IPC Electronics Midwest 2010

An Investigation into Hand Sanitizers and Hand Lotions and Potential Risks to High Performance Electronics

Douglas O. Pauls

Rockwell Collins

Biography

Principal Materials and Process Engineer

Doug holds a B.A. in Chemistry and Physics from Carthage College, Kenosha, Wisconsin, and a B.S. in Electrical Engineering from the University of Wisconsin, Madison, but he has somehow morphed into a materials scientist over the years.

In his career, Doug has worked as a Materials Engineer for the Naval Avionics Center in Indianapolis, and served as Technical Director of Contamination Studies Laboratories, in Kokomo, Indiana. He is presently a Principal Materials and Process Engineer at Rockwell Collins, Cedar Rapids, Iowa. Doug has been an active IPC member for over 25 years and present chairs the IPC Cleaning and Coating Committees. He has participated in several national and international research programs and specification development efforts, winning numerous accolades along the way.

Doug's areas of expertise include: humor, investigations on materials properties, troubleshooting and optimizing electronics manufacturing processes, failure analysis, environmentally conscious manufacturing, manufacturing residue analysis, surface insulation resistance testing, adhesives and conformal coatings.

His primary task is to serve as a thorn in the side of his arch nemesis, Dave Hillman.

Doug is known to have a pathological fear of free time, has been happily married for 24 years. He has 3 children and so has little free time, but does some woodworking, woodcarving, and occasionally sneaks away to do some hunting and fishing. Principal Materials and Process Engineer, Advanced Operations Engineering

Executive Summary

As people become more concerned about the global outbreaks of various strains of influenza, more precautions are being taken with respect to personal hygiene. A common precaution involves the use of hand sanitizer solutions or similar germicidal agents. For manufacturers of electronic assemblies, this may mean a potential transfer of these solutions/agents to the surface of the assemblies as a contaminant material. Similarly, many production employees in the electronics industry deal with harsh chemicals, which often remove hand oils, resulting in chapped or dry skin. The use of hand lotions may or may not be allowed, depending on the manufacturer, with a similar concern regarding transfer of unknown chemicals to the assembly surface. This paper is an examination of some typical hand sanitizers and hand lotions and their impact on high reliability electronic hardware.

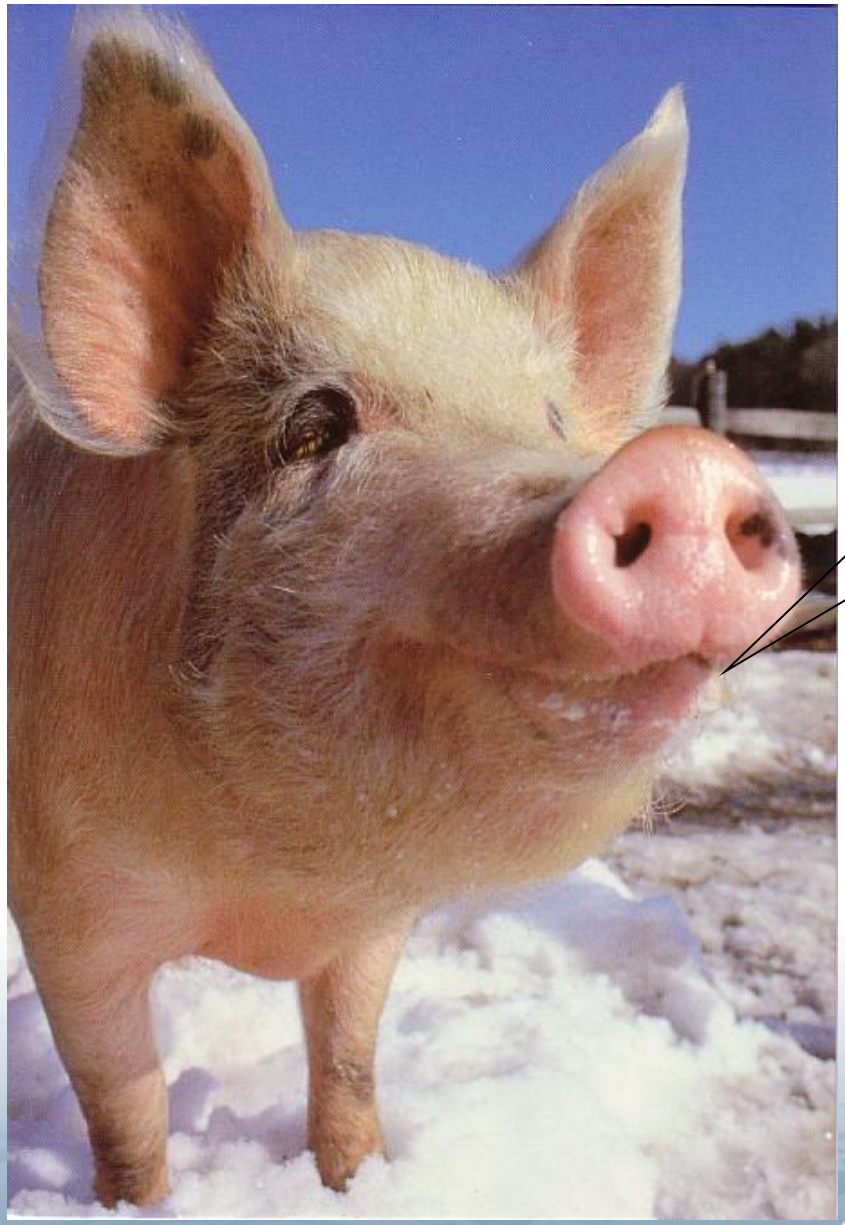
Contact Information

400 Collins Rd NE
M/S: 108-101
Cedar Rapids, IA 52498-0505
Phone: 319-295-2109
Fax: 319-295-6060
Email: dopauls@rockwellcollins.com

An Investigation Into Hand Sanitizers and Hand Lotions and Potential Risks to High Performance Electronics

Doug Pauls and Mike Vosatka
Rockwell Collins
Cedar Rapids, IA USA

Association Connecting Electronics Industries


Hello

Interesting Iowa Facts

- Iowa raises more than 15 million hogs annually
- Iowa population is about 3 million
- That's about 5 hogs per capita
  - Mine are Larry, Curly, Moe, Shemp, and Fred
- So something called "Swine Flu" really gets our attention
- As of December, 2009, there were 38 H1N1 deaths in Iowa, thousands globally
  - Shut down many Iowa schools (40-50% of students out)
- Pandemic flu outbreaks drive many concerns about germs and change peoples behavior
  - Increased drives for germ-free surfaces

Cedar Rapids 2008

- Cedar Rapids flooded – 9.8 square miles - $1B damage
- Lost 3 out of 4 industrial water wells
- Everyone asked to conserve water wherever possible
- Rockwell Collins instituted water saving measures
- Put sanitizer solutions in all rest rooms with a clear message to use them instead of washing hands
- Lasted for about 3 weeks
- Saw no negative impacts on electronics from this action

H1N1 Impacts

- To address concerns about H1N1
  - Sanitizers in all the restrooms
  - Can we put them on the manufacturing floor?
  - Are there “approved” or “non-approved” kinds?
  - Are the residues a risk to our electronics?
  - How do we clean surfaces to reduce germs?
- And while you’re at it….
  - Have a qualified hand lotion, in use for 10+ years
  - Used mostly to improve contact with ESD wrist straps
  - Lots of dry/chapped hands from chemicals or from Iowa winters
  - Due to negotiated union rules, cannot comment on items in “personal” containers, like hand creams
  - Are these more persistent residues a risk?

