CLEANING LABORATORY EVALUATION SUMMARY

SCL #:	1995
DateRun:	01/04/1995
Experimenters:	Donald Garlotta, John Bulko
ClientType:	Capacitor Manufacturer
ProjectNumber:	Project #1
Substrates:	Steel, Tin
PartType:	Part
Contaminants:	Abrasive, Cutting/Tapping Fluids, Lubricating/Lapping Oils, Oil
Cleaning Methods:	Ultrasonics
Analytical Methods:	Gravimetric
Purpose:	To evaluate ultrasonic and immersion cleaning.

Experimental Procedure:

Commonwealth Sprague Capacitor Company (CSCC) currently manufacturers capacitors for a variety of applications and markets. Products are classified under SIC codes 3569, 3629, 3674 and 3675. During production, tin-plated steel capacitor cans and covers are stamped and drilled to provide access holes for wire leads, impregnation with dielectric fluids, soldering and assembly. Cans and covers must be free of any contaminants after cutting and drilling operations so as not to compromise electrical properties. Presently, all can pieces are cleaned by vapor degreasing using trichloroethylene prior to assembly. Once impregnated and/or filled with oil, the cans are sealed holes soldered and excess rosin-based flux removed in a final cleaning step. Several capacitor types require multiple vacuum impregnation steps in forming the capacitor's core composition. Cleaning after these operations is done using 1,1,1-trichloro-ethane vapor degreasing. After cleaning, finished units are tested to validate electrical specifications, painted, stamped and packaged for shipment. Commonwealth Sprague Capacitor has requested assistance with:

- identifying an alternative cleaning process to replace tri- chloroethylene vapor degreasing of capacitor cans and covers,
- alternatives for removing rosin-based flux after soldering operations and
- evaluating the performance of Degreeze 500 solvent cleaner as a potential alternative for cleaning rosin-based flux contaminated capacitors.

Results:

The first cleaning trials performed were conducted using 316 stainless steel test coupons as the substrate and two machining/ drilling fluids, Hydraking 32AW (King Oil Co.) and Kutwell 40 (Exxon Co.). Both process fluids were completely removed (100.8% and 100.7% for Hydraking 32AW and Kutwell 40, respectively) using a 10% solution of Daraclean 282 (WR Grace) with ultrasonic agitation (Crest Ultrasonics) for five minutes at 151°-153°F followed by a two minute rinse at 137°-140°F in tap water and then deionized water. Since both contaminants were completely cleaned from the steel surfaces under the given conditions, the cleaning process was repeated using five tin-plated steel capacitor can covers. The covers were approximately 2" in diameter, had two holes drilled about the center and were lightly soiled with the aforementioned process fluids. After a 15 minute period of ultrasonication at 144°F followed by successive five minute rinses in tap and DI water and ambient air drying, the tin-plated steel surfaces showed areas of rust especially around the edges of the holes and outer circumference.

In light of the apparent surface corrosion observed, additional aqueous cleaning products were screened for compatibility using a Branson 8200 benchtop ultrasonic bath (3 gal. capacity; 400 W output). TABLE 1 lists the cleaning products tested, conditions used and results. Results are based on visual examination of the tin-plated steel capacitor can covers after ambient air drying for 60 minutes. As shown in TABLE 1, Kutwell 40 was more readily removed compared to the Hydraking 32AW process fluid under the listed conditions.

Cleaning trials were continued to identify one set of conditions that would effectively remove both contaminants completely. As shown in TABLE 2, by increasing the concentration of the cleaning solution to 20% for two cleaners, all soils were extracted from the surface of the metal covers. However, rust formation was again noted shortly into the drying stage. Testing of two additional cleaning products, Micro (International Products) and Hurrikleen (Hurri-Safe) at 10% dilution also proved effective on both contaminants but suffered the same drawbacks of rust formation (see TABLE 2).

As a result of the continued rust problem, the cleaning process was altered to reduce the period of tap water rinse from five minutes to five seconds on the premise that this would minimize the loss of any corrosion inhibitors imparted to the surface through contact with the cleaning solution. Results are tabulated in TABLE 3 using a Crest Ultrasonics bath (6 gal. capacity; 600 W output) and five minute ultrasonication period. As indicated, a 10% solution of Daraclean 232 (WR Grace) at 138°F for five minutes was effective in removing the contaminant with no rusting observed.

