

Current Metalworking Fluid Issues

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Manager of Cimcool® Research & Development



1884: Cincinnati Screw and Tap Company

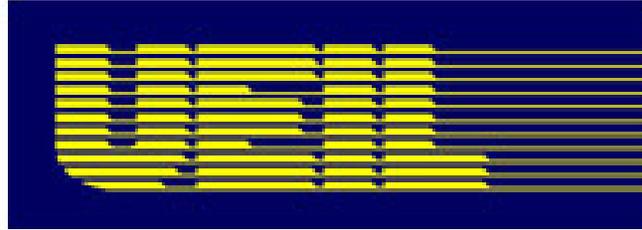


Corner of Pearl & Plum Streets in Cincinnati, Ohio, USA

CIMCOOL® History

- Known as Cincinnati Milling Machine Company.
- Prior to WW2 metal was machined with either straight oils or “soluble oils”.
- 1938 – Cincinnati began research into improving the metal removal process
- The Cimcool Division was formed in 1944
- On May 5, 1945 shipped the first 5-gallon pail of **Cimcool®** metal cutting fluid – the first semi-synthetic (low oil) fluid on the market.
- Currently over 40 US Patents
- Products for all industrial applications





4th Symposium on Metal Removal Fluids – Global Challenges

Barcelona, Spain

14-16 September 2011

ilma



STLE



Stands for

**Independent Union of the
European Lubricants Industry**

Similar to ILMA in the USA

4th Symposium, 2011

- Held in Europe for the first time.
- Key symposium for the Global Industrial Metalworking Fluid Industry.
- Attendance was low (185) compared to US.
- Provided an opportunity for participants to gain a unique understanding of the current critical challenges that face the industry.
- Three topic sessions:
Innovation – Application – Regulation

2011 UEIL Symposium News

Kline & Company Market Analysis for Global MWF Use:

- Global consumption of MWF was 2.2 million tons in 2010
- Asia had largest usage at 41%, Europe 27%, N. America 28%
- Removal fluids were 49% of volume, forming was 31%, metal protecting fluids were 11%
- In N. America 88% of usage is water-based
- In Europe there was a significant shift towards water based MWFs (**61%**). This is a reversal from previous years when straight oils dominated!
- Asia uses **65%** water-based
- MWF demand (2007-2010) in Asia grew (3.3% annual rate), but declined in Europe (-1.8%) & N. America (-7.8%)
- Global MWF consumption is projected to grow thru 2015
(5% in Asia, 2% in N. America & 1% in Europe)

Future of Metalworking Fluids, 10 years Ahead

Presented by John Burke of Houghton Intl.

Seven Major Factors Influencing Change:

1. Operation of factory of the future – zero discharge
2. Organized Labor:
 - Oil mist to $0.5\text{mg}/\text{M}^3$
 - More detailed MSDS
3. Targeted chemicals: Borates, Cl-paraf., Formaldehyde, Silicone, NPEO, Petroleum Oil
4. Government Regs: VOC limits, Biocide Usage
5. End-User Restrictions
6. Formulator Restrictions
7. Public Pressure for Change

Future of Metalworking Fluids, 10 years Ahead

Presented by John Burke of Houghton Intl.

Predicted Trends:

- Chemical management by outside services/competitors
- Less MWF consumption per part. Market not growing.
- Smaller fluid sumps & fewer central systems
- Light weight materials: Al, Mg, polymer composites
- Dense, hard to machine materials: compacted graphite iron
- Water will be re-used
- Petroleum oil based products will continue to dominate because oil can be re-refined/recycled/reused
- Compatible chemistries: coolant, cleaners, machine lubes
- Minimum Quantity Lubrication (MQL) gaining but not dominant.

Southern California Air Quality Management District (SCAQMD)

- Los Angeles has problems with air quality
- VOC are known contributors to photochemical smog.
- VOC = Volatile Organic Compounds
- Decided to control VOC in metalworking fluids (?)

Los Angeles, California



New Southern California VOC Limits

- Rule #1144 – New Limits
 - Metal Removal Fluids: 75g/l
 - Precision Metal Removal: 130g/l
(Carbide grinding & certain Al & Mg operations)
 - Metal Forming Fluids: 75g/l
 - Metal Treating: 75g/l
 - Metal Protecting: 50g/l
 - Direct Contact Lubricants: 50g/l
- Applies to as-used dilutions, not concentrates
- New method for determining VOC content

Volatile Organic Compounds (VOC)

- Previously EPA Method 24 was used to determine VOC content.
- Designed for paints & coatings. Not accurate enough.
- Heat 3 ml sample at 110°C for 60 minutes and measure weight change.)
- New **TGA** method (**Thermo-Gravimetric Analysis**), which has now become an ASTM procedure, ASTM E1868-10.
- New conditions: 81°C for 110 minutes, 10 mg sample, N₂ gas flow
- The new TGA method is more accurate & reproducible
- Values are generally lower than those from Method 24.

