Cleaning Of Assembled PCS A Crucial Way of Enhancing Product Reliability and Avoiding Problems in the Field

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Abstract

Over the last years more and more International newspapers reported in Europe / USA and Japan:

"Tunnel train got stuck under the Channel – thousands of people stranded "
Recall of thousands of cars to workshops for control and repair
Power Failures left households without energy for hours.

Very often news like this relate to malfunctions of electric and electronic circuits under adverse conditions or sometimes even in normal operating environment.

Considering that in the automotive industry – one of the most dynamic and innovative driving economic force in industrialized countries the number of complex electronic circuits will increase drastically over the next decade - ensuring reliability will become a focus in high- quality electronics production.

Highly integrated circuitry and the permanent miniaturization makes high quality production more and more crucial.
The reliability of such complex circuitry can be ensured using cleaning in all steps of the production process, from stencil cleaning to PCB cleaning prior to coating or painting in order to increase the reliability and life span of the units into which such circuitry will be installed.

The use of environmentally friendly water based chemistries instead of ozone layer depleting VOC-containing solvents – once the standard in the electronics industry- as well as the use of respective machines that operate under the condition of saving energy and resources will gain more and more importance and cannot be neglected anymore.

The presentation will deal with all kinds of aspect of cleaning to ensure the reliability of electronic circuitry in ever changing operation conditions in the most important industrial areas.

Over the last years consumers have read more and more often in newspapers or even got information on national news channels about major recalls of products even from internationally reputed corporations in different industrial fields .
This is particularly obvious in of the driving industries for innovation and expertise in the electronics field – the automotive industry.
Without mentioning any names companies previously not known for quality concerns are now making more and more often the headlines.Even though not many details are disclosed often it is electronics which fail or cause problems in the field and which are the reason for such re-calls.

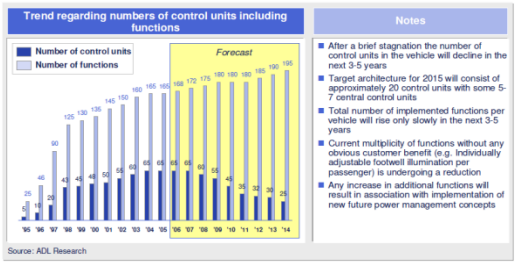
We can assume that there are some general explanations/ implications

- Separation of R&D and prototyping of products to mass production
  The place of development of an electronics assembly is only in very few cases the place where the product will finally be manufactured
- Globalization
  International procurements of components and production capacity is more and more dominant in the market
  Miniaturization of components and packaging
  Multifunctional highly integrated circuitry will be used more often in higher packing densities and ever smaller available space yet with higher demands for reliability.

Reports of marketing and research institutes close to the automotive industry show that over the next years the number of central control units in a car will go down with the number of functions per unit rising.
That means more integrated circuitry and higher packing density yet also more issues to consider.

Table 1: Central control units

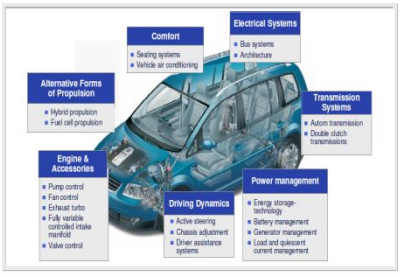
For numbers of control units in the car a reduction is indicated; existing and any new future functions must be distributed over fewer control units



With an ever increasing need for safety and control we see a multitude of new functions coming up.

Figure 1: Increased safety and control in cars

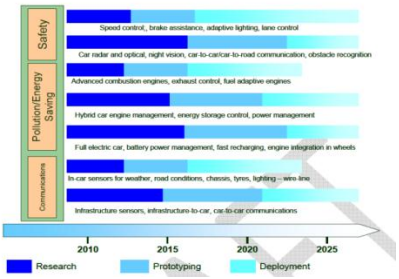
The Study deals with future use of power electronics in automotive technology



While effects need to be addressed and monitored closely and carefully in order to improve long term reliability of electronics in general on the production level there are numerous influences on the reliability of assemblies that need to be looked at as well

Figure 2: More and comprehensive functions

Timeframe



On the production level this is clearly the residues on the electronics circuits / PCBs which to some extent are avoidable but to some not.
Cleaning those residues is important for long term reliability.

