Understanding the Cleaning Process for Automatic Stencil Printers

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The automatic stencil wiper – first line of defense

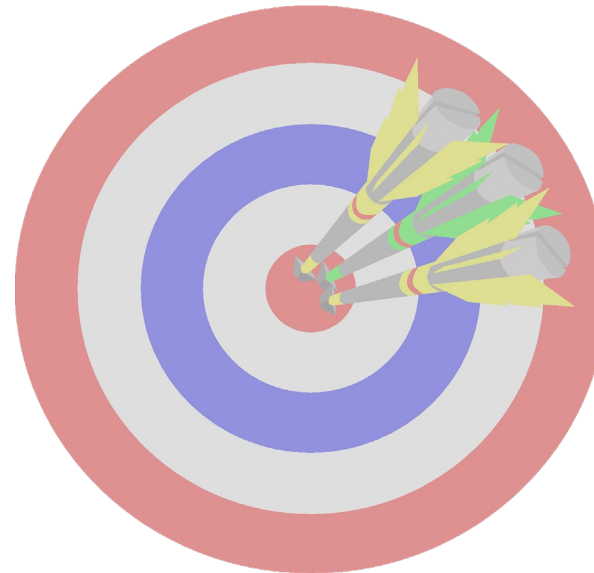
- The Printing process and why we need to focus on the wiping function
- Frequency of wiping
- Wiping options
- Wiper profiles
- Event driven wiping
- Advanced options
- Materials – Paper
- Materials – Solvent
- Preventive maintenance
- Random stuff

Primary goal of the printing machine

To print or place an exact amount of material in a precise location.

Simply - Align the board to the stencil

- Solder Paste
- Adhesives
- Flux
- Solder Spheres
- Thick Film

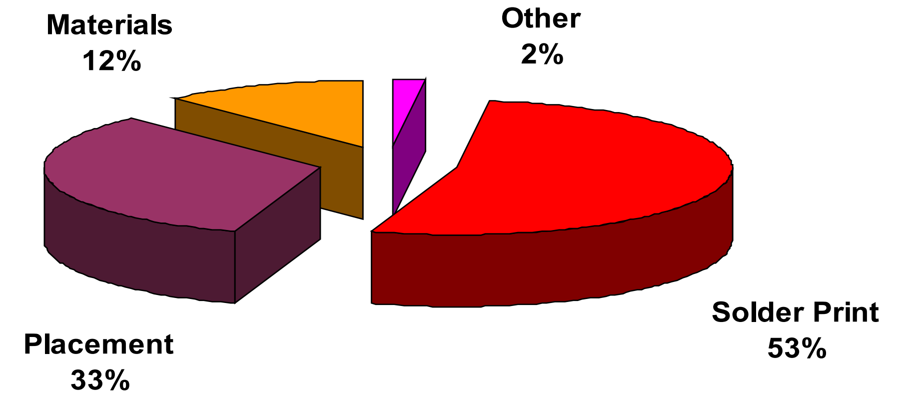


However the printing process has become much more than that.......

To address defects and yield – the printing process has the largest impact

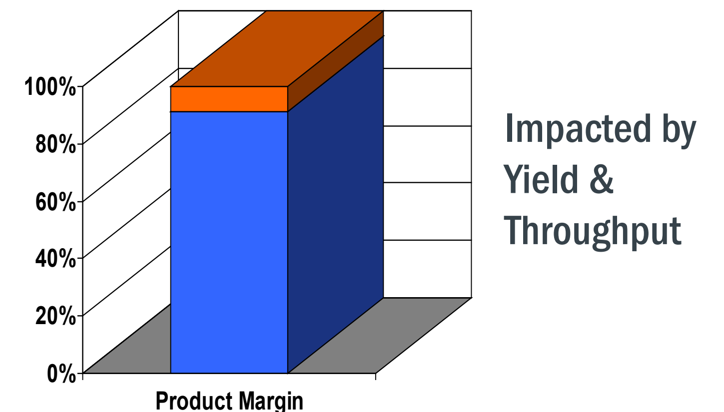
SMT Defects:

- Printing process is the major cause for yield loss (50-75%)
  Auto stencil wiping is the critical tool for addressing these defects.



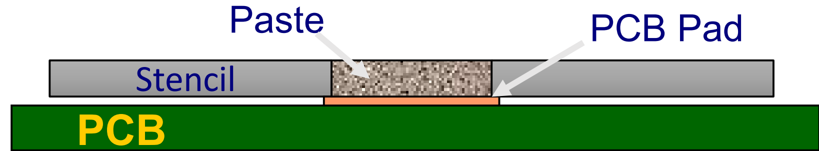
Printing Process is critical to success:

- Confirmed by 86% of SMT industry
  (Value in Use Survey 2016)
  Yield & Throughput influence up to 91% of the margin made on a particular assembly

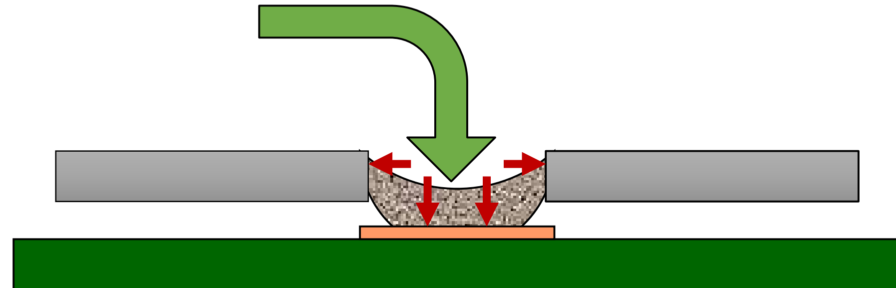


Impacted by Yield & Throughput

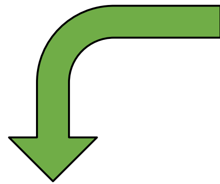
Why Wipe the SMT Stencil?

