Analysis of Lubricity Properties of Metal Cutting Fluids

Senior Design Proposal submitted to the
Department of Mechanical and Materials Engineering
College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science
in Mechanical Engineering Technology

by

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Problem Statement

Metal cutting companies have no way of checking the lubricity properties of their coolants which can degrade over time. This issue can cause companies to spend tens of thousands of dollars on cutting fluid materials as well as machine and maintenance issues. The metal cutting industry needs a low cost and easy way of testing coolant lubricity properties on site so that they are aware of when their cutting fluid will cause quality issues.

Research

Background of the Problem

Coolant, or cutting fluid, is a liquid that is commonly applied while a machining operation is taking place. The main functions of this fluid are to remove heat generated while cutting metal, to reduce friction between the tool and the workpiece, and to remove metal chips and other contaminants from the workpiece. (1) The quality of this coolant will degrade as it is used. Over time, the coolant can become contaminated by sludge, metal chips, and fine metal particles from machining materials. These contaminants, the fine metal particles in particular, can reduce the quality and the precision of the products by increasing the friction between surfaces. (2) Detecting and removing these contaminants from the coolant is an important step in increasing the quality of work and the life of the tools used. Cooling lubrication has a significant influence on the work result and must be honed to the proper specifications for the proper material. (4) This problem overall affects manufacturing companies that require cutting fluids for machining products. It affects the quality of their work as the more a tool wears the less precise the drilling or cutting will be. It affects the tool life which needs to be replaced for quality purposes and could also lead to safety issues that may arise. It will affect the quality of the work, the delivery time to the customer and it can be costly to try and solve this issue. It also affects the customer as the delivery time will get delayed due to the constant changeover of tooling and cutting fluid changeover. In a case presented to our group, a company has had a significant issue with tool life, and they are replacing several drills weekly due to the poor lubricity of the cutting fluid. The supplier of the tooling has come back to the company and reported that they were unsure if they would be able to keep up with the high demand for drills needed for machining. The way they attempt to combat this problem is by replacing cutting fluids at a high rate which is an expensive and time-consuming process as they are losing production time when they drain and refill their fluid supply at the machine. The other approach is a high turnover of cutting inserts or drills. These solutions, while they solve the problem, add an unnecessary amount of time for changeover and downtime. It also is a massive expenditure that is not sustainable to justify a high level of production of this fluid and tooling changeover. In a certain scenario a company was running high level production and were replacing drilling tools at a constant rate due to the ineffectiveness of the cutting fluid, the supplier of the tooling notified the machining company that they would not be able to keep up with the high level of tooling turnover and that they will be unable to provide drills at the high rate needed. Another property of coolant that can have a great impact on the efficiency of the process is the pH level. In general, a higher pH level-coolant can provide protection against corrosion for ferrous metals, and a pH level closest to 7 in the coolant will protect against corrosion for nonferrous metals. Other reasons for having a stable and tested pH value in coolant include the solubility of the metal, dermatitis, and the propagation of bacteria and fungi. (3) This is a property that needs to be tested and treated for the best results in machining processes.

Applicable Standards

ANSI B11.6-2022: Safety Requirements for manual turning machines (6)

ASTM D6079-22: This is the standard test method for evaluating lubricity by HFRR. (7)

ASTM G99: This is the standard testing method for wear testing on a pin-on-disk test. (9)

ASTM D2881-19: Standard Classification for Metalworking Fluids and Related Materials. (13)

State of the Art

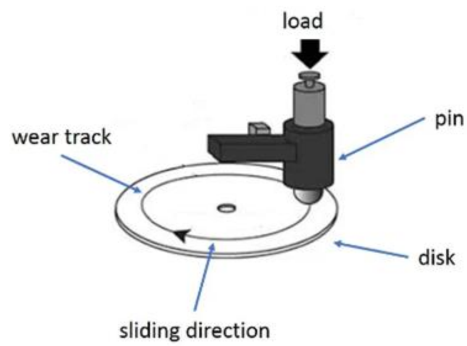
HFFR Test

High Frequency Reciprocating Rig Testing consists of a 6mm ball with a Rockwell hardness of C58-66 Is moved on a 10mm disc which is a Vickers VH3019210 hardness. The ball moves 1mm back and forth at a speed of 0.1m/s for 75 minutes. The ball is loaded with a 200gram load which is applied to the disc which has the fuel or fluid which is used to lubricate the system. The lubricity is measured by the wear scar left on the plate after the allotted time as well as by the temperature during the test. The results are measured in microns and record the length and width of the wear scar. The greater the wear scar, the lower the lubricity of the fluid (5). The pro of this test is that it is small and relatively simple to use. However, it does not reproduce the actual metal cutting process or give any additional information on what can be done to improve the properties of the fluid.

Pin-on-Disk Test

The Pin-on-Disk test uses a device such as a tribometer to measure the friction and wear of material pairings. This test requires using standard parameters of load, duration, and frequency, as well as using a counter body material to test against. During the test, the counter body, being a steel ball or pin, is moved around a circular path over the material to be tested with a defined standard force of approximately 5 Newtons. The frictional force or coefficient of friction is measured throughout the process (8).

The device used in this process, a tribometer, is a device used to simulate friction and wear between two surfaces. It is a common tool, but often requires specialty manufacturing to provide specific testing conditions and dimensions (9). Some of the disadvantages of the Pin-on-Disk test include having a limited predictive value for design, and issues with the geometry of the counter body (10).



1: Schematic of a pin on disk tribometer (9)

Pendulum Scratch Test

The pendulum scratch test consists of creating a scratch on a surface using a swinging pendulum. Like the previous two tests, the indenter will swing onto a piece of material covered with a certain amount of oil or fluid being tested. Pendulum will be dropped with the same load from the same height every time and will indent the same material with the same geometry. The scratch depth is measured in microns and used to determine the lubricity properties of the material. Like the HFFR test it is small and relatively simple to use. However, it does not reproduce the actual metal cutting process or give any additional information on what can be done to improve the properties of the fluid.

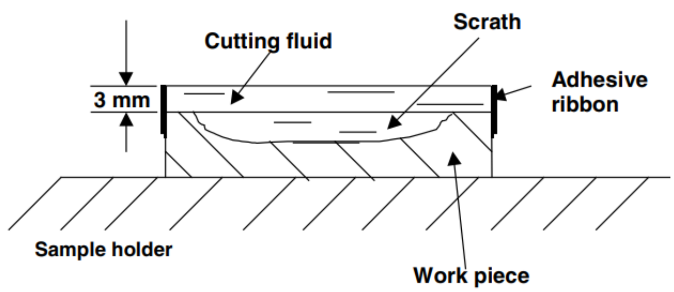


Figure 2. Cross Section view of scratch produced

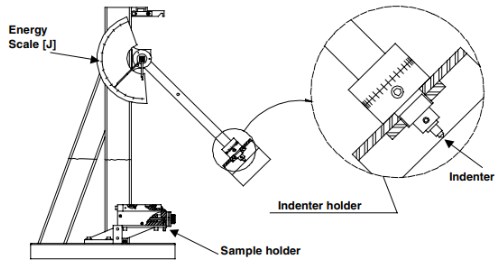


Figure 3. General view of the pendular instrument (Franco, 1989).

Metal Cutting Fluid Test Kit

While this is not a machine specific state of the art it is an option for testing cutting fluids lubricity and composition. These testing strips measure the bacteria level as well as the ph of the cutting fluid. The strips are placed into the coolant or cutting fluid tank or storage and in twenty minutes it will give a reading (12) The strips can be read after the twenty minutes and the more debris and bacteria on the strips the more contaminated and the lubricity is compromised and even deterred. While it specifically does not measure lubricity it measures the bacteria and ph levels which can show the amount of containment such as chips or dust from the machining application which can all relate back to lubricity. The more bacteria and containments the chance of poor lubricity increases even if the ph levels are consistent (12).

These tests have been proven to not be completely accurate and while it is measuring the cutting fluid itself there is no true test on the machining part of the process just the sitting fluid. These strips are also just a baseline test and do not give any true insight on the fluid's ability just its status. This state of the art is easy for common checks but does not provide an in-depth test or trial to see the fluids capabilities.

End User

The end user of a tabletop device used to test cutting fluid lubricity would be coolant manufacturers as well as companies in the metal cutting and machining industry. Coolant manufacturers can use this device mainly to test fresh product to ensure that it meets the specifications required for proper use. Companies in the metal cutting industry can use the device in the same way to ensure that its income coolant meets specifications as well. However, a more beneficial use of this device would be to test recycled coolant fluid. These companies often recycle their cutting fluid to save money. However, the recycled fluid often will contain metal parts and chips which can greatly affect the properties as well as the machines using it. This device will allow these companies to analyze their recycled material and be able to adjust its properties with additives, restoring it back to the desired properties. They will have a head start when their coolant is going bad and be able to identify what needs changed before the quality drop off is present in the finished materials. It will allow them to save money on tooling changeover as the tool life should be maximized and utilized to its full ability.