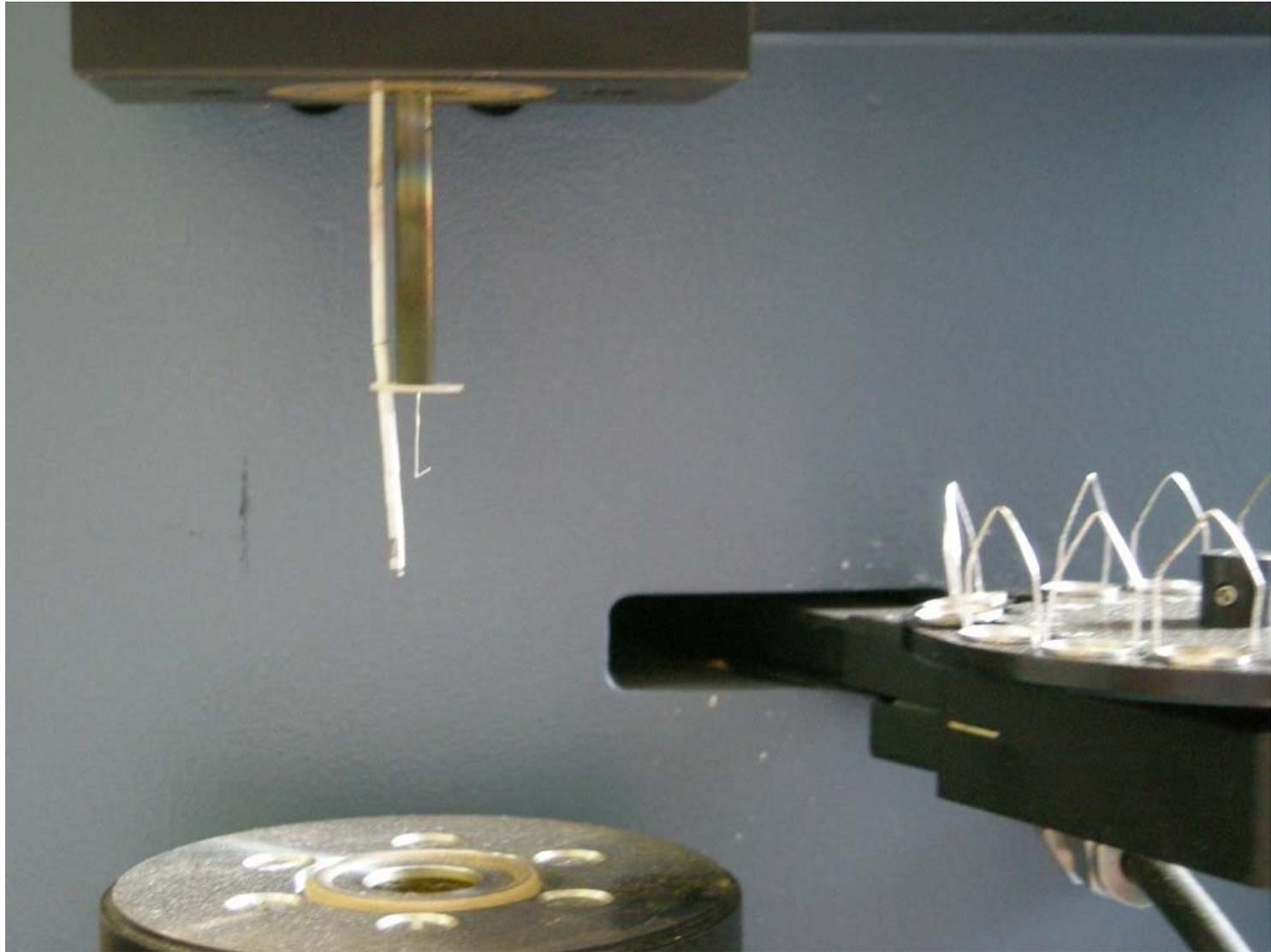
VOC Test Method



Automated TGA Unit

TGA Instrument – Weighing Pan

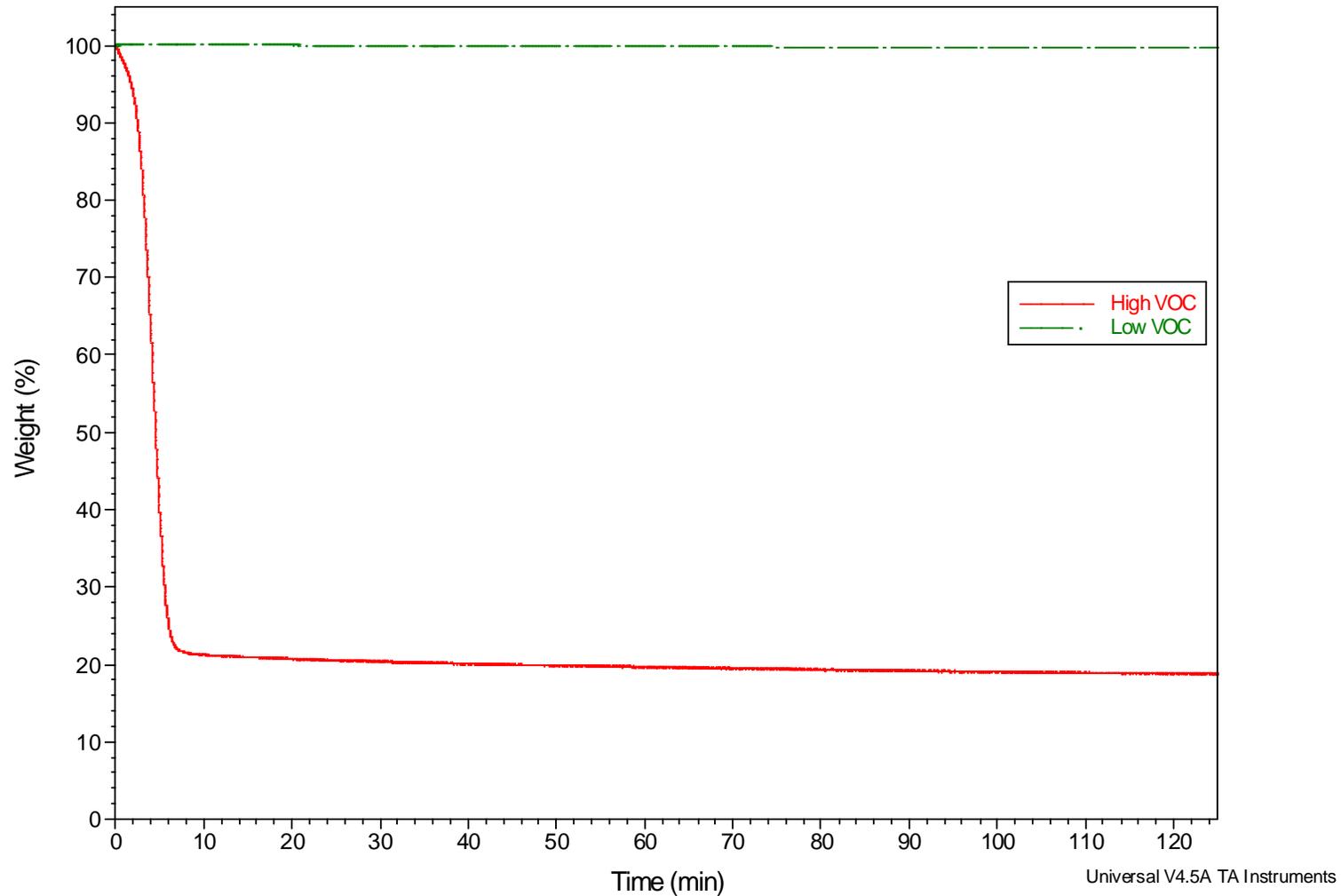




Sample TGA Curves

High VOC - Solvent cut-back Rust Preventative

Low VOC - ISO 22 Hydraulic Oil



VOC – Enforcement

- VOC content must appear on label, effective Jan 1, 2012
- For each calendar year (Jan 1 through Dec 31) beginning with 2011 and continuing until 2013, a metalworking fluid or direct-contact lubricant manufacturer or supplier shall submit by April 1 of the following year, an annual quantity and emissions report for products subject to the rule sold within the District.
- SCAQMD will start large MWF end user inspections in February with the intent of verifying VOC's are within a range of the value shown on the label.
- The real enforcement will begin in July when the sell-through provision is over.
- Fines expected to be a major source of revenue for SCAQMD! (\$10,000/day)

VOC – Regulations

- Other states (MI, PA) have shown interest in Rule 1144.
- Concern that each state may set different limits
- Labels would need to be several feet long!

