

# Soy-Based Neat Oil & Water-Soluble Coolant Summary



## New Environmental Technology for Small Business (NETSB) Project Summary

NETSB, a program developed by the Iowa Waste Reduction Center (IWRC) at the University of Northern Iowa, strives to increase the use of new environmental pollution prevention technology by small business, resulting in measurable environmental and economic benefits.

When choosing which technologies to test, the IWRC recognized three key areas of consideration: environmental criteria, economic measures and small business use feasibility. The equipment should have a positive impact on the environment, such as pollution prevention or energy savings. The technology should be evaluated considering capital costs, operational costs and return on investment. And finally, the equipment should be applicable in a small business environment.

In 2006-2007, the IWRC placed several types of potential pollution prevention technologies at small businesses throughout Iowa including: soy-based metal working fluids, Rasers heat reclamation equipment, Zerowaste wastewater treatment systems and Green Earth perchloroethylene dry-cleaning alternative.

## Small Business Placement Description

Soy-based metalworking fluid (MWF) placements took part in two phases. Both soy-based neat (straight) oil and soy-based water-soluble coolant were included in Round One (Spring 2006) placements. The soy-based neat oil placements were straightforward since petroleum and soy oils were compatible and cross contamination wasn't an issue. Soy-based water-soluble coolant placements exhibited more variability and posed individual problems. Market data suggested over two-thirds of machine shops in Iowa use petroleum-based water-soluble coolant; therefore Round Two (Fall 2006) placements were limited to soy-based water-soluble coolant.

Twenty (20) Iowa machine shops took placements of soy-based neat oil, soy-based water-soluble coolant or both. Placements were made throughout the state of Iowa and in various types of machining processes. Machining applications and types of metals worked varied widely.

## Technology Description

Several steps are necessary to convert metal stock into useful metal products. These steps are conducted by businesses in the metal working industries; specifically described by Standard Industrial Classification (SIC) Codes 3400-3499.<sup>1</sup>

The fabricated metal industry shapes products from stock material through one or more machining processes. Machining operations require the use of tools to refine the shape of the work piece by removing small amounts of material from it. Examples of machining processes include drilling, milling, turning, planing, sawing and grinding. Machining processes use various products such as cutting fluids, lubricants, hydraulic fluids, cooling or quench oils, and cleaning solutions.

Machining involves high-pressure, metal-on-metal moving contacts between tool and work piece. To reduce the heat and friction caused by these operations, MWFs are circulated over the work surface. These fluids are used to:

- Control and reduce the temperature of tools and work surfaces;
- Reduce friction and vibration by acting as a lubricant;
- Wash away chips and metal debris;
- Improve the quality of the machined surface; and
- Inhibit corrosion and rust on newly exposed surfaces.

In addition to MWFs, many machines require hydraulic fluids and lubricants that frequently leak into the work area and may contaminate MWFs. Eventually MWFs become spoiled or contaminated and must be replaced. The heat generated during the shaping process can degrade MWFs or cause a loss of water and degradation of additives. Bacterial growth

may cause contamination and lead to fluid deterioration as well.

Metal working fluids are divided into two types: water-soluble coolants and neat (straight) oil.

Petroleum-based water-soluble coolant is the most common MWF used in industry. Water-soluble coolants are generally comprised of 5% cutting fluid and 95% water and are used in processes that require a bath of product to continually remove shavings or grind away from the part being machined. Water-soluble coolants also improve cooling capabilities.

Some severe cutting operations require the use of neat oil. Neat oil is 100% product and does not contain water. Some petroleum-based neat oils contain additives such as sulfur and chlorine that act as wetting or extreme pressure agents. Unlike water-soluble coolants, neat oil offers excellent lubricity, longer tool life, rust protection and extended oil life.<sup>2</sup>

## Soy-Based Metalworking Fluids

The use of soy-based fluids for metalworking began as an alternative to conventional products (petroleum-based, synthetics and semi-synthetics). Soy-based MWFs, like many other agriculture-based fluids, exhibit superior lubricity in many industrial applications. Additionally, many companies are interested in products that are developed

from renewable resources that help agribusiness. Specifically, soy-based MWFs may exhibit some or all of the following advantages over conventional petroleum-based products:

- Produce less smoke and mist resulting in reduced inhalation problems;
- Contain no chlorine or sulfur, both regulated substances;
- Eliminate dermatitis issues;
- Reduce retooling costs; and
- Increase productivity.

Soybean oil has a higher molecular weight, a higher flash point and lower volatility when compared to petroleum oil. These properties help soy-based MWFs bond well with metals, serving as an effective friction reducer (lubricant). Reduced wear on tools and machinery enhances the longevity of these durable goods. Vegetable oil-based MWFs may be less toxic and may reduce disposal costs when compared with conventional petroleum-based fluids.<sup>3</sup>

## Environmental Background

It's estimated over 1 billion gallons of MWFs are used every year.<sup>4</sup> Eventually MWFs spoil or become contaminated and must be replaced. Waste MWFs are harmful to the environment because of high oil content, biochemical oxygen demand, high concentration of surfactants and because they may carry other hazardous metals and chemicals.<sup>5</sup> Waste fluids are subject to rule

under the Resource Conservation and Recovery Act (RCRA). The treatment and disposal of spent MWFs can comprise up to 15% of the total machining costs at an average machining facility.<sup>6</sup> Other machining wastes include metal fines and oily wastewater.