Summary of Research

The research addresses a critical issue within the metal cutting industry, the degradation of coolant lubricity properties over time and the lack of a cost-effective on-site testing solution. Metal cutting companies face significant financial burdens as they spend substantial sums on cutting fluid materials and must deal with machine and maintenance problems resulting from deteriorating coolant quality. The research underscores the pressing need for a low-cost and user-friendly tabletop device capable of assessing coolant lubricity properties. The report also highlights the detrimental effects of coolant degradation on manufacturing processes, tool longevity, and product quality. To combat these issues, the study discusses several state-of-the-art testing methods, such as the High-Frequency Reciprocating Rig Test, Pin-on-Disk Test, Pendulum Scratch Test, and Metal Cutting Fluid Test Kit. While these methods have their advantages, they are not without limitations, emphasizing the need for a more comprehensive and accessible solution to evaluate cutting fluid performance.

The end-users of the proposed tabletop device are coolant manufacturers and companies in the metal cutting and machining industry. Manufacturers can employ the device to assess the quality of their fresh products, ensuring they meet the necessary specifications for effective machining. For metal cutting companies, the device offers a valuable tool to monitor both fresh and recycled coolant fluids. Particularly beneficial for recycling efforts, the device enables these companies to analyze their recycled materials, detect contamination, and make necessary adjustments to restore coolant properties. By preemptively identifying coolant issues, these companies can extend tool life, improve manufacturing quality, and minimize the financial burden of frequent tool changeovers. Overall, this research points toward a much-needed solution that has the potential to enhance efficiency, reduce costs, and maintain product quality in the metal cutting industry.

Quality Function Deployment

Customer Features:

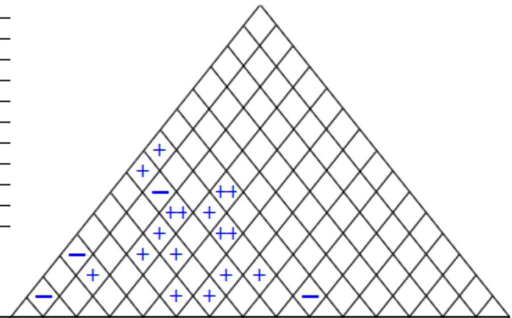
- Lower Cost
- Durability
- Safety
- Longevity
- Ease of Use
- Effectiveness
- Lightweight
- Material Enhancement Information

Engineering Characteristics:

- Cheaper Materials ($)
- Strength of materials (tests per machine)
- Required additives (g or m^3)
- Weight of device (lbs)
- Time of operation (sec)
- Time required for training (days)
- Time to set-up (sec)
- Frequency of maintenance (event/mo)
- Energy efficient (kW)
- Assembly volume (ft^3)

House of Quality:

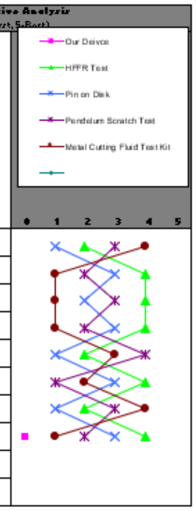
Title:	Senior Design HOQ
Author:	Ben Mockey, Craig Schuermann, Dan Burdine
Date:	9/29/2023
Notes:	



Legend

Θ	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
—	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
X	Objective Is To Hit Target	

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	Cheap Materials ($)	Strength of Materials (Tests per machine)	Required Additives (g or m^3)	Weight of Device (lbs)	Time of Operation (sec)	Time Required for Training (days)	Time to Set Up (sec)	Frequency of Maintenance (events/mo)	Energy Efficient (kW)	Assembly Volme (ft^3)						Our Deivce	HFFR Test	Pin on Disk	Pendelum Scratch Test	Metal Cutting Fluid Test Kit
				Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	▼	▲	X	▼	▼	▼	▼	▼	▼	▼						Competitive Analysis (0-Worst, 5-Best)				
1	9	12.9	4.0	Lower Cost	Θ	O	O	O		▲	O	O	Θ	O							2	1	3	4
2	9	6.5	2.0	Durability	O	Θ		▲	▲		▲	O		▲							4	3	2	1
3	3	9.7	3.0	Saftey	O	▲		▲	O	O	O	O	O	▲							4	2	3	1
4	9	12.9	4.0	Longevity	O	O	O	▲	▲	O	O	Θ	O	▲							4	3	2	1
5	9	16.1	5.0	Ease of Use			O	O	Θ	Θ	Θ	O		O							2	1	4	3
6	9	16.1	5.0	Effectivness	O		Θ		O	O	O	▲	O	O							4	3	1	2
7	9	9.7	3.0	Lightweight	O	O		Θ	▲		O	▲	▲	Θ							2	1	3	4
8	3	16.1	5.0	Material Enhancment Information			O			▲	▲		O	O						0	4	3	2	1
9																								
10																								
				Target or Limit Value	$2,000	100	-	200	5	2	30	2	1.44	90										
				Difficulty (0-Easy to Accomplish, 10-Extremely	5	6	7	5	0	3	0	5	3	4										
				Max Relationship Value in Column	9	9	9	9	9	9	9	9	9	9										
				Weight / Importance	280.6	174.2	319.4	203.2	251.6	290.3	351.6	277.4	290.3	300.0										
				Relative Weight	10.2	6.4	11.7	7.4	9.2	10.6	12.8	10.1	10.6	11.0										



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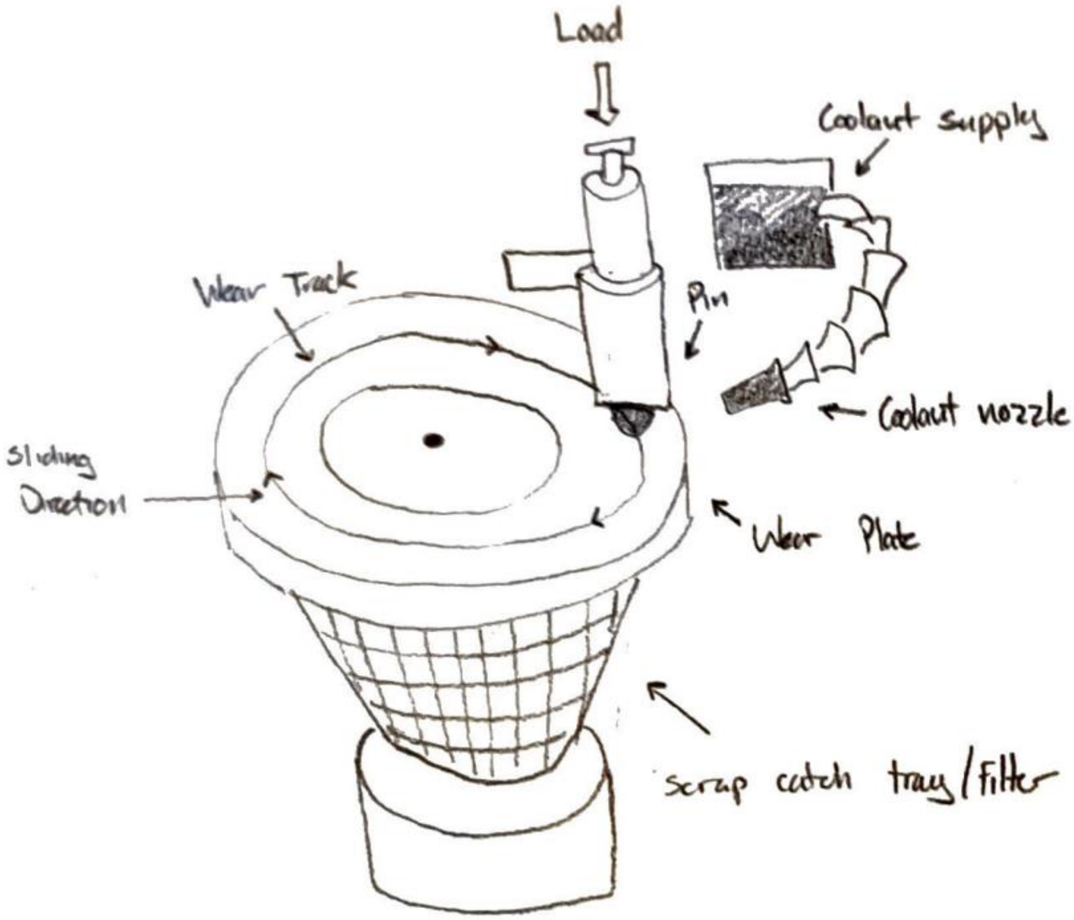
Product Objectives:

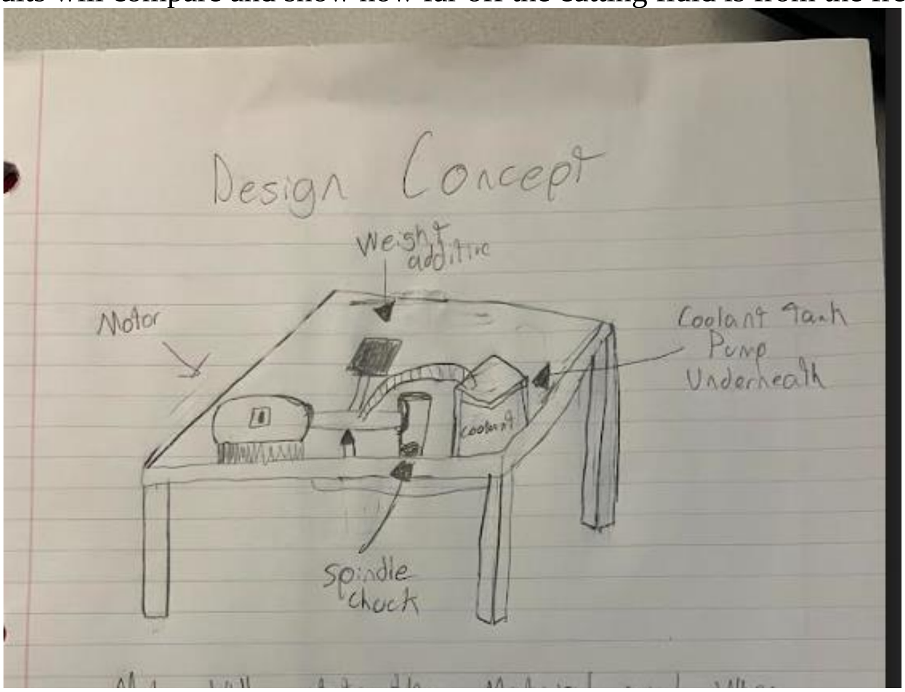
- Cheaper Materials: Cost under or around $2,000 (Weight = 10.2)
- Strength of Materials: The machine should be able to complete over 100 tests before replacing the cutting tool (Weight = 6.4)
- Required Additives: Device should require recyclable and high-quality additives for use. (Weight = 11.7)
- Weight of Device: Device should be easy to maneuver and not require anything more than a pallet jack. (Weight = 7.4)
- Time of Operation: Device should be able to complete tests, set up, and analysis in under 5 minutes. (Weight = 9.2)
- Time Required for Training: Device should have simplicity of operation and require minimal human input. (Weight = 10.6)
- Time to Set-up: Device should have a minimum set-up time of 30 seconds. (Weight = 12.8)
- Frequency of Maintenance: Device maintenance should only depend on cutting tool life and motor, minimum 100 tests before maintenance. (Weight = 10.1)
- Energy Efficient: Device should be able to run off 1440 Watts (standard outlet) (Weight = 10.6)
- Assembly Volume: Device should take up no more than 90 ft^3 (work bench sized) (Weight = 11)

Concepts Drawings

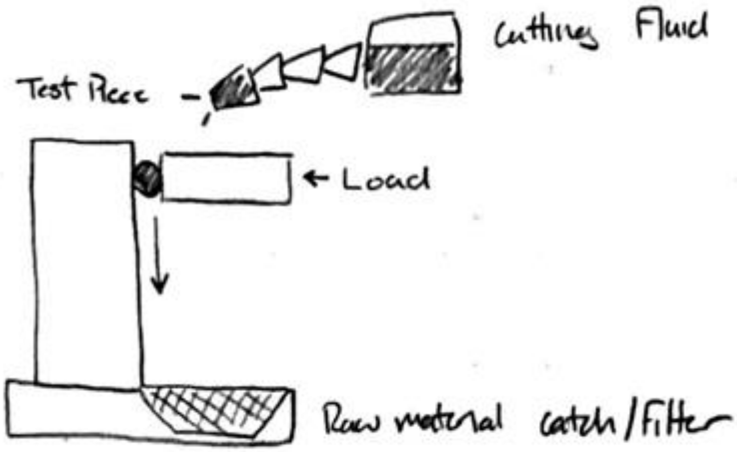
Concept 1: This concept is a modified version of the pin and disc test. Instead of applying a uniform amount of coolant fluid over the entire disc, fluid will be applied in similar fashion to actual machining processes to the point of contact of the load. During the test, the counter body, being a steel ball or pin, is moved around a circular path over the material to be tested with a defined standard force of approximately 5 Newtons. The frictional force or coefficient of friction is measured throughout the process with a tribometer. The test will also be substantially longer than the original pin and disc test to allow buildup of material shavings, this will be used to measure the clearance ability of the fluid as well as if there are any extra unwanted materials from the fluid. The material will be filtered after the test collecting the new scrap material.



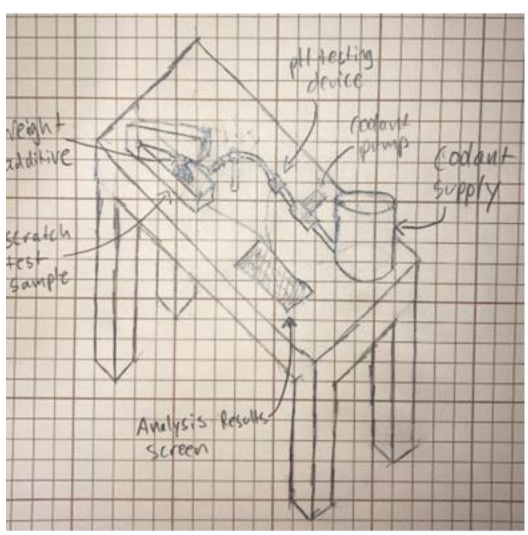
Concept 2: This Concept is a table design built for in-house testing. The testing process uses a rotary motor where it connects to a raw material rod whether it is steel or aluminum and leads into a rotary stationary chuck that allows the rod to spin at a high rate. While the rod is spinning, weight will be added to a lever type axis whereas weight increases a cutting insert will be raised onto the rod and will begin cutting the raw material as more weight is added. During this process, the cutting fluid that is being analyzed will be pouring onto the cutting insert so that it is an efficient and clean cut. The data points of cut time, required weight and possibly surface finish will be compared to a "golden" sample that is made from a brand-new batch of cutting fluid. The results will compare and show how far off the cutting fluid is from the fresh sample.



Concept 3: This concept will test the lubricity properties of the cutting fluid by running a steel ball straight down the work piece while applying the cooling fluid in a similar fashion to normal machining process. The depth of the scratch will be measured as well as the heat generated and friction. Alongside these factors the total amount of metal shavings will be measured, and these factors will be compared to a baseline result of running the tests with cutting fluid that meets proper requirements.

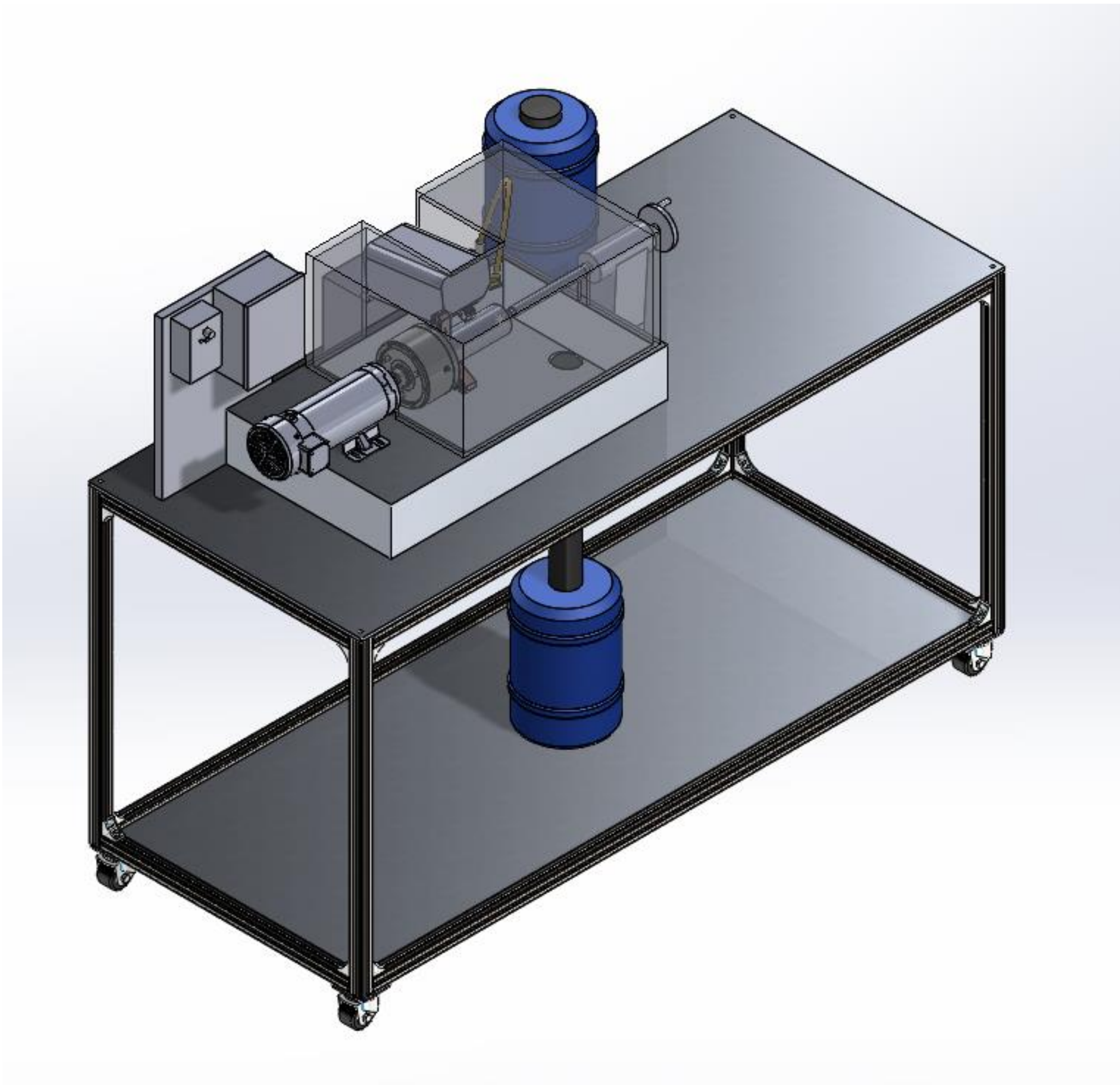


Concept 4: This concept is a tabletop workbench design which uses a pH test as well as a lubricity test in order to test the quality of the cutting fluid. The coolant is held in a coolant supply tank which is then pumped through a pipe through a pH testing device and then to be discharged onto a rotating standardized test sample which will be scratch tested by a standardized, weighted pin onto the test surface below. This scratch test and pH test will be measured and displayed onto an analysis results screen.

