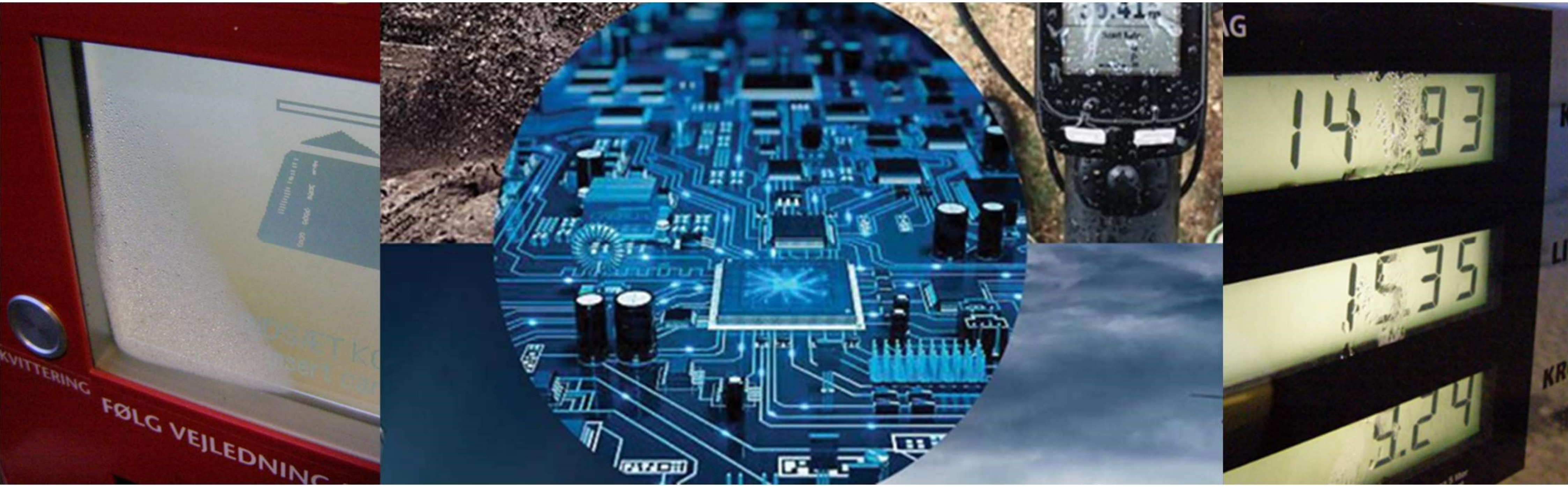

Methods for humidity protection of electronic products – an overview
Presented at the virtual EUROCORR 2020

FORCE Technology, Kim A. Schmidt, 2020-09-02, version 1

Copy of handouts can be obtained via mail to: kasc@force.dk

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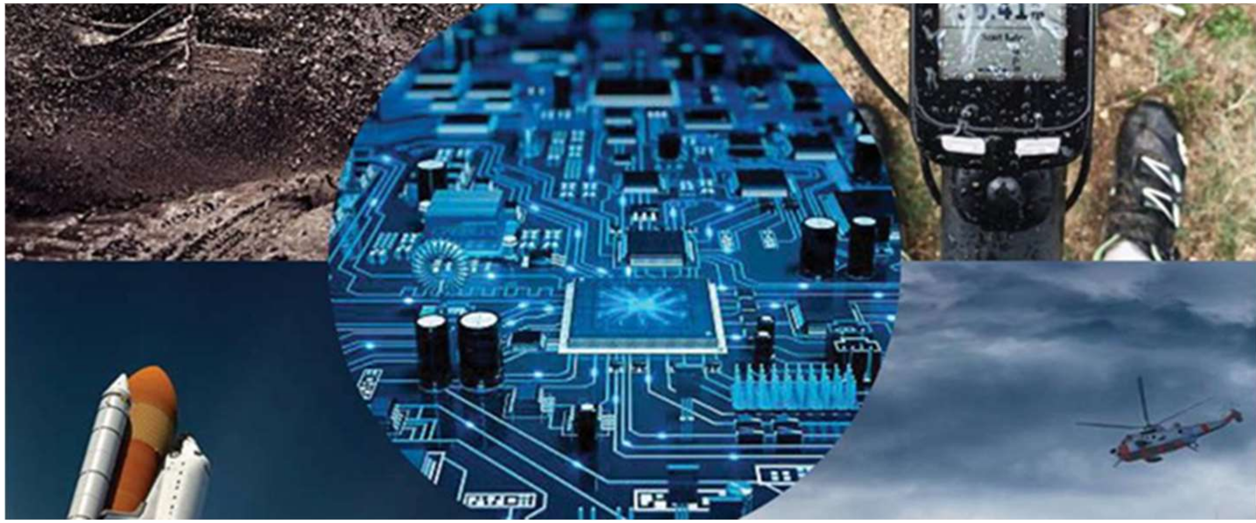
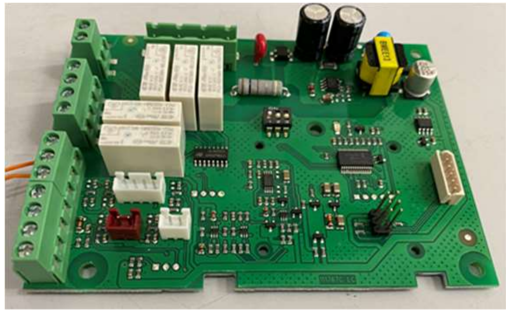
Outline

