant is needed.
- The internal cost to process spent coolant is far below what an outside contractor would charge.

Barriers

All corporate change encounters barriers. LMAS faced the following barriers to implement its coolant maintenance program:

- Management needed a strong justification to change. The proponents of the new program needed to show that:
  - costs would decrease, not increase;
  - tool life would be extended; and
  - less waste disposal would result.
- Maintenance oilers were afraid of losing their jobs.
- Production management was reluctant to release machines for necessary modifications.
- The costs of handling spent cutting fluid internally were low, so the gain from waste minimization was minimal.
- Funding was needed for machine modifications, purchasing equipment, and training production and maintenance personnel.

Coolant

LMAS currently uses a soluble oil coolant, but it is evaluating a semisynthetic coolant to help control bacteria and reject oil. In the future, LMAS plans to use a portable centrifuge to remove tramp oil.

3.10.3 Summary of Site Visits

Topic	Halliburton Energy Services	LMAS
Filtration	• Performs filtration at each sump with portable bag filter units (has 5 units for 250 machines) while machines operate.	• Uses permanent filtration machines for 8 central sumps serving 24 different types of machines
Recycling	• Discontinued use of its centrifuge because of frequent breakdowns, high maintenance costs, and high cost of parts such as filters.	• Uses a recycling contractor that brings a mobile centrifuge on site. Contractor recycles fluid from spent holding tanks and moves recycled fluid to clean tanks.
Tramp oil	• Uses disk system to remove tramp oil at the sump while machine is operating. Tramp oil is also placed in the evaporator.	• Contractor that performs coolant recycling reclaims tramp oil and places it in a holding tank for a reclaimer to pick up. • Some sumps have a rope system that removes tramp oil when machine is not operating.
Final waste product	• Exhausted coolant is moved to an evaporator and dehydrated into sludge. Sludge is placed in a rail car and removed by a contractor.	• Exhausted coolant is sent to an on-site Waste Water Treatment Facility as part of LMAS's oily waste.
Coolant personnel	• Coolant coordinator, an assistant, and contractor sweepers devoted to coolant management.	• Maintenance oilers and a mechanical maintenance supervisor that also handle other duties, such as preventive maintenance. Union shop.
Biocide	• A minimum of biocide is used. Coolant coordinator controls all biocide. Uses monitoring results for guidance on when to add. Uses biocide as a corrective measure.	• Contractor recycler adds mild biocide as part of recycling process. Contractor also adds biocide to sumps as needed. No LMAS personnel handle biocide.
Monitoring	• Checks coolant concentration daily on every machine. Adds tap water as needed. • Checks bacteria count for each machine every one to two weeks. Results are available in 15 minutes.	• Checks coolant concentration daily. Adds makeup (from recycled tank) as needed. • Checks bacteria count weekly. Results are available in 24 hours. • Checks pH weekly. Results are available immediately. *Continued on the next page...*

3.10.3 Summary of Site Visits, continued

Topic	Halliburton Energy Services	LMAS
Shop Structure	• Changed the shop structure to use focus factories which helps track coolant usage and ensure product consistency.	• Consolidated machine shops by product type to provide better controls, avoid duplication of effort and reduce inventory costs.
Record Keeping	• Keeps manual service logs for each sump to record readings, additions, conditions, and comments.	• Keeps a computer database of readings, additions, conditions, and comments.
Mixing Coolant	• Automated 19 to 1 ratio with a centrally located Unimix machine. Placed in 55-gal drums on hand carts for distribution.	• Automated 20 to 1 ratio with several Unimix machines. Fluid is distributed via 350-gal coolant dispensing carts.
Number of Machines	250 machines, individual sumps, average capacity of 100 gal.	Approximately 200 machines with individual and central sumps, average capacity 50 gal (individual) or 3,000 gal (central)
Criteria for Disposing of Coolant	Cannot salvage the coolant due to high bacteria count.	Cannot recycle coolant due to contamination, high bacteria count.
Type of Coolant	Semisynthetic	Soluble oil

3.11 Step 11: Communicate Results

Overview

This section presents the Best Management Practices (BMPs) learned from the site visits.

