

## PowerXL™

DA1 + DC1 Variable Frequency Drives and DE1 Variable Speed Starters  
Conformal Coating on Eaton PowerXL Variable Speed Drives



Level 1	<p>1 – Fundamental – No previous experience necessary</p> <p>2 – Basic – Basic knowledge recommended</p> <p>3 – Advanced – Reasonable knowledge required</p> <p>4 – Expert – Good experience recommended</p>
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# EATON

Powering Business Worldwide

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## Danger! - Dangerous electrical voltage!

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally restarted.
- Verify isolation from the supply.
- Cover or enclose any adjacent live components.
- Follow the engineering instructions (AWA/IL) for the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions.
- Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states.
- Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation.
- Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatching of the emergency-stop devices must not cause a restart.
- Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been properly installed and with the housing closed.
- Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, mechanical interlocks etc.).
- Frequency inverters may have hot surfaces during and immediately after operation.
- Removal of the required covers, improper installation or incorrect operation of motor or frequency inverter may destroy the device and may lead to serious injury or damage.
- The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live frequency inverters.
- The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE).
- Transport, installation, commissioning and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations).
- Installations containing frequency inverters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the frequency inverters using the operating software are permitted.
- All covers and doors must be kept closed during operation.
- To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the frequency inverter (increased motor speed or sudden standstill of motor). These measures include: – Other independent devices for monitoring safety related variables (speed, travel, end positions etc.). – Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). – Never touch live parts or cable connections of the frequency inverter after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs.

## Disclaimer

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## 1 General

Conformal coating is a process that applies a protective layer onto a surface, normally electrical or electronic circuit boards and components, to improve general reliability and life expectancy, and also to help protect against harsh or degrading environment conditions.

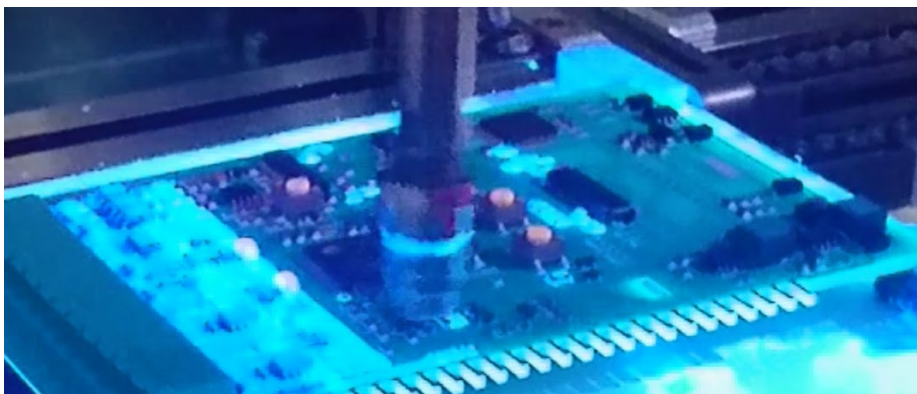
This application support note is intended to highlight and explain the use of conformal coating in the manufacture of Eaton's range of variable speed drives (VSD's), what benefits this brings to our products, and how that relates to applications and environments where drives can commonly be used.

'Conformal coated PCB's' is a statement regularly utilized in marketing literature and specifications without the necessary detail of what level of coverage is being provided, the type of conformal coating used, and how the coating is applied, all of which will have significant bearing on the benefits a conformal coat will consistently provide.

Conformal coating is not a one stop fix to negate any and all negative effects an environment might have on any electrical product. Eaton and our chosen partners and distributors have considerable experience in the wide variety of environments that VSD's are often requested to operate in and should there be any questions or concerns relating to a particular environment then further advice should be sought from your local Eaton office.

## 2 How does Conformal Coating benefit electrical products?

The application of conformal coating on products and PCB's can help to mitigate or reduce the impact of adverse environmental conditions when used appropriately to improve overall reliability and life expectancy. Conditions such as high levels of humidity, corrosive gases in the atmosphere, or airborne contamination, can severely shorten the life expectancy of any electrical product used in such environments and a conformal coat can help improve resistance in this area.



Selective machine applied conformal coating process

Particularly in the case of high density IC's and processors (where spacing between component legs and PCB tracks is minimal) the presence of any moisture or contaminant in the atmosphere could quickly cause arcing or interference. Especially in such cases the use of conformal coating is becoming more common within the manufacturing industry.

There are several types of conformal coat available but generally an appropriate coating substance is chosen based on the required temperature range, moisture / humidity resistance, chemical resistance, curing times, flexibility, and environmental considerations for the compound being used.

Conformal Coating is not a complete solution for all types of applications and environments, and needs to be carefully considered as part of the overall technical solution when such conditions are known to exist. Temperature range, moisture / humidity levels, and chemical strength vary greatly in combination with exposure time and could ultimately lead to a premature failure despite the electronic part having some level of conformal coating applied.

However the use of a conformal coat should always be seen as a positive benefit provided by the manufacturer to help improve the general reliability and life expectancy of their products.

### 3 Eaton use of Conformal Coating

As part of Eaton's commitment to reliability we have employed the use of conformal coating to enhance quality and robustness of our products. Previously Eaton has used conformal coating on high density surface mount components that can be most susceptible to moisture and contaminants in the atmosphere. Eaton have since extended our use of conformal coating to all areas of Surface mount as a part of our continuous quality improvement strategy.

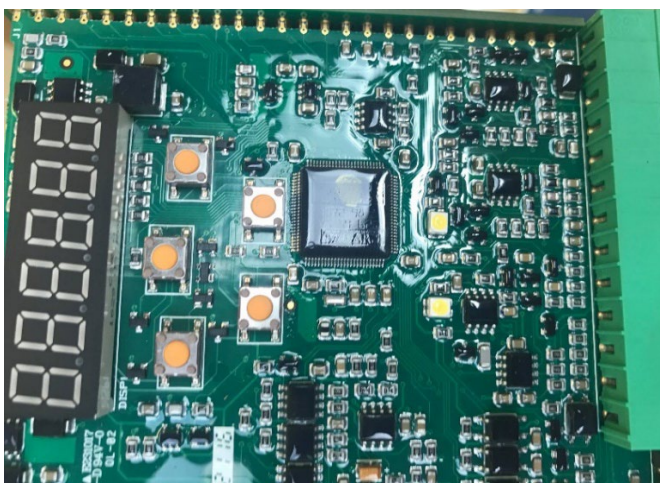
Eaton currently employ an Acrylate resin (AR) based conformal coating. This type of coating provides a good general protection for electronic circuits with good dielectric strength and high abrasion resistance. It provides an effective and durable protective barrier against humidity, salt, corrosive vapours, dirt, and dust.

Eaton use machine applied (automated spraying) process to coat our boards. It is a selective coating that applies the coating specifically in the areas required in a uniform and consistent manner. Eaton's target benefits from this approach to conformal coating our boards is to provide the following:

- No Hand application of coating
- No loss of adhesion.
- No voids or bubbles.
- No dewetting, mealing, peeling, wrinkles (non-adherent areas), cracks, ripples, fisheyes or orange peel.
- No embedded/entrapped foreign material.
- No discoloration or loss of transparency.
- Completely cured and uniform finish.

The following table summarize the use of conformal coating on Eaton Current product range production.

Product Range	Coverage	Application
DE1	High density / narrow pitch components only on all SMT boards.	Machine Applied, Selective Coating
DC1-E1	Majority coverage of all SMT boards (except where coating may cause other issues)	Machine Applied, Selective Coating
DA1	Majority coverage of all SMT boards (except where coating may cause other issues)	Machine Applied, Selective Coating



Example of an Eaton PCB with machine applied conformal coating.

## 4 Variation and limitations of conformal coating

As stated previous, to say PCB's are conformal coated is not enough to fully appreciate the level and consistency of conformal coating being applied to a product.

Some manufacturers will choose to only coat fine pitch components, some will provide minimal coverage in precise area, or elect to coat only the main processor PCB, and some may choose to manually spray or brush apply conformal coating such that consistency is not controlled and areas risk being missed or resulting in poor coverage. All of these variations would permit the claim of 'Conformal coated PCB's' by the manufacturer.

Likewise it is generally not possible to carry out what is termed a 'Fully Tropicalisation' where all internal surfaces and components are fully coated. VSD typically have power and control connections, communication ports, buttons, and various other internal buses that make such coverage impractical from both a product manufacture and user perspective. If a VSD is to be used in an environment where premature failures are likely then a more practical solution is to consider using a VSD with

higher ingress protection (IP) rating or to relocate the VSD outside of the area of concern or a combination thereof. Certainly the designer need to consider that there will be uncoated areas with the VSD and how best they can ensure optimum life expectancy.

It is not just the PCB's that need to be considered in relation to potential environmental hazards, non-pcb components such as plugs and connector, fans, conventional / power capacitors, inductors, transformers, links, switches, and power modules may also be vulnerable in such conditions.

Some harsh and corrosive gases can settle on or seep inside and component and can continue to attack and degrade that component even after the product is removed from the hazardous atmosphere. Even for high IP rated enclosures (although they offer an enhanced level of protection) a gas may be permitted to enter the enclosure during installation or seep into the enclosure over time.



Examples of Eaton high IP (IP66 / NEMA 4X) rated product

## 5 What standards are relevant to the use of conformal coating?

Typically international standards relevant to this subject are focused toward the enclosure type and the degree of ingress protection they provide rather than being specific to the use or qualification of conformal coating. IEC use the IP rating system, and UL the NEMA rating system, to qualify an enclosure as suitable for specific environments and conditions and this is outside of the scope of this application note.

Some manufacturers choose to state compliance with environment standards with an associated category level, with the most common being the IEC 60721-3 standard.

IEC 60721-3-1 and 60721-3-2 concern storage and transport environmental conditions and are not particularly relevant, or are easily mitigated against when it comes to VSD transport and storage.

