

Liquid Crystal Polymer Machining/Grinding Fluid

0817 Pollution Abatement Ashore Program

May 2004

Technical POC

NFESC, Code 421

Phone 805 982-1341

Management POC

NFESC, Code 45

Phone 805 982-1674

Objective & Navy EQ Requirements



Objective: Demonstrate and Validate Liquid Crystal Polymer (LCP) as a Metal Working (cutting) Fluid at a Navy Shipyard

Requirements	Priority	Requirement Title
3.1.01.d	Medium	Minimize Waste for Spent Cutting Fluids

- **Cutting Fluids at Navy Facilities “wear out” Due to Solids, Bacterial, and Tramp oil Contamination.**
 - **Large Disposal Volumes of Spent Cutting Fluids.**
 - **High Replacement Costs of Worn Cutting Tools.**
 - **Greater O&M Costs.**
 - **Annual Navy Savings of \$140K.**
 - **Annual DOD Savings (Army) of 1.2M**

Clean Water Act

- **Clean Water Act (CWA) 40 CFR 122; Resource Conservation and Recovery Act (RCRA) 40 CFR 262; The Pollution Prevention Act of 1990, and Executive Order 13148 *Greening the Government Through Leadership in Environmental Management.***

Approach

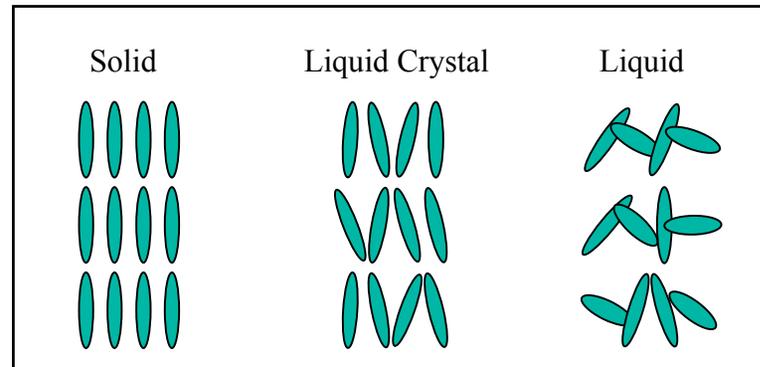


- **Test LCP on Machining/Grinding Process**
- **Replace Straight Oil/Soluble Oil Fluids**
- **One Year Production Environment Evaluation**
 - Shop 31, NSY Pearl Harbor
 - Current Usage- Blasocut Oil/Water Miscible Fluid
- **Determine Success Parameters**
 - LCP Durability
 - Reduction Fluid Usage
 - Tool Life Extension-Metals Compatibility
 - Microbial Growth Reduction
 - MSDS Data
- **Leverage EPA/LCP Test Data**

Technology Description



- LCP Developed by EPA and LCP Tech Inc.
- LCP Tech - Dr. Rakesh Govind of the University of Cincinnati
 - EPA has Patent Rights for Government applications
 - LCP Tech Inc. has Patent Rights for New Applications
- LCP a New Environmentally Friendly Lubricant
- Comprised of Long, Rigid, Cylindrical Molecules; Tend to Align on Long Axis



Technology Description

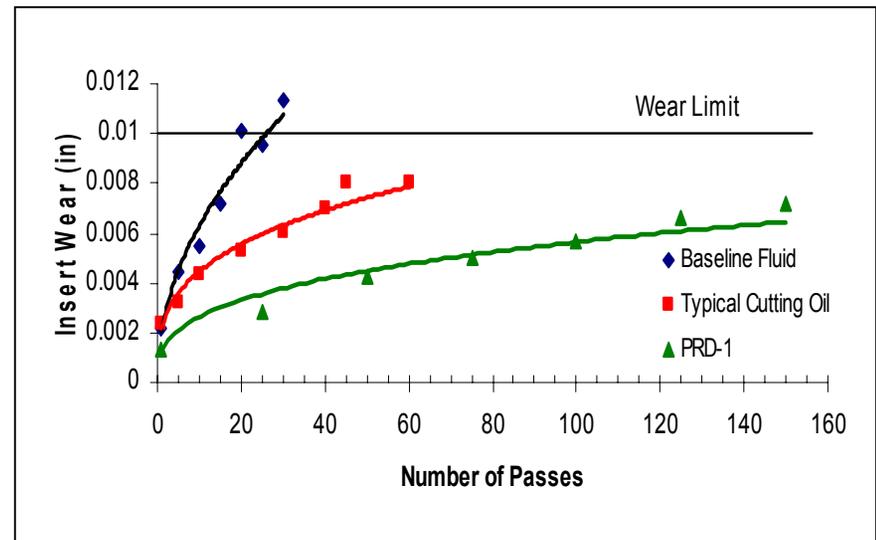
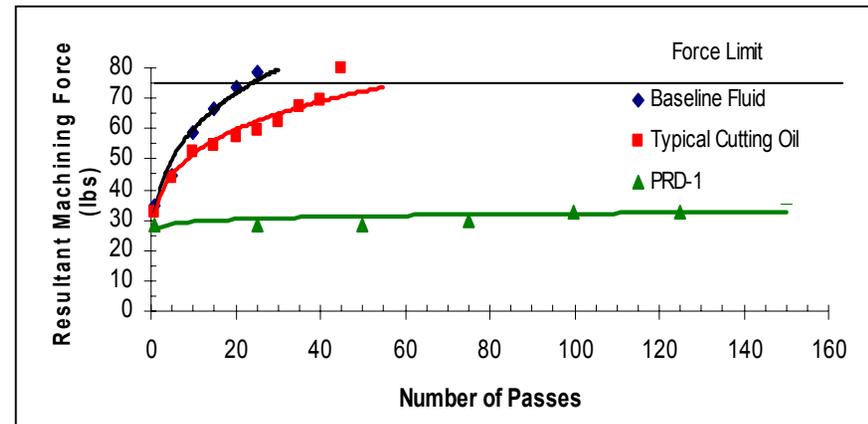