Normally, Step 11 of the benchmarking methodology includes implementing improvements and monitoring the results. In this case, implementation is not within the project scope. However, because of the ideas shared in this study, another participating DOE site is planning to incorporate some of the techniques in its process.

This section provides results and offers options so that individual sites may create their own implementation plans.

3.11.1 Best Management Practices Recommended by Halliburton

Worker Process Ownership

- Use Service Tags and logs to track coolant concentration, additives, and bacteria count. Records help employees maintain peak coolant performance by tracking what corrects coolant problems. The records have raised employee awareness of precisely what the concentration should be for each machining process.
- Let employees know the real costs of doing business. Charge each focus factory on a real cost basis, not an overhead figure calculated by square footage. When real costs are tracked, an employee's efforts can make a difference in cost control.
- Each focus factory pays for each waste stream it produces. By creating ownership of the waste stream, it cannot be passed off as someone else's problem.
- Write down procedures for coolant maintenance, stipulating the parameters for changing out cutting fluid. Train employees so that everyone understands proper procedures.

Technology

- Use the simplest technology available. For example, Halliburton uses discount-store aquarium pumps to aerate their coolant. The evaporator was constructed with reconditioned and on-hand materials.
- Use coolant as a tool, not as a scapegoat.
- Seek new technology. The best equipment today may not be the best tomorrow. Seek alternatives for high-maintenance, expensive equipment.
- Don't get stuck on a brand name. Be willing to try other brands of coolant and use a scientific approach to evaluation. A manufacturer may be willing to customize a coolant for your shop's use. Every coolant manufacturer has many different types of coolants.

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3.11.1 Best Management Practices Recommended by Halliburton, continued

Procurement	• Negotiate contracts proactively. Halliburton's Health, Safety, and Environment (HSE) department compared the coolant disposal costs for each of its three sites (Duncan, Dallas, and Fort Worth) and discovered that there was a major difference for the plant in Dallas. The HSE department renegotiated the Dallas contract, reducing coolant disposal costs by 70%. • Work closely with the coolant vendor. Check the coolant vendor to make sure that it has a quality control program. A site visit may be necessary. Also, ask the vendor to inform you of changes in the suppliers or raw materials. These changes might affect coolant performance and lets the plant know what factors might affect manufacturing quality.
Communication	• Establish good working relationships among satellite facilities and share information. For example, any regulatory noncompliance affects every Halliburton site. If the Dallas facility has a compliance problem, it affects Duncan and Fort Worth. A first-time problem in Duncan may be considered a second offense if a similar problem has occurred in Dallas or Fort Worth. Work together to prevent the same problem from occurring at other sites. • Encourage employees to contribute ideas and then implement those ideas. The evaporator was conceived by a plating shop employee who was outside the machine group. • Encourage communication across job categories; for example, give the manufacturing engineers direct, on-the-factory-floor contact with the machinists. Have an open-door policy so that a machinist does not have to make an appointment to see a manager.
Management Processes	• Be willing to change and continually improve. Revisit old issues to see whether change is now possible. The only constant is change. • Limit operator access to means of disposal. When an operator feels the coolant is ready for a change, the coolant coordinator provides the testing and verification of exhausted coolant. The manufacturing engineer has the final decision, based on measurable values, not operator intuition. The coolant coordinator attempts to adjust the coolant through concentration changes, stabilizer additions, or biocide applications. Patience pays off in fewer coolant changes.