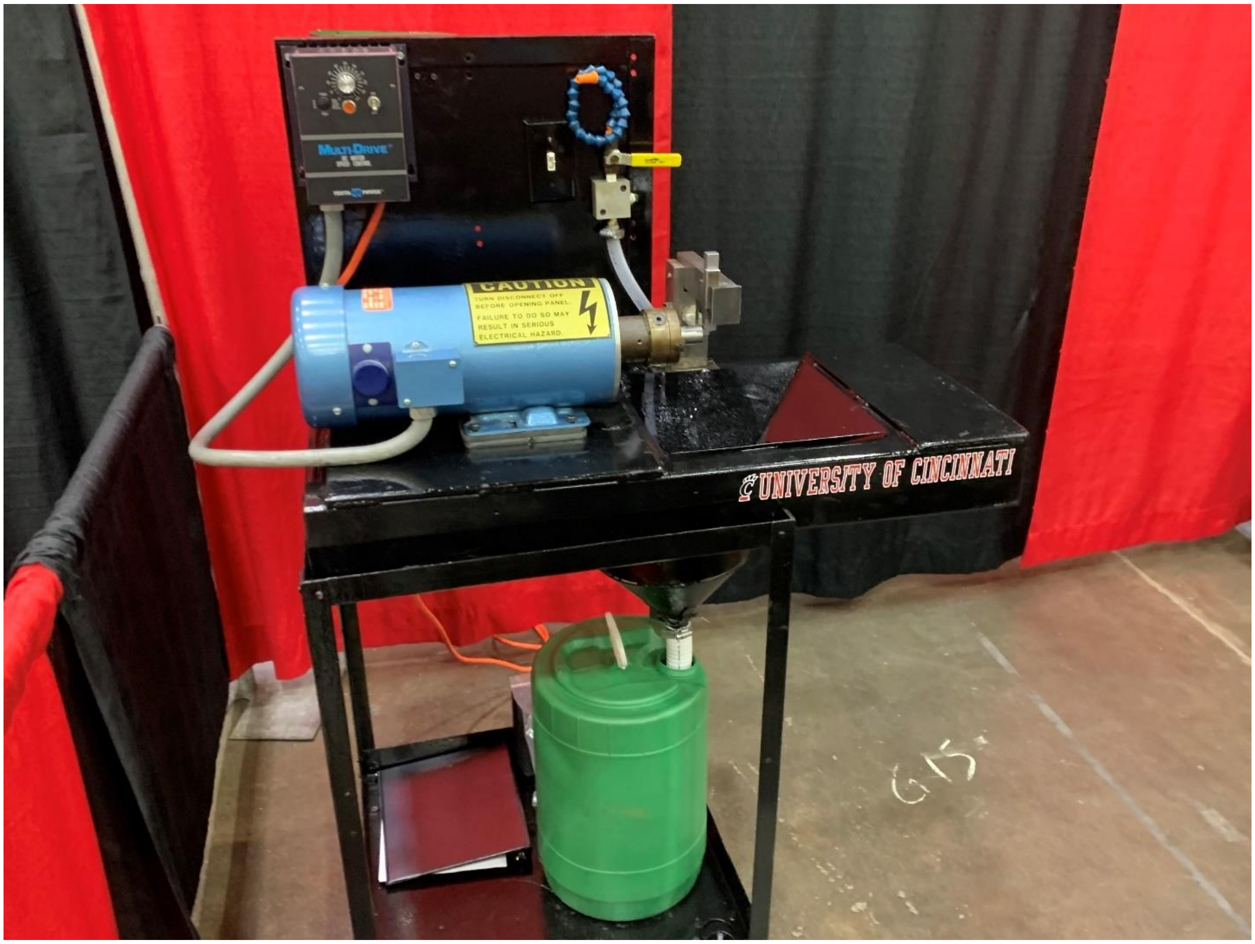


Design

Design Concept



Final Design



Load Conditions

- AISI 8260 Low Carbon Steel
- 1” Diameter
- 1.5” Length
- C6 Carbide Inscribed Circle Turning Insert
- Initial Spindle Speed – 800 RPM
- Final Spindle Speed – 520 RPM
- Applied Load – 4.5 lbf
- Cutting fluid rate – 1.0 gal/min

Machine Components

Motor:
- Danfoss Electronics Inc. DC Motor
- 1800 RPM
- 1.5 HP
- Highly Controlled Speed

Motor Controller:
- Penta KB Power
- Multi-Drive Motor Speed Controller

Cutting Tool:
- C6 Carbide
- Inscribed Circle Turning Insert

Weight Additive:
- Standard weight for testing consistency.
- Will be fabricated in machine shop.

Chuck:
- 2” diameter

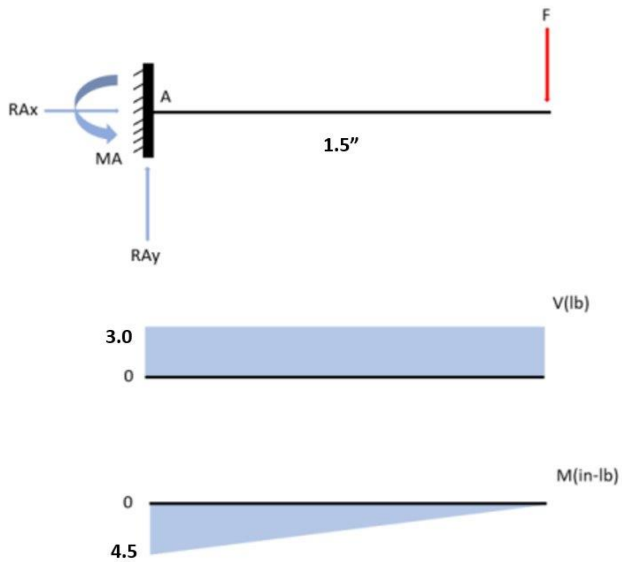
Cutting Fluid Pump:
- LFE Fluids Control Division
- Model E-7
- 1.0 gal/min

Hose:
- Acetal Plastic
- 5’ length
- 1/2” diameter

Nozzle:
- 1/4” Loc-Line Coolant Hose
- 30 psi max pressure

Design Analysis

- AISI 8260 Alloy Steel
- Yield Strength = 55,800 psi
- Shear Modulus = 11,600 ksi



$$\Sigma Fx = 0$$

$$\mathrm{RA}x = 0\ lbf$$

$$\Sigma Fy = 0$$

$$3.0 - RAy = 0$$

$$RAy = 3.0\ lbf$$

$$\mathrm{MA} = 3 * 1.5\ in$$

$$MA = 4.5\ in - lb$$

$$D = 1\ in$$
$$A = \pi * 0.5^2$$
$$A = 0.785\ in$$

$$\tau = \frac{4V}{3A} = \frac{4 * 3}{3 * 0.785}$$
$$\tau = 5.096\ \mathrm{psi}$$

$$I = \frac{\pi d^4}{64} = \frac{\pi * 1.5^4}{64}$$
$$I = 0.25\ lbf - in - s^2$$

$$\sigma_b = \frac{-My}{I} = \frac{-4.5 * 0.5}{0.25}$$
$$\sigma_b = 9.0\ psi$$

Testing Protocol & Methods

Methods

- Facing Operations with applied cutting fluid
- Dry Test with material
- Test with Standard Cutting Fluid
  - Determine Baseline measurements
- Test with Recycled Cutting Fluids
  - Compare to baseline
- Alter Testing Conditions based on results

Protocol

1. Fill supply tank with desired cutting fluid to be tested
2. Place testing piece into the chuck and tighten
3. Position cutting fluid hose over test piece and turn on pump
4. Turn on motor to 520 RPM (65%) and lower cutting tool onto the piece
5. While cutting, take necessary measurements (Testing Methods page)
6. When the cutting operation is completed, shut off motor, then the pump.
7. Repeat all steps for any additional cutting fluids and compare results

Independent Variables

- Raw Material - AISI 8620 Alloy Steel
- Spindle Rotations per Minute – 520 RPMs
- Cut Length – 0.03 inches
- Cut Depth – 0.30 inches
- Coolant Flow – 1 Gallon Per Minute
- Coolant Type - NOVAMET 875 Cooling Lubricant

Dependent Variables

- pH
  - Compare acidity difference to control
- Time
  - Standard time of cutting
- Current
  - Ammeter
  - Measure variances in motor current

- RPM
  - Tachometer
  - Measure variances in RPM

Results

Test	Cutting Fluid	PH Level	Time (sec)	Current (amps)	RPM
1	A	9	9.9	2.1	792
2	A	9	14.14	1.6	788
3	A	9	16.4	1.4	792
4	B	7.5	9.83	2	783
5	B	7.5	7.44	2.4	770
6	B	7.5	5.53	3	770
7	C	9	--	--	--
8	C	9	--	--	--
9	C	9	--	--	--