Formaldehyde Condensate Biocides

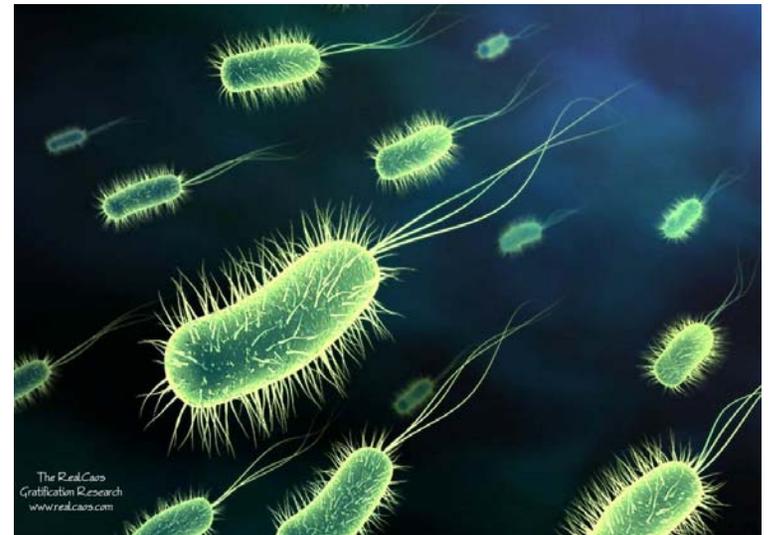
- **Triazine is one of the lowest cost, yet most effective microbial control agents.**
- **Triazine-free products are more expensive**



Illustration: Don Smith

Formaldehyde Condensate Biocides

- **What are they?**
 - Reaction products of formaldehyde (HCHO) + one or more other organic molecules (ex: “Grotan”)
 - Very effective at killing bacteria
 - Many have secondary benefits as neutralizing amines, boost pH, rust inhibition, destroy endotoxins
 - Toxicity profile for triazine is very different from that of formaldehyde!

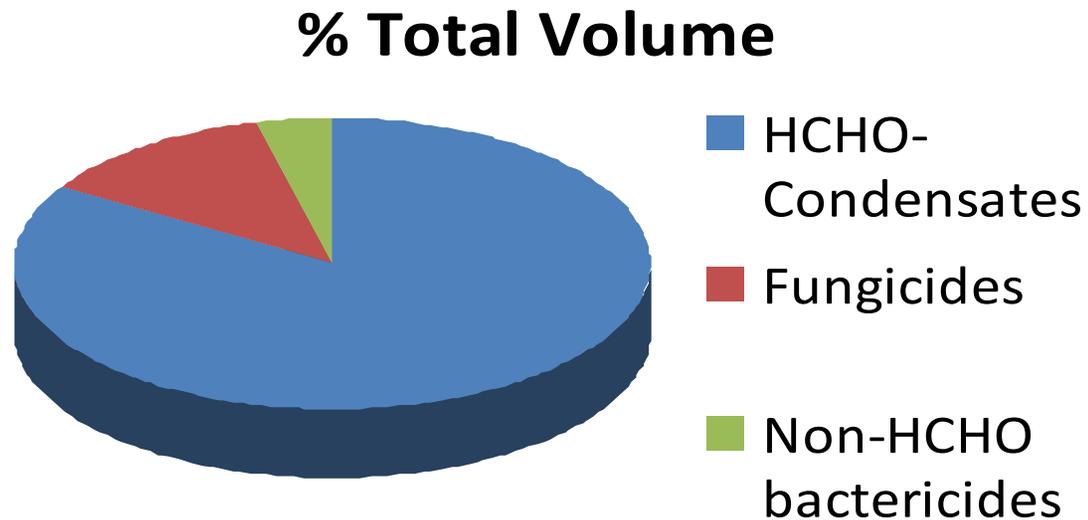


Formaldehyde Condensate Biocides

- **Some Information about Formaldehyde:**
 - Formaldehyde is a naturally-occurring chemical
 - Our own bodies make it!
 - Humans exhale about 5 ppb formaldehyde in our breath!
 - Also present in our blood and urine
 - Normal blood levels bathe every bodily tissue

Formaldehyde Condensate Biocides

- Represent > 80% by volume of MWF microbicide use in the U.S.



Formaldehyde Condensate Biocides

- **Recent US EPA action**

- In April 2010, EPA notified Triazine producers that they must change product labels to state that the maximum permissible dose in MWF was to be 500 ppm instead of 1500 ppm!
- Decision was based on new concerns about formaldehyde being a human carcinogen.
 - NTP has recently recommended that HCHO be listed as *“known to be a human carcinogen”*.

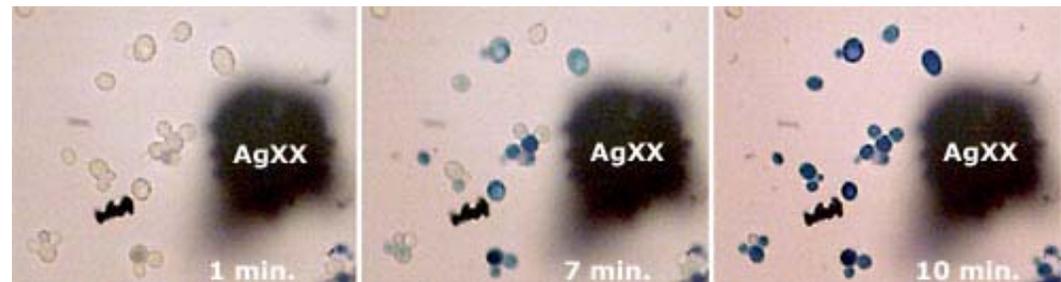
- However, EPA has since decided to review this decision and are currently not enforcing it.
- The US EPA is targeting Triazine first, but they have already indicated that they plan to similarly limit the maximum permissible dose of the other HCHO condensates, too.