- Motivation
- Humidity & corrosion stresses
- Principles for humidity protection
- Pros & cons for some of the methods
- Practical examples
- Summary





Motivation

If only looking into produced number of electronics in form of Printed Circuit Board Assemblies, most of the PCBA's will be used in indoor conditions with low levels of humidity and corrosion stress. And no special precautions for humidity protection has to be implemented.

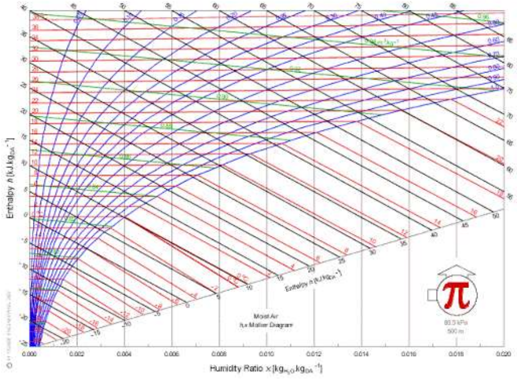
But when electronics is to be used in **humidity and corrosion challenging environments** like:

- Automotive
- Marine (ships)
- Offshore (oil, gas, wind turbines)
- Mobile/portable/wearables
- (list not exhaustive)

the humidity and corrosion stresses are so high, that **special humidity and corrosion protection means, must be implemented** in order to ensure a certain lifetime and a minimum number of issues.

This presentation will give an overview of some of the commonly used methods for humidity protection of electronic products.

Humidity & corrosion stressors

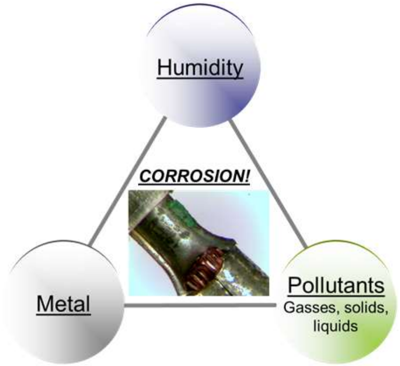


Humidity:

- Static (steady state) or dynamic (cyclic) – always in combination with temperature
- Many parameter: Absolute humidity, water vapor pressure, dew point, relative humidity….
- Many failure modes: Condensation, increased leak currents, corrosion….
- Many transmission paths: With air flow, through diffusion, sorption (ad- and ab-)….

Corrosion:

- Internal pollutants – from production processes….
- External pollutants – from ambient: Sea salt, road salt, exhaust gasses, chemicals, sweat….