Soy-based MWFs are industrial products that come from a renewable resource. Using soy-based products inadvertently guides companies away from the controversies, pollution, energy consumption and waste generated during the extraction, transportation, use and disposal of petroleum products. The use of biochemicals, such as soy, may reduce upstream and downstream pollution.<sup>7</sup>

## Health & Safety Background

According to the National Institute for Safety and Health (NIOSH), more than 1 million workers (including machinists, mechanics, metal workers and machine operators) are exposed to petroleum-based MWFs in the United States. Primary exposures to petroleum-based MWFs occur through exposed skin contact or inhaling/ingesting particles, mists and/or aerosols.<sup>8</sup> Exposure to conventional petroleum-based MWFs are known to contribute to several health concerns including:

- Irritant or reactive dermatitis due to removal of natural protective oils in the skin;<sup>9</sup>
- Folliculitis due to repeated skin exposure;

- Decreased lung function due to repetitive inhalation of aerosols; and
- Increased occurrence or worsening of respiratory diseases such as asthma, bronchitis and hypersensitivity pneumonitis due to inhalation of mists.

Components of petroleum-based MWFs such as formaldehyde are known irritants to the eyes, nose and throat. Additives have long been blamed for increased cancer risk and irritant or reactive dermatitis.

Constituents of petroleum-based MWFs like glycol ethers and pentachlorophenol may cause birth defects or decrease a worker's ability to have children.<sup>8</sup> Several studies summarized by NIOSH also indicated an association between petroleum-based MWF mist exposure and cancers, including cancer of the larynx, rectum, pancreas, skin, scrotum and bladder.<sup>3</sup>

Finally, misting of soluble petroleum-based MWFs during machining processes can contribute to an unsafe working environment by making floors and work surfaces slippery.

Animal studies have shown that exposure to vegetable oil-based MWFs may cause fewer health concerns than petroleum-based fluids. When mineral and vegetable oils were injected directly into animal lungs, the body removed the vegetable oil slowly over several months. However the mineral oil caused slight fibroses of the lung and was still observed in the body after 2-3 months. Additionally, after mice were exposed to

vegetable, animal and mineral oil mists, the vegetable and animal oils were removed from the lungs within 4 days, but the mineral oils mostly remained in the lungs.<sup>10</sup>

The health and safety benefits of soy-based MWFs also include reduced dermatitis issues. Soy-based MWFs superior adhesion properties may reduce the occurrence of misting. Reduced misting results in a decrease of inhalation-related health problems and creates a safer work environment by reducing slippery floors and work surfaces.

It is becoming more widely accepted that businesses may improve working conditions and decrease health and safety concerns by using bio-based products. Plant-derived chemicals are usually lower in toxicity, flammability and corrosivity when compared to their petroleum-based counterparts.<sup>7</sup>

## Outcomes

### SOY-BASED NEAT OIL (ELM SOYEASY NUCUT PLUS OR ELM SOYEASY UNICUT)

#### TECHNOLOGY ACCEPTANCE AND USE OUTCOMES

Nine facilities tested soy-based neat oil manufactured by Environmental Lubricants Manufacturing, Inc. (<http://www.elmusa.com/>). Seven liked the product performance and are still using it. One facility approved of the

product but thought it was priced prohibitively and did not order more.

The most commonly reported reasons for liking the soy-based neat oil included: decreased smoking, drag-out loss, machine plugging, misting, rusting, odor and makeup material required. Other positive observations included: increased lifespan of the soy-based neat oil, increased productivity and tool life as well as healthier and safer working conditions and the perceived environmental benefits of using a bio-based product. The idea of supporting the local agricultural community was an advantage expressed by all facilities that approved of the soy-based neat oil.

The remaining facility experienced considerable problems with the soy-based neat oil going rancid very quickly. The soy-based oil was replaced with fresh stock that also went rancid within 10 days. Neither the facility, the product manufacturer nor the IWRC was able to determine the reason for the rancidity issues at this facility.

#### POLLUTANT REDUCTION OUTCOMES

Three facilities witnessed measurable waste reduction. One company reduced waste neat oil disposal from 935 gallons/year to 467.5 gallons/year. Another facility routinely disposed 110 gallons annually. After switching to soy-based neat oil, it has yet to have a disposal event 1-1/2 years later (a reduction of at least 155 gallons). Finally, another

company was able to reduce waste neat oil disposal from 6,000 gallons/year to 500 gallons/year, an annual reduction of 5,500 gallons.

These reductions in waste are attributed to observed increased life of the soy-based neat oil and decreased disposal when compared to petroleum-based products.