Discussion

The heavily reused sample had a much lower pH than the fresh sample and the slightly reused sample. Sample A, which was new, had a pH of 9. While sample B had a pH level of 7.5. The initial tests were done with the motor set to 800 RPM, and it was seen that there was a correlation between the load on the motor measured by the current and the sample of cutting fluid. The average load on the motor for sample A was 1.7 amps and the average load for sample B was 2.47. There was also a correlation between the reduction in spindle speed and the type of sample. For sample A the RPM of the motor dropped to an average of 790 while the RPM for sample B dropped to an average of 774. Both the spindle speed and the load on the motor are possible indicators that can be used to identify the reusability of recycled material. The error that is visible in the results is the cutting time. The cutting time was seen to be greater for the fresh sample and less for the used sample, which is opposite of what was expected. It can also be seen that sample A has a range of 6 seconds for each test, while sample B has a range of 4 seconds for each test. This issue is believed to be caused by the lack of rigidity in the cutting tool and cutting arm assembly. This issue caused the initial testing phase to be concluded before all samples were tested. This was done to reduce the rpm, increase the weight additive, and attempt to increase the rigidity of the piece. At the beginning of the second testing phase issues with the motor were encountered before any more data could be collected. The connections for all the wiring were checked as well as the power source and the motor brushes, none of which were the issue. The issue was not properly identified due to the extensive work it would take to either disassemble the current motor and inspect its components or to purchase an entirely new motor, both of which were not possible with the current budget and timeframe remaining. For future testing, it is advised to redesign the apparatus to ensure that all components have an acceptable level of rigidity as well as allowing the cutting arm to be adjusted to the sample size, rather than having it stationary. These issues that were encountered in this project can mostly be attributed to the lack of funding, causing most of the project to be assembled using recycled and scrap parts.

Conclusion

Testing the ability to identify factors that are linked to the lubricity and quality of metal cutting fluids delivered optimistic results. It was observed that certain factors such as the pH level of the cutting fluid, the load applied to the motor measured in amps, and the reduction in spindle speed measured in rotations per minute, have a direct correlation to the quality of the cutting fluid. As the quality of the fluid decreases, the pH level and the spindle speed also decrease, while the load applied to the motor increases. Due to errors encountered in the testing process, this data is not enough to confidently conclude that these factors can accurately determine the quality and lubricity properties of metal cutting fluids. However, they do indicate a relationship between the factors and fluid quality which will require further testing to meet the desired success criteria.

Project Management

Project Budget Limit

There is a planned budget of around $300. Most materials and components that were used were either scrapped from other projects or fabricated using scrap materials available in the lab. Our budget was spent on hardware such as hoses and fittings, wires and electrical components, the coolant nozzle, the metal for the funnel, and the paint.

Component	Cost
Hardware	$70
Electrical	$80
Coolant Lines	$50
Materials	$70
Cleaning and Paint	$30

Key Milestones

- **Design II**
  - Design Decision
  - Meet with shop technicians
  - Calculations / Finite Element Analysis
  - Final Design and Drawings
- **Design Presentations – January 2024**
- **Design III (Manufacturing)**
  - Order Materials - At least 3 Months before Expo
  - Manufacture – 3 Months before Expo
  - Build – 6 Weeks before Expo
  - Test – 3 Weeks before Expo
- **Tech Expo - April 2024**
- **Final Presentation - April 2024**

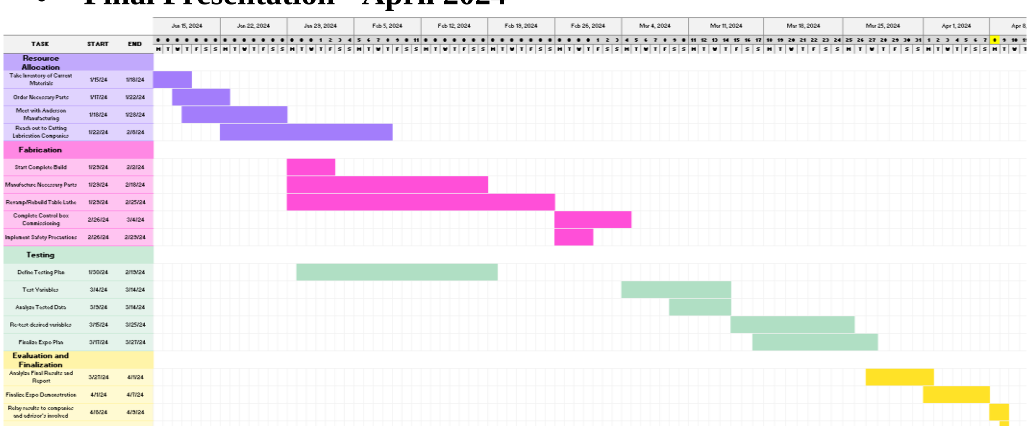


Figure 1: Senior Design III Schedule

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1. Gupta, Rajkumar. What Are Cutting Fluids>. Mechanical Jungle. [Online] [Cited: August 31, 2023.] https://mechanicaljungle.com/types-of-cutting-fluids/.
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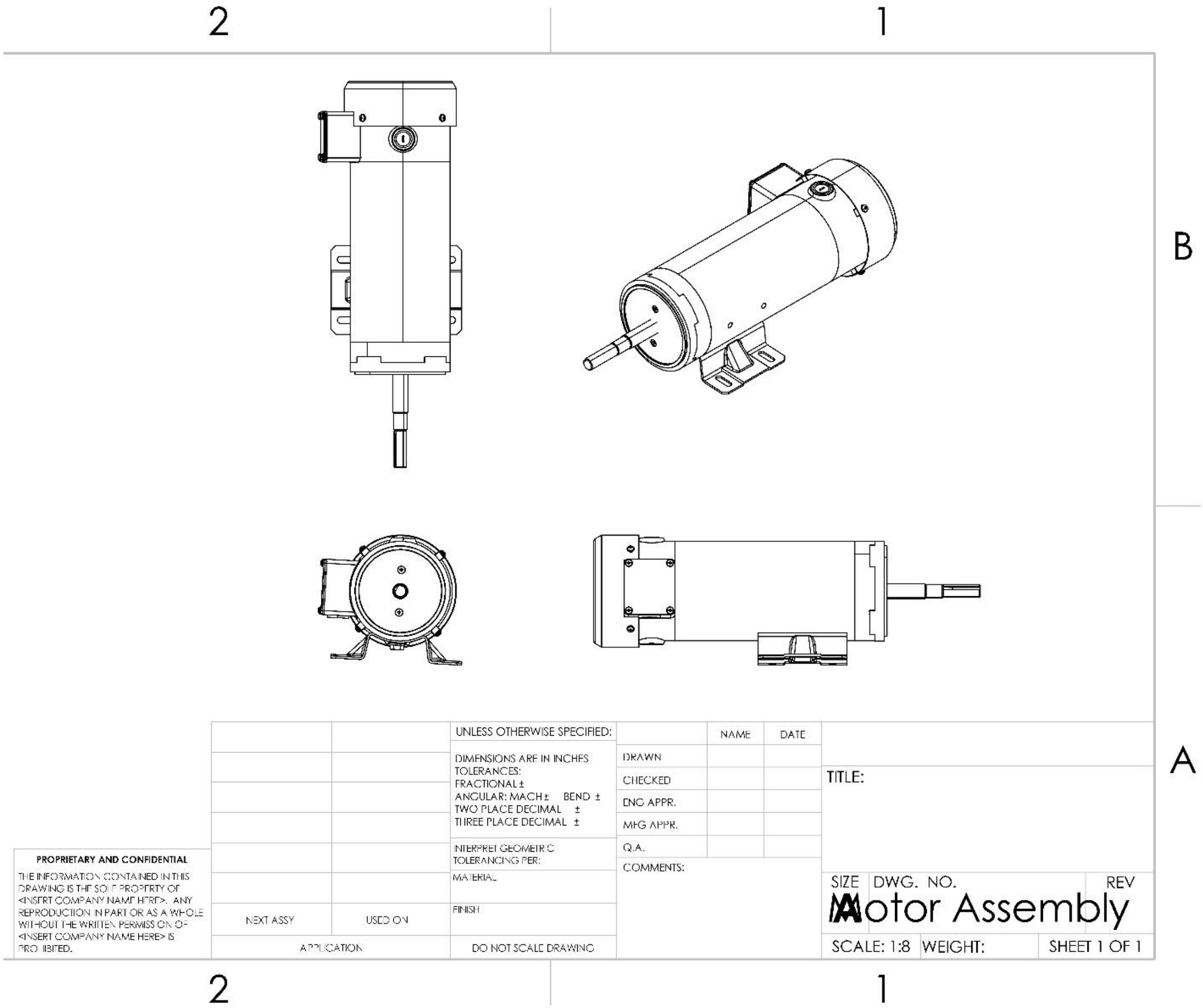
Appendix:



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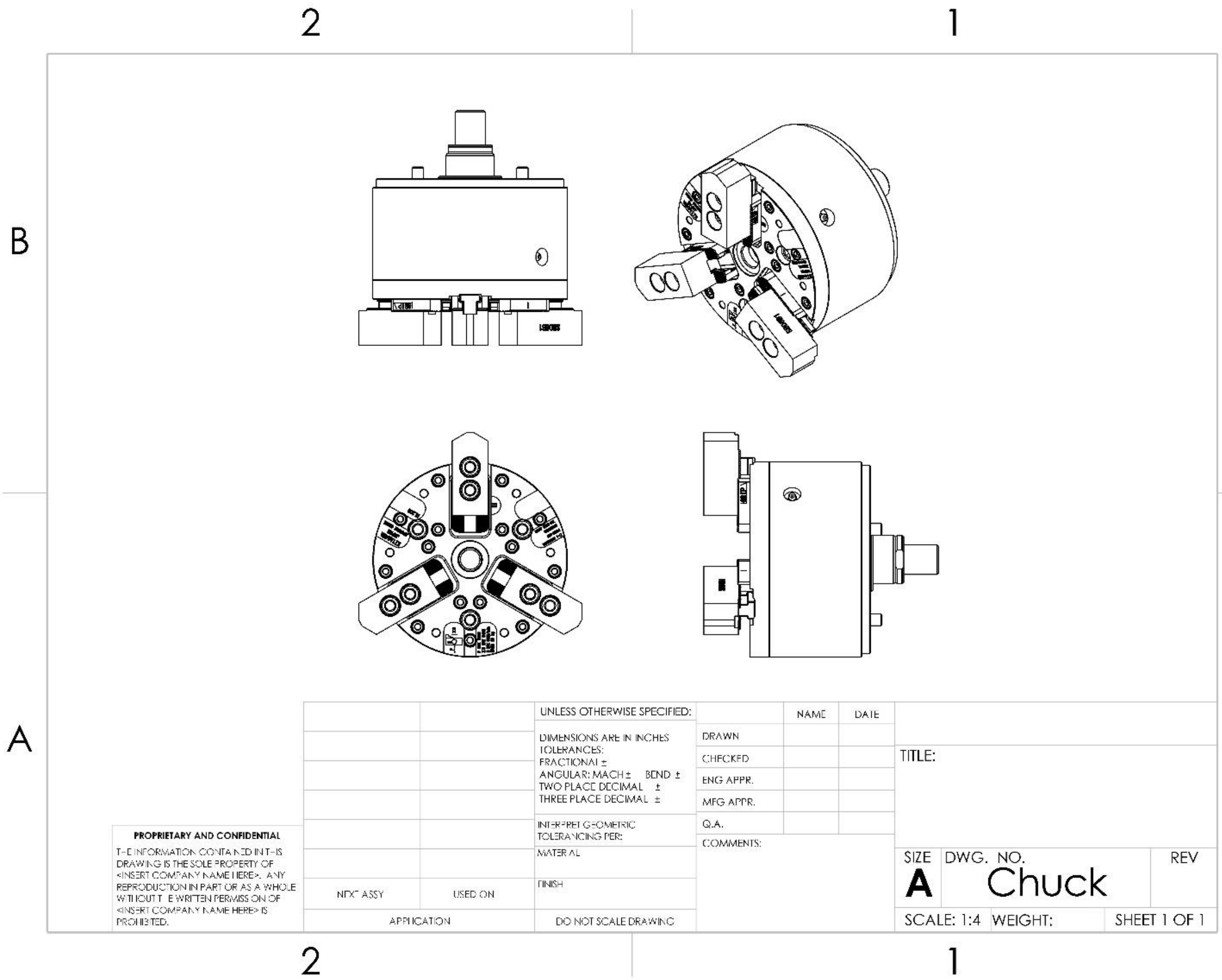
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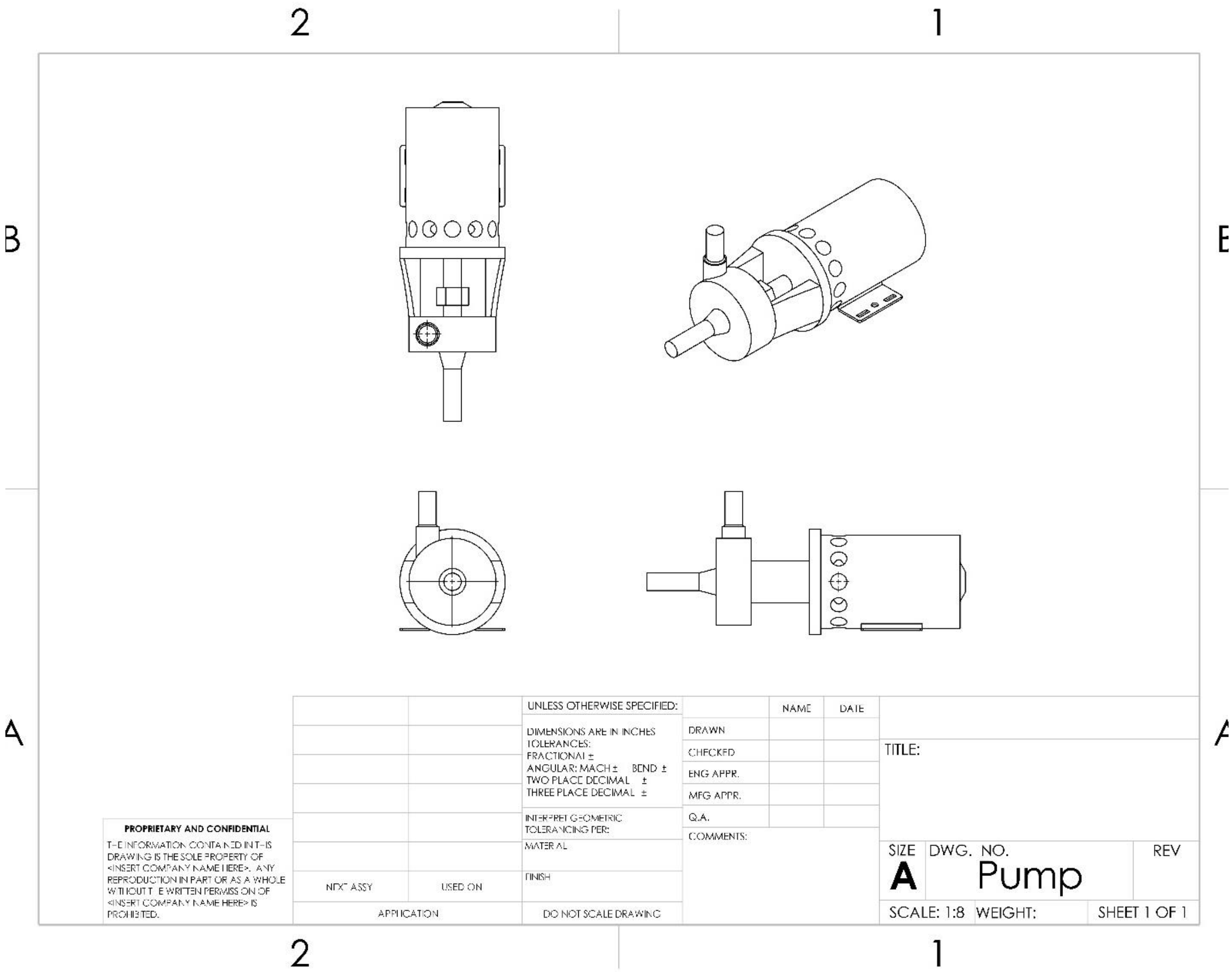