A useful source

NORME INTERNATIONALE — **CEI**

INTERNATIONAL STANDARD — **IEC**

60068-3-4

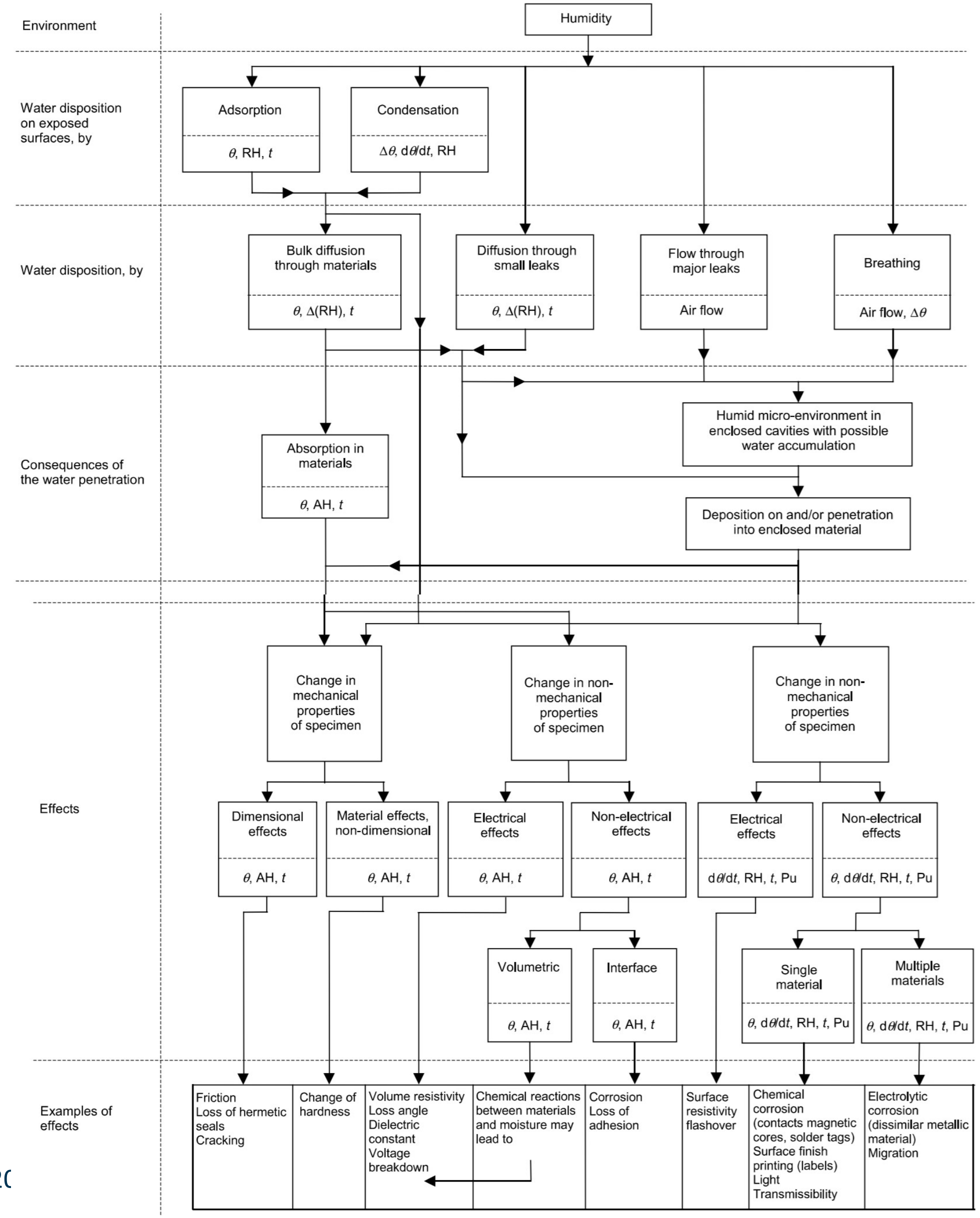
Première édition
First edition
2001-08

Essais d'environnement –

Partie 3-4:
Documentation d'accompagnement et guide –
Essais de chaleur humide

Environmental testing –

Part 3-4:
Supporting documentation and guidance –
Damp heat tests



Humidity protection principles

"Tight":

- Hermetic "100% tight": No humidity ingress during lifetime
- Semi-hermetic: Delayed humidity ingress

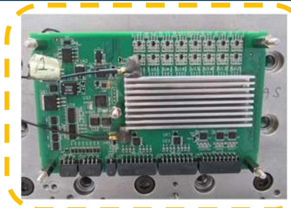
Ventilated:

- Through opening
- Through membrane ("Gore-vents")
- Active or passive (fan or "breathing")

Dehumidification:

- Temperature increase from internal heat dissipation ("operation")
- Temperature increase from external power source
- "Passive" (desiccants etc.)
- "Active" (condensation trap with active cooling)

