

CLEANING LABORATORY EVALUATION SUMMARY

SCL #: 2001
 DateRun: 06/20/2001
 Experimenters: Jason Marshall
 ClientType: Metal
 ProjectNumber: Project #1
 Substrates: Aluminum, Carbon Steel, Stainless Steel, Steel
 PartType: Coupon
 Contaminants: Cutting/Tapping Fluids, Lubricating/Lapping Oils, Dirt, Fingerprints, Oil
 Cleaning Methods:
 Analytical Methods:
 Purpose: SUMMARY OF FINDINGS
 Experimental Procedure: Four cleaning products were found to be very successful in removing the various metal working fluids used at Ruland Manufacturing. The products and manufacturers are listed in Table 1.

Table 1. Successful Cleaning Products

| Manufacturer | Product |
|-----------------|-----------------|
| Envirosolutions | Green Stuff |
| Oakite Products | Inproclean 3800 |
| Today & Beyond | Beyond 2001 |
| WR Grace | Daraclean 283 |

Results: Ultrasonic energy increased the effectiveness of the four solutions resulting in quick cleaning times, under two minutes, and an average cleaning efficiency of 99.83%. Table 2 lists the results from the different contaminant removal trials.

Table 2. Summary of Cleaning Trials

| Contaminant | WA Wood C-Eblis Cutting Oil | WA Wood C-Eblis Cutting Oil | Chemtrol 331 | Spartan Chemical MOAC 2945 | Hubbard Hall Inc Metal Guard 270 | WA Wood #30 Lube Oil | Precision Finishing Chemtrol 229 | Milacron Cimperial 1070 | MOAC 2945, pH Boost, Anti Foam, CA-12 |
|------------------|-----------------------------|-----------------------------|--------------|----------------------------|----------------------------------|----------------------|----------------------------------|-------------------------|---------------------------------------|
| Equipment | Immersion | Ultrasonic | Ultrasonic | Ultrasonic | Ultrasonic | Ultrasonic | Ultrasonic | Ultrasonic | Ultrasonic |
| Inproclean 3800U | 80.92 | 98.72 | 100.05 | 99.98 | 99.91 | 99.07 | 99.68 | 100.01 | 100.10 |
| Daraclean 283U | 80.79 | 99.76 | 99.97 | 99.89 | 100.1 | 98.26 | 99.94 | 100.09 | 100.19 |
| Green StuffU | 75.67 | 100.9 | 100.08 | 100.08 | 99.92 | 99.79 | 99.40 | 100.10 | 100.04 |
| Beyond 2001U | 75.01 | 99.83 | 99.99 | 100.08 | 99.42 | 99.19 | 99.90 | 100.08 | 100.10 |
| Shopmaster | 65.35 | N/T | N/T | N/T | N/T | N/T | N/T | N/T | N/T |
| Formula 815 GD | 72.45 | N/T | N/T | N/T | N/T | N/T | N/T | N/T | N/T |
| Armakleen E 2001 | 73.22 | N/T | N/T | N/T | N/T | N/T | N/T | N/T | N/T |
| ND 17 | 74.03 | N/T | N/T | N/T | N/T | N/T | N/T | N/T | N/T |
| Water | N/T | 55.13 | N/T | N/T | N/T | N/T | N/T | N/T | N/T |

The C-Eblis oil was found to be the most difficult contaminant to remove from the steel coupons due mainly to its physical characteristics (i.e. viscosity, insoluble in water). Two other contaminants, Metal Guard 270 and #30 Lube Oil, were also not soluble in water. However these two oils had lower viscosity (based on visual analysis) than the C-Eblis oil and were easier to remove from the surface. Both of these fluids needed less than one minute of ultrasonic cleaning, whereas C-Eblis needed around 2 minutes. Based on the results of the cleaning trials, it would be recommended to clean parts coated in the C-Eblis oil using ultrasonic energy to ensure proper cleaning. As stated, all four cleaning products performed equally effective in removing the different contaminants.

From the trials conducted, Green Stuff had the highest cleaning efficiency five times and Daraclean 283 had the highest 3 times. Beyond 2001 had the second highest efficiency 4 times and Inproclean 3800 at

CLEANING LABORATORY EVALUATION SUMMARY

3 times. Overall, Green Stuff had the most overall successful cleaning trials. Table 3 lists the ranking of products.

Table 3. Ranking Of Cleaning Products

| Ranking | 1 | 2 | 3 | 4 | # Top 2 Cleaning |
|-----------------|---|---|---|---|------------------|
| Inproclean 3800 | 1 | 3 | 3 | 2 | 4 |
| Daraclean 283 | 3 | 2 | 2 | 2 | 5 |
| Green Stuff | 5 | 1 | 2 | 1 | 6 U |
| Beyond 2001 | 1 | 4 | 2 | 2 | 5 |

Parts Cleaning in Laboratory

The cleaning of the supplied parts yielded the same consistent cleaning by all four cleaning solutions. The Envirosolutions Green Stuff and Today & Beyond 2001 showed the most signs of cleaning taking place. This could be attributed to either better cleaning of the parts or simply, just dirtier parts.