Points To Keep In Mind

- With only a few exceptions, Rockwell Collins cleans all of its assemblies, usually multiple times (4-5 times is not unusual)
- We do not require gloves or finger cots to handle assemblies for this reason
- There is always a final aqueous clean step prior to conformal coating, and ALL handling after this step is done with gloved hands
- Only interested in intermediate process effects from transferred residues
  - In-circuit testing, adhesive applications, soldering

Material Selected

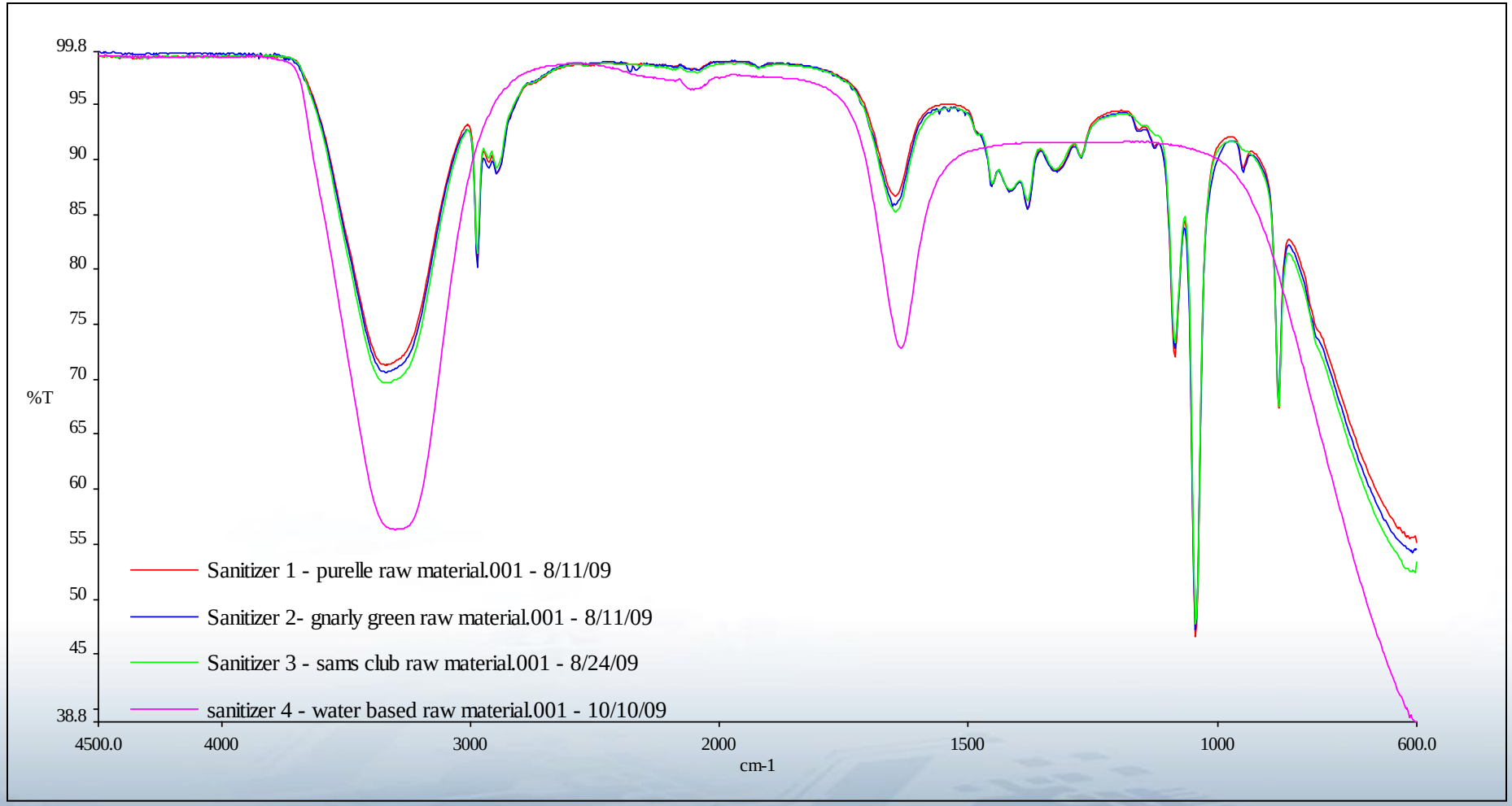
- Sanitizers
  - Purell Hand Sanitizer with Moisturizers and Vitamins
  - Sam's Club Hand Sanitizer
  - Germ-X Gnarly Green Sanitizer
  - X3 Labs, X3 Clean Foaming Hand Sanitizer (non-alcohol sanitizer)
- Lotions
  - Chemtronics Static Free Hand Guard (qualified)
  - Jergens Ultra Healing® Extra Dry Skin Moisturizer with Vitamin E (contains aloe vera)
  - Bath and Body Works Midnight Pomegranate Hand Cream (no aloe vera)

Study Initiated

- Five Areas to Study
  - Chemical Analysis
    - What chemicals are present
  - Residue Transfer Study
    - Do the sanitizer/lotion residues actually transfer to the surface of an assembly?
  - Impact on Electrical Parameters
    - Do transferred residues impact dielectric strength or surface insulation resistance?
  - Impacts on Adhesion
    - Can transferred residues interfere with proper bonding of an adhesive to the assembly and component?
  - Impacts on Solderability
    - Will transferred residues adversely impact solderability of the assembly in intermediate operations?

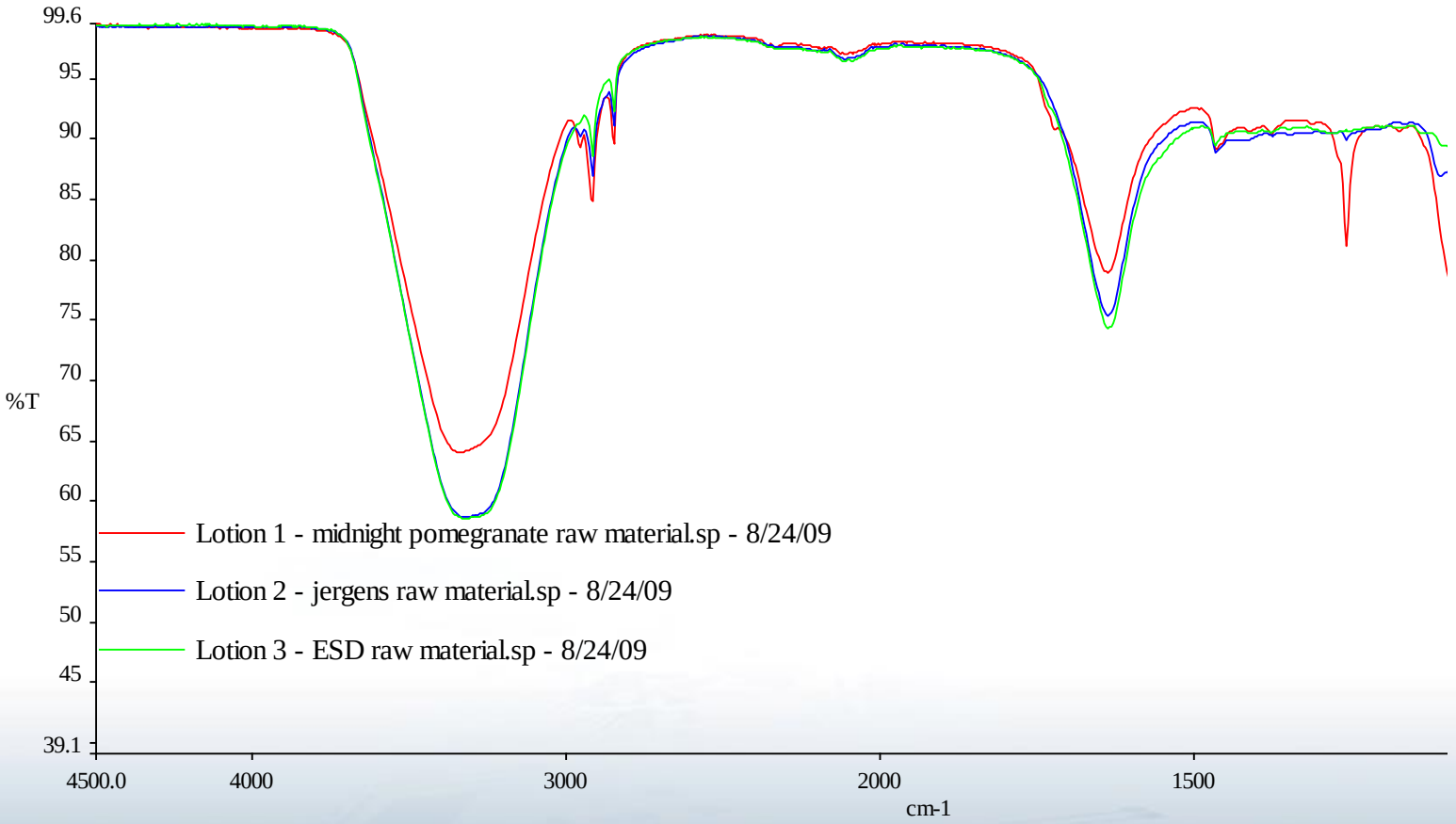
Electronics IPC Midwest

Chemical Study



FTIR Scan of Sanitizers

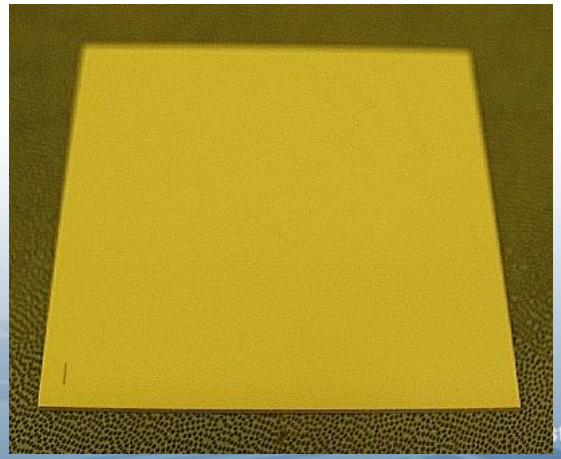
Chemical Study



FTIR Scan of Lotions

Residue Transfer Study

- Substrate – 2” x 2” alumina material
- No organic or ionic materials extractable
- Handled using treated hands
- Extracted to look for residues
- Acetonitrile used for FTIR extractions
- 10% isopropanol / 90% DI water used for ion chromatography extractions