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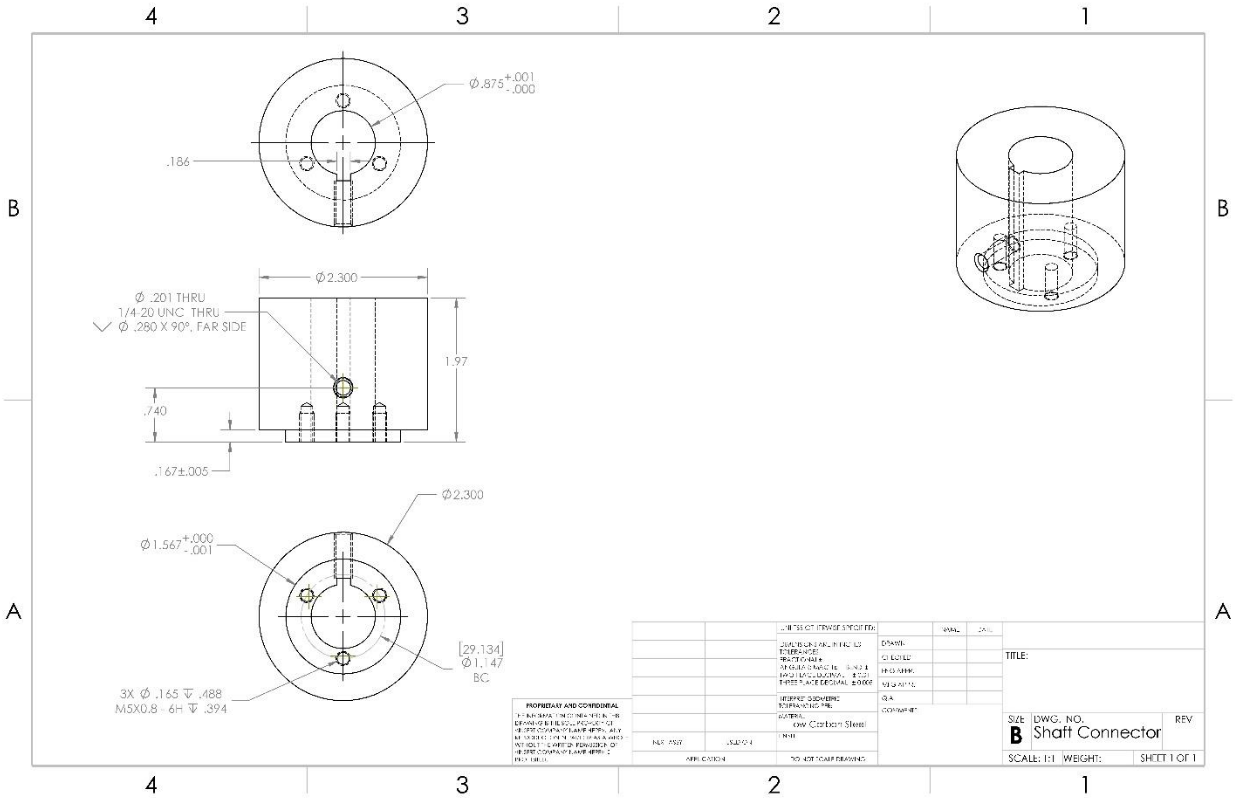
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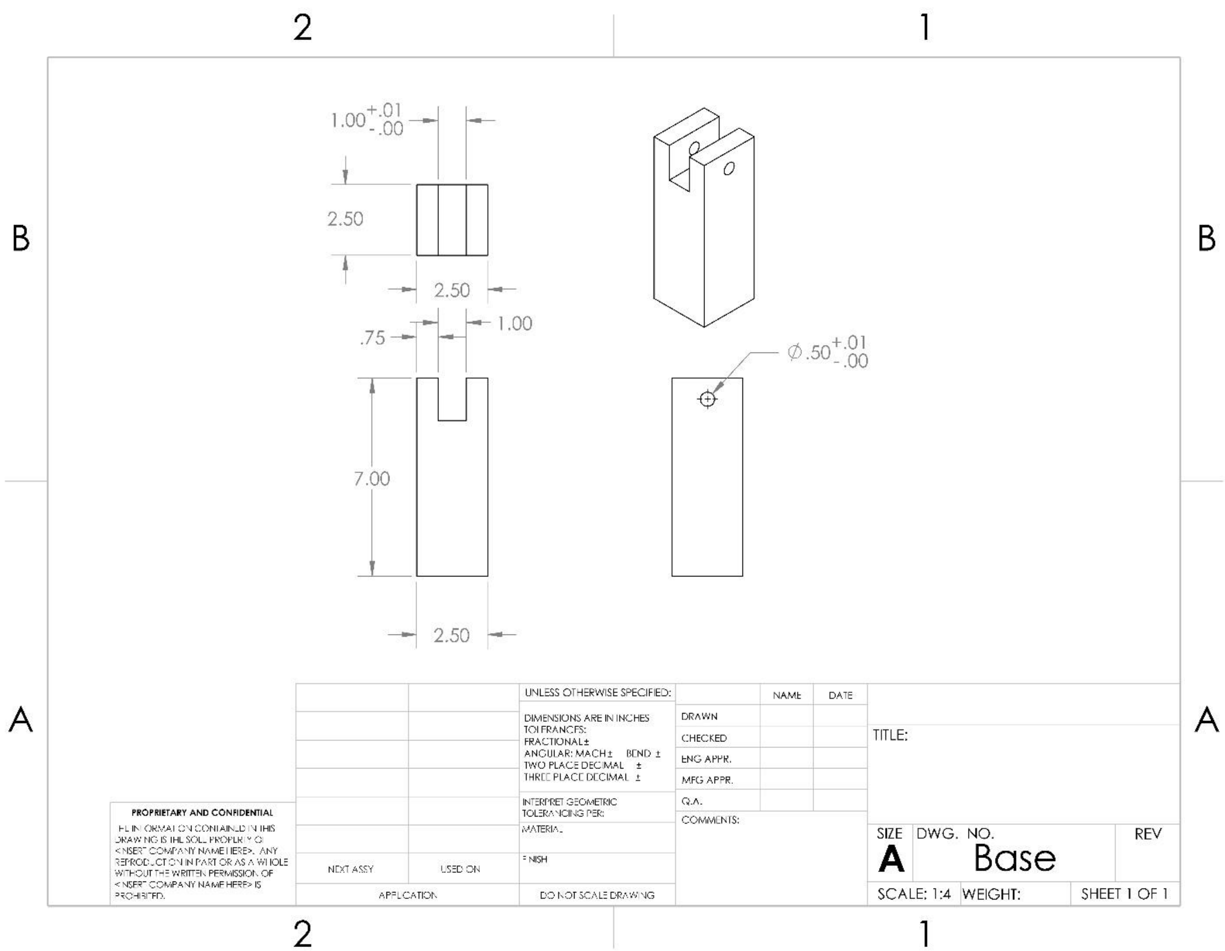

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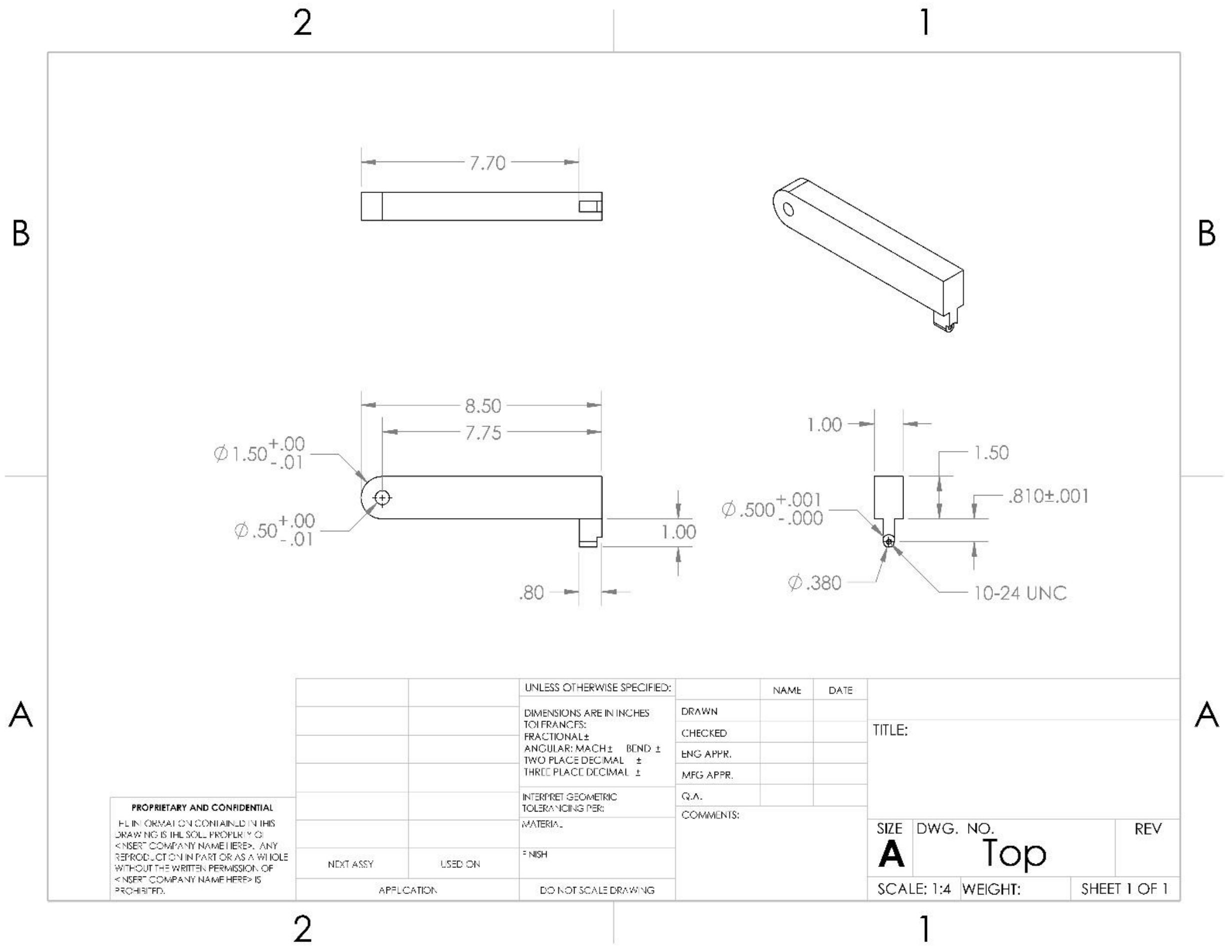

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SAFETY DATA SHEET

1. Identification

Product identifier	**NOVAMET 875**
Other means of identification	
Article-No.	40870330
Recommended use	Water-miscible metal working fluid. Industrial use.
Recommended restrictions	None known.
Manufacturer/Supplier	Oemeta, Inc. 2339 South Decker Lake Blvd West Valley City, UT 84119 Phone: (+1) 801 953-0381 Fax: (+1) 801 953-0446
Further information obtainable from	Oemeta Service Phone: (+49) 4122-924-132 Fax: (+49) 4122-924-157
Emergency Telephone Number	Toll Free Access within USA, Canada, Mexico: 1.866.519.4752 (24h) Outside of the US please call: (+1) 760 476 3962 (24h) Please provide the following code: 333910

2. Hazard(s) identification

Physical hazards	Not classified.
Health hazards	Not classified.
OSHA defined hazards	Not classified.
Label elements	
Hazard symbol	None.
Signal word	None.
Hazard statement	The mixture does not meet the criteria for classification.
Precautionary statement	
Prevention	Observe good industrial hygiene practices.
Response	Wash hands after handling.
Storage	Store away from incompatible materials.
Disposal	Dispose of waste and residues in accordance with local authority requirements.
Hazard(s) not otherwise classified (HNOC)	None known.
Supplemental information	None.