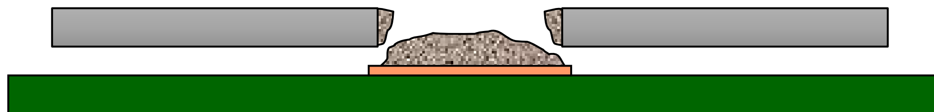


After solder paste flows into the apertures, it sets up and sticks to both the stencil walls and the pads.

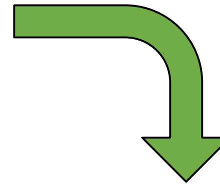


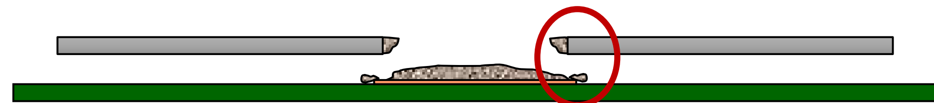
At separation, the forces holding the deposit to the pad must overcome the forces holding the deposit to the stencil walls. The paste near the wall stretches and snaps.





Depending on the pad wall area ratio, a portion of the paste will release to the PCB, while some will stay in the aperture

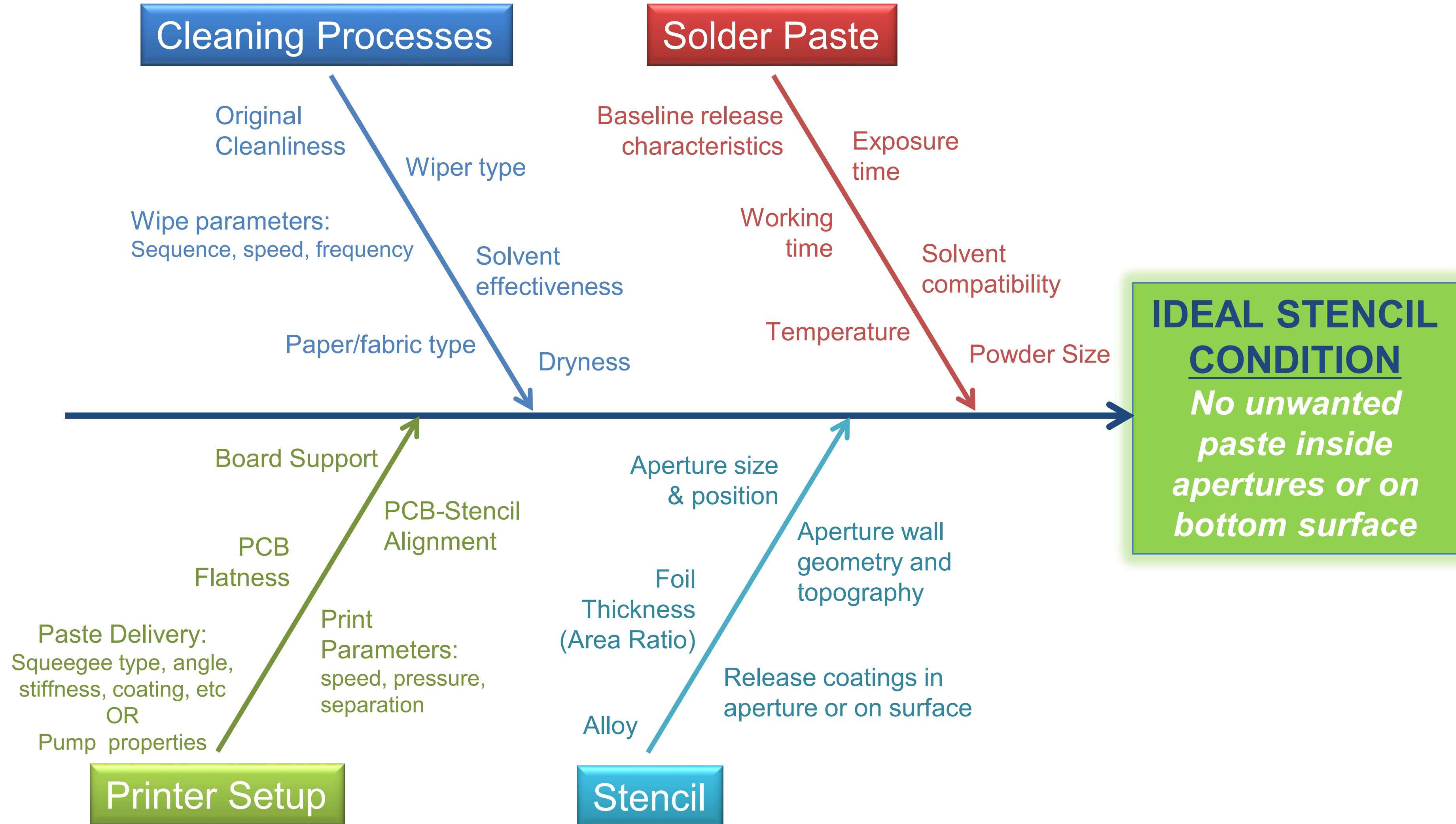




Some paste may also stick to bottom of stencil due to stringing, bad gasketing or pump out

Why do we wipe?