Cleaning of course is a concept for all stages of electronics production not only for the assembled PCBs and electronic circuitry. The following table gives an overview of typical areas and types of contamination to consider.

Table 2: Cleaning - a concept in all stages of production

Segment	Goods to be cleaned	Contamination				
		SMD-Adhesive	SMD-Paste	Flux (Colophonium condensation)	Flux (Colophonium residues)	Dust / oil / grease
FINE-CLEANING	1 2 Screen/PumpPrint-Stencils	X	X			
	3 Solder carriers / masks				X	X
	4 Misprints (PCB's)	X	X		X	
	5 PCB ass. / DCB's / Hybrids				X	X
MAINTENANCE-CLEANING PARTS-CLEANING	6 Condensation traps (Filter, radiators from convection reflow ovens)			X	X	X
	Reflow oven (Process zone)				X	X
	7 Solder-frames				X	X
	8 Squeegees, scrapers	X	X			
	Machine parts (Flux unit, sheet metal, pumps, etc.)			X	X	X
	9 Process chamber (Soldersystems)			X		X
	10 11 PCB-storage racks / trays				X	X
	12 ESD-boxes / container				X	X
	Other machine parts	X	X	X	X	X

If we take the example of the automotive industry we have the situation that a car should run reliably forgive the European examples– in the South of Sicily (Italy) where we see outside temperatures of 50°C and more in summer– in Great Britain with its high level of rainfalls per year almost all through the year – and in the cold North of Sweden with temperatures in winter of minus 30° or less.
Electronics subject to such influences need to be resistant to temperature and humidity

Different environments put additional and considerable stress on electronic assemblies.

Besides the automotive industry there are of course other quality dependent industries which are affected, such as railway, medical, the air and space industry as well as industrial electronics.
In order to control and minimize the effects of such environmental impacts often electronics will be protected using painting, coating or varnishing.

At this point in production cleaning comes in to enhance and ensure reliability.

Nobody likes to have PCBs with all kinds of defects or surface contamination or with an appearance that already indicates "Problem ahead".

What are the reasons for cleaning? It is a general requirement, removal of contaminants and residue which can cause problems in the field. Typical applications are
Wire bonding , coating, varnishing and often customers require cleaning for optical reasons especially in visible areas. Amber-colored residue just does not look nice where it should not be appearing.

Likewise important is the solving of problems arising from misprints or after rework for example. While nobody really likes a misprint and many even deny having or knowing them at all, they pose a risk and that risk should be avoided or removed . Flux on flux in case of rework is not a way to go. Here cleaning-off all the residue is the only way.
besides of course throwing away which however makes production more expensive in the long run.

That brings us to the point of No-clean paste and fluxes which indicates that cleaning is not necessary still let us take a look a 2 statements to be found:

- International producer of fluxes and paste
- French research institute specialized in soldering

Even the manufacturer admits that on certain occasions even no-clean fluxes should be cleaned. It is just more difficult to do so and requires special processes and chemistries.

Speaking about cleaning the way we understand it is cleaning using environmentally friendly and non-hazardous water based cleaning detergents.
Detergents that have considerable advantages over previously well known and popular VOC (volatile organic compounds) containing solvents.

There are some major arguments against VOC´s and in favour of water based detergents.

But with light comes shadow – nothing is only good and nothing is only bad.

When handling water based detergents in PCB cleaning systems the rinse water issue needs to be addressed.
Drag-over of detergent / contaminant residue will contaminate the rinse water and we need to look at limit values to determine rinse water quality prior to draining it into sewerage networks
Those limit values will differ from country to country, even from village to village.

A water analysis can help to determine when rinse water values are still permissible to allow draining and modern cleaning systems help to change rinse water automatically in order to respect those values.
The cost for such a water analysis is fairly moderate versus the advantages gained.