- **Desirable LCP characteristics include:**
 - **Low toxic**
 - **Less dense than water**
 - **Not attacked or biodegraded by bacteria or fungi**
 - **Recyclable & Reusable**
 - **Physiologically inert**
 - **Immiscible with water or aqueous mixtures**
 - **Transparent**
 - **Stable in presence of oxidizing agents**
 - **Un-reactive with acidic and alkaline solutions**
 - **Boiling point greater than 550°F**

Technology Description



- FY02 EPA Preliminary Performance Testing
- International Working Industry Group Milling Test
- EPA Force and Insert Wear Tests
- Tool Life is the Number of Milling Passes an Insert Experiences Before it Demonstrates a Resultant Cutting Force of 75 lbs
- Insert Wear with LCP=.00722 in. after 150 Passes
- Insert Wear with Typical Oil =0.00760 in. after 54 Passes



Benefits-Before/After Comparison



- Annual Navy Savings of \$140K
- ROI = 1.75 (DOD = 5000)
 - Assuming LCP triples Existing Cutting fluid and Cutting Tool Service life at Navy Metal Working Facilities

Annual Navy Cutting Fluid Costs				
	Procurement	Disposal	Tooling	O&M
Before Conventional Fluid *	\$30K	\$60K	\$75K	\$45K
After LCP	\$10K	\$20K	\$25K	\$15K
Expected Savings	\$20K	\$40K	\$50K	\$30K

*Shipyard values extrapolated Navy wide.

Milestones and Major Deliverables



MILESTONE	FY03				FY04				FY05			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Research Metal Working, LCP and Related Equipment												
2. Survey Test Site												
3. Develop Test Plan, Safety Plan, & Other Docs												
4. Identify/Purchase LCP & Associated Test Hardware												
5. Install LCP Test Equipment												
6. Perform Field Testing/Data Collection												
7. Initiate Technology Transfer/Implementation												
8. Analyze Results and Write Final Test Report												

- Project Stopped as of 4/4/03.
- Awaiting FY03 EPA and NIOSH Test Results due 7/03, Received 2/2/04
- Compatibility with elastomers, paints, and other metals
- Cleaning or ease of removal from machines and parts.
- Inhalation, skin rash and eye irritation.

Project Coordination



- **Pearl Harbor NSY Environmental Office, Code 106.3.**
 - Shop 31- Proposed Test Site.
- **Benet Laboratories at U.S. Army Watervliet Arsenal.**
 - Provided U.S. Army Metal Working Cost Metrics.
- **U.S. EPA.**
 - Conducting 2003 Tests to Evaluate Fluid Cleaning Compatibility, Metals Compatibility, Safety Data
- **National Institute of Occupational Safety and Health (NIOSH).**
 - Conducting Exposure testing for Oral Toxicity, Skin rash, and Eye Irritation.
- **TechSolve Inc.**
 - Evaluate LCP Performance as a Metal Working Fluid for EPA.

Technical Accomplishments to Date



- **Research LCP Metal Working and LCP Applications**
- **Identified Navy Demonstration Site**
 - Navy Shipyard Pearl Harbor
- **Completed Additional Safety Data**
 - Eye and Skin Response
- **Completed Ecotoxicological Properties**
- **Completed Physical Properties Comparison**
- **Submitted ESTCP Proposal to Fund Further DEM/VAL**
 - U.S. Army Watervliet Arsenal Potential Test Site

Technical Accomplishments to Date



•Summary of Acute Dermal and Eye Irritation Tests (MB Research Laboratories, Spinnerstown, PA).