Possible Process Modifications

According to the basic routings utilized at the facility, C-Eblis is cleaned in eleven different steps and on all three substrate types (Carbon Steel, Stainless Steel and Aluminum). After each use of C-Eblis, the parts are degreased. In the majority of the manufacturing process, the rings are made using the oil, cleaned and then worked on further with more C-Eblis. Would it be possible to eliminate the cleaning step after the initial formation of the ring and proceed directly to the countersink, milling, drilling and tapping steps?

There are six cleanings areas that are removing the water-soluble contaminants from the various substrates. Each of these fluids was easily removed using ultrasonic cleaning. Due to the ease of cleaning, ultrasonic cleaning may not necessarily be needed. Therefore a second form of mechanical energy could be used in place, such as spray washing or vibrational/tumbling immersion systems. Table 4 lists the steps involved in the manufacturing process with the new cleaning processes inserted in place of the vapor degreasing with TCE.

Table 4. Proposed Cleaning for Basic Routings

Carbon Steel parts are 80% of volume
Aluminum parts are 5% of volume

Stainless Steel parts are 15% of volume

| 64% Carbon parts | Chemical Used | 12% Stainless parts | Chemical Used | 2.5% Aluminum parts | Chemical Used |
|--------------------------------|-----------------------------|--------------------------------|-----------------------------|--------------------------------|-----------------------------|
| Making ring from bar | C-Eblis (some #30 lube oil) | Making ring from bar | C-Eblis (some #30 lube oil) | Making ring from bar | C-Eblis (some #30 lube oil) |
| Cleaning (remove?) | Ultrasonic | Cleaning (remove?) | Ultrasonic | Cleaning (remove?) | Ultrasonic |
| Counter sink, Mill, Drill, Tap | C-Eblis | Counter sink, Mill, Drill, Tap | C-Eblis | Counter sink, Mill, Drill, Tap | C-Eblis |
| Cleaning | Ultrasonic | Cleaning | Ultrasonic | Cleaning | Ultrasonic |
| Grind | Chemtrol 311 10% | Grind | Chemtrol 311 10% | Grind | Chemtrol 311 10% |
| Stamp | | Stamp | | Stamp | |
| Tumble | Chemtrol 311 10% | Tumble | Chemtrol 311 10% | Tumble | Chemtrol 311 10% |
| Blacken | Sodium hydroxide | Oil to displace water | Metal Guard 270 | Oil to displace water | Metal Guard 270 |
| Oil | Metal Guard 270 | Cleaning | Either spray or U.S. | Cleaning | Either spray or U.S. |
| Assemble | | Assemble | | Assemble | |
| | | | | | |
| 16% Carbon parts | | 3% Stainless parts | | 2.5% Aluminum parts | |
| Making ring from bar | C-Eblis (some #30 lube oil) | Making ring from bar | C-Eblis (some #30 lube oil) | Making ring from bar | C-Eblis (some #30 lube oil) |

CLEANING LABORATORY EVALUATION SUMMARY

| | | | | | |
|-------------------------------|------------------|-------------------------------|------------------|-------------------------------|------------------|
| Cleaning | Ultrasonic | Cleaning | Ultrasonic | Cleaning | Ultrasonic |
| Countersink, Mill, Drill, Tap | MOAC 10% | Countersink, Mill, Drill, Tap | MOAC 10% | Countersink, Mill, Drill, Tap | MOAC 10% |
| Oil to displace water | Metal Guard 270 | Oil to displace water | Metal Guard 270 | Oil to displace water | Metal Guard 270 |
| Cleaning | Spray or U.S. | Cleaning | Spray or U.S. | Cleaning | Spray or U.S. |
| Grind | Chemtrol 331 10% | Grind | Chemtrol 331 10% | Grind | Chemtrol 331 10% |
| Tumble | Chemtrol 331 10% | Tumble | Chemtrol 229 20% | Stamp | |
| Hone | C-Eblis | Oil to displace water | Metal Guard 270 | Tumble | Chemtrol 229 20% |
| Stamp | | Hone | C-Eblis | Oil to displace water | Metal Guard 270 |
| | | Stamp | | | |
| Cleaning | Ultrasonic | Cleaning | Ultrasonic | Cleaning | Spray or U.S. |
| Blacken | Sodium Hydroxide | | | Some to anodize | |
| Oil | Metal Guard 270 | | | | |
| Assemble | | Assemble | | Assemble | |

Summary:

Conclusion:

SCL Process Recommendations

Using any of the four products would result in successful cleaning of all the metal working fluids involved in the manufacturing process at Ruland. Due to the design of the parts containing holes and threads, ultrasonic cleaning would provide the best mechanical agitation. Drying of the supplied parts demonstrated the need to be able to remove the water located inside the threads of the different parts. The laboratory utilized a heat gun that removed the water with some difficulty. To further enhance the drying, a convection oven would provide proper drying at a faster rate.