

Science. Applied to Life.™

3M[™] Novec[™] Electronic Grade Coatings

Electronics Materials Solutions Division

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3M[™] Novec[™] Electronic Grade Coatings

... protect your electronics against moisture, dirt and grime, corrosion or contamination with easy to apply surface modifiers





3M[™] Novec[™] Electronic Grade Coatings product range

Application methods

Performance & Durability

Application examples

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Context

Growing demand on the electronic market for:

- More compact electronic equipment, mobile devices with increasing amount of functions
- Devices usable in a variety of outdoor conditions
- \Rightarrow Protecting sensitive components from humidity is an increasing challenge

Conformal coatings are:

- Permanent and UV or temperature cured resins.
- Resins are acrylic, PU, silicone, epoxy.
- Thickness is >25µ

Novec coatings are not conformal coatings.



The 3M[™] Novec[™] brand – safe and sustainable chemistry

3M[™] Novec[™] Electronic Grade Coatings are low viscosity fluorochemical solutions in segregated hydrofluoroether fluids that dry to ultrathin, protective coatings.

They help protect against moisture, water immersion, oils, chemicals, sulphur and environmental corrosion.

 Non-ozone depleting

- Non-flammable
- Low toxicity
- Short atmospheric lifetime
- Low global warming potential (GWP)

Advanced materials that balance safety, performance and environmental sustainability

Segregated Hydrofluoroether Chemistry $R_h - O - R_f$



1, 1, 1, 2, 2, 3, 3, 4, 4 – nonafluoro-4-methoxybutane



Novec coatings



- Transparent solution with very low surface tension that dries to create a thin protection film on a wide variety of substrates (metals, composites, PCB etc)
- Hydrophobic and oleophobic film=> protects against humidity, oils, dust, corrosion & contamination.
- Available in different versions: air drying with or without UV tracer, or heat curable.
- Easy and fast application, by dipping, spraying or dispensing.
- Dissolved in Novec fluid, giving excellent EHS&R properties.



3M[™] Novec[™] Engineered Fluids

The right balance on Performance, Safety and Environment

Performance

- solvency
- compatibility
- low surface tension & viscosity excellent wetting
- wide liquid range
- Dielectric
- Chemically inert

Safety

- non flammable
- low toxicity safe to use
- stable

Environment

- zero ozone depletion
- short atmospheric lifetime
- low global warming impact
- low water solubility
- not hazardous air pollutant,



F-Gas regulation

Regulation based on the Kyoto protocol (1997)

- \Rightarrow aims to reduce climate change (GWP)
- \Rightarrow HFC, PFC and SF6 are in scope

17 May 2006: the European commission publishes the **Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases (F-Gas Regulation).**

 \Rightarrow Regulation applicable since 4 July 2007

 \Rightarrow HFC, PFC et SF6 are in scope with use **restrictions**, and a few bans.





F-Gas regulation update

- Updated F-Gas regulation voted by EU parliament mid March 2014
- Publication in the EU journal pending & expected by summer 2014.
- New points in the updated F-Gas regulation:
 - Ban of HFC-23 started 1 January 2015
 - Phase down scenario for all other HFCs (targeting 21% in 2030 of the average quantities placed on the market between 2008 and 2011)

 Years
 Maximum Quantity of on tennos of CO.

Maximum Quantity of HFCs (based on tonnes of CO ₂ equivalent) That Can be Placed in the Market
100% (of 2008-2011 average)
93%
63%
45%
31%
24%
21%

HFEs are not targeted for bans, neither by the current, nor by the updated F-Gas regulation

3M

The liquid coating product range

Product	Appearance	Active material conc.	Solvent	Polymer type	Density	Solvent boiling point
1700	Transparent	2%	3M™ Novec™ 7100 Electronic Grade Coatings	Fluoroacrylate	1.5	61°C
2704	Yellow	4%	3M™ Novec™ 7200 Electronic Grade Coatings	Fluoroacrylate + UV tracer	1.41	76°C
2708	Yellow	8%	3M™ Novec™ 7200 Electronic Grade Coatings	Fluoroacrylate + UV tracer	1.40	76°C
2702	Transparent	2%	3M™ Novec™ 7200 Electronic Grade Coatings	Hybrid fluoroacrylate	1.43	76°C



The dry coating product range

Product	Appearance	Thickness	Refractive index	Drying time	Polymerisation
3M™ Novec™ 1700 Electronic Grade Coatings	Transparent	0.1 à 1µm	1.39	5-60s	No
3M™ Novec™ 2704 Electronic Grade Coatings	Transparent to yellow (depending on thickness)	0.2 à 1µm	1.3778	5-60s	Νο
3M™ Novec™ 2708 Electronic Grade Coatings	Transparent to yellow (depending on thickness)	0.5 à 1µm	1.3778	5-60s	No
3M™ Novec™ 2702 Electronic Grade Coatings	Transparent	0.1 à 1µm	1.41	30-90sec	30 min at 80°C



Product comparisons

3M[™] Novec[™] 2702 Electronic Grade Coatings specifics:

- Hybrid fluoropolymer --- heat curable --- permanent
- Elevated resistance against abrasion and agressive environment
- Dissolved in 3M[™] Novec[™] 7200 Engineered Fluid



3M[™] Novec[™] 2704 Electronic Grade Coatings & 3M[™] Novec[™] 2708 Electronic Grade Coatings specifics:

- Higher concentration gives better moisture and abrasion resistance; better durability.
- PCB can be repaired --- solder through
- UV tracer embedded in the polymer matrix (type 1700) for quality control.
- Dissolved in Novec 7200 fluid vs 3M[™] Novec[™] 7100 Engineered Fluid for better flowing → more uniform coverage.



Product characteristics

Very thin polymer film (0,2 to 1μ):

- Total PCB coverage guaranteed, even under low stand off components
- Capable of correctly coating sharp edges
- Solder through coating for easy repair
- Usually no need for masking

Attention for:

- Mechanical resistance
- Needed dielectric strength

Excellent chemical resistance to solvents and atmospheric pollutants.



Application Method

Application methods

Dipping at room temperature:

- No temperature control on bath
- Evaporative losses from tank controlled by cooling coils
- Dipping time: 30s
- Air drying in just a few seconds

Spraying

Selective dispensing

3M recommends dipping at room temperature

Advantages of dipping at room temperature:

- Simple & inexpensive equipment
 - Easiest application method
 - Fast \rightarrow 1 minute process time
 - Highest productivity
 - Lowest consumption



Coating Machine





Coating thickness

The coating thickness depends on:

• The polymer concentration in the dipping tank

(Higher concentration increases the bath viscosity)

• The speed at which the PCB is taken out of the bath



The coating thickness does not depend on the substrate dwell time in the bath



Process control

Controlling coating bath concentration:

- By measuring NVR on a bath sample
- By measuring the refractive index



Quality control after deposition

PCB coverage

 By UV for 3M[™] Novec[™] 2704 Electronic Grade Coatings and and 3M[™] Novec[™] 2708 Electronic Grade Coatings

Coating thickness

- By ellipsometer
- By refractometer (if the substrate refractive index is known)
- By electron microscope after « freeze-fracture »











Possible operations after coating

Manipulation by touching or pressure

For repair:

- Coating can easily be removed with its corresponding solvent (except 3M[™] Novec[™] 2702 Electronic Grade Coating)
- Local repair possible by soldering through the coating

PCB functionality testing with « probe tester »

Connectors can also be dip coated. Insertion force creates enough abrasion to ensure electrical contacts.

No need for masking!



Performance & Durability

Abrasion resistance

Test description

- Bare PCB (FR4) coated with:
- 3M[™] Novec[™] 1700 Electronic Grade Coating (air dried)
- 3M[™] Novec[™] 2702 Electronic Grade Coating (cured 60 minutes at 100°C)

 \Rightarrow Novec 2702 coating more abrasion resistant than Novec 1700 coating, due to its curing.







Temperature resistance

Can support 175°C (3M[™] Novec[™] 1700 Electronic Grade Coating) to 200°C (3M[™] Novec[™] 2702 Electronic Grade Coating) for 24h and maintain its resistance for chlorinated silicone oil IPC CC 830 B standard:

- Temperature/humidity ageing at 85°C/98% RH for 120 days
- Thermal shock (-65°C / +125°C)
- Do not exceed following temperatures
- 150°C for the liquid coating
- 250°C for the dry fluoropolymer



Hydrophobic - Oléophobic

Fluoropolymers

- Have NO chemical affinity; with water, and none with solvents
- Surface tension of 15 mN/m