Type of Test	Test Protocol	Performing Laboratory	Test Results	Conclusion
Acute Dermal Irritation in Rabbits	EPA 40 CFR 156.340	MB Research Laboratories	There were no erythema or edema noted at any observation period	LCP Fluid is not a dermal irritant
Acute Eye Irritation in Rabbits	EPA 40 CFR 158.340	MB Research Laboratories	There was no corneal opacity or iritita noted at any observation period. Conjunctival irritation noted in 3/3 eyes, cleared by 72 hours.	Ocular administration of LCP Fluid produced conjunctival irritation which cleared by 72 hours.

Technical Accomplishments to Date



- **Completed Ecotoxicological Properties**
 - Not Harmful to Plants or Animals
 - Does not Affect Plant Growth, Seed Germination
 - No Impact on Marine or Terrestrial Life
 - Does Not Bio-accumulate in Food Chain
 - Does not Oxidize Easily
 - Breaks Down Efficiently in the Environment
 - Pass Oral Toxicity Test
 - Low Acid Number
- **Completed Metals Compatibility**
 - Boeing Tested Four Different Metals, Two Samples each
 - No Corrosion Noted, Results Similar to Distilled Water
- **Completed Resistance to Microbial Growth-ASTM E686**
 - Does not Kill Microbes Present, but Does Not Support Growth

Technical Accomplishments to Date



•Completed Physical Properties Comparison

Properties	Mineral Oil	Polyglycol	Vegetable Oil	Synthetic Ester	LCP Fluid
Percent Biodegradability	42-49	6-38	72-80	55-84	N/A
Toxicity, LC50, Trout, EPA 560/6-82-002	389 -> 5000	80 -> 5000	633 -> 5000	> 5000	> 5000
Oxidation Stability, TOST hours, ASTM D 943	1000 – 2000	< 500	< 75	< 500	<500
Lubricity ASTM D 2266	Good	Good	Good	Good	Excellent
Viscosity Index ASTM D2270	90-100	100-200	100-250	120-200	> 400
Foaming ASTM D892	Pass	Pass	Pass	Pass	Pass
Pour Point °C (°F) ASTM D 97	-54 to -15 (-65 to 5)	-40 to 20 (-40 to 68)	-20 to 10 (-4 to 50)	-60 to 20 (-76 to 68)	-200 to 150 (-328 to -238)
Compatibility with Mineral Oil	-	Not miscible	Good	Good	Good
Relative Cost	1	2 – 4	2 – 3	5 – 20	2 – 3

Implementation Strategy and Plans



- **Provide Technical Report to NAVFAC, NAVSEA, NAVAIR, EPA**
- **Post Results at Joint Service P2 Library and P2 Conference**
- **NFESC use Established Working Groups to Aid Implementation**
 - Army Environmental Center Briefed
 - Joint Group On P2 (JGPP)
 - Tri-Service Environmental Center
- **Users- Navy Metal Working Occurs at Shipyards, SIMAs, Aviation Depots.**
 - Pursue FY05 ESTCP funds to continue DEM/VAL and Implementation at Army Watervliet Arsenal (R. Lebaron) and NSY Pearl Harbor (Shon, Sheely)
- **Consultants and Regulators Assistance**
 - EPA Consultant – Mr. Roger Wilmoth, Government Applications, LCP
 - Army Consultant – Phillip Darcy, Benet laboratories
 - Test Lab Consultant - Tom McClure - TechSolve

Logic Model for LCP Project



<p>Navy Benefits</p>	<p>The primary benefits to Navy are reduced cutting fluid usage, tool life extension, metals compatibility, reduced microbial growth, and associated cost savings.</p>
<p>Customer Capability</p>	<p>Using LCP as a cutting fluid will allow the shops to extend the interval for fluid changeout in the vital production shop environment, reducing downtime and disposal volume.</p>
<p>Products</p>	<p>The specific item this project provides, if successful, is a capability to use a new synthetic cutting fluid, based on Liquid Crystal Polymer formulation.</p>
<p>Project Milestones</p>	<p>MS#1- Research Metal Working, LCP and Related Equipment(Q2,FY04). MS#7- Perform Field Testing/Data Collection (Q3,FY05)</p>
<p></p>	<p></p>

Summary



- **Navy Primary Benefits of LCP Cutting Fluid:**
 - **Tripling Cutting Fluid and Cutting Tool Service Life**
 - » Lower Fluid Procurement and Disposal Cost.
 - » Lower Cutting Tool Procurement Cost.
 - » Lower Operation and Maintenance Cost.
 - » Minimize Shop Downtime to Fluids Changeout
 - » Improved Environmental Shop Conditions
- **Proposed Additional ESTCP Funding to Leverage Navy Demonstration to DOD level.**
 - **Army DEM/VAL Test of LCP and Bio-Lubricants**