Handling/Treating Method

- Hands thoroughly washed with soap and hot water and dried with paper towels
- Hands treated with a “typical” amount of the candidate material
- Substrates in question were then handled for 30-45 seconds

Ion Chromatography Results

Description	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
Blank - Hands Only	0.10	0.23	0.10	0.00	0.00	0.00	0.34
After Purell	0.23	0.37	0.12	0.00	0.00	0.00	0.21
After Sam's Club	0.03	0.10	0.00	0.00	0.00	0.00	0.00
After Mid. Pom	0.06	0.14	0.00	0.00	0.00	0.00	0.00
After Jergens	0.05	0.14	0.00	0.00	0.00	0.00	0.00
After ESD Lotion	0.00	0.10	0.00	0.00	0.00	0.00	0.00
After Gnarly Green	0.06	0.10	0.00	0.00	0.00	0.00	0.00
After X3	0.00	0.18	0.00	0.00	0.00	0.00	0.00

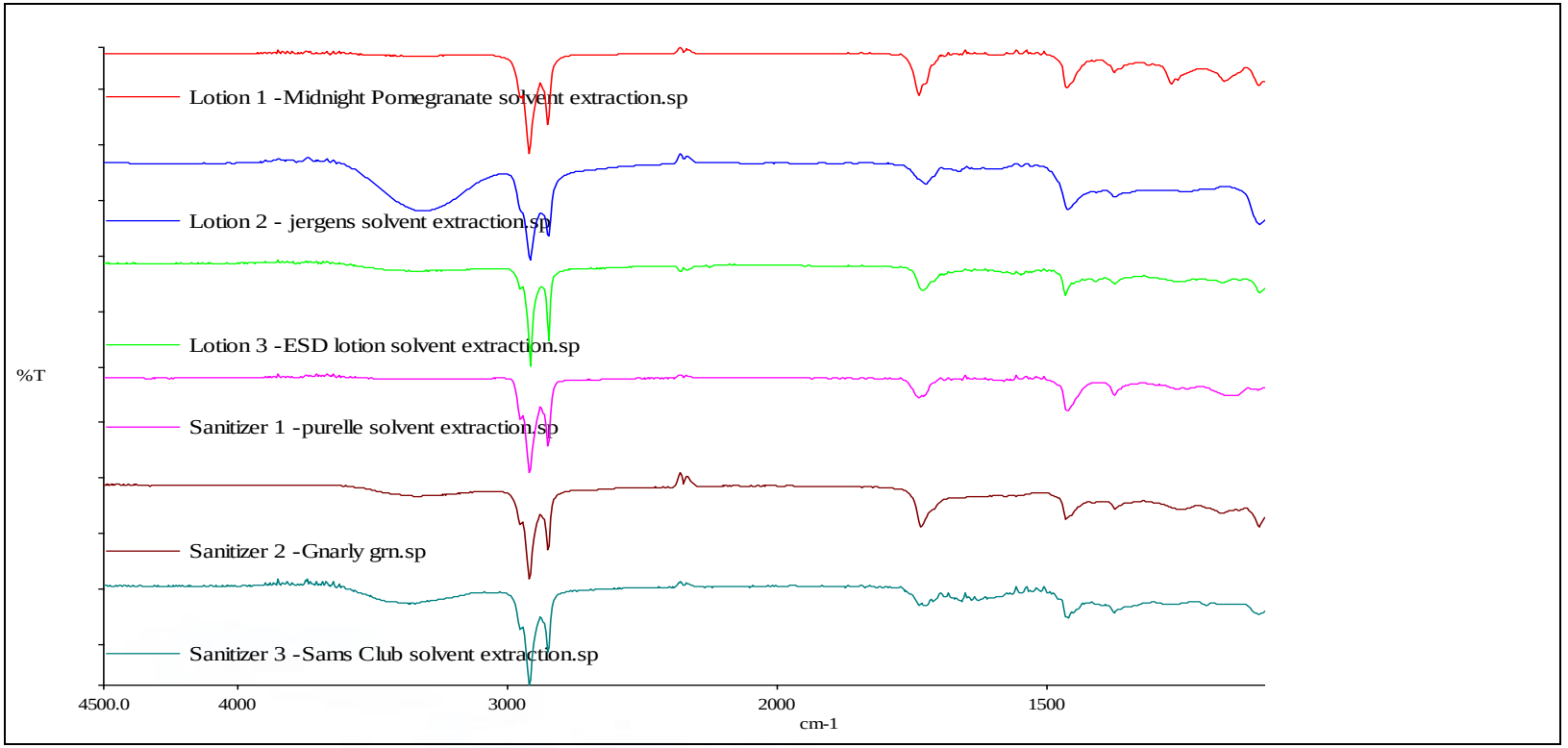
- Details of the chromatographic method in the paper
- Values in micrograms per square centimeters
- How clean is clean or clean enough?
  - Chloride: 0.75 µg/cm^2
  - Sulfate: 1.0 µg/cm^2
- Fluoride value is probably a combination of ions

Ion Chromatography Results

Description	Lithium	Sodium	Ammonium	Potassium	Calcium	Magnesium
Blank - Hands Only	0.00	0.32	0.00	0.00	0.00	0.00
After Purell	0.00	0.51	0.00	0.34	0.48	0.00
After Sam's Club	0.00	0.00	0.00	0.00	0.00	0.00
After Mid. Pom.	0.00	0.25	0.00	0.00	0.00	0.00
After Jergens	0.00	0.32	0.00	0.00	0.00	0.00
After ESD Lotion	0.00	0.00	0.00	0.00	0.00	0.00
After Gnarly Green	0.00	0.00	0.00	0.00	0.00	0.00
After X3	0.00	0.00	0.00	0.00	0.00	0.00

- Cations are seldom a problem – use as a process indicator
- Sodium is very common material
- All values are considered to be desirably low
- Nothing of any interest here

FTIR Results



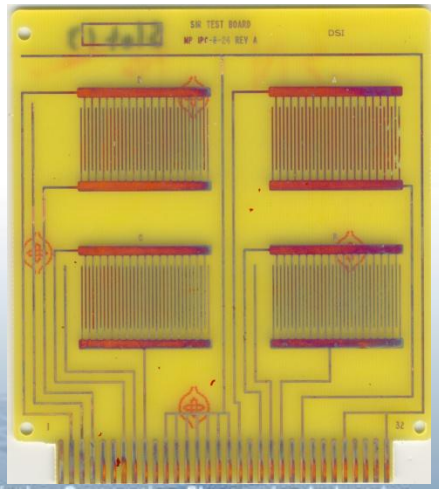
- Acetonitrile extractions
- Some sanitizer and lotion residues DO transfer to the substrate
- Method is qualitative, not quantitative, and very sensitive

Residue Transfer Conclusions

- Some material transfers to the substrate
- Ionic material transferred is no greater than for bare hands alone
- Levels found would not be considered as a significant risk for electrochemical failures
- Residues do not represent a chemical risk

Electrical Performance

- Dielectric Withstanding Voltage Test (hipot)
  - DC voltage ramp from 0 VDC to breakdown
  - Tested in uncoated condition
- Surface Insulation Resistance
  - Insulation resistance at ambient conditions
  - Elevated conditions (85C/85% RH) with frequent monitoring
  - Final resistance at ambient
  - Visual examination after tests
  - Tested in both coated and uncoated conditions
  - Tested in both cleaned and uncleaned conditions
- IPC-B-24 Standard Test Board
  - Patterns A-C treated
  - Pattern D not treated as a control



DWV Test Results

Material	Ave. Breakdown Voltage Controls (kV)	Ave. Breakdown Voltage Treated (kV)
Purell	1.7	1.40
Sam's Club	1.8	1.11
Germ-X Gnarly Green	1.8	1.08
Jergens Ultra Healing	1.6	1.35
Midnight Pomegranate	1.5	1.30
Chemtronics Lotion	1.6	1.12
X3 Clean	1.4	1.40

- Some degradation, compared to unprocessed control
- Overall level is still very high (~ 1 KV / 20 mil space)
- The decrease is not considered as significant
- Did not test what decrease would be from untreated hands – would expect similar degradation

SIR Results

- SIR Testing generates a LOT of data, especially measuring hourly
  - Used a Gen3 Systems AutoSIR data logger

- Used 100 megohms (8.0 LogOhms) as pass fail metric
  - *Chris Mahanna: I've been testing a lot of crazy crap for years and 8 is the answer.*
- Generally higher is better, consistent is good
- Post SIR visual examination done to determine
  - Any signs of corrosion
  - Any signs of electrochemical migration (dendrites)
  - Any signs of coating degradation (adhesion)

SIR – Purell

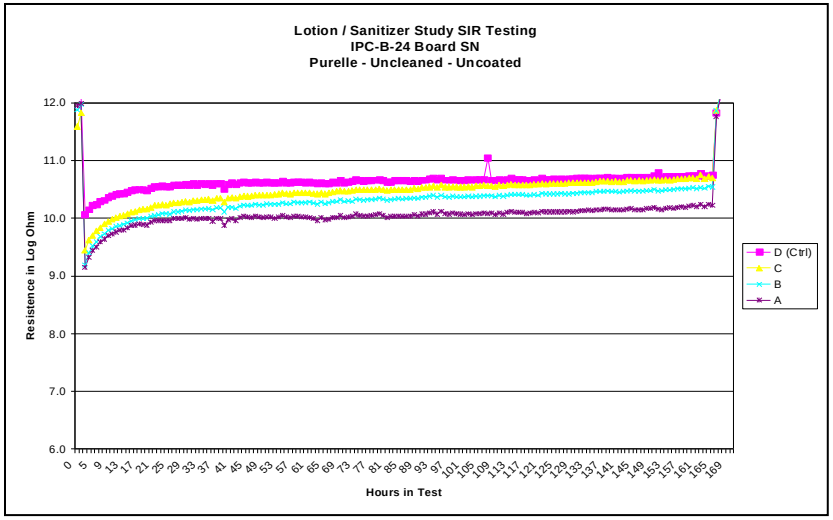


Figure 9

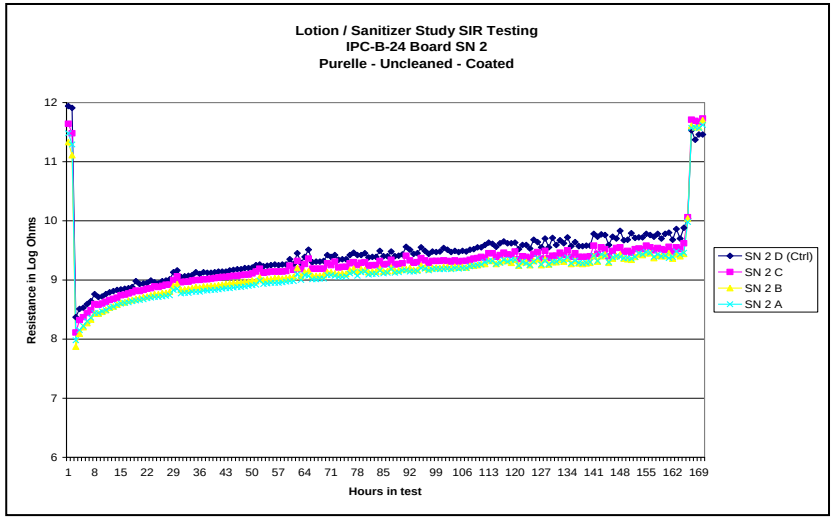
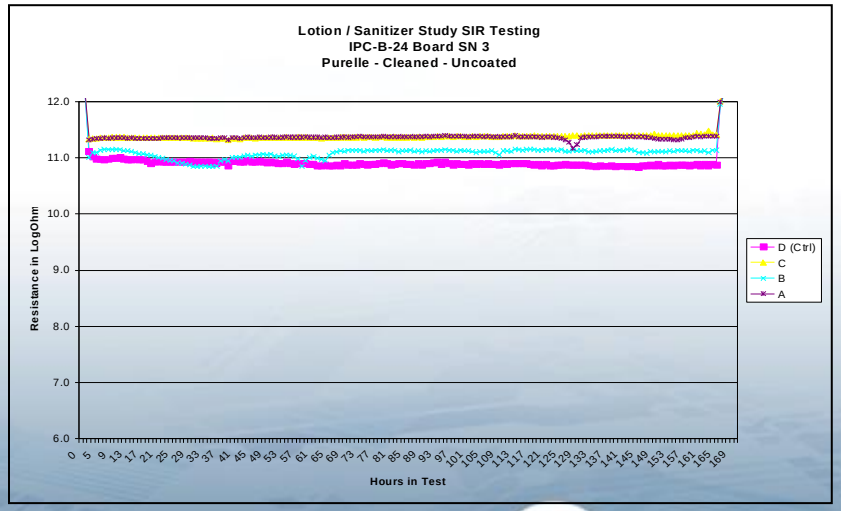


Figure 10



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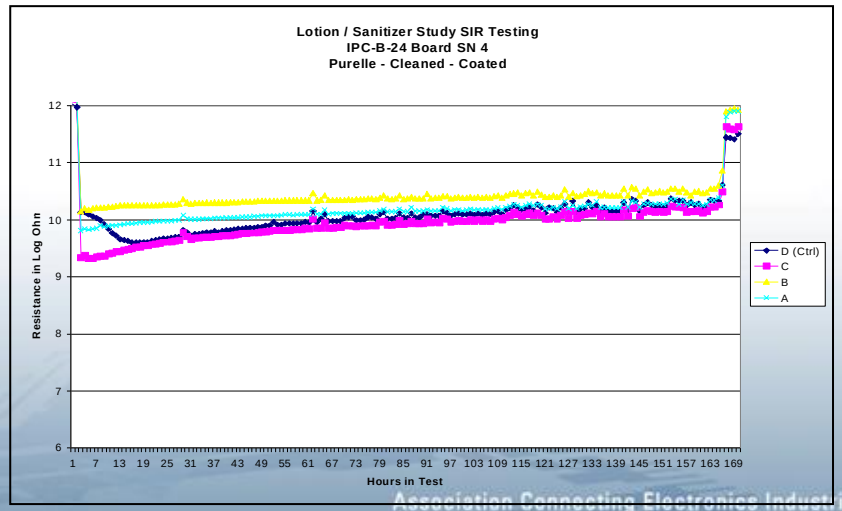
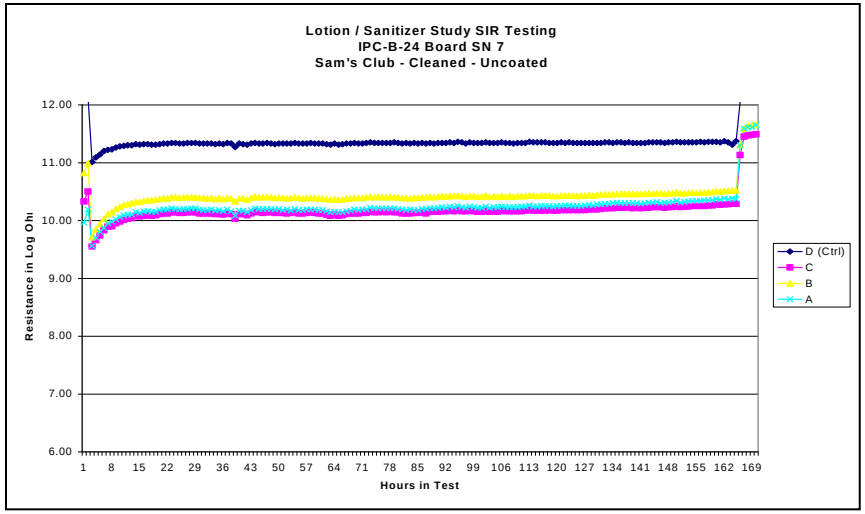


Figure 12

SIR – Sam's Club



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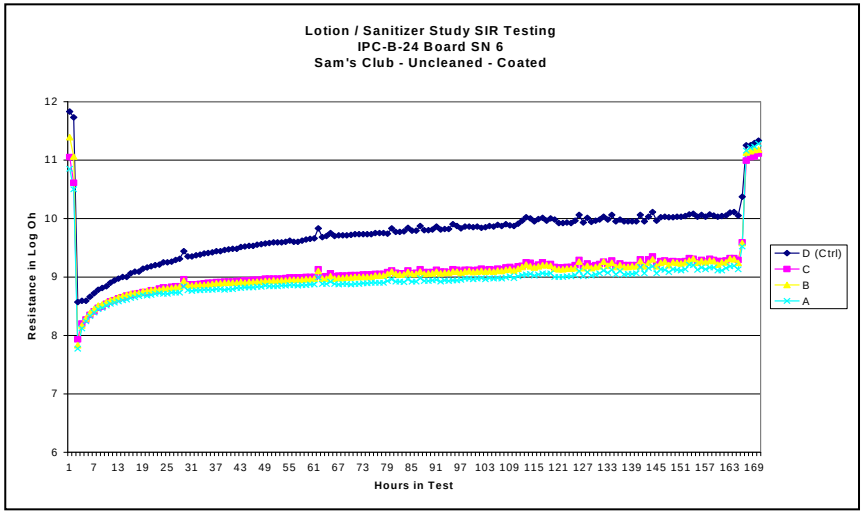

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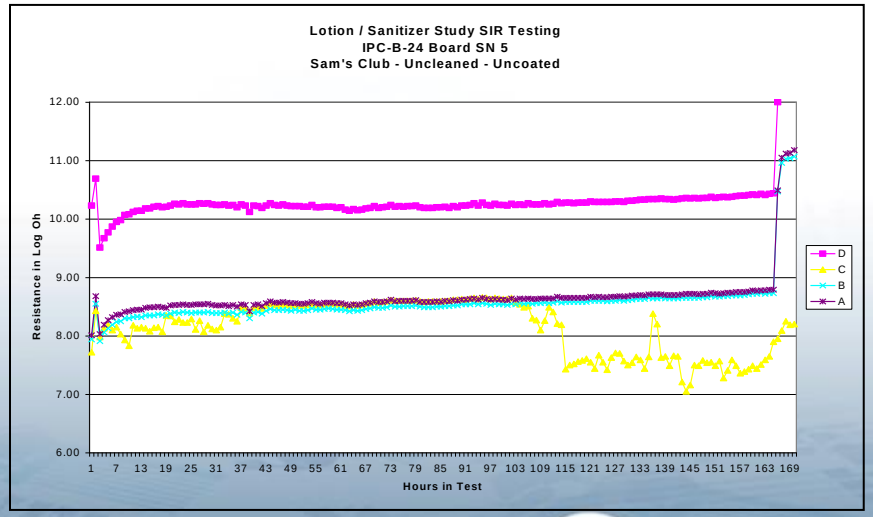

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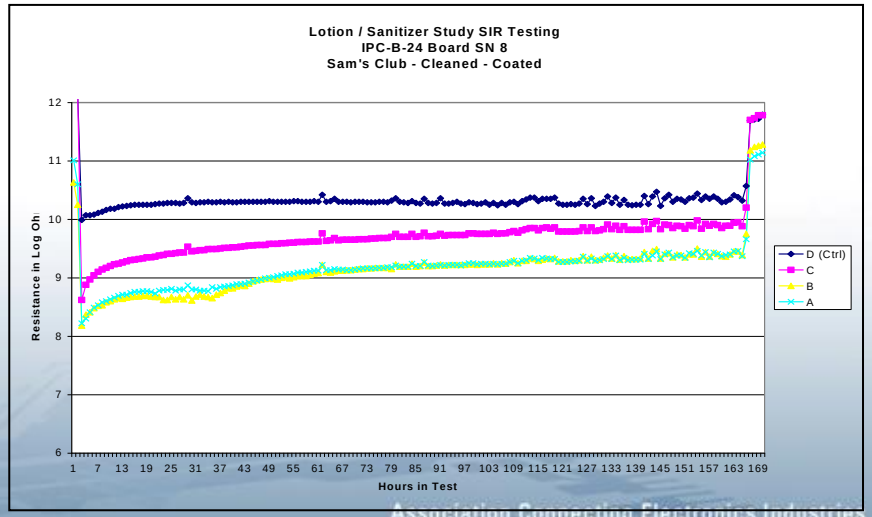
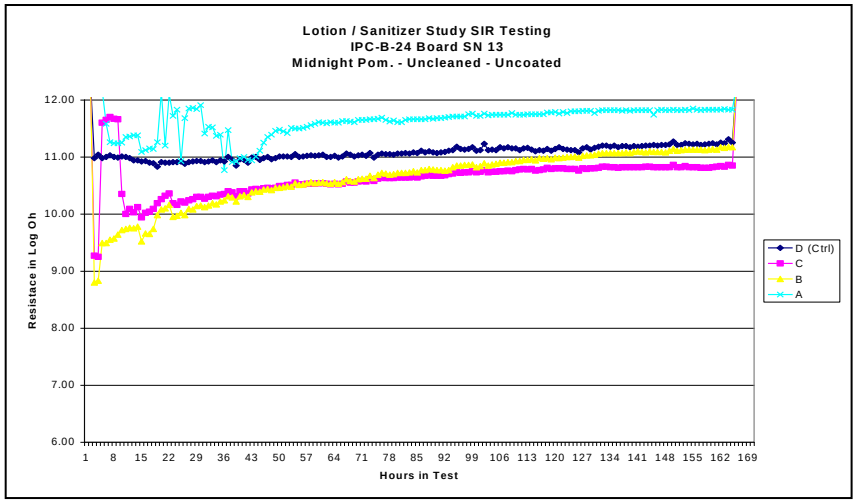


Figure 16

SIR – Midnight Pomegranate



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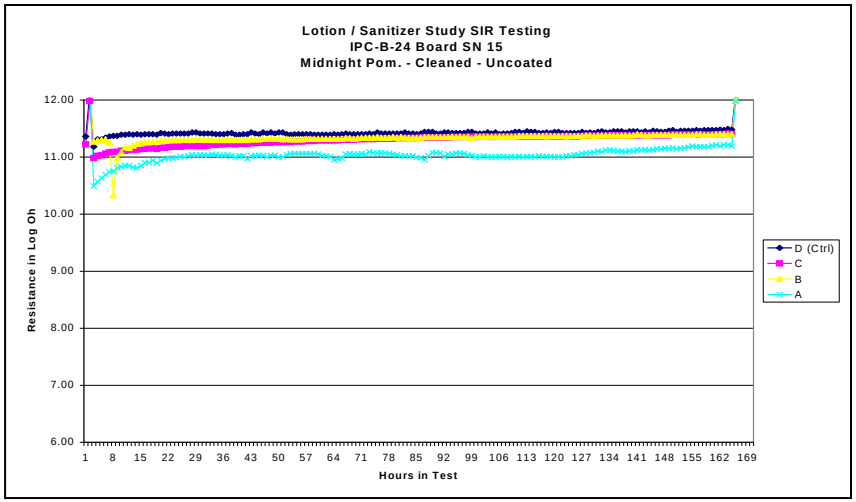

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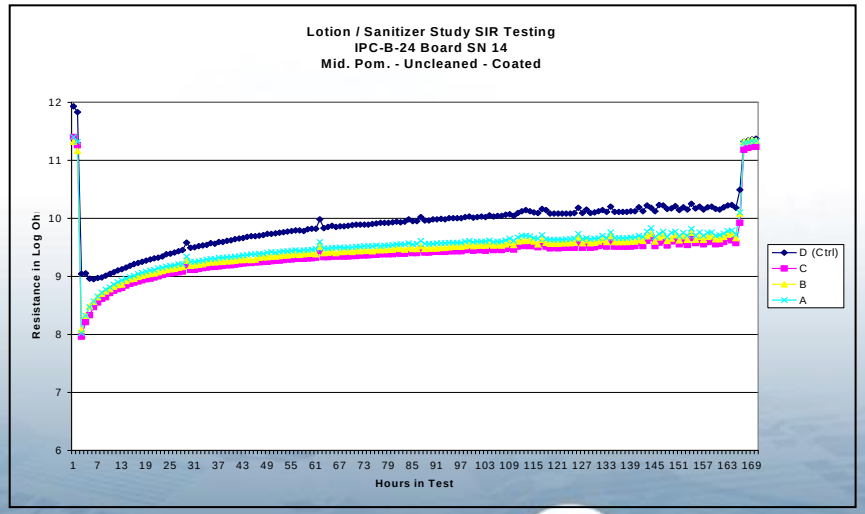

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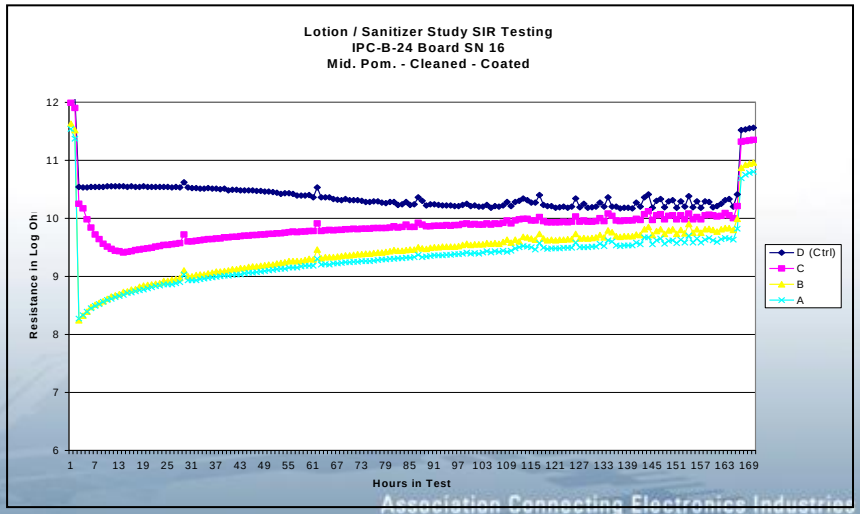
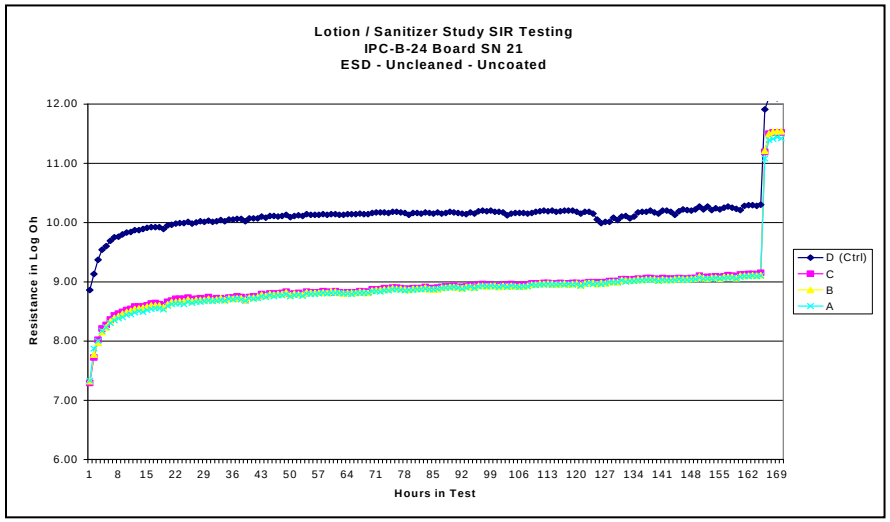


Figure 24

SIR - Chemtronics



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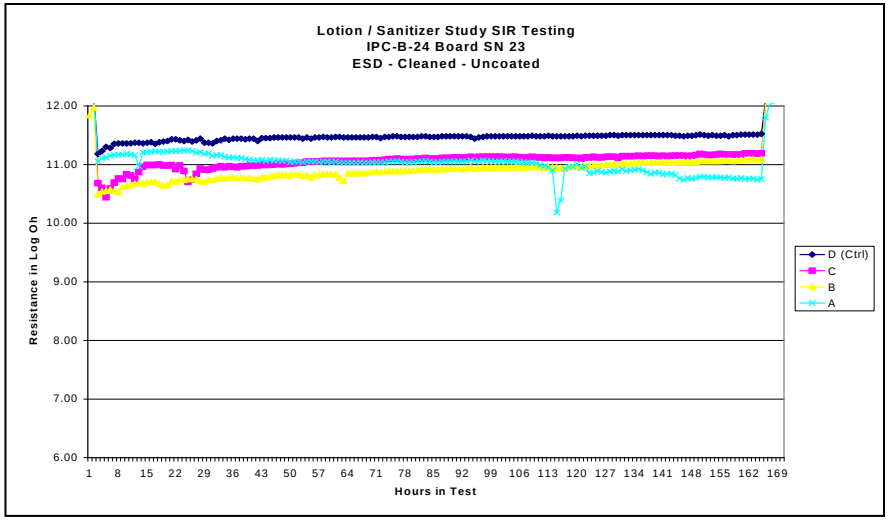
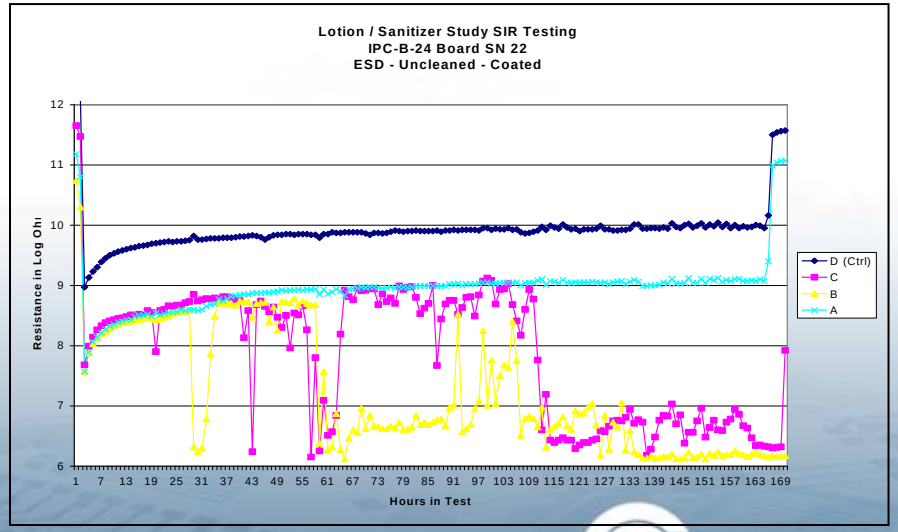


Figure 30



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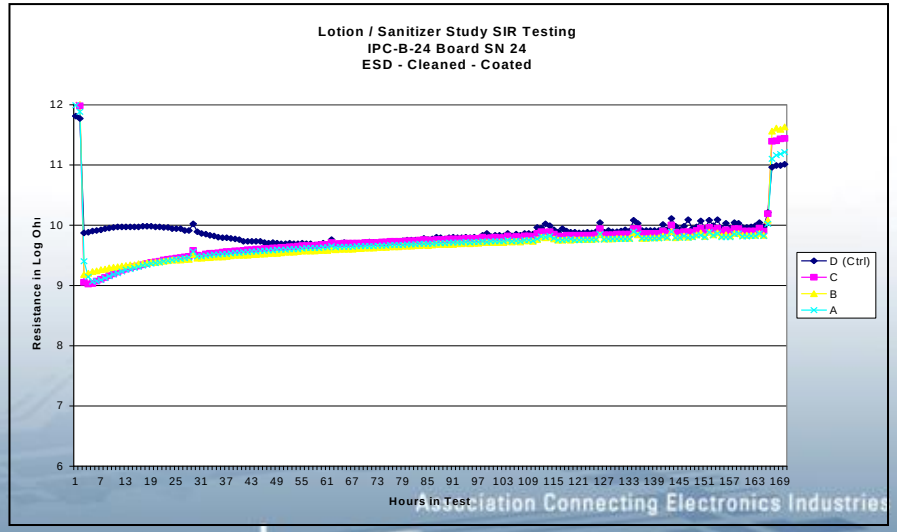


Figure 32

Post SIR Visual Exam

- No corrosion or metal migration noted on any test pattern, control or treated
- No signs of coating degradation
- No signs of coating adhesion loss