- Gasketing
- How often we wipe is a direct result of how well the board and stencil are positioned and sealed
- Contributors of gasketing issues:
  - Incorrect or varied board thickness
  - Variation of mask thickness
  - Encroachment of mask on pads
  - Pads recessed below mask
  - Nomenclature / silk screens
  - HASL
  - Board warpage
  - Bar code labels
  - Damaged or worn stencils
  - Loss of stencil tension
  - Insufficient tooling / support
  - Board holding interference
  - Vacuum
  - Squeegee over pressure
  - Mismatch of aperture to ball size
  - Machine contamination

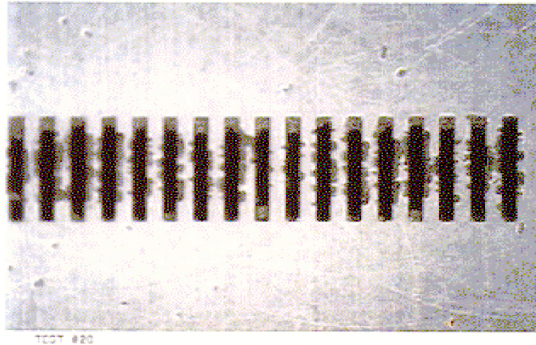

Cleaning Processes
Original Cleanliness
Wiper type
Wipe parameters: Sequence, speed, frequency
Solvent effectiveness
Paper/fabric type
Dryness
Solder Paste
Baseline release characteristics
Exposure time
Working time
Solvent compatibility
Temperature
Powder Size
IDEAL STENCIL CONDITION
No unwanted paste inside apertures or on bottom surface
Board Support
PCB-Stencil Alignment
PCB Flatness
Print Parameters: speed, pressure, separation
Paste Delivery: Squeegee type, angle, stiffness, coating, etc OR Pump properties
Printer Setup
Aperture size & position
Aperture wall geometry and topography
Foil Thickness (Area Ratio)
Release coatings in aperture or on surface
Alloy
Stencil

Taking the guess work out of Frequency

- Most customers “Guesstimate” the wiper frequency
- Apply same frequency number to each individual printer program
- Issue: wiping frequency is not linear
- Under-wiping
  - Allow paste to build up on bottom of stencil
  - Solder balls, bridging poor gasketing
  - Allows paste to build up in apertures resulting in clogging and decreased material transfer
- Over-wiping
  - Elimination of flux that acts like lubricant during material transfer
  - Excess paper and solvent consumption
  - Cycle time hit
- Simple DOE can determine a starting point for wiping
- Use of onboard Inspection or down stream SPI is another tool to determine or adjust frequency

Determining Wiper Frequency Manually

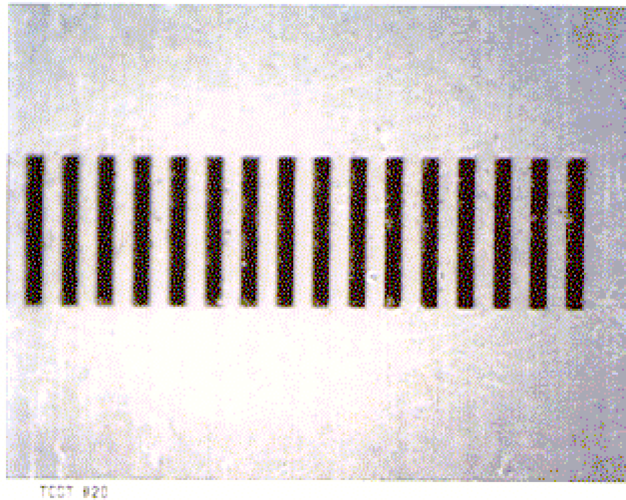
- Inspect the stencil and ensure the stencil is clean
- Print 1 board
- Jog vision system to inspect stencil bottom surface for paste residue (Squeeze Out)
- If there is no evidence of Squeeze Out, print another 1-2 boards
- Repeat this until you see Squeeze Out

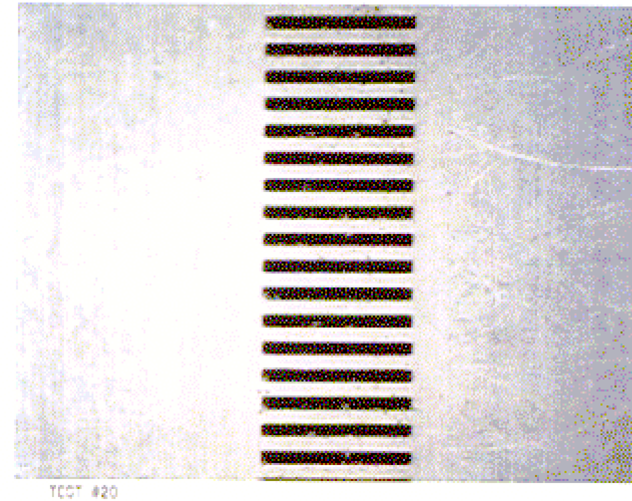


Solder paste residue bridging the gaps between the apertures

Clean Stencil

Subtract 1 - 2 prints from the determined number of prints for your “wipe frequency”





Stencil after a wiper cycle

Wipe Types

- Dry Wipe – most common used – addresses the solder balls on the bottom of the stencil caused by bleed-out from the aperture
- Vacuum Wipe – address the aperture to remove paste and address clogging of the aperture
- Solvent wipe – used to address the flux on the bottom of the stencil