TABLE 1				
Branson 8200 Ultrasonic Bath				

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Conditions: 15 min. duration @ 133°F				
Tap water rinse 5 min. @133°F				
Substrate: Tin-plated Steel capacitor can covers				
Manufacturer	Buckeye	Sky Products	Modern Chemical	Sunshine Makers
Product	Shopmaster	Cleaner #10	Blue Gold	Simple Green
Concentration	10	10	10	10
Contaminant	Results			
Hydraking 32AW	Oil remaining	Oil remaining	Clean	Oil remaining
		rust present	rust present	rust present
Kutwell 40	Clean	Clean	Clean	Clean

TABLE 2
Crest Ultrasonics Bath
Substrate: Tin-plated steel capacitor can covers
Conditions: 15 min.duration @ 140°F
Tap water rinse 5 min. @ 140°F

Manufacturer	Buckeye	Sky Products	International Products	Hurri-Safe
Product	Shopmaster	Cleaner #10	Micro	Hurrikleen
Concentration	20	20	10	10
Contaminant	Results			
Hydraking 32AW	Clean	Clean	Clean	Clean
	rust present	rust present	rust present	rust present
Kutwell 40	Clean	Clean	Clean	Clean
	rust present	rust present	rust present	rust present

TABLE 3
Crest Ultrasonics Bath
Substrate: Tin-plated steel capacitor can covers
Contaminant: Hydraking 32AW

Cleaner	Agitation time (min)	Temp F	Rinse time (sec)	Rinse Temp F	Observations
Hurrikleen	5	150	5	140	Clean with rust
Micro	5	136	5	140	Clean with rust
Cleaner #10	5	136	5	140	Soil remaining
Daraclean 232	5	138	5	140	Clean rust free

After determining an effective cleaning product, gravimetric analysis was performed to verify the cleaning performance quantitatively. Two clean tin-plated steel capacitor cans (3"long x 2" diameter) were sectioned into pieces of varying size (12 total) for use as the substrate to be contaminated. All pieces were weighed prior to contamination and again after application of 10- 50mg of either Hydraking 32AW (six pieces) or Kutwell 40 (six pieces). The can pieces were then cleaned using a similar process outlined in Table 3 using ultrasonic agitation followed by rinsing in tap water (5 sec.) and drying under a system of air knives (2) for two minutes. All sections were weighed again after each cleaning trial. Performance data are compiled in TABLE 4 with " % REMOVAL" being the average change in weight of the six tin-plated steel pieces. It is apparent from the weight change data that % REMOVAL values greater than 100% indicated the loss of metal substrate. Duplicate trials using Daraclean 232 as well as trying several different cleaners all showed

similar results. When uncontaminated sections were placed in tap water at 146°F and cycled through the cleaning stages, weight losses between 1.5-10.1mg were recorded suggesting that ultrasonic agitation was responsible for the substrate loss.

TABLE 4
Crest Ultrasonics Bath
Substrate: Six tin-plated steel capacitor can pieces per cleaning trial

Contaminant: Hydraking 32AW				
Cleaner	Concentration	Agitation time (min)	Temp F	% Removal
Daraclean 232	10	5	146	178.9
Daraclean 232 Repeat	10	5	144	150
Gillite 0650 Cl	10	5	140	137
Seawash Neutral	10	5	138	192.7
Contaminant: Kutwell 40				
Daraclean 232	10	5	144	154.6
Daraclean 232 Repeat	10	5	138	120.3
Gillite 0650 Cl	10	5	141	135
Seawash Neutral	10	5	140	163.6

The cleaning process was then converted to agitated immersion following a similar sequence of stages and duration. Repeating the blank run with clean can pieces immersed in tap water at 140°F for 5 minutes produced no weight changes (within experimental error), thus verifying the harmful effects caused by ultrasonication.