Table 3: Limit values for rinse water disposal in Germany

Requirements for the rinse water quality in PCB production (in mg/l)										
NH4-N	***COD***	***Iron***	***Fluoride***	***VOC***	***Phosphor***	***Toxicity***				
50	*600*	*3*	*50*	*10*	*2*	*6*				
Requirements for the rinse water quality n PCB production prior to mixing (mg/l)										
AOX	***Arsenic***	***Lead***	***Chrom***	***Chrom VI***	***Cyanide***	***Copper***	***Nickel***	***Silver***	***Sulfid***	***Tin***
1	*0,1*	*0,5*	*0,5*	*0,1*	*0,2*	*0,5*	*0,5*	*0,1*	*1*	*2*
Limit values differ from country to country										

It is also possible, yet with a very high energy demand to evaporate such rinse water, yet the cost must be calculated for both investment and operation of such systems.

Depending on the number of cycles and the amount of rinse water volume to be dealt with a collection in storage containers with subsequent pumping in tankers and professional disposal by industrial waste collection companies is another possibility. The cost can be calculated fairly easily

Controlling the cleaning result of course is important but everyday business
Optical inspection, climatic cyclic testing and ionic contamination measurement as per prevailing norms and regulation such as reference IPC and other applicable industry standards help to make sure that cleaning offers solutions to improve functionality and long term reliability of electronic assemblies.

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General explanations / implications: product re-calls

- Separation
- Globalization
- Miniaturization
- Production

R& D - Production
International Purchasing
Packing densitypackaging
Residues

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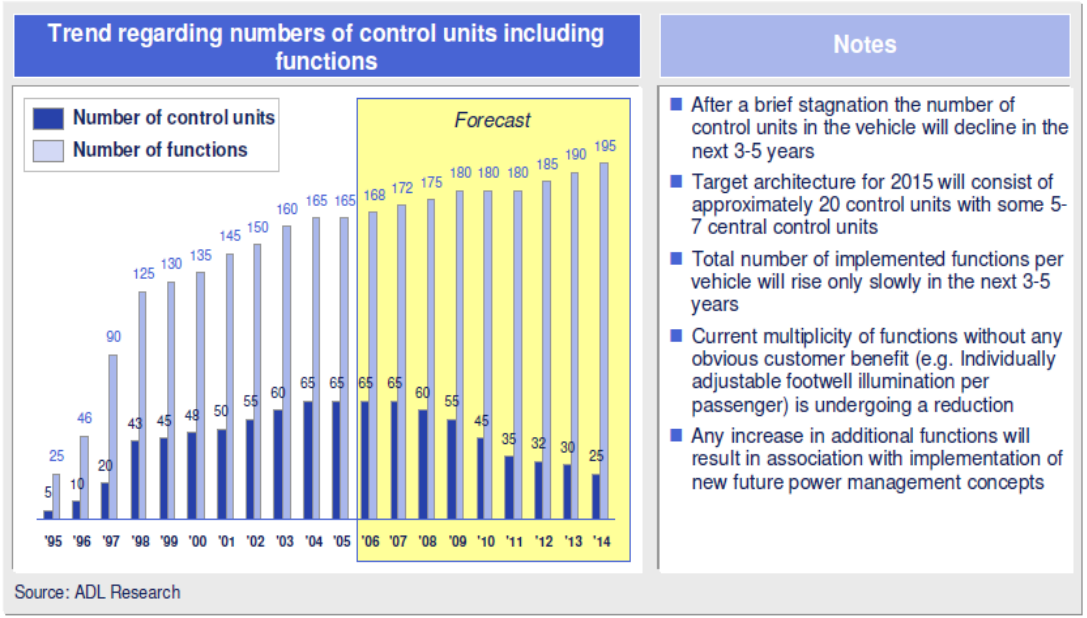
Production / Automotive industry

Table 1: Central control units [1)]

For numbers of control units in the car a reduction is indicated; existing and any new future functions must be distributed over fewer control units