Formaldehyde Condensate Biocides

- **Impact of EPA's action – What to expect:**
 - 500 ppm Triazine is not an effective level
 - Microbial control will be more expensive
 - MWF bio-deterioration problems will increase
 - Endotoxin levels will increase, leading to possible respiratory issues
- Formaldehyde donor chemistries also being evaluated in Europe under the Biocidal Products Directive (BPD) and REACH
- Biocide-free products – Are they safer?

Alternative to Biocide Use Proposed

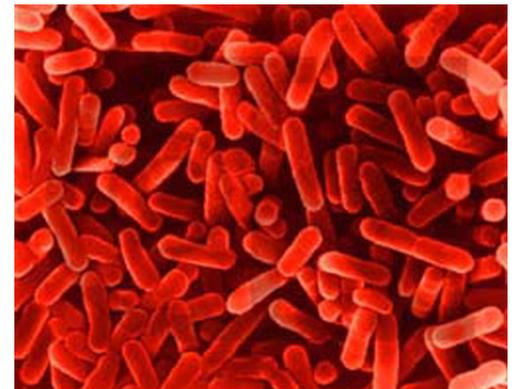
- Largentec Vertriebs GMBH presented a talk on **AgXX[®]** - a new bioactive contact catalyst to decontaminate water-based fluids.
- Sterilizing action of silver effective against more than 650 different species of bacteria, fungus, and viruses.
- Improved performance over conventional silver technology.



Shows effect against yeast cells with time.

“Electronic Nose”

- Developed by IWT in Bremen, Germany
- Microorganisms secrete gaseous substances
- New device gives results in 6 minutes
 - Compare to 48-72 hours for typical agar methods
- Real-time, on-line monitoring
- No “per-sample” material costs
- Expected to increase sump-life
- Improve machining process stability
- Unit not yet commercial



Boron & Boric Acid

- Used for Fe corrosion inhibitor, pH buffering, microbial resistance
- No regulatory issues in the US or Canada currently
- Very few US customers request boron-free MWF
- Boron is on Japan's PRTR list.
- In Europe, boric acid and borax are considered reproductive toxins
 - Only fluids containing >5.5% free boric acid must carry the "Danger" label.
 - Some people believe the trend is to be boron-free

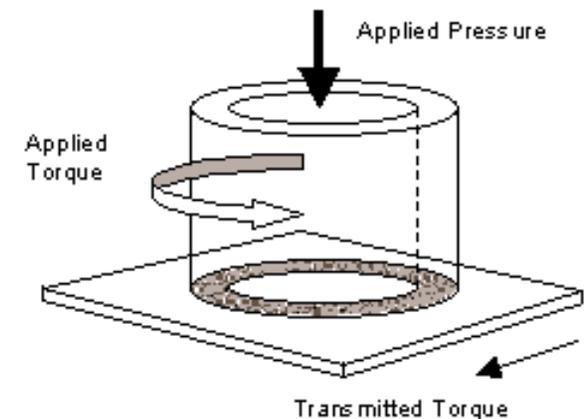


Chlorinated Lubricants

- Situation in Canada:
 - Medium chain CP recently declared “CEPA Toxic”
 - Only Long chain (C₁₈-C₃₈) are considered “not toxic” to human health.
 - No date set for banning the Medium chains
- Possible US EPA regulation could go as far as banning production of Short chain chlorinated paraffins (10 to 13 carbons with 3-12 chlorines)
- Medium chain not affected (14-17 carbon chain)

Twist Compression Test

- Ted McClure of **TRIBSYS** spoke about the Twist Compression Test (TCT)
- Cylinder under pressure turns against metal strip
- Creates a lubricant starved condition common to many metalworking operations.
- Extreme pressure lubricants are activated under severe conditions. TCT detects lubricant film breakdown.
- Friction Forces and Time to Breakdown monitored
- Could become an ASTM test method later this year.