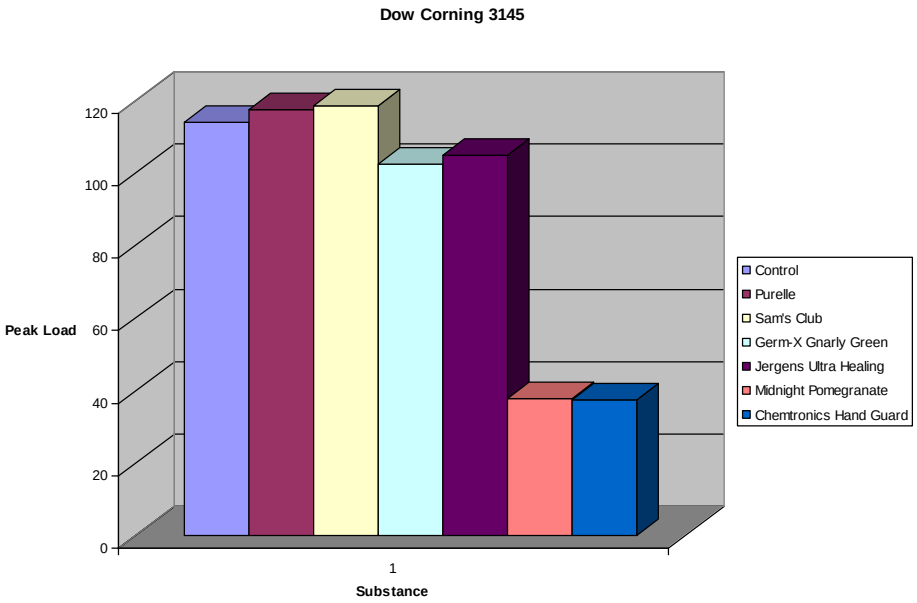
SIR Conclusions

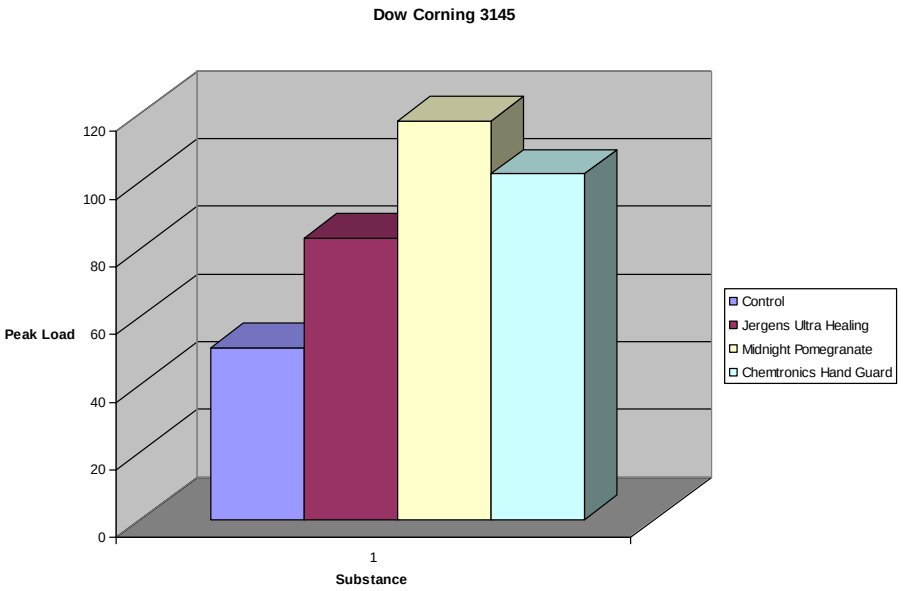
- Sanitizer and lotion residues do have an effect on SIR in the uncleaned condition, though the impact will depend on the chemical nature of the residue and the amount of residue left on the assembly surface.
- The performance of the cleaned samples shows that the standard Rockwell Collins aqueous cleaning process adequately removes the sanitizer and lotion residues to acceptable levels, even though some of the sanitizer and lotion residues have an impact even after cleaning and conformal coating.
- None of the test samples showed any corrosion or electrochemical migration (dendritic growth). This indicates that the residues were not ionic in nature and the effects were due to the attraction of water vapor by the hydrophilic nature of the residues.

Adhesive Study

- We use adhesives for parts staking - vibration
- Studied four commonly used adhesives
  - Dow Corning 3145 RTV one-part silicone adhesive
  - Dow Corning SE 1700 two-part silicone adhesive
  - Araldite 2040 two-part urethane adhesive
  - Loctite 382 Tak Pak cyanoacrylate adhesive
- Used Lap Shear testing with FR-4 laminate strips (copper etched off)
- Used a 45 mil bond line for all except Tak Pak (2 mil bondline)
- One FR-4 strip handled with treated hands, opposite strip not touched (3 replicates)
- Cured using standard processes
- Pulled to breaking on tensile tester

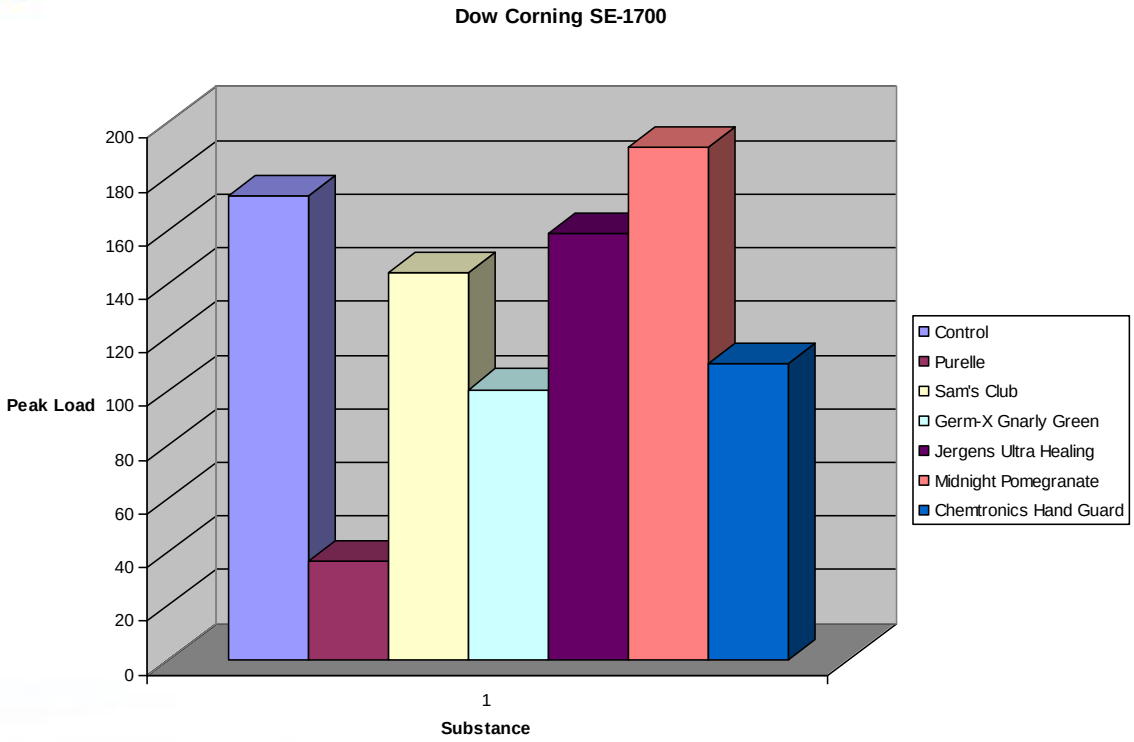
Dow Corning 3145





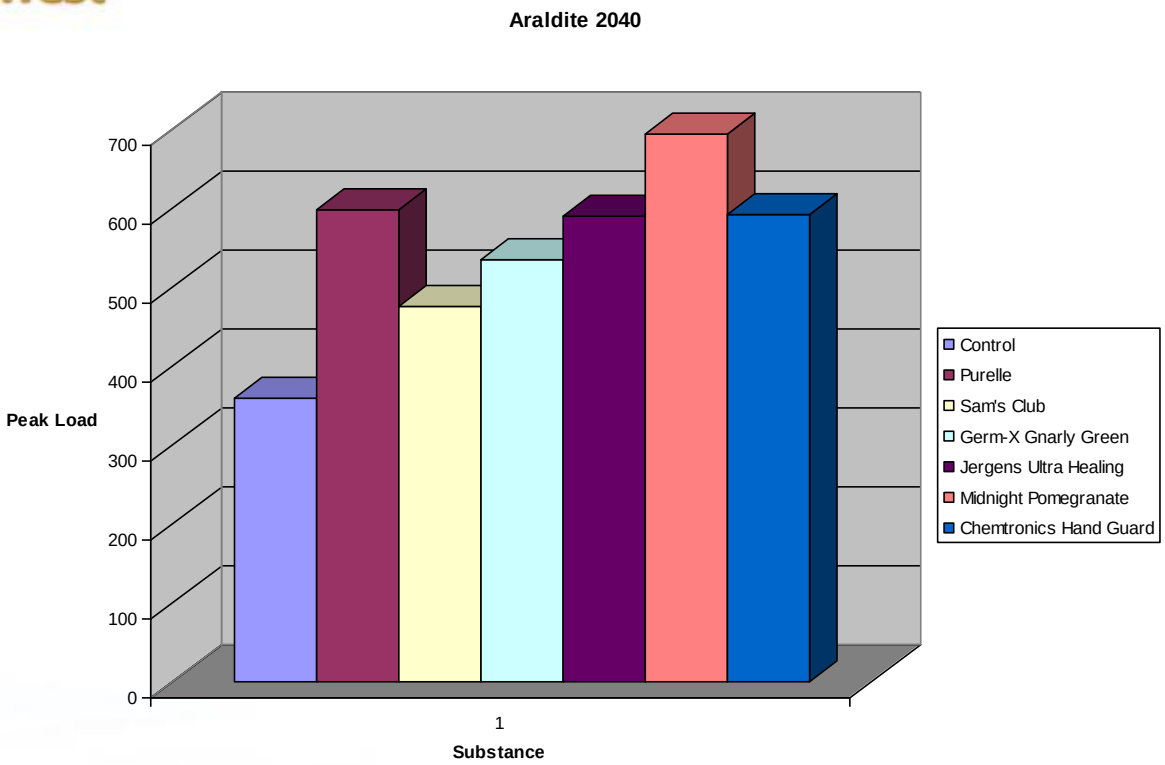
- One part, moisture cure, RTV silicone
- Many problems with inconsistent cure
  - Repeated the test with the lotions
  - Problems with accelerated cure
- All failures were at the handled interface
- I don't trust this data