Hydrophobic \rightarrow corrosion resistance

Example with 3M[™] Novec[™] 2702 Electronic Grade Coating:

- Anti-wetting, Anti migration, Anti corrosion
- Effective barrier for water, hydrocarbons & silicone oils
- Corrosion resistant in warm and humid environments

Copper track structures at 50V exposed at 90%RH and 25/65°C cycles during 1 week. IPC-TM-650 2.6.3.4



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Resistance to water at dew point

- The test allows to evaluate a coating performance on a PCB upon the condensation of a moisture film on its surface.
- Reading of PCBs resistance after 5s in a water vapour saturated atmosphere.
- Results:
 - Without coating: 1.5E+4 ohm
 - With 3M[™] Novec[™] 1700 Engineered Grade Coating: 1,5E+8 ohm
 - \rightarrow the resistance increases 10 000 ohm

The 3M coating significantly improves the PCB resistivity during a "dew point test".



Resistance to salt water mist

Salt water mist conditions according to ASTM B117-09 Temperature : 35°C Humidity: 95% Salt solution: 5% NaCl pH=6.5~7



1700<2702 1700<2704<2708

IPC-B-25A PCBs with copper conductors, cleaned with 3M[™] Novec[™] 72DA Engineered Fluid, then coated:
•3M[™] Novec[™] 1700 Electronic Grade Coating air dried
•3M[™] Novec[™] 2702 Electronic Grade Coating polym 60 minutes at 100°C.

- •Salt water mist according to ASTM B117-09
- •Visual inspection after 48 hours exposure



Novec 2702 gives a better protection in a salt water mist environment

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Resistance to air pollutants

Exposure to corrosive gases type S^0 , H_2S , SO_2 ASTM B809, test called "Flowers-of-Sulfur"

• Typical test conditions, 50 °C, 90-92 %RH, 1-4 weeks





Corrosion protection due to sulfur SEM Analysis



3M[™] Novec[™] 2708 Electronic Grade Coating, after 28 days exposure to test FoS

	Surface Insulation Resistance (Ω)				
Sample	Initial	7 days	14 days	21 days	28 days
uncoated	6.67E+15	6.67E+15	6.67E+15	2.21E+15	2.57E+12
Novec 2708	6.67E+15	6.67E+15	6.67E+15	6.67E+15	6.67E+15



Measured at **100 V**, after 60 s using a QuadTech 1865 Megohmmetre





Summary

Why choose 3M[™] Novec[™] Engineered Grade Coatings?

Excellent protection

- Hydrophobic and oleophobic
- The low surface tension solvent allows for an **optimal coverage**, even in between the smallest spaces
- Resistant to aggressive environments.

Benefit from the favourable EHS&R profile of Novec

• Low GWP, ODP=0, non flammable, low toxicity

Improved productivity

- Fast process \rightarrow the coating process is no longer a limiting process step
- No need for masking
- Coated PCBs can easily be repaired => waste reduction

Economic benefits

- Low chemicals consumption
- Favourable return on investment



Application Examples

Customer case study 1 – Fire Detectors

Customer	
Product	3M™ Novec™ 1700 Engineered Grade Coatings
Description	Application on PCBs for fire detection
Requirement	Protection from SO ₂ & humidity
Results	Novec 1700 qualified for protection against this environment with easy application and no need for masking the connector.







Customer case study 2 – Protection of ACF from humidity

Customer	
Product	3M™ Novec™ 2704 Engineered Grade Coatings
Description	PCB – ACF protection
Requirement	Protection of ACF from humidity
Results	Novec 2704 offers sufficient protection against humidity. There is no need for thermal curing. (Heating impossible in this application).
	Replaced a thick conformal coating with the same protection level whilst benefitting from an easy application method.









Customer case study 3 – PCB Coating

Customer	
Product	3M™ Novec™ 2702 Engineered Grade Coatings
Description	Need to protect PCBAs (relay systems) from outside humidity
Requirement	
Results	Novec 2702 allows to achieve this protection in a tropical environment. Easy process with no need for masking







Customer case study 4 – Protection of semiconductor surfaces

Customer	
Product	3M™ Novec™ 1700 Engineered Grade Coatings
Description	Solution for protecting aluminium wafer contacts from corrosion during the dicing process.
Requirement	
Results	Novec 1700 offers a simple protection with an easy removal method, using the Novec 7100 solvent, right after the dicing process





Thank you!