Design strategy: Humidity barrier

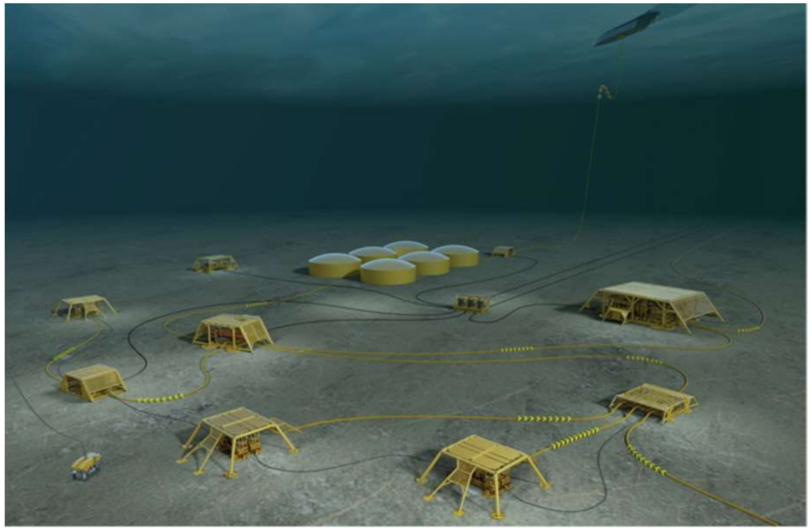
Die level	Component	PCBA	Module	System
IC without packaging	Active & complex (Integrated Circuit)	Printed Circuit Board with component	ESP/ABS Control Module	Car (Vehicle)
				
Jedec JP001	AEC-Q100/101	IPC-xx (IPC-5012 ? IPC-A-60D ?)	ISO 16750 (Location Classes)	Mission profile based (No generic test standard).

Hermetic component ? Conformal coating ? Semi-hermetic box ?

Hermetic

Material selection for enclosure - use only:

- Metals
- Ceramics
- Glass

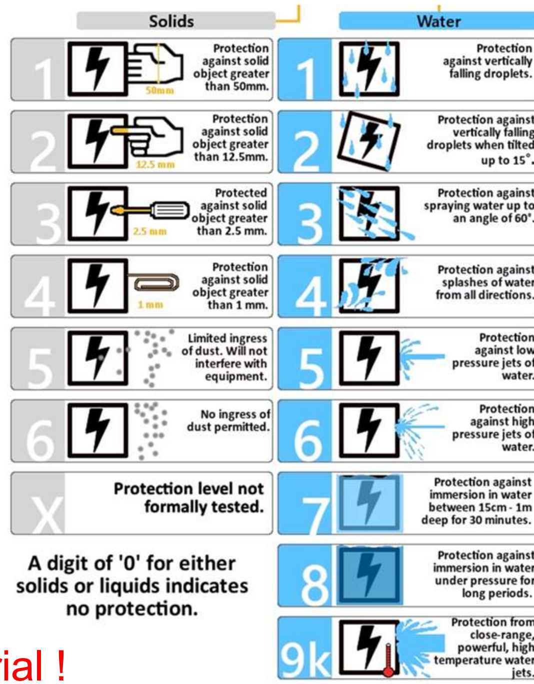


Cons:

- Not practical for “normal” electronics
- No standard electrical wire though the barrier
- Expensive

Semi-hermetic

Polymers often used - open for diffusion (example on next slide)

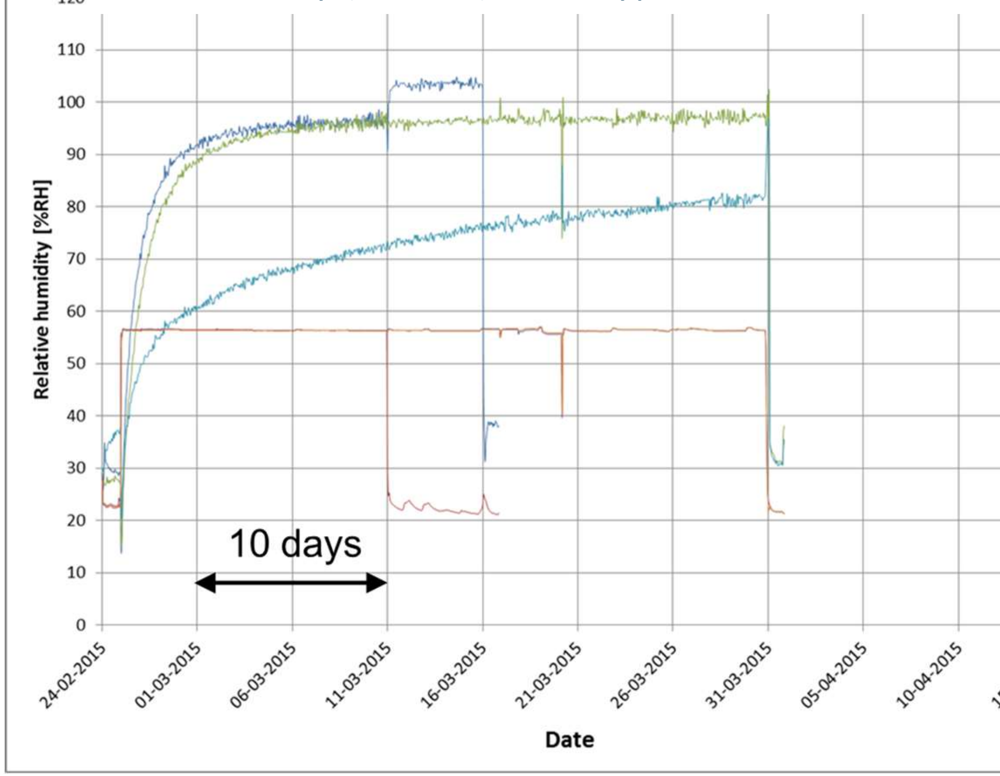


Cons:

- Only a limited lifetime
- A high IPxx class is not equal to “humidity tight”
- Lifetime depending on total humidity ingress – not just diffusion trough bulk material !
- Many practical issues may limit the theoretical lifetime
- Remember to consider diffusion through:
  - Electrical wires
  - Connectors
  - Door locks
  - Etc.

Humidity ingress rates

2 polymer boxes and 1 metal box subjected to an external step in temperature (55°C) and humidity (95%RH). Both types are IP66 rated !



Time constants approx.:

15 days for metal box and

1.3 day for plastic boxes

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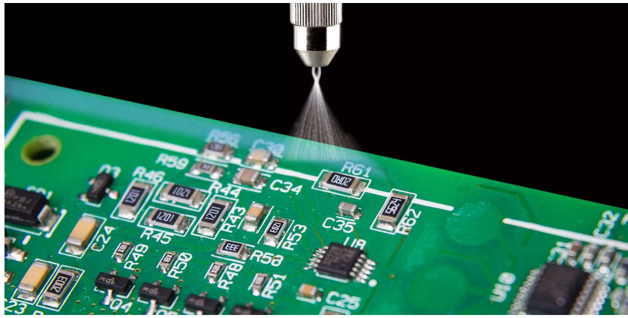
Use of Gore™-vents

Gore-vents can be used to ventilate enclosures. And thereby prevent accumulation of water in semi-hermetic enclosures subjected to dynamic temperature and humidity conditions without allowing liquid water, dust or other particles to enter the enclosure.

GORE™ Membrane Vents POV/M12x1,5 High Airflow

Cons:

- The internal conditions will not be “better” than the ambient conditions
- Condensation on internal parts cannot be avoided
- A semi-hermetic enclosure is normally necessary
- A certain effective membrane area is necessary
- The rest of the enclosure must be watertight (it takes very long time to evaporate and ventilate liquid water)
- May be clogged by particles like dust, salt crystals etc.
- “Drying out periods” needed



Use of conformal coating

Conformal coating (CC) can be applied to a PCBA in order to protect the PCBA surfaces against humid environments. There are many different CC materials and several ways of applying CC to a PCBA. Use of spot-coating may be relevant for some applications – even with different CC materials on the same PCBA.

Cons:

- Selecting the “right” CC for a given product and application is not a trivial task
- The PCBA layout should be optimized for CC
- The production process is “quite delicate”
- A high level of cleanliness before application of CC is crucial – and can be difficult to obtain !
- De-masking around connectors – and other entry points - can be difficult
- Repair and re-work can be difficult

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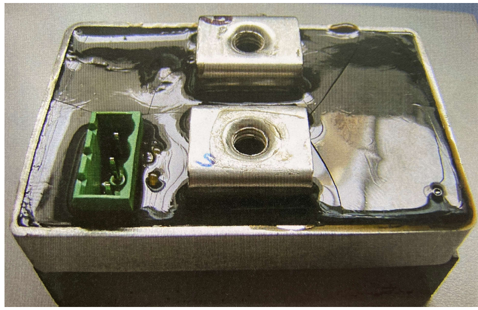
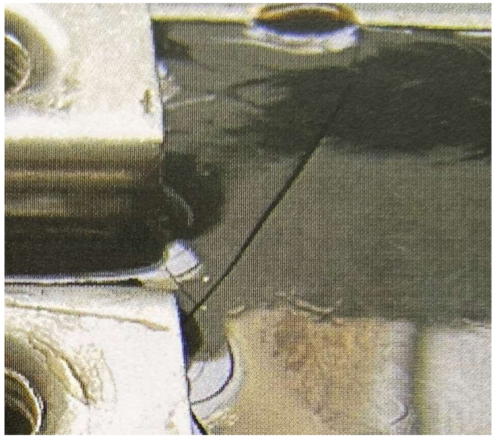


Use of potting compound

A potting – or molding – compound (PC) can be applied between a PCBA and the enclosure in order to protect the PCBA surfaces against humid environments. There are many different PC materials.



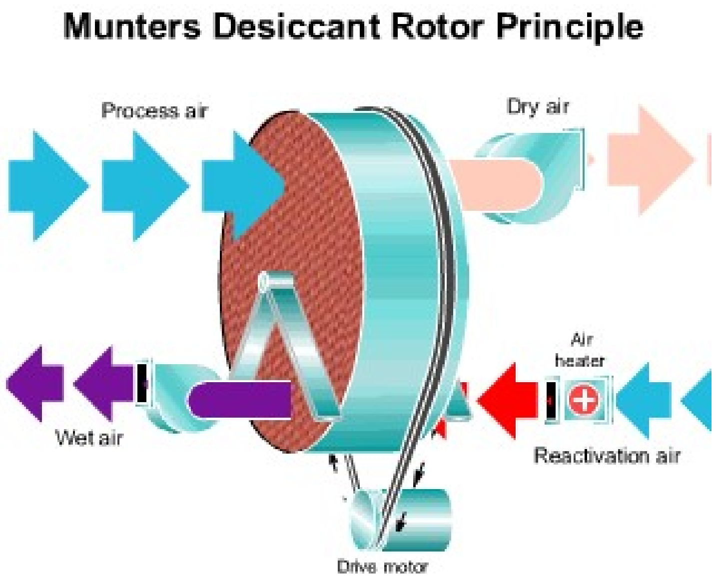
Cons:

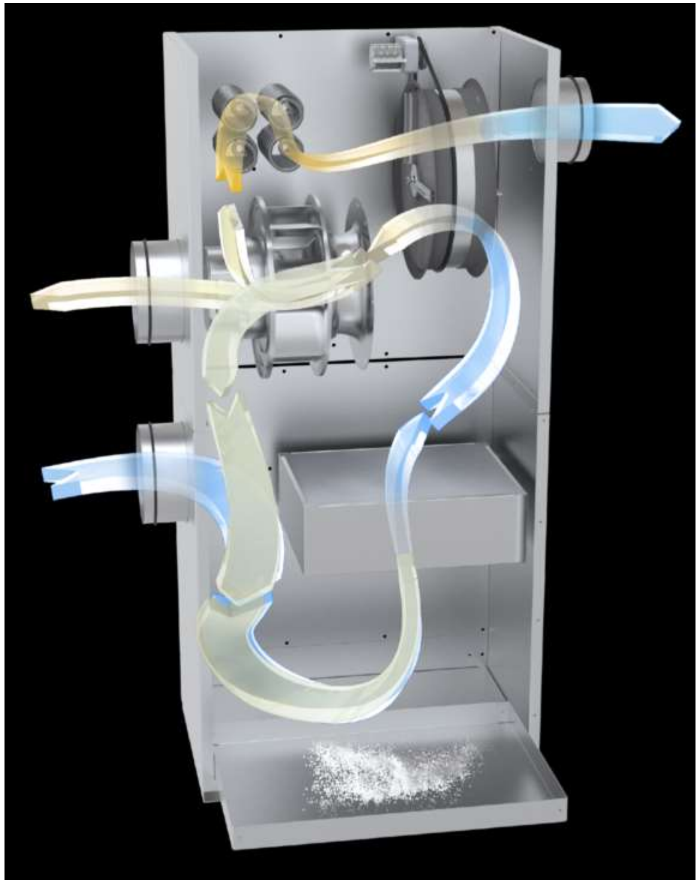
- As for Conformal Coating **plus**:
- A stiff PC may reveal cracks during temperature cycling
- A stiff PC may tear off components from the PCBA during temperature changes
- Electrical connections from the ambient into the PC, should be solid metal without polymer insulations (no multi strand wire into the PC)
- Repair and re-work practically impossible