Wipe frequency

- >15 – excellent gasketing – aperture sizes are not challenging
- 10-15 – good gasketing with the occasional anomaly
- 5-10 – Average wipe frequency – some challenging apertures – some gasketing issues
- 2-5 – Poor gasketing – mismatch of materials – stencil design issues – very challenging components
- 1-each print – something is wrong - requiring a wipe after every print – micro components – pushing envelope

Wiper profile – wipe 1

File View Operations Utilities Help

Edit Process Programs (Ed Demo 81018)

Setup Info | Auer Boat | Board Handling | Tooling | Vision | Separation | Print Head | Wiper | Dispenser | Barcode | Inspection | Boa

Enable Wiper

Wiper Profiles

Add Profile | Remove Profile | Change Profile | Edit Selected Profile

Event	Profile	Frequency	Stroke Graphic
On Board	Medium Wipe	8	

Paper Feed Mode: Continuous

Adjust Stroke Length: 0.00000 in

Hop Over: 0.00000 in

NOTE: If Stroke Length + Hop Over exceed the wiper travel range, the stroke will be truncated.

OK Cancel

Machine Status
Ready

Next Squeegee
Rear To Front

Production Status

SMEMA
Waiting Upstream
Downstream Busy

1 2 3

Alarm Type | Severity | State | Date | Details

Temperature: 76.9 Deg F Humidity: 33 pct | Administrator | Units: Imperial | Automatic | Print Limit: None | Production Timers: Active

Wiper profile – wipe 2

File View Operations Utilities Help

Edit Process Programs [Ed Demo 81018]

Setup Info | Auer Boat | Board Handling | Tooling | Vision | Separation | Print Head | Wiper | Dispenser | Barcode | Inspection | Boa

☑ Enable Wiper

Wiper Profiles

Add Profile | Remove Profile | Change Profile | Edit Selected Profile

Event	Profile	Frequency	Stroke Graphic
On Board	Medium Wipe	8	
On Board	Medium Plus	16	

Paper Feed Mode: Continuous

Adjust Stroke Length: 0.00000 in

Hop Over: 0.00000 in

NOTE: If Stroke Length + Hop Over exceed the wiper travel range, the stroke will be truncated.

OK Cancel

Machine Status Ready

Next Squeegee Rear To Front

Production Status

SMEMA Waiting Upstream Downstream Busy

1 2 3

Alarm Type	Severity	State	Date	Details

Temperature: 76.6 Deg F Humidity: 34 pct | Administrator | Units: Imperial | Automatic | Print Limit: None | Production Timers: Active

Wiper profile – wipe 3

File View Operations Utilities Help

Edit Process Programs (Ed Demo 81018)

Setup Info | Auer Boat | Board Handling | Tooling | Vision | Separation | Print Head | Wiper | Dispenser | Barcode | Inspection | Boa

☑ Enable Wiper

Wiper Profiles

Add Profile | Remove Profile | Change Profile | Edit Selected Profile

Event	Profile	Frequency	Stroke Graphic
On Board	Medium Wipe	8	
On Board	Medium Plus	16	
On Board	Heavy Wipe	40	

Paper Feed Mode: Continuous

Adjust Stroke Length: 0.00000 in

Hop Over: 0.00000 in

NOTE: If Stroke Length + Hop Over exceed the wiper travel range, the stroke will be truncated.

OK Cancel

Machine Status Ready

Next Squeegee Rear To Front

Production Status

SMEMA Waiting Upstream Downstream Busy

1 2 3

Alarm Type | Severity | State | Date | Details

Temperature: 76.8 Deg F Humidity: 33 pct | Administrator | Units: Imperial | Automatic | Print Limit: None | Production Timers: Active

Additional Parameters

- Recent studies have shown a Vac/Vac/Dry or a Solvent/Vac/Vac/Dry wipe is most effective
- The first vacuum wipe pulls solder from the aperture and forms stalactite's hanging from the aperture

Continuous vs index mode

- **Continuous** mode – advances the paper during wiper motion ensuring fresh paper is applied during the wipe – maximum paper consumption
- **Index** mode – paper is advanced a pre-determined amount then is stationary during wiper motion – minimum paper consumption
- **Continuous** has shown to clean better and prevent “snowplowing” of the paste particularly when vacuuming

Hop over

- Used to address snowplow effect – retracts plenum and moves over end point

Overtravel

- Wipe stroke pre-determined by squeegee stroke – allows extension of stroke – eliminates contamination of gold fingers if present

Wiper speed

- Recommended speed of wipe or solvent stroke – 2 Inch/second
- Recommended speed of Vacuum stroke – 1 inch/second

Event driven wiping

- Key events that can trigger defects:
  - Pause in printing
  - First 1-4 prints
  - Additional paste added
- Custom Wipes to target specific events in the printer
- Pause in printing
  - Based on thixotropic index of paste
  - Recommend a medium plus wipe
- Kneed function
  - Squeeze out is the issue
  - Heavy on the dry wipe / no solvent
- During paste dispense
  - Utilize printer window to do additional wipe