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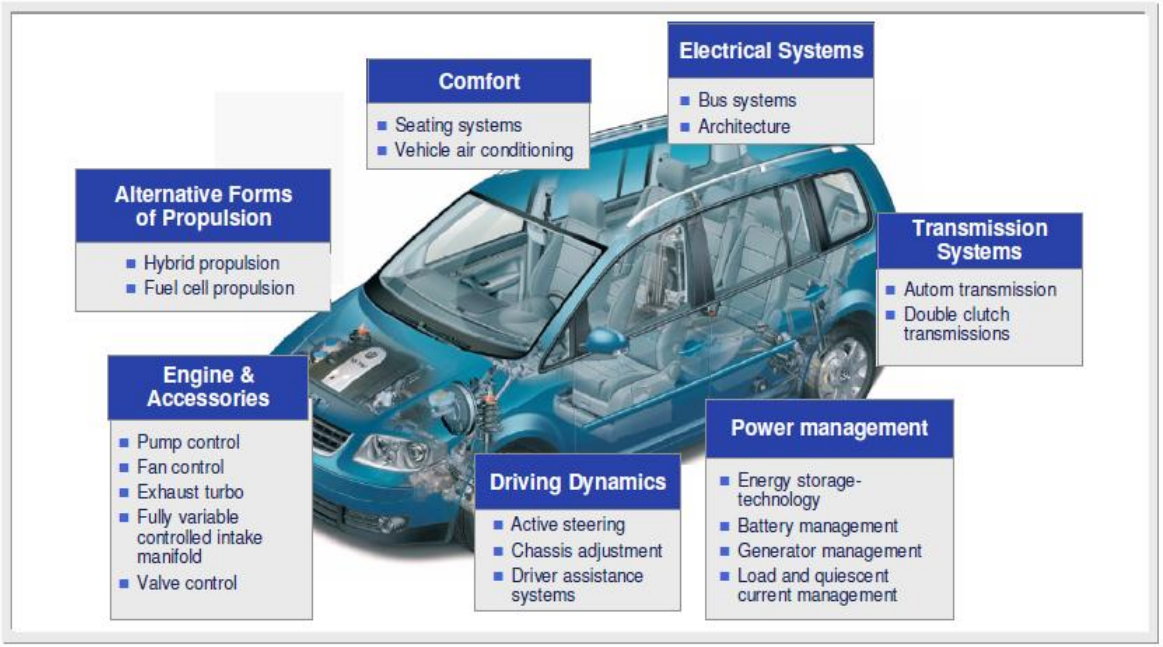
Production / Automotive industry

Table 2: Increased safety and control in cars [2)]

The Study deals with future use of power electronics in automotive technology



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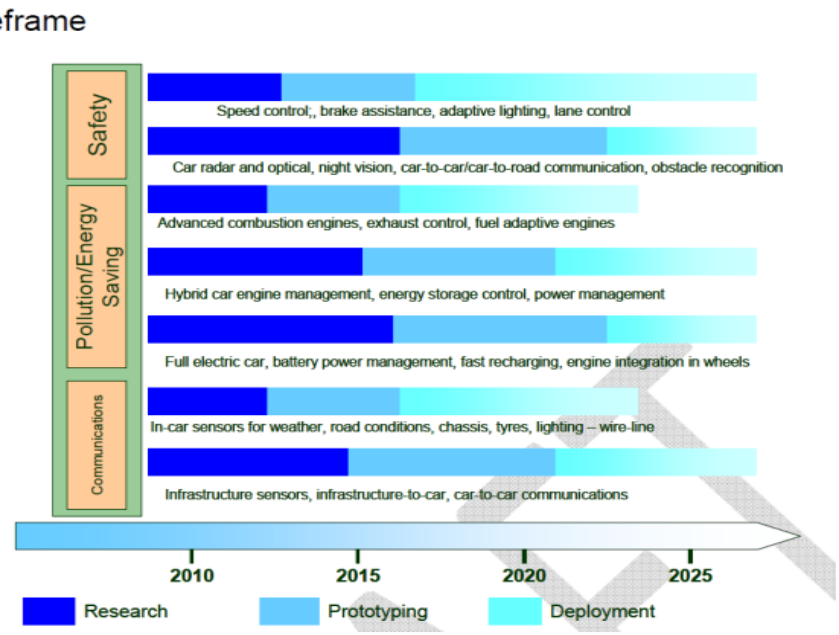
Production / Automotive industry