Example of active dehumidification @ system level

Dehumidification of offshore wind turbines

- Desiccant rotor (example from Munters)
- Desiccant rotor and desalter (example from Cotes)

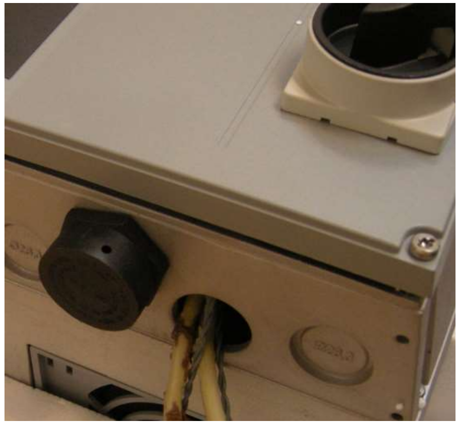


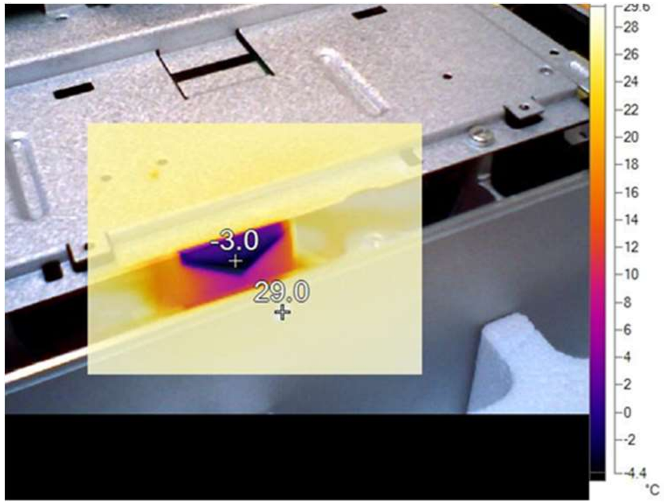


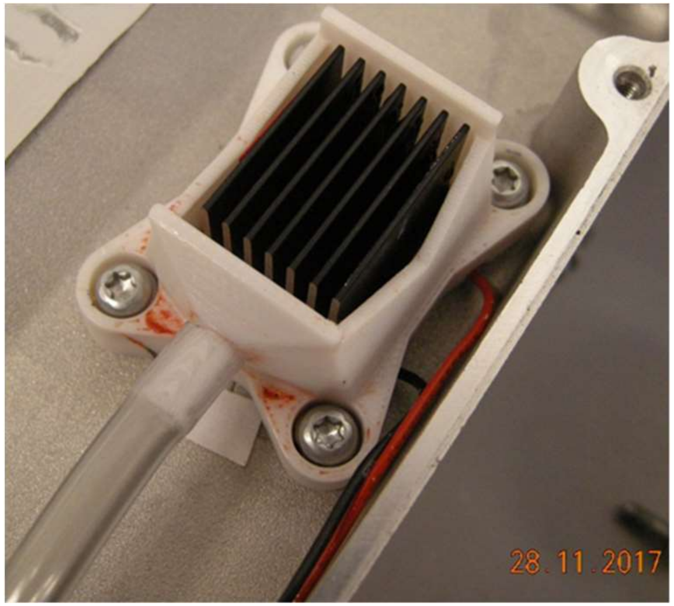
Example of active dehumidification @ product level

Active dehumidification of frequency converter

- Applied to semi-hermetic product (IP54)
- A Peltier element supplied with 5 VDC (I ≈ 0,9 ADC)
- Between a heat sink (cold side) and the chassis (hot side)
- A funnel and an outlet hose (for the condensed water)
- A drain plug