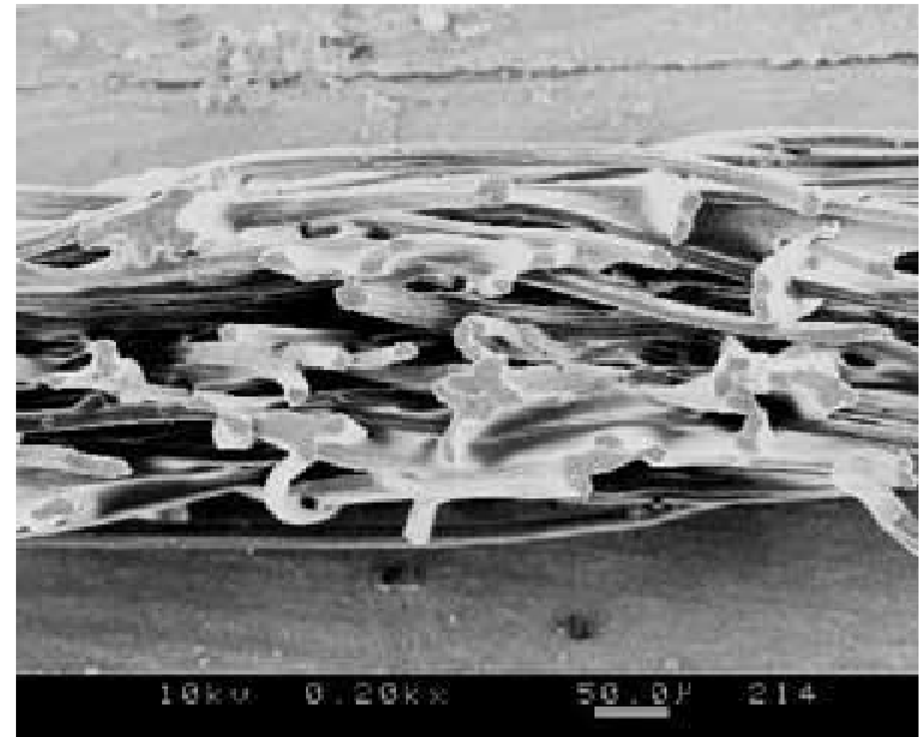
Wiper Paper

- "Printers are only as good as the material that you put into it" – the same can be applied to the wiper
- Using low-cost paper directly influences the wiper ability to clean the stencil
- In general, there are two types of papers used in stencil wiping: papers made with synthetic fibers held together with glues (called binders), and papers made from a mix of natural and synthetic fibers that do not use glue.
- The papers ability to absorb both the solder and solvents reflects on the cleanliness of the stencil

Glue Binders

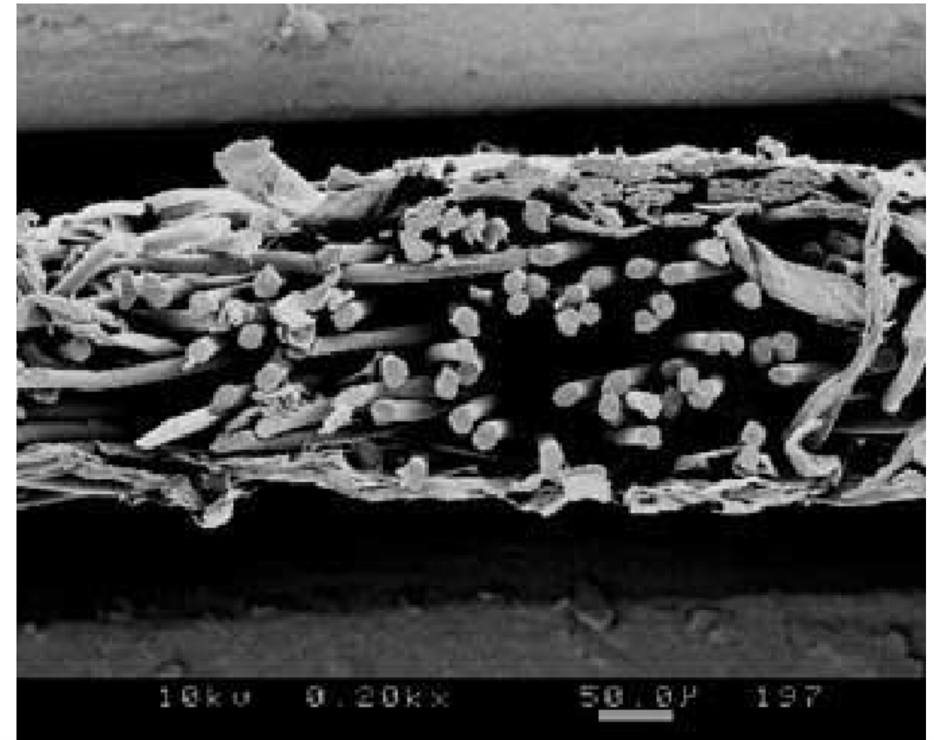
- Synthetic fibers found in paper usually are polyester or rayon.
  - In general, about 30% of the paper's weight is found in binders.
  - These papers have a harder surface, lower tensile strength, absorb less contamination and are less expensive than glue-less versions.

- Cross-section microphotograph of polyester paper made with binders, enlarged 200 times.
  - The fibers are coated with glue, making surfaces hard and unable to absorb contamination.
  - Most empty space in the wipe has been filled with binders, reducing the ability to pick up solder paste.



Hydro-Entangling

- Some paper is made using a process called “hydro-entangling”
  - This process involves laying raw fibers of polyester and cellulose onto a conveyor belt and intertwining the fibers with high-pressure jets of water
  - Heat and pressure then are used to dry the slurry into the proper configuration
- Lacking glue, hydro-entangled papers have a softer feel
  - They are more absorbent, thicker and stronger than ordinary paper
  - The flat, rough cellulose fibers (thin, top layer) are highly absorbent, but weak and prone to lifting
  - The rounder polyester fibers (middle and bottom) provide structural strength and open space to pick up solder paste



Hydro-Entangled, Single-Fiber Polymer

- A new material consisting of a hydro-entangled, single-fiber polymer based on regenerated cellulose was developed.
- This fabric, which is completely synthetic, contains no natural fibers or binders.
- Under a microscope, the long, thin, hard fibers are identical and homogenous, giving the fabric an open structure.
- The material is a pale, off-white color and highly absorbent.
- The fabric scores well on the solder paste pick-up tests for non-liquid contamination.