3.11.2 Best Management Practices Recommended by LMAS

Worker Process Ownership

- Conduct coolant familiarization classes for all production management, machine operators, maintenance management, and associated crafts. LMAS considers training to be a key factor to successful coolant management. LMAS sent the union safety chairman, shop steward, maintenance oilers, and the mechanical maintenance supervisor to the coolant vendor's three-day seminar out of state.
- Stress housekeeping and machine cleanliness to extend coolant life through reduced contamination.
- Perform daily checks on the coolant concentration to ensure proper levels, resulting in better parts finish and extended tool life.
- Perform weekly checks on pH, conductivity, and bacteria. These factors serve as determining indicators for coolant change, allowing coolant to be recycled before deteriorating to a point where it can no longer be recycled. In the past, LMAS operators judged coolant condition by smell alone, which is not reliable because bacteria may be high when the pH is 7.6, which would inhibit the odor. Conductivity tests provide information on total dissolved solids (TDS) that can affect coolant performance.
- Let employees work in teams to address projects that enhance the coolant management program.
- Support hourly employees and use their suggestions to make necessary modifications to reduce the time and materials related to coolant.

Technology

- Recycle coolant before it becomes rancid to reduce disposal costs and purchases of new fluid.
- Use a high quality coolant to reduce odors and contact dermatitis, making the work environment more operator-friendly. Even if the cost of the concentrate is higher, the longevity of the coolant offsets the higher cost.
- Install automatic coolant control mixing devices to maintain coolant level and proper concentrate-to-water ratio. This practice saves labor.
- Install coolant return lines from machine beds to coolant sumps, eliminating loss of coolant to industrial waste lines. This also helps avoid stagnation and results in less bacteria growth.
- Install controlled coolant nozzles at the cutters to deliver a low pressure coolant stream to the point of cut, eliminating excessive mist and sling-off.
- Disconnect coolant lines running from coolant pumps to industrial waste to eliminate the possibility of accidental dumping of coolant.

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3.11.2 Best Management Practices Recommended by LMAS, continued

Technology, continued

- Switch from 55-gal drums to 350-gal totes to save money on disposing of and handling the drums.
- Line concrete coolant sumps with steel to eliminate coolant contamination.
- Install baffles, filters, or seals as needed to eliminate excessive generation of mist from chip removal system.
- Seal all access holes from trenches to coolant sumps to eliminate floor runoff contamination of coolant.
- Provide for circulation of coolant in sumps during machine down times to retard growth of anaerobic bacteria, thus extending coolant life.
- Start with a cleaner machine. Perform thorough machine cleaning with pressure spray to remove as many bacteria as possible before adding new coolant.
- Make sump cleaning easier by replacing heavy, hard-to-handle steel sump covers with aluminum covers.

Procurement

- If a contractor is used for recycling services, negotiate the contract every two to three years. Encourage competitive bids from other contractors to keep prices down.
- Work with a vendor that is willing to help. The coolant vendor created a training program specific to LMAS's facility and conducted two weeks of training on site. Also, the vendor sent a chemist for two weeks to work with LMAS. The vendor also made recommendations for machine modifications that helped prolong coolant life.
- Investigate other types of coolant. LMAS is evaluating semisynthetic coolant to help reject tramp oil and reduce bacteria.

Management Processes

- Create a long-range plan and follow it. Because of the massive size of the sumps and number of machines at LMAS, they knew effective change would take a long time. With the help of their coolant vendor, LMAS adopted a five-year plan for the conversion to the new coolant management system.
- Consolidate machine shops by product type to provide better controls, avoid duplication of effort, and reduce inventory costs.
- Perform routine coolant changes on the weekends to avoid machine downtime when production schedules conflict.

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3.11.2 Best Management Practices Recommended by LMAS, concluded

Management Processes, continued

- Be willing to accept some machine downtime. Because of production schedules, LMAS had difficulty freeing the machines to make modifications. By working closely with production process personnel, the work was moved to other machines to enable the needed changes.
- Base the decision to change the coolant on defendable data, not operator intuition.
- Use a computer database to record data and track trends. The database holds information on pH, conductivity, concentration, and bacteria. Record when recycling occurred, when the sump was changed, etc., to be able to produce trend data and help define metrics that indicate machine performance and provide points of comparison. Machines that use abnormal amounts of coolant can be easily spotted. The database can also record comments.
- Educate management on the benefits of preventive maintenance.