Aerospace Fluid Testing

- Prof. Dragos Axinte of Rolls Royce presented machining tests used to evaluate all fluids on aerospace alloys:
 - “VIPER” grinding (“Very Impressive Performance Extreme Removal”)
 - Milling
 - Drilling
 - Tapping
 - Turning



Aerospace Fluid Testing

- Brian Hovik with **Boeing** presented “Application of Lubricants, BAC 5008” - testing they follow for MWF.
- Supplier pays for IWIG machining test to be run at independent lab.
- BAC 5008 testing by Boeing or qualified 3rd party lab could cost \$100,000 and take 12 months to complete.
- BAC 5008 Standard Tests are:
 - 12.1 Weight Change Corrosion
 - 12.2 Stress Corrosion
 - 12.3 Metal Sandwich Corrosion
 - 12.4 Galvanic Corrosion
 - 12.5 Titanium Compatibility
 - 12.6 Sealant Compatibility
 - 12.7 Paint Compatibility
 - 12.8 Micro-Structure Effects

USDA BioPreferred Program

- US Department of Agriculture = USDA
- New USDA program to promote increased use of bio-based products.
- Products derived from biobased, renewable, sustainable and low environmental impact resources (animal, vegetable or marine based)
- Carbon-14 dating methods used to discriminate between product carbon resulting from modern carbon input and that derived from fossil-based input.



USDA BioPreferred Program

- To carry to BioPreferred label, the product must have a certain minimum bio content
- The minimum required varies by product category.
 - MWF, High performance $\geq 40\%$
 - MWF, General Purpose $\geq 57\%$
 - MWF Straight Oil $\geq 66\%$



Positive and Negative Features of Green Chemistry

Positives

- Lower VOC
- Higher flash & fire points
- Greater viscosity stability
- Excellent lubricity
- Renewability feature
- Neat oil applications
- Can succeed with a lot of attention paid to the system

Negatives

- Cost compared to mineral oil
- More vulnerable to microbial contamination
 - Rancidity
 - Bad odors
- Stability problems
 - Hydrolysis
 - Oxidation
 - Bio-deterioration
- Problems with recycling
- Interfere with food chain production



MWF Based on Vegetable Oils for Grinding Operations

Dr. Amaya Igartua of Tekniker (Spain)

- Compared five emulsion fluids on various tests, including tapping torque and cylindrical center-type grinding
 - 1 mineral oil emulsion
 - 1 synthetic emulsion (?)
 - 3 emulsions based on high oleic sunflower oil