- The fibers are smooth, consistent and hard.
  - The paper includes extensive voids and cavities to pick up solder paste.
  - There is no cellulose to rip or shred, or binders to dissolve and contaminate the stencil.

Paper Compared (Dry Wipe Data Only)

	High End Paper	Typical Paper	Paper Using Glue
Base Weight (oz/per yd^2)	1.87	1.56	1.11
Tensile Strength (LB’s)	29	31	16
Thickness (Mils)	15	12	11
Absorption (ML H^2O/M^2)	391	290	231
Fiber Shedding (particles >0.5 mm/m^2. x103)	127	1,130	20
Extractable IPA %	0.08%	0.07%	0.98%
Solder Paste Pick-up Test	77%	61%	33%

Solvents

- Usage on solvents split down the middle with yes or no
- A NO to solvent is often based on a negative experience that can be traced to:
  - Negative effect on the print process following solvent application
  - Poor solvent performance
  - Application method used
  - Mismatch of solvent to printing material
  - Misunderstanding of what solvents do
- Most common solvent used is Isopropyl Alcohol – which now has its issues
- Chemistry companies, prior to 7 years ago, did not understand the printing process and its requirements
- Often what was being recommended to be applied to the printer is also used to clean boards or stencils in a tank
- Requirements of the print process and new chemistries have improved performance in the printer and have a targeted this application

Isopropyl Alcohol

Alcohol Types

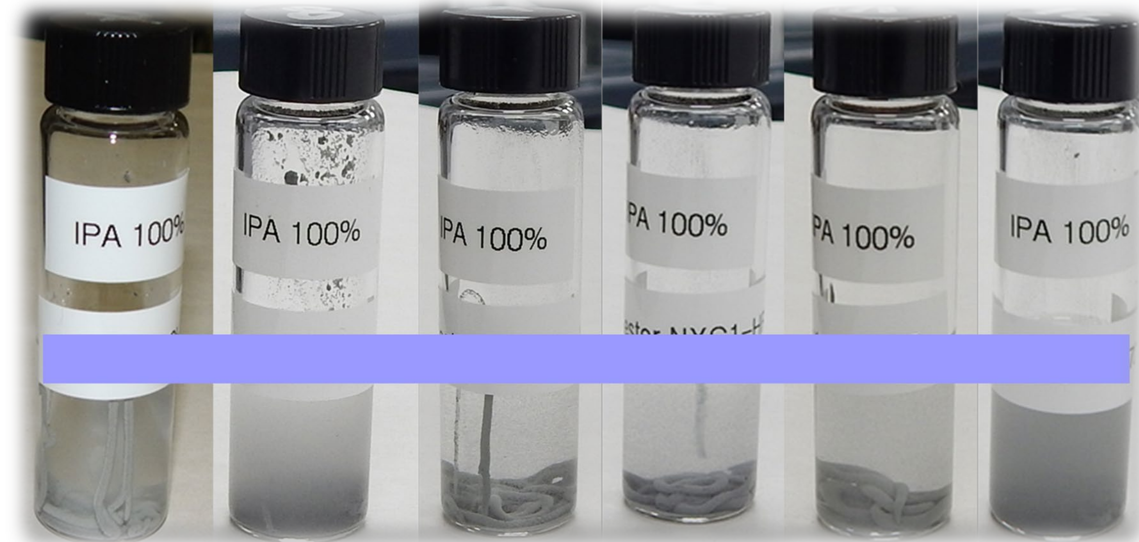
- Ethanol – Fermented / yeast – consumable
- "*the root cause and solution to all of life's problems*" – Homer Simpson
- Methanol – Fermented / wood – toxic
- Ethanol + Methanol = denatured alcohol
- Propanol – Fermented / bacterium (Clostridium Acetobutylicum) - feeds on cellulose – common name – Rubbing Alcohol
- Isopropyl - mixture of Propanol and ethyl methyl ether - secondary alcohol that uses a binder