Table 3: More and comprehensive functions [3)]



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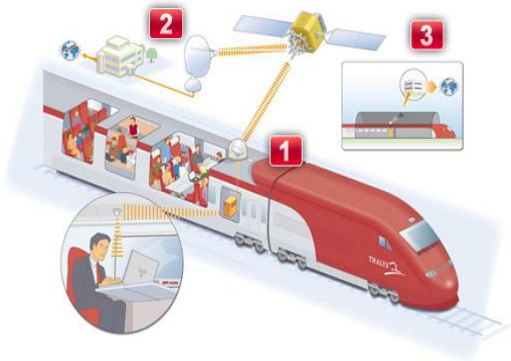
Quality dependend industries

- Automotive
- Railway
- Air & Space
- Medical



- Industrial electronics

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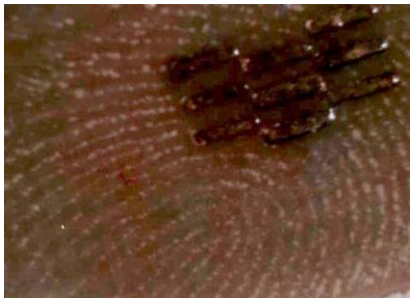
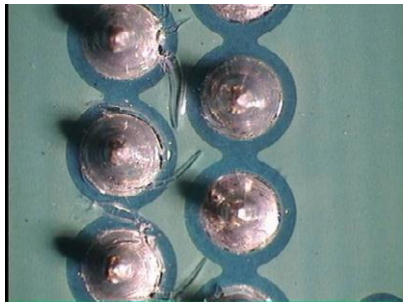
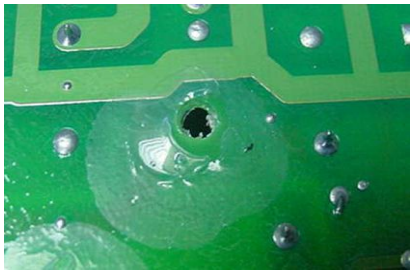
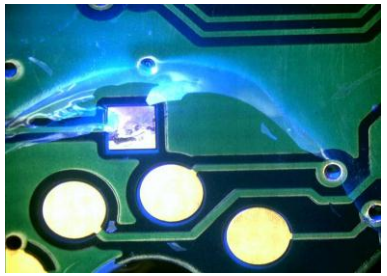
Production / Automotive industry

Typical effects of residues on assembled PCB's [5)]





.....nobody likes to see this

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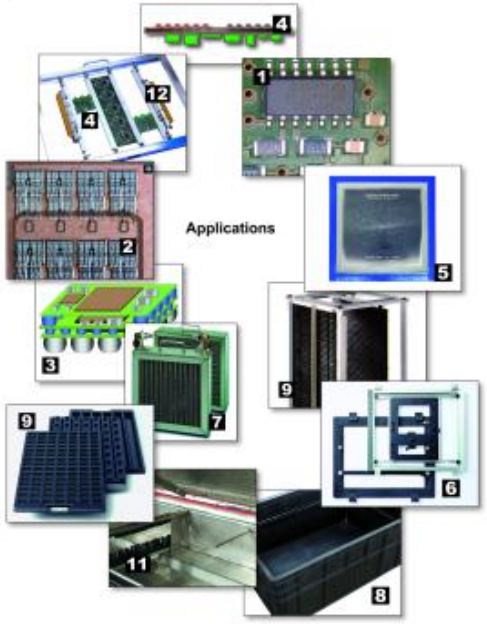
Production / Automotive industry

Table 4: Cleaning – a concept in all stages of production [4)]

CLEANING IN ELECTRONIC PRODUCTION

The kolb Matrix: What contamination must be cleaned in which production area?