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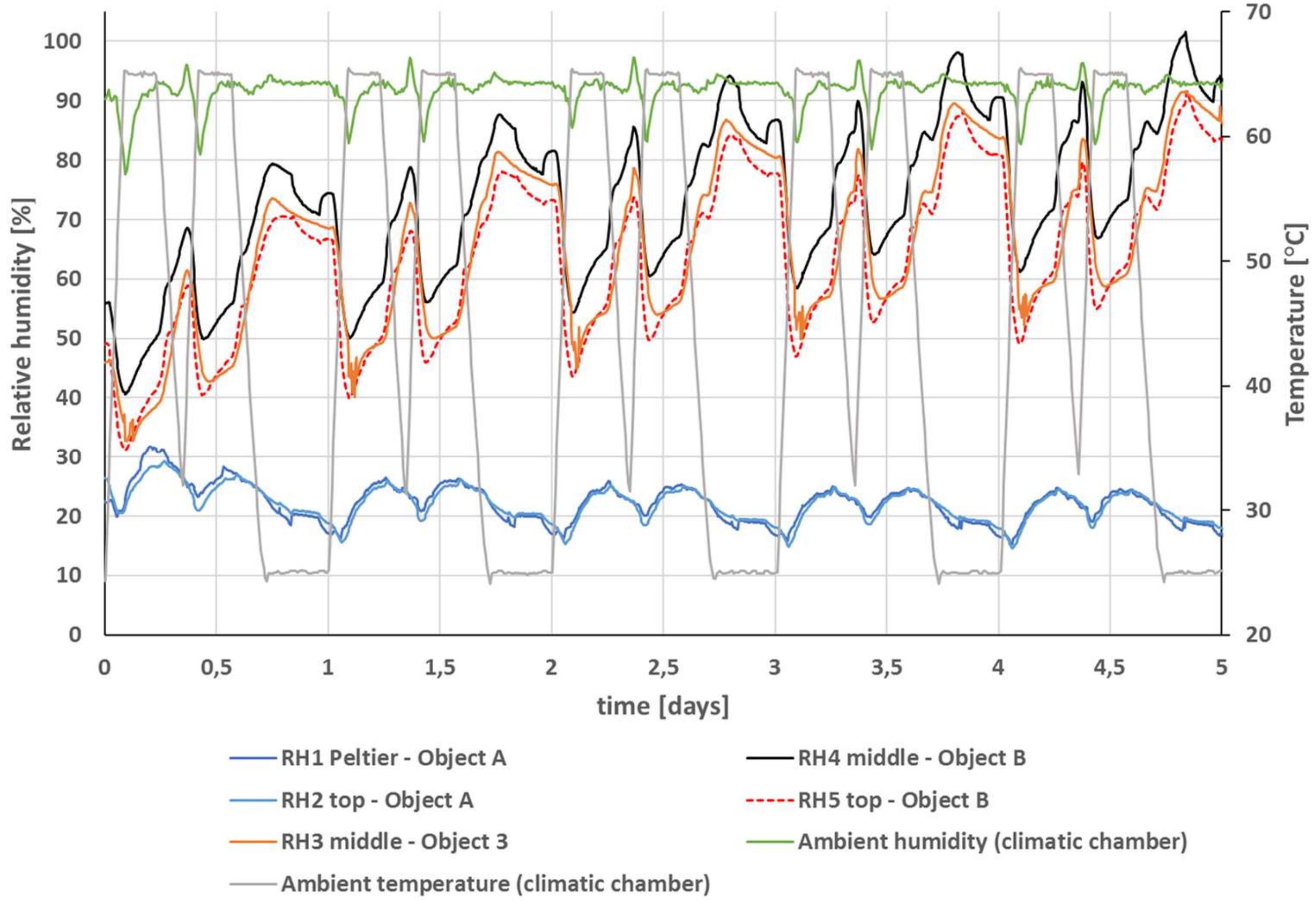
Active dehumidifier: Results



The active de-humidifier is in Object A (the blue curves)

Results:
Internal RH level kept below 30% RH during a IEC 60068-2-38 cyclic humidity test

Summary

- Some kind of humidity protection methods must be applied for electronics used in humidity challenging environments
- A clear humidity protection strategy should be made already in the conceptual phase of the product development
- All humidity protection method has drawbacks
- There is not a “one and only method that fits all”
- Often several methods are combined
- Clear “interface agreement” between manufacturer and sub-supplier needed

Acknowledgements

Thanks to all our many customers and partners for:

- Their cooperation
- Their input to our huge knowledge base
- Numerous cases and examples

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