3.11.3 Waste Minimization Options for Metal-Cutting Fluids

Additional Research

In addition to the information learned on the site visits, the team also performed a brief literature search for best management practices and solutions to problems encountered in machine shops. This search was not intended to be comprehensive but can be considered a starting point. Appendix C provides the results of that research.

☞ OUTCOME OF BENCHMARKING STEP 11:
Coolant control, recycle/recovery techniques, improved technology, and best management practices were documented for improved waste minimization of DOE machine shop operations related to cutting fluids.

3.12 Step 12: Continue to Conduct Benchmarking of Process

Ongoing Process

Normally, benchmarking is an ongoing process. The best waste minimization technology today may be outmoded and outclassed by new developments. This step is not currently being pursued because of cost and schedule constraints, but would be necessary for actual process improvements.

Changes Made by Participants

Through the benchmarking project, some of the participants learned new techniques and renewed their efforts to minimize waste streams at their facilities.

Several participants are exploring the adaptation and implementation of the technology and best practices found at the benchmarking partners' sites.

3.12.1 Best Management Practices Recommended by DOE

Additional Best Practices

During the course of the project, the following additional best practices were recommended by DOE sites:

- Coolant must be maintained properly. Taking careful readings and measuring correct quantities of coolant concentrate, water, and makeup ingredients are vital to extending coolant life.
- Get people to do their job right. Machinists may know what they are "supposed" to do, but may not always follow procedures.
- Management has to support change before change is possible.
- Waste minimization loses priority when the site will only save three cents a gallon and volume is low.
- Lower the lubrication pressure to the minimum setting to cut down on tramp oil.
- In small shops, the cost of equipment and chemicals to recycle, filter, and control bacteria may not be justified for the size of the waste stream. A contractor may be better equipped to deal with the waste stream.
- Management must have a commitment to more than just producing parts. Scheduling for machine down-time to allow preventive maintenance is vital to keeping the machine performing well.
- Use preventive maintenance to curb machine oil leaks. Keep to a regular schedule of machine preventive maintenance that provides for quarterly inspection and annual major overhaul.

4.0 Conclusions and Recommendations

Results and Recommendations

Because results and recommendations are an integral part of the benchmarking effort, they are included in the main body of the report.

> See Sections 3.10 and 3.11 for the results of the benchmarking project for aqueous cutting fluid and recommendations for best management

Learning Process

The benchmarking process is also a learning process. As the project progresses, the most important quality for a team to have is the ability to be flexible, to shift gears, and to handle the unexpected. This section is written for benchmarking project leaders or team members to help them anticipate and hopefully avoid pitfalls in future benchmarking efforts.

4.1 Lessons Learned

Modifying the Methodology

A full benchmark is a long and rigorous process; the team had to modify the benchmarking process to accommodate the needs of the customer, DOE management. Several steps of the benchmark process can be successfully modified but none can be eliminated. Implementation, which is a major part of traditional benchmarking, could not be accomplished with this project because the team used a consensus process rather than a specific process. The process information was gathered from a variety of sites so there was no way to write an implementation plan that would apply to more than one site.

Benchmarking Lessons Learned

The following lessons were learned during the benchmarking project:

- Change is driven by economic factors.
- Employees must buy in and feel ownership for processes and results.
- Cultural factors such as whether a shop is union or nonunion can create barriers.
- Serious commitment from the process expert team members is essential. Not all team members will be equally committed.
- Progressing in a timely manner improves chances for success.
- It is hard to adapt best management practices to very different sites. Factors such as the presence or lack of a union, differing state and local laws, and corporate culture have a variety of impacts.

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