Segment	Goods to be cleanes	Contaminations				
		SMD-Ad-hesive	SMD-Paste	Flux (Colophony condensation)	Flux (Colophony residues)	Dust / oil / grease
Ultra-Fine Cleaning	1 PCB assemblies				X	X
	2 DCB				X	X
	3 Hybrids / HDI / SiP				X	X
	4 Misprints (misprinted PCB)	X	X		X	
Fine Cleaning	5 Stencils / PumpPrint	X	X			
	5 Screens	X	X			
	6 Carrier / Masks				X	X
Maintenance & Parts Cleaning	7 Condensation Traps (Filter, radiators from convection reflow ovens)			X	X	X
	8 ESD boxes / Container				X	X
	9 PCB storage racks / Trays				X	X
	10 Machine parts (Flux units, sheet metal, pumps etc.)			X	X	X
Manual Cleaning	11 Process chamber (Soldersystems)			X		X
	12 Other production tools	X	X	X	X	X



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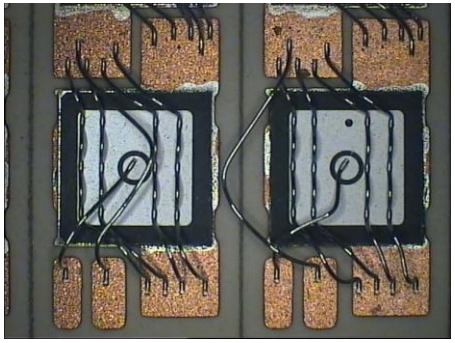
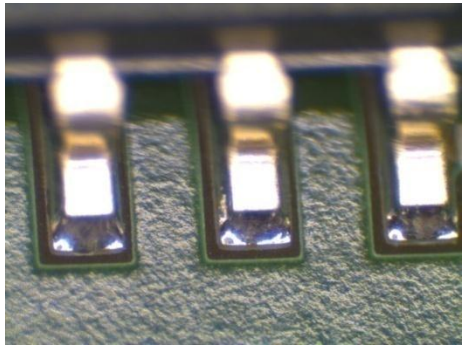
Production / Automotive industry

Requirements

- Wire bonding
- Coating
- Painting
- Optical / customer requirements





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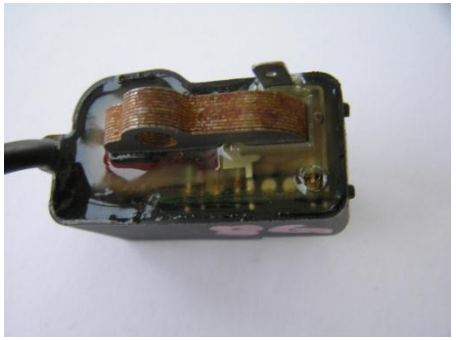
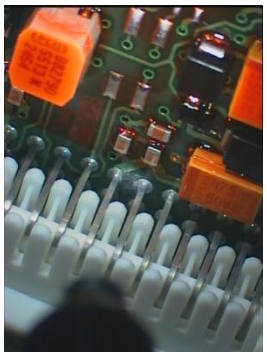
Production / Automotive industry

- **Rework**
- **Misprint**
- **Different types of flux**





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No – clean solder paste and flux [6)]

„Cured residues of No-Clean solder pastes based on synthetic resin fluxes generally require a careful selection of an adequate cleaning process."

"No-Clean" or „ Low Residue" Fluxes contain Rosin (natural flux) solids in smaller quantities than in normal Rosin fluxes such as R(Rosin), RA(Rosin activated) or RMA(Rosin mildly activated) types. They contain less active agents and they have been chosen mainly because of cleaning cost reduction because it is possible **sometimes** to leave the residues on the board without being a functional problem on the short and long run."