3. Composition/information on ingredients

Mixtures

Chemical name	Common name and synonyms	CAS number	%
Distillates, petroleum, hydrotreated light naphthenic		64742-53-6	50 - < 60
Alcohols, C16-18 and C18-unsatd., ethoxylated		68920-66-1	1 - < 5
Boric acid		10043-35-3	1 - < 3
Ethanol, 2-(2-butoxyethoxy)-		112-34-5	1 - < 5
Ethanol, 2,2'-(methylimino)bis-		105-59-9	1 - < 5
Other components below reportable levels			30 - < 40

4. First-aid measures

Inhalation Move to fresh air. Call a physician if symptoms develop or persist.

Skin contact Wash off with soap and water. Get medical attention if irritation develops and persists.

Eye contact Rinse with water. Get medical attention if irritation develops and persists.

Ingestion Rinse mouth. Get medical attention if symptoms occur.

Most important symptoms/effects, acute and delayed Direct contact with eyes may cause temporary irritation.

Indication of immediate medical attention and special treatment needed Treat symptomatically.

General information Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media Water fog. Foam. Dry chemical powder. Carbon dioxide (CO_2).

Unsuitable extinguishing media Do not use water jet as an extinguisher, as this will spread the fire.

Specific hazards arising from the chemical During fire, gases hazardous to health may be formed.

Hazardous combustion products Combustion products may include the following: Carbon oxides (CO, CO_2); nitrogen oxides (NO, NO_2).

Special protective equipment and precautions for firefighters Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

Fire-fighting equipment/instructions Move containers from fire area if you can do so without risk.

Specific methods Use standard firefighting procedures and consider the hazards of other involved materials.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures Keep unnecessary personnel away. For personal protection, see section 8 of the SDS.

Methods and materials for containment and cleaning up This product is miscible in water.

Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water.

Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination.

Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.

Environmental precautions Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling	Avoid prolonged exposure. Observe good industrial hygiene practices.
Conditions for safe storage, including any incompatibilities	Store in original tightly closed container. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Occupational exposure limits

The following constituents are the only constituents of the product which have a PEL, TLV or other recommended exposure limit. At this time, the other constituents have no known exposure limits.

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value	Form
Distillates, petroleum, hydrotreated light naphthenic (CAS 64742-53-6)	PEL	5 mg/m3	Mist.

US. ACGIH Threshold Limit Values

Components	Type	Value	Form
Boric acid (CAS 10043-35-3)	STEL	6 mg/m3	Inhalable fraction.
	TWA	2 mg/m3	Inhalable fraction.
Distillates, petroleum, hydrotreated light naphthenic (CAS 64742-53-6)	TWA	5 mg/m3	Inhalable fraction.
Ethanol, 2-(2-butoxyethoxy)- (CAS 112-34-5)	TWA	10 ppm	Inhalable fraction and vapor.

US. NIOSH: Pocket Guide to Chemical Hazards

Components	Type	Value	Form
Distillates, petroleum, hydrotreated light naphthenic (CAS 64742-53-6)	STEL	10 mg/m3	Mist.
	TWA	5 mg/m3	Mist.

Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Individual protection measures, such as personal protective equipment

Eye/face protection	Wear safety glasses with side shields (or goggles).
Skin protection	
Hand protection	Wear appropriate chemical resistant gloves. Recommendation: 706 Lapren (KCL, Germany) with a layer thickness of at least 0.6 mm. The selection of the suitable gloves does not only depend on the material, but also on further marks of quality and varies from manufacturer to manufacturer. As the product is a preparation of several substances, the resistance of the glove material can not be calculated in advance and has therefore to be checked prior to the application.
Other	Wear suitable protective clothing.
Respiratory protection	In case of insufficient ventilation, wear suitable respiratory equipment.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Physical state	Liquid.
Color	Yellow.
Odor	Characteristic.
Odor threshold	Not available.
pH	9.5 ASTM D 1287
Melting point/freezing point	Not available.
Initial boiling point and boiling range	Not available.
Flash point	Not available.
Evaporation rate	Not available.
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	Not available.
Solubility (water)	Completely miscible.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.
Other information	
Density	960.00 kg/m³ ASTM D 1298
Explosive properties	Not explosive.
Kinematic viscosity	40 mm²/s ASTM D 445 (104 °F (40 °C))
Oxidizing properties	Not oxidizing.

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	No hazardous decomposition products are known.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.

11. Toxicological information

Information on likely routes of exposure

Inhalation	Prolonged inhalation may be harmful.
Skin contact	Based on available data, the classification criteria are not met.

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Eye contact	Based on available data, the classification criteria are not met.
Ingestion	Based on available data, the classification criteria are not met.
Symptoms related to the physical, chemical and toxicological characteristics	Direct contact with eyes may cause temporary irritation.

Information on toxicological effects

Acute toxicity

Components	Species	Test Results
Alcohols, C16-18 and C18-unsatd., ethoxylated (CAS 68920-66-1)		
__Acute__		
Dermal		
Liquid		
LD50	Rabbit	> 2000 mg/kg
Oral		
Liquid		
LD50	Rat	> 2000 mg/kg
Boric acid (CAS 10043-35-3)		
__Acute__		
Dermal		
Solid		
LD50	Rabbit	> 2000 mg/kg
Oral		
Solid		
LD50	Rat	> 2600 mg/kg
Distillates, petroleum, hydrotreated light naphthenic (CAS 64742-53-6)		
__Acute__		
Dermal		
Liquid		
LD50	Rabbit	> 5000 mg/kg
Inhalation		
Mist		
LC50	Rat	> 5.53 mg/l, 4 hours Saturated Vapor Concentration
Oral		
Liquid		
LD50	Rat	> 5000 mg/kg
Ethanol, 2-(2-butoxyethoxy)- (CAS 112-34-5)		
__Acute__		
Dermal		
Liquid		
LD50	Rabbit	2764 mg/kg
Oral		
Liquid		
LD50	Mouse	2410 mg/kg
	Rat	3305 - 3384 mg/kg

Components	Species	Test Results
Ethanol, 2,2'-(methylimino)bis- (CAS 105-59-9)		
Acute		
Dermal		
Liquid		
LD50	Rabbit	5990 mg/kg
Oral		
Liquid		
LD50	Rat	4680 mg/kg

* Estimates for product may be based on additional component data not shown.

Skin corrosion/irritation Prolonged skin contact may cause temporary irritation.

Serious eye damage/eye irritation Direct contact with eyes may cause temporary irritation.

Respiratory or skin sensitization

Respiratory sensitization Not a respiratory sensitizer.

Skin sensitization This product is not expected to cause skin sensitization.

Germ cell mutagenicity No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.

Carcinogenicity Not classifiable as to carcinogenicity to humans.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not regulated.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity Not classified. Animal ingestion studies in several species, at high doses, indicate that boric acid can cause reproductive and developmental effects. This product is not considered to pose a reproduction/developmental risk to humans. For further information, please refer to section 15.

Specific target organ toxicity - single exposure Not classified.

Specific target organ toxicity - repeated exposure Not classified.

Aspiration hazard Not an aspiration hazard.

Chronic effects Prolonged inhalation may be harmful.

12. Ecological information

Ecotoxicity Not available.

13. Disposal considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site.

Local disposal regulations Dispose in accordance with all applicable regulations.

Hazardous waste code The waste code should be assigned in discussion between the user, the producer and the waste disposal company.

Waste from residues / unused products Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).

Contaminated packaging Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code Not established.

15. Regulatory information

US federal regulations This product is not known to be a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories

Immediate Hazard - No
Delayed Hazard - No
Fire Hazard - No
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical No

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

Food and Drug Administration (FDA) Not regulated.

US state regulations California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

US. California. Candidate Chemicals List. Safer Consumer Products Regulations (Cal. Code Regs, tit. 22, 69502.3, subd. (a))

Boric acid (CAS 10043-35-3)
Distillates, petroleum, hydrotreated light naphthenic (CAS 64742-53-6)

US. California Proposition 65

Not Listed.

Further information

Weight of evidence: In the European Union, boric acid containing products are not classified as toxic for reproduction if the content of boric acid is below 5.5% (Regulation (CE) 1272/2008 and adaptations to technical progress).

16. Other information, including date of preparation or last revision

Issue date

08-03-2017

Revision date

08-03-2017

Version #

1.0

HMIS® ratings

Health: 0
Flammability: 1
Physical hazard: 0

NFPA ratings

Health: 0
Flammability: 1
Instability: 0

NFPA ratings

Ratings of aqueous dilution

HMIS® ratings when diluted to 20% or less: Health: 0, Flammability: 0, Physical Hazard: 0.
NFPA ratings when diluted to 20% or less: Health: 0, Flammability: 0, Instability: 0.

Disclaimer

The information in the sheet was written based on the best knowledge and experience currently available. The editor cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use.

Approved.

TR03082017