Quantitative results using the agitated immersion cleaning process are shown in TABLE 5 for several cleaning products tested. As indicated earlier (see TABLE 3), a 10% solution of Daraclean 232 effectively removed both machining oils while preserving the integrity of the tin-plated steel substrate. Two additional candidate cleaners were selected for evaluation due to their lower pH properties (7-9 pH range) as compared to the more alkaline solution, Daraclean 232 (pH≈12). Tin is highly sensitive to alkaline environments over a pH of 10. Daraclean 232 is a liquid amine blend of ferrous and nonferrous corrosion inhibitors, silicate, nonionic surfactants, anionic surfactant, EDTA and a citrus fragrance at less than 0.5% in a water base. This product contains no phosphate, chloride or nitrite.

The last series of cleaning trials was performed using rosin-based flux(#115) as the contaminant. Initial experiments were performed using ultrasonic agitation of 10% Daraclean 232 for 5 minutes at temperatures between 134°-145°F followed by 15 sec. tap water rinse at 140°-142°F and air knife drying for 2-5 minutes. Specimens appeared clean and free of rust by visual inspection. Inspection under a long wave UV lamp (black light) confirmed the complete removal of applied flux. Parallel cleaning trials using an agitated immersion process to clean rosin-based flux contaminated surfaces remains to be completed.

Commonwealth Sprague Capacitor also requested that Degreeze 500 (Solvent Kleen, Inc.), a hydrocarbon solvent cleaner, be evaluated for removing rosin-based flux from capacitor cans and assembled units. The solvent was used in an agitated immersion process to clean fluxed capacitor covers for 5 minutes at 75°F followed by immediate drying under air knives for 2 minutes without rinsing. Black light inspection revealed several spots of suspected contaminant remaining, thus indicating incomplete cleaning under the stated conditions. Evaluation of flux removal from assembled capacitors (after soldering operations to attach wire leads) using Degreeze 500 is being contemplated.

TABLE 5
Agitated Immersion Wash Substrate: Three tin-plated steel capacitor can pieces per cleaning trial

Contaminant: Hydraking 32AW					
Cleaner	Concentration	Agitation time (min)	Temp F	% Removal	Effective
Daraclean 235	10	5	136	64.6	
Gillite 0650 Cl	10	5	136	1100	
	10	5	138	101.8	Yes

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Daraclean 232					
Contaminant: Kutwell 40					
Daraclean 235	10	5	140	112	
Gillite 0650 Cl	10	5	136	107.8	
Daraclean 232	10	5	140	101.4	Yes

A note of concern must be mentioned regarding the objectionable odor emitted when using the Degreeze 500 solvent cleaner in the cleaning trials. Although no permissible exposure limits to this product are indicated on the Material Safety Data Sheet, health effects do include eye irritation, mild skin irritation and nasal/respiratory irritation upon excessive overexposure. Other health, safety and disposal issues may also be of concern depending on how this product is used, handled and integrated into the cleaning operations and manufacturing process at the company.

Summary:

Substrates:	Steel, Tin				
Contaminants:	Abrasive, Cutting/Tapping Fluids, Lubricating/Lapping Oils, Oil				
Company Name:	**Product Name:**	**Conc.:**	**Efficiency:**	**Effective:**	**Observations:**
International Products Corporation	Micro (no longer available)	10	0.00	☐	
Buckeye International	Shopmaster	10	0.00	☐	
Simple Green	Concentrated Industrial Strength Cleaner and Degreaser	10	0.00	☐	
Sky Products Company Inc	Cleaner #10	10	0.00	☐	
Magnaflux	Daraclean 232	10	0.00	☑	
Warren Chemical Company	Sea Wash Neutral	10	0.00	☐	
Carroll Company	Blue Gold Heavy Industrial Cleaner	10	0.00	☐	
Hurri Kleen Corportion	HurriSafe - Hot Immersion Degreaser	10	0.00	☐	
Man Gill Chemical Company	Gillite 0650 Cl	10	0.00	☐	

Conclusion:

In conclusion, an aqueous cleaning chemistry was found that effectively removed machining and stamping fluids from tin-plated steel capacitor cans and covers. Using an agitated immersion process at 138°-140°F for 5 minutes, a 10% solution of Daraclean 232 completely removed both Hydraking 32AW and Kutwell 40 contaminants while preserving the substrate and eliminating corrosion. Ultrasonic agitation was found to cause the loss of metal substrate and was disqualified from further evaluation.