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The solution: suitable machinery with proper chemistry

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Distinction of cleaner groups

Solvent (VOC – based) cleaning liquids

Extremely harmful for human beings / high toxicity
Special explosion protection necessary in production due to low flash point
Mostly 100% VOC (volatile organic compounds) and high evaporation ratio
Persistent and environmentally harmful (ozone layer depletion)
Extensive protection and safety requirements regarding storage and handling

Solvent cleaners are an old technology, today they can almost completely be replaced by semi-aqueous or aqueous cleaning detergents

Water based cleaning detergents

No specific protection and handling precautions are necessary / neglectable toxicity
No explosion protection is necessary / high to no flash point
Water soluble solvents only with low evaporation ratio
Environmentally compliant (ISO EN 14001 compatible) even regenerative types are available often good bio degradability

Water based cleaning chemistries offer a wide range of application previously dominated by VOC cleaners.

Cleaning of Assembled Pcbs – A Crucial Way of Enhancing Product Reliability and Avoiding Problems in the Field

Water based chemistries

With light comes shadow

● Rinse water disposal ● Limit values ● Water Analysis

Table 5: Limit values for rinse water disposal in Germany

Requirements for the rinse water quality in PCB production (in mg/l)										
NH4-N	***COD***	***Iron***	***Fluoride***	***VOC***	***Phosphor***	***Toxicity***				
50	*600*	*3*	*50*	*10*	*2*	*6*				
Requirements for the rinse water quality n PCB production prior to mixing (mg/l)										
AOX	***Arsenic***	***Lead***	***Chrom***	***Chrom VI***	***Cyanide***	***Copper***	***Nickel***	***Silver***	***Sulfid***	***Tin***
1	*0,1*	*0,5*	*0,5*	*0,1*	*0,2*	*0,5*	*0,5*	*0,1*	*1*	*2*
Limit values differ from country to country										

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Water based chemistries

Rinse water disposal

- Controlled disposal of validated quality
- Collection in tanks / reservoirs
- Evaporation

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The cleaning result

Verification / permanent control

- Normes and standards
- Equipment

Test method: e.g. Ionic contamination measurement [7)]
Norms: e.g. IPC-TM 650 2.3.25c & IPC 7526 J-STD_001C and optical Documentation min. 40 x Zoom

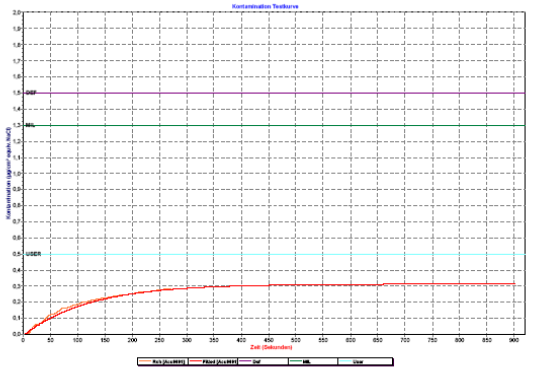
Concoat Systems

Test Konditionen & Paramater

PCB Name	: ACU
PCB Referenz	: 1_25.10.05_A200_30%Cl20_1% 50°1200s
Test Datum & Zeit	: 26.10.2005 16:06:05
Lenght	: 100 mm
Width	: 150 mm
Bauteilfläche	: 0 mm²
Lösungstemperatur	: 27.9 °C

Pass / Fail

Dateiname	: C:\Programme\CMxx SE\Acu\Acu0001.res
reele Messdauer	: 4 min 31 sec
Wert beim Schnitt	: 0.286 µg/cm² equiv.NaCl
Wert an der Asymptote	: 0.307 µg/cm² equiv.NaCl
Def Grenze (Pass/Fail)	: Pass : 1.500 µg/cm² equiv.NaCl
Mil Grenze (Pass/Fail)	: Pass : 1.300 µg/cm² equiv.NaCl
Benutzer Grenze (Pass/Fail)	: Pass : 0.500 µg/cm² equiv.NaCl
Grad der Übereinstimmung	: 99.6 %



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Charts and tables in this presentation taken from:

1-3 ADL Research, Market and Technology Studay, Automotive Power Electronics,
4 DIMA, the Netherlands
5 Kolb Cleaning Technology GmbH
6 Web pager of internationally well-known solder paste and flux producer
7 French Laboratory specialized in soldering technology
8 picture courtesy of : Multicore

Thank you for your attention!