### **ECONOMIC OUTCOMES**

Five facilities were able to measure significant annual cost savings by switching to soy-based neat oil: \$805, \$10,932, \$11,560, \$53,500, and \$1,111,950.

As reported by these companies, the fiscal benefits are attributed to: increased lifespan of the soy-based neat oil, decreased annual disposal fees, increased tool life and increased productivity.

### **CONCLUSIONS**

As a result of these NETSB placements, it was observed that most facilities using conventional petroleum-based neat oil would benefit by switching to soy-based neat oil. Eight facilities observed measurable positive economic or pollutant outcomes, in addition to benefits not so easily measured such as decreased health problems for machine operators and support of the agricultural economy.

Only one facility experienced operational problems with the soy-based neat oil, which with more observation may be attributed to specific working conditions at the site such as machines used, oil maintenance programs and/or types of metals being worked.

### **SOY-BASED WATER-SOLUBLE COOLANT (ELM SOYEASY XXL PLUS)**

#### **TECHNOLOGY ACCEPTANCE AND USE OUTCOMES**

Seventeen facilities tested soy-based water-soluble coolant manufactured by Environmental Lubricants Manufacturing, Inc. (<http://www.elmusa.com/>). The outcome for soy-based water-soluble coolant was split, with more disliking its performance than approving of it.

Seven facilities liked the performance of the soy-based water-soluble coolant and six of them have continued to use it. One facility used up the supply provided to them as part of the study, but did not order more due to the increased purchase price when compared to the petroleum-based water-soluble coolant they were using.

Reported reasons for liking the soy-based water-soluble coolant were similar to those reported for soy-based neat oil including: decreased odor, misting and rusting and increased lubricity. A healthier and safer working environment and the perceived environmental benefits of using a bio-based

product were important. The idea of supporting the local agricultural community was an advantage expressed by all facilities that approved of the soy-based water-soluble coolant.

Ten facilities disliked the soy-based water-soluble coolant and either discontinued using it immediately, or didn't order more after their supply was exhausted. The most reported reasons for discontinuing use of the soy-based water-soluble coolant were rancidity and gumming of the product on the machines and parts. Other negative observations included: poor finish quality, decreased tool life and increased odor and cost.

Three companies reported unexpected problems with the soy-based water-soluble coolant. One facility experienced severe disruption to production due to the product having been expired upon entering the system. The expired soy-based water-soluble coolant gummed up on the machines and reportedly cost the facility thousands of dollars in lost productivity and clean up. The facility expressed it was unaware of an expiration date for the product. Despite this major setback, this particular company purchased a fresh supply of the soy-based water-soluble coolant and is still using it.

Another facility experienced similar gumming issues, but the problems were reportedly attributed to storing the soy-based water-soluble coolant below 40° F per

Environmental Lubricants Manufacturing, Inc. Again, this facility was unaware of any storage restrictions.

Two additional facilities expressed frustration with the need to mix the soy-based water-soluble coolant very rich in comparison with the petroleum-based product they had been using. This translated into the need to purchase more soy-based product than petroleum-based product and resulted in the facilities being unable to continue using the soy-based product due to higher than anticipated cost increases.

### **POLLUTANT REDUCTION & ECONOMIC OUTCOMES**

Unlike the facilities that tested the soy-based neat oil, none of the sites that tested soy-based water-soluble coolant observed waste reduction or cost savings.

It was anticipated that like soy-based neat oil, the soy-based water-soluble coolant would exhibit a longer lifespan than conventional petroleum-based coolants, however this was not measurable. Some facilities expressed the notion that the soy-based water-soluble coolant was actually lasting longer, but most of those facilities experience sporadic work orders. This made it almost impossible to gauge increased product lifespan, decreased waste disposal or other factors such as increased tool life and productivity.

**CONCLUSIONS**

As a result of these NETSB placements, clear-cut reasons or circumstances warranting conversion to soy-based water-soluble coolant were not apparent. As is the trend with petroleum-based water-soluble coolants, those facilities working mainly with cast iron and stainless steel experienced the most problems with rancidity.

The successful conversion to soy-based water-soluble coolant may be dependent on the working conditions in the facility, including the metals being worked, the machining processes being performed, the frequency of coolant use, the general cleanliness of the site and whether the facility maintained a regular coolant maintenance schedule.

Some facilities were willing to work through any issues that arose with the soy-based water-soluble coolant and even change working habits and conditions to allow it to work optimally. However most facilities expressed conversion from petroleum-based water-soluble coolants to soy-based water-soluble products be less troublesome.

More detailed studies are necessary to better determine the conditions under which soy-based water-soluble coolant would work optimally.

**ACRONYMS USED IN THE CASE STUDY**

- IWRC ....Iowa Waste Reduction Center
- ELM .....Environmental Lubricants Manufacturing
- MWF.....Metal Working Fluid
- NETSB .....New Environmental Technology for Small Business
- NIOSH .....According to the National Institute for Safety and Health
- RCRA.....Resource Conservation and Recovery Act
- SIC .....Standard Industrial Classification

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