IEC 60721-3-3 relates to operational environmental conditions. This part of the standard might be seen to be more relevant as it seeks to categorize environments and qualify product for use in those areas. Some of the more common classes include.

- Class 3C1: Applies to rural and urban areas with low industrial activities and moderate traffic. Be aware that salt mist may be present in sheltered locations of coastal areas
- Class 3C2: Applies to locations with normal levels of contaminants, experienced in urban areas with industrial activities scattered over the whole area, or with heavy traffic.
- Class 3C3: Applies to locations in the immediate neighborhood of industrial sources with chemical emissions.

For Eaton Current product range the following enclosure types can be considered to be appropriate for EN60721-3-3 harsh environments:

Product Range	Enclosure Rating	EN60721-3-3 Classification
DE1	IP20	Not applicable
DC1-E1	IP20	3C2 / 3S2
	IP66	3C3 / 3S3
	IP20	3C2 / 3S2
	IP66	3C3 / 3S3
	IP55	3C3 / 3S3

## 5.1 Environmental influences

Environmentally influential size	Unit <sup>1)</sup>	Class <sup>2)</sup>									
		3C1R limit	3C1L limit	3C1 limit	3C2 average limit		3C3 <sup>3)</sup> average limit		3C4 <sup>3)</sup> average limit		
a) Sea-salt	-	-	-	- <sup>4)</sup>	occur from salt mist						
b) Sulfor dioxide	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,01 0,0037	0,1 0,037	0,1 0,037	0,3 0,11	1 0,37	5 1,85	10 3,7	13 4,8	40 14,8	
c) Hydrogen sulfide	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,0015 0,01	0,01 0,0071	0,01 0,0071	0,1 0,071	0,5 0,36	3 2,1	10 7,1	14 9,9	70 49,7	
d) Chlorine	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,001 0,00034	0,01 0,0034	0,01 0,0034	0,1 0,036	0,3 0,1	0,3 0,1	1 0,34	0,6 0,2	3 1	
e) Hydrochloric	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,001 0,00066	0,01 0,0066	0,01 0,0066	0,1 0,066	0,5 0,33	1 0,66	5 3,3	1 0,66	5 3,3	
f) Hydrofluoric	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,001 0,0012	0,003 0,0036	0,003 0,0036	0,001 0,012	0,03 0,036	0,1 0,12	2 2,4	0,1 0,12	2 2,4	
g) Ammonia	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,03 0,042	0,3 0,42	0,3 0,42	1 1,4	3 4,2	10 14	35 49	35 49	175 247	
h) Ozone	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,004 0,002	0,01 0,005	0,01 0,005	0,05 0,025	0,1 0,05	0,1 0,05	0,3 0,15	0,2 0,1	2 1	
i) Nitrogen oxides	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0,01 0,005	0,1 0,052	0,1 0,052	0,5 0,26	0,1 0,52	3 1,56	9 4,69	10 5,2	20 10,4	

<sup>1)</sup> The values given in cm<sup>3</sup> / m<sup>3</sup> are calculated from the values given in mg / m<sup>3</sup>, based on the temperature of 20 ° C and an air pressure of 101.3 kPa. The values are rounded.

<sup>2)</sup> Mean values are the expected average values (long-term values). The limits are peak values. They do not occur for more than 30 minutes daily up. Average values are the expected average values (long-term values). The limits are peak values. They do not occur for more than 30 minutes daily.

<sup>3)</sup> Classes 3C3 and 3C4 do not require that the limit values of all specified influencing factors be considered together as an environmental condition. If necessary, the values of individual environmental inputs can be selected from these classes. In this case, the limit values of class 3C2 apply to all non-specified environmental inputs.

<sup>4)</sup> Salt mist can occur in coastal areas and at sea only in partially enclosed locations.

Environmental influencing factor	Unit	Class			
		3S1	3S2	3S3	3S4
a) Sand in air	mg/m <sup>3</sup>	-	30	300	3.000
b) Dust (suspended matter)	mg/m <sup>3</sup>	0,01	0,2	0,4	4
c) Dust (precipitation)	mg/(m <sup>2</sup> x h)	0,4	1,5	15	40

## 6 Conclusions

Eaton's use of conformal coating on PCB's in the above mentioned products is done predominantly to protect circuit boards and to make them less vulnerable to adverse environmental conditions in line with Eaton's policy for continuous product improvement.

Although conformal coated boards do provide some additional protection against harsh environments having a detrimental effect on product life time of electronic parts they are not to be considered a complete solution in such cases. It is necessary to always consider the choice of enclosure and relocation of the drive as the preferred solutions in such cases.

Eaton variable speed drives are available in a range of enclosure type in order to provide the most optimized solution in the wide range of environments and operating conditions and this is usually the best starting point when selecting a drive best suited for an application. Should there is any doubt of concerns regards the suitability of an environment for reliable drives operation then you should always seek guidance from your local Eaton office or approved sales partner.