Issues with Isopropyl

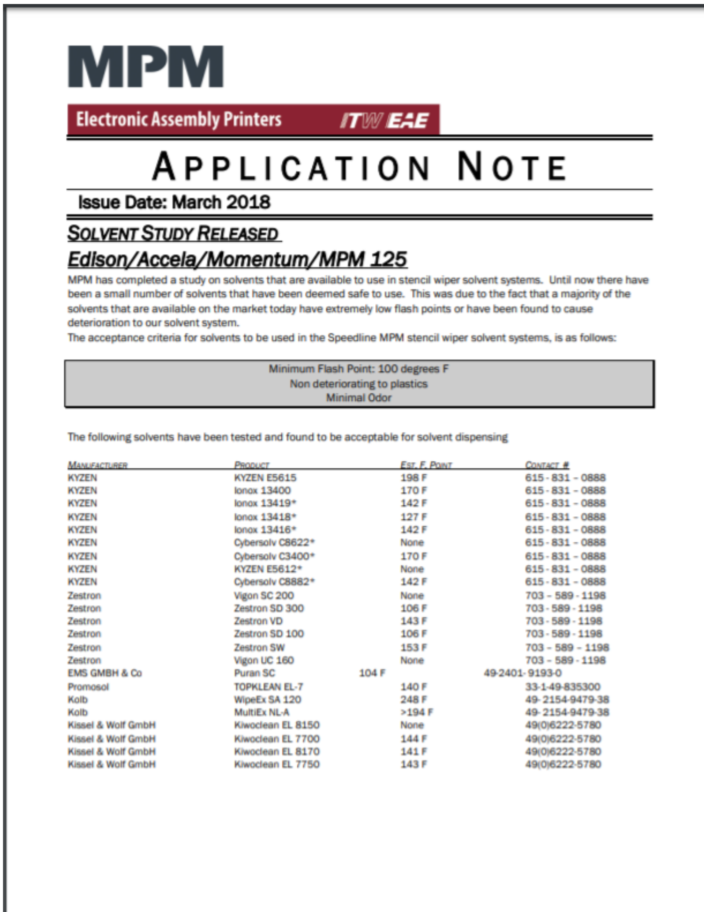
- Flash Point = 53 F (open cup) 55 F l (closed cup)
- Defined as a Class 1B flammable liquid (same as Gasoline)
- Definition of a flammable liquid – flash point below 100 F
- National Fire association
- US Environmental Protection Agency (EPA)
- US Occupational Safety and Health Administration (OSHA)
- Previously Isopropyl was a match as it was the solvent of choice used in paste
- Newer paste designs use a solvent to increase stencil life – can react badly to Isopropyl
- Results in "clumping" of paste when combined with flux
- Less than 90% purity will leave residue on stencil that will result in poor transfer efficiency

Solvent Checklist

- Chemical compatibility with the solder paste
  - Dissolve the flux & free up the powder spheres
  - No bad reaction with paste that affects paste viscosity
- Process compatibility
  - Dry evenly and at a controlled rate
  - No adverse paste reactions
  - Leave no residue
- Equipment compatibility
  - Does not attack valves, seals, pumps, reservoirs
- Safety & health
  - Non-toxic, non-flammable, low- (or no-) odor



Approved Solvents



MPM

Electronic Assembly Printers ITW EAE

APPLICATION NOTE

Issue Date: March 2018

SOLVENT STUDY RELEASED

Edison/Accela/Momentum/MPM 125

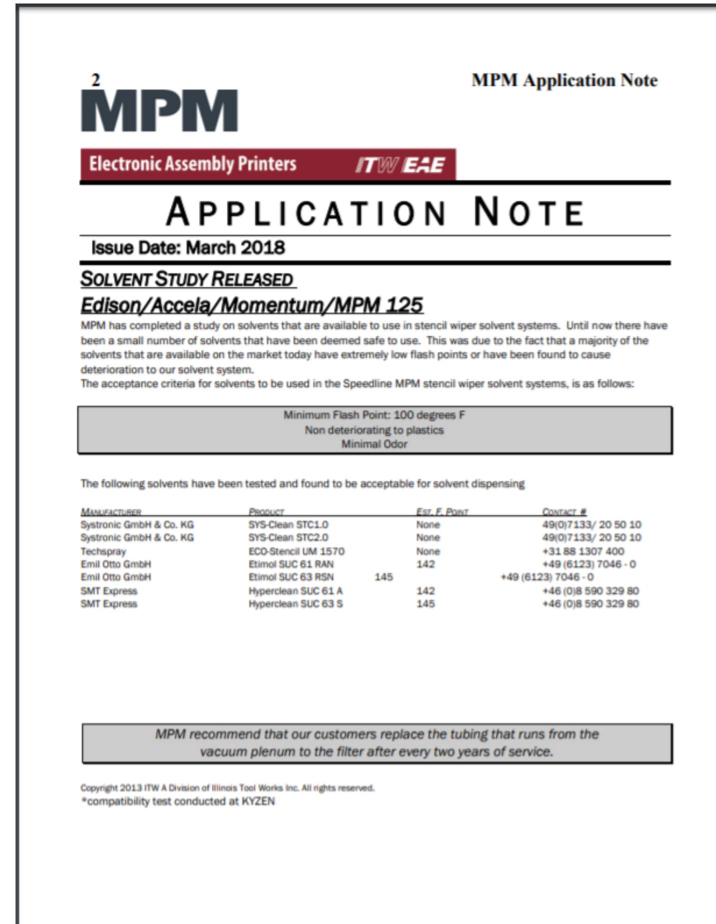
MPM has completed a study on solvents that are available to use in stencil wiper solvent systems. Until now there have been a small number of solvents that have been deemed safe to use. This was due to the fact that a majority of the solvents that are available on the market today have extremely low flash points or have been found to cause deterioration to our solvent system.

The acceptance criteria for solvents to be used in the Speedline MPM stencil wiper solvent systems, is as follows:

Minimum Flash Point: 100 degrees F
Non deteriorating to plastics
Minimal Odor

The following solvents have been tested and found to be acceptable for solvent dispensing