Dow Corning SE 1700



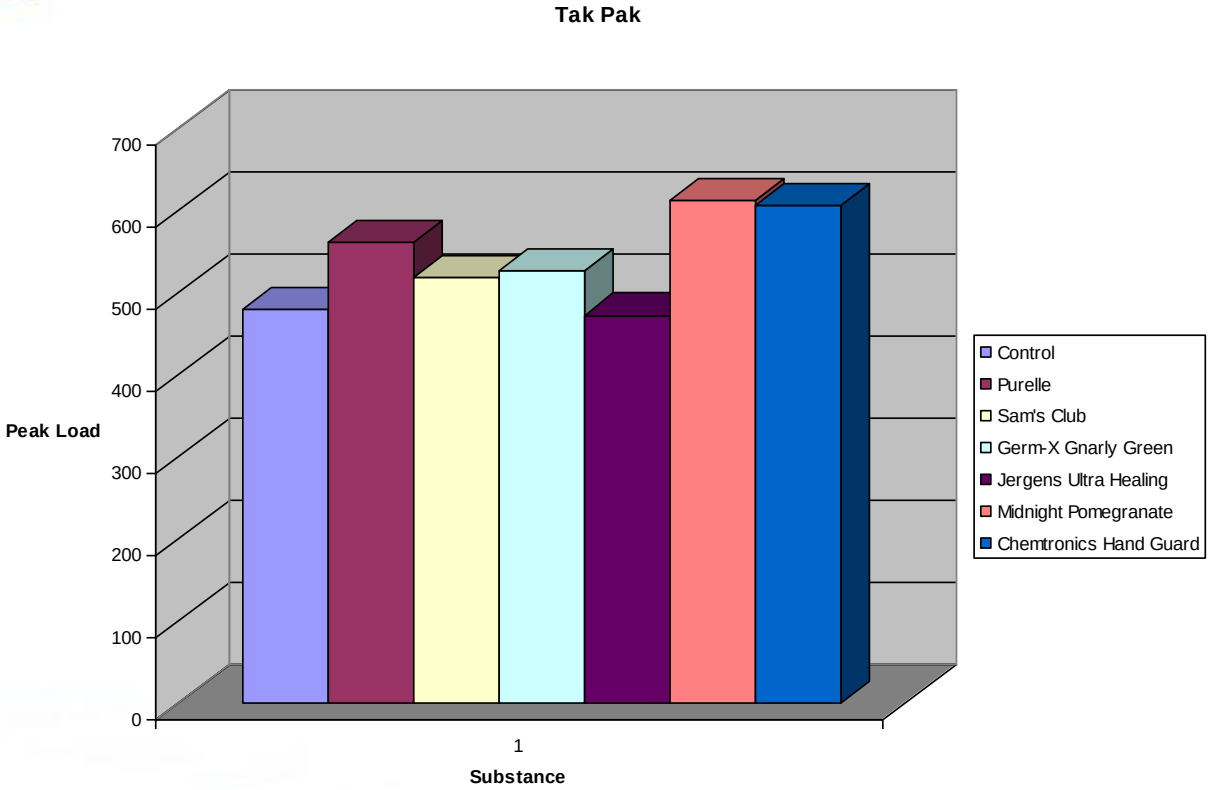
- Two part, catalyzed/heat cure silicone adhesive
  - Accelerated cure 1 hour @100C
  - Several days passed till testing
- Failures were at handled interface
- Purell samples – could be poisoning, could be experimental error

Araldite 2040 Urethane



- 2 part thermal cure urethane adhesive
  - Normal set 4 hours, accelerated cure 1 hour @100C
  - Several days passed till testing
- Failures were at handled interface

Loctite 382 Tak Pak Cyanoacrylate



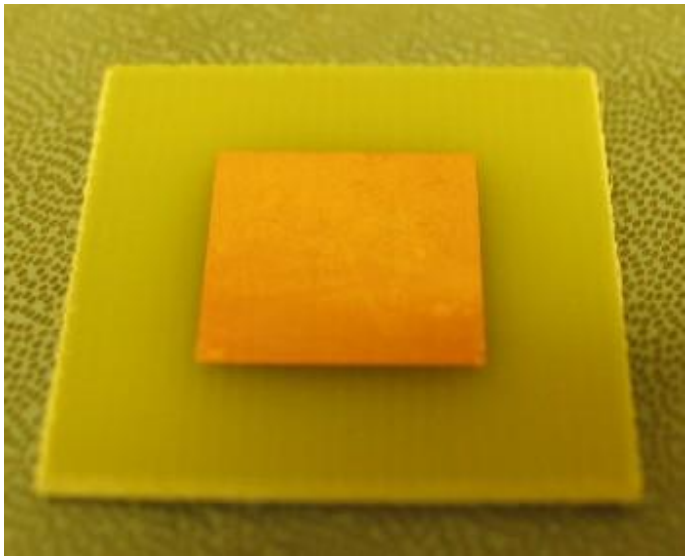
- 2 mil bond line (very thin)
- Accelerant used on one surface
- Instant curing though several days passed till test
- Failures were at handled interface

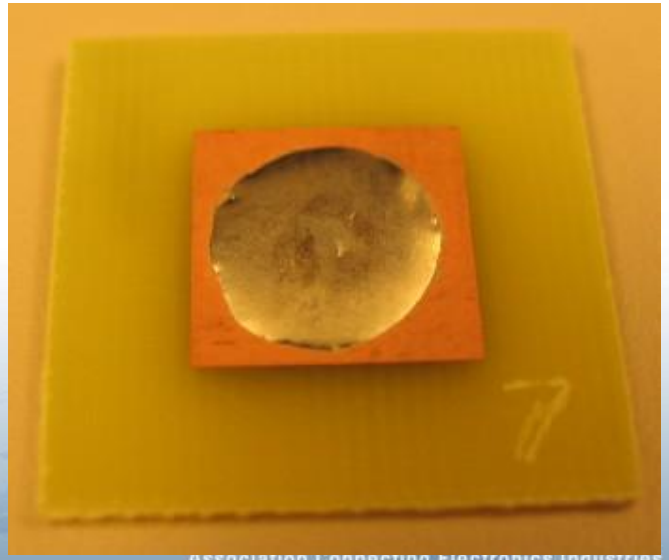
Adhesive Study Conclusions

- Almost all failures occurred at the interface where residues had been applied
- Most decreases in lap shear strength believed to be due to variations in cure
  - Especially the DC3145 RTV moisture cure
- Loctite 382 and Araldite 2040 appeared to be unaffected by residues
- Cure mechanism of the DC SE 1700 possibly poisoned by Purell sanitizer residues
  - Could also be experimental error
- Too much variability to draw firm conclusions
  - Need to redo this part with greater control
- Overall risk considered to be low
  - Operators wear gloves during adhesive application
  - Generally a cleaning operation prior to adhesive application

Solderability Study

- Do residues affect solderability?
- FR4 laminate, various finishes
  - Copper OSP
  - Tin Lead HASL
  - ENIG
  - Immersion Silver
- Printed with a set amount of solder paste (Indium SMQ92J)
  - Half over residues, half not
- Reflowed in a nitrogen inert tin-lead reflow process
- Cleaned in a standard saponified aqueous cleaning process
- Coupons dried then measured
- Spread Factor calculated





Solder Spread Results

- Rockwell Collins requires an 85% spread factor as a minimum
- All samples passed this 85% minimum
  - Most were in the 93-96% range
- No negative impacts from either sanitizer residues or lotion residues

Overall Conclusions

- Sanitizers and Hand Lotions are not a significant risk to us because:
  - We clean obsessively
    - If you are a no-clean assembler, might re-assess
  - Residues transferred are low and non-ionic in nature
  - Minor impacts on DWV
  - Variable levels for SIR but still most above 8 LogOhms
  - Most adhesive application operations are done with gloved hands, eliminating cross contamination
    - Highly variable methodology in this test
  - No adverse impact on solderability
  - Realistically, these residues are no worse than many of the other residues (e.g. flux, solvents) that get on peoples hands

Lessons Learned

- Adhesive methods too variable – must rethink
- Need to train the co-ops on the adhesive methods first
- Never ever let anyone else in your facility know you are doing an evaluation like this
  - Got dozens of calls and e-mails to test an operator's favorite brand to get on the "approved" list

Recommendations

- Sanitizers
  - The best method for cleaning hands is with soap and hot water
  - It is recommended that the hand sanitizers remain in rest room:
    - keep non-essential liquids out of a manufacturing area due to the potential for contamination
  - If kept to the rest rooms, there is additional time for any volatile materials to evaporate, minimizing any potential transfer of residues to the assemblies
  - Keep plastic containers away from ESD assemblies or treat with a staticide
  - Clean surfaces with isopropanol or denatured alcohol – simple solution

Recommendations

- Lotions
  - Do not initiate a “witch hunt” if you clean
  - Topically clean areas to receive adhesives prior to application
  - Wear gloves during adhesive application
  - Educate your operators on these residues

Electronics IPC Midwest

Questions?

Contact Information

Doug Pauls
Principal Materials and Process Engineer
Advanced Operations Engineering
Rockwell Collins
MS 108-101
400 Collins Road NE
Cedar Rapids, IA 52498
Desk: 319.295.2109

Truly A Man Worth Hiring