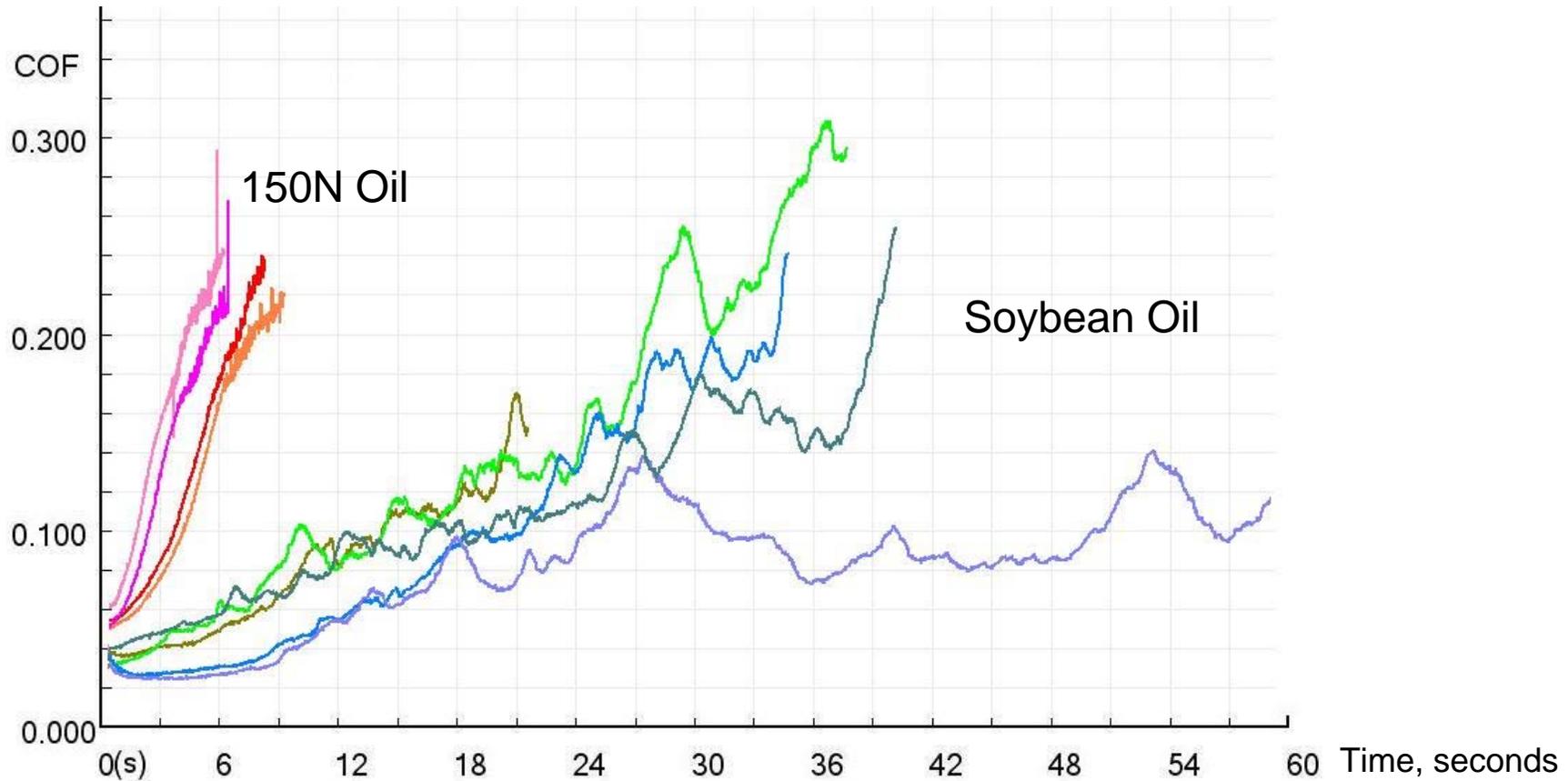


MWF Based on Vegetable Oils for Grinding Operations

Dr. Amaya Igartua of Tekniker (Spain)

- On ASTM D5619 Tapping-Torque test (1215 steel), percent tapping efficiency was best for the vegetable based fluids than for mineral oil: 104, 106 & 108% vs 100%
- Grinding test results varied depending on the steel (two types tested)
 - The veg oil fluids had lower coefficient of friction than the mineral oil fluid.
 - The surface finish was better with the vegetable oil fluids.
 - Wheel life was better with vegetable oils than with mineral oil. However, the synthetic emulsion was best.

Twist Compression Test Comparing Mineral & Vegetable Oils



- Soy clearly a better lubricant than 150N mineral oil
- Major torque fluctuations

**How can I get the best performance
from my metalworking fluid?**



Rule #1 – Start with a good clean-out!

- Use a good machine cleaner
- Remove all the old fluid
- Remove all the old metal chips
- Remove biofilms from surfaces

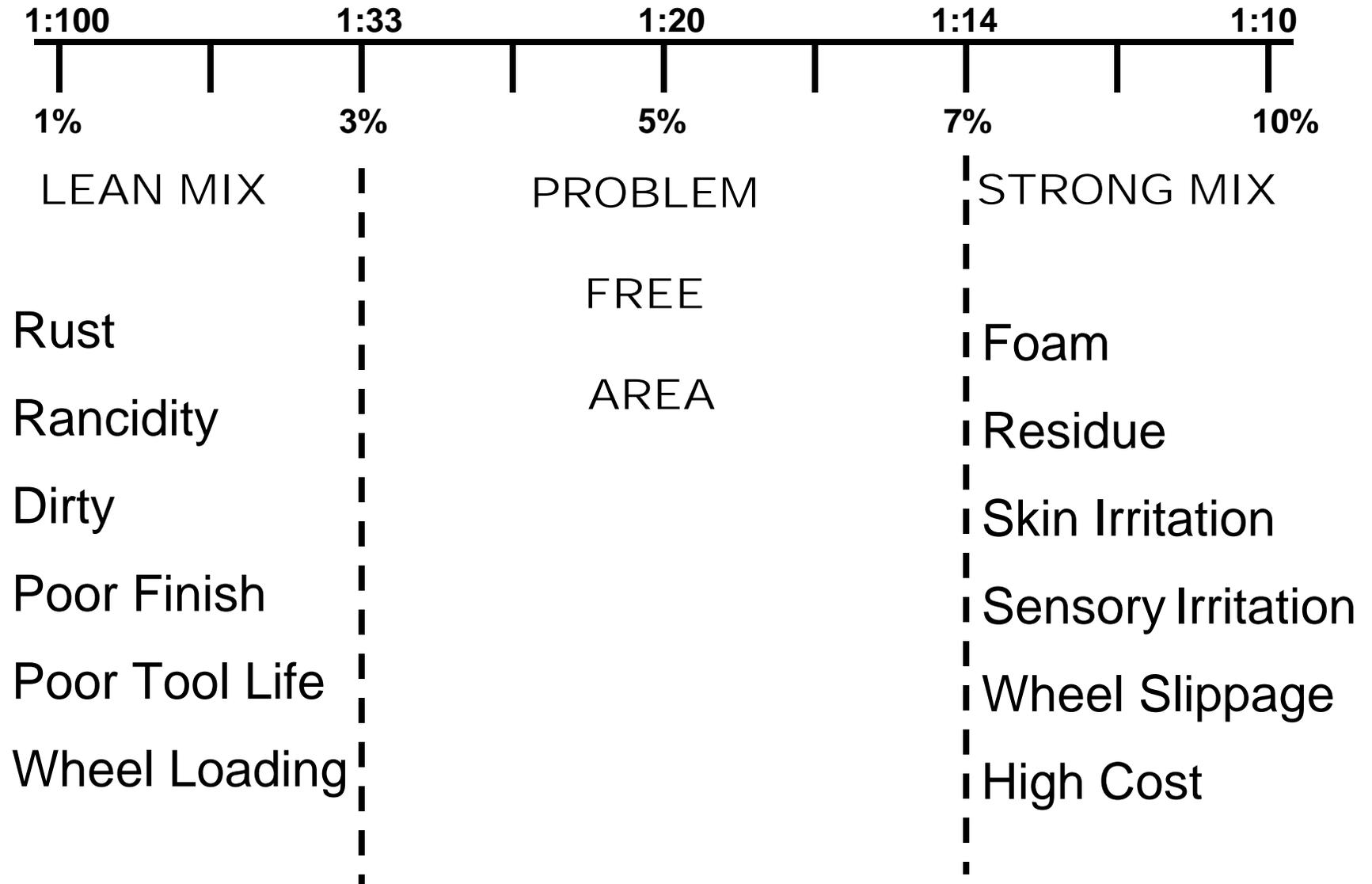


Rule #2 - Use Good Quality Water!

- Water make up ~95% of the fluid volume.
- Water quality affects:
 - Lubricity
 - Residue
 - Corrosion/Rust Control
 - Foam
 - Bacteria / Mold
 - Concentrate Usage
 - Cleanliness
 - pH

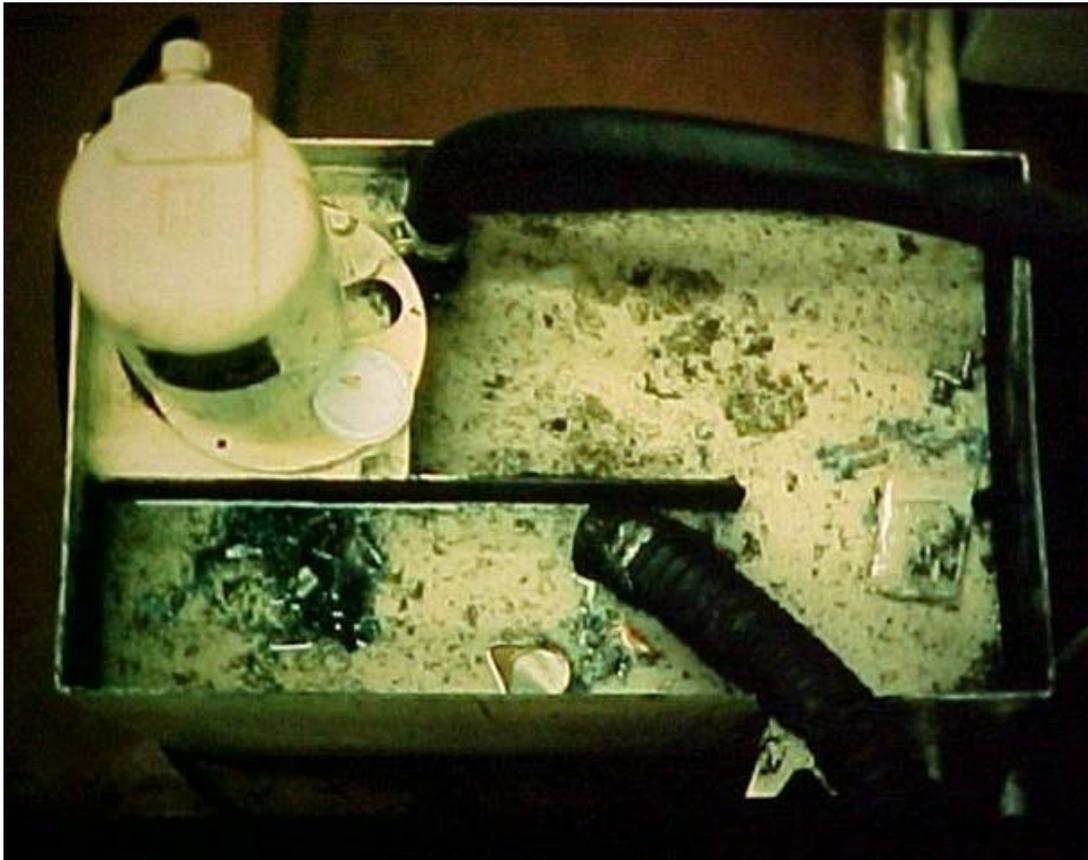


Rule #3 - CONCENTRATION CONTROL



Rule #4 - Keep it Clean!

Avoid contaminants



Thank you for your attention!