Manufacturer	Product	Est. F. Point	Contact #
KYZEN	KYZEN E5615	198 F	615 - 831 - 0888
KYZEN	Ionox 13400	170 F	615 - 831 - 0888
KYZEN	Ionox 13419*	142 F	615 - 831 - 0888
KYZEN	Ionox 13418*	127 F	615 - 831 - 0888
KYZEN	Ionox 13416*	142 F	615 - 831 - 0888
KYZEN	Cybersolv C8622*	None	615 - 831 - 0888
KYZEN	Cybersolv C3400*	170 F	615 - 831 - 0888
KYZEN	KYZEN E5612*	None	615 - 831 - 0888
KYZEN	Cybersolv C8882*	142 F	615 - 831 - 0888
Zestron	Vigon SC 200	None	703 - 589 - 1198
Zestron	Zestron SD 300	106 F	703 - 589 - 1198
Zestron	Zestron VD	143 F	703 - 589 - 1198
Zestron	Zestron SD 100	106 F	703 - 589 - 1198
Zestron	Zestron SW	153 F	703 - 589 - 1198
Zestron	Vigon UC 160	None	703 - 589 - 1198
EMS GMBH & Co	Puran SC	104 F	49-2401- 9193-0
Promosol	TOPKLEAN EL-7	140 F	33-1-49-835300
Kolb	WipeEx SA 120	248 F	49- 2154-9479-38
Kolb	MultiEx NL-A	>194 F	49- 2154-9479-38
Kissel & Wolf GmbH	Kiwoclean EL 8150	None	49(0)6222-5780
Kissel & Wolf GmbH	Kiwoclean EL 7700	144 F	49(0)6222-5780
Kissel & Wolf GmbH	Kiwoclean EL 8170	141 F	49(0)6222-5780
Kissel & Wolf GmbH	Kiwoclean EL 7750	143 F	49(0)6222-5780



2 MPM Application Note

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Manufacturer	Product	Est. F. Point	Contact #
Systronic GmbH & Co. KG	SYS-Clean STC1.0	None	49(0)7133/ 20 50 10
Systronic GmbH & Co. KG	SYS-Clean STC2.0	None	49(0)7133/ 20 50 10
Techspray	ECO-Stencil UM 1570	None	+31 88 1307 400
Emil Otto GmbH	Etimol SUC 61 RAN	142	+49 (6123) 7046 - 0
Emil Otto GmbH	Etimol SUC 63 RSN	145	+49 (6123) 7046 - 0
SMT Express	Hyperclean SUC 61 A	142	+46 (0)8 590 329 80
SMT Express	Hyperclean SUC 63 S	145	+46 (0)8 590 329 80

MPM recommend that our customers replace the tubing that runs from the vacuum plenum to the filter after every two years of service.

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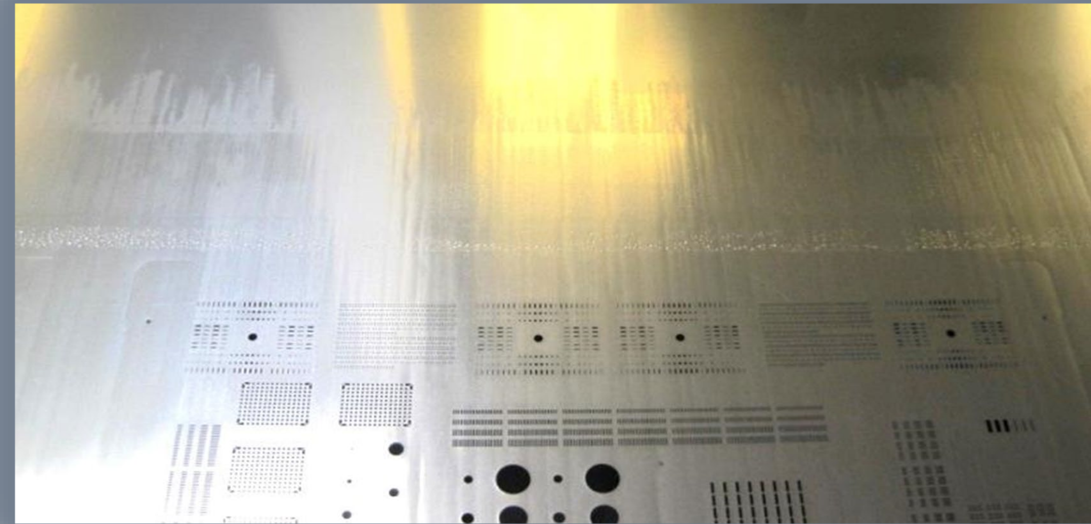
*compatibility test conducted at KYZEN

Solvent conclusions

- Evaporation rate of chemistry critical to printer application
- Good indicator is the flash point of the material – the lower the flashpoint – the better the evaporation rate
- Test for residues – mirror test
- Avoid water-based solvents for the printer
- Petroleum based solvents should be also be avoided
- Check with your paste manufacturer for compatibility of solvents
- Work with chemistry vendors for best application
- Always start wipe cycle with the solvent wipe
- Match the solvent to the material and application – one size does not fit all



Preventive Maintenance

- Check the owner's manual for preventive maintenance for your individual machine
- Replace Vacuum filters based on requirements
- Check main drive belts/chains for proper tension
- Clean all bushings and remove any foreign material from wiper assembly
- Check and replace vacuum hosing as needed especially if using solvent
- Remove plenum and remove any material build up in trough – check plenum bow if present
- Inspect plenum for damage – verify match of plenum to stencil/foil size

Random Stuff

- Motion additions to wiping process has shown no improvement in wiping
  - Ultrasonic
  - X- Motion
- Nano- coating of stencils
  - Confusion on Aculon Nano-Clear – reduces wipes/ buildup of paste – not focused on release
  - Nano-coating will wear from the bottom of stencil
  - New coating methods – Plasma coating / baking improve coating life
- Paper wash
  - No input
- Paperless wiper development
  - Effectiveness of wipe
  - How to indicate alternative wiping material is contaminated
  - TBD

Summary

- Under stencil wiper is the first defense against defects
- Matching the wiper profile and frequency to the individual boards – where one size does not fit all
- The wiper like the printer in general – process as good as the material applied
- Base wiper paper used on performance not cost
- Solvents when used correctly can contribute a positive influence to the stencil cleaning process
- Keep up with wiper PM for optimum performance