GLOVE POLYMER BEHAVIORS WHEN IN CONTACT WITH HOT AND COLD SURFACES

SAFETY BRIEFING

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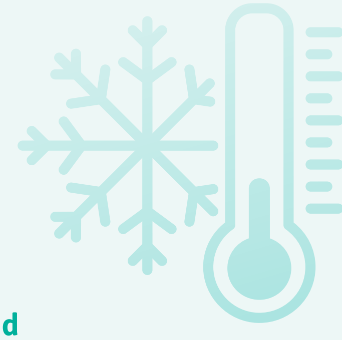


Within many industrial environments or applications, the risk of variable temperatures can be as important as the primary chemical hazard. Understanding how chemical gloves behave and interact with both contact heat and cold is an important factor to remain protected and productive. This briefing aims to discuss the effects temperature can have on each of the main polymers.

PROPERTIES OF PROTECTIVE GLOVES

How hand protection will perform under variable temperature conditions will depend on the rubber polymer it is made from. Heat and cold have varying effects on different types of rubbers which impact both protection and performance.

Polyvinyl Chloride (PVC) Gloves

PVC gloves have a large proportion of plasticisers within them to make the raw PVC, which is a rigid plastic, usable as a glove. Plasticisers are materials which are added to the PVC to make it softer and more flexible. However, they have no protective properties, so chemical gloves with a high proportion of plasticisers perform poorly as chemical barriers.

PVC IN THE COLD

Due to the number of plasticisers in PVC gloves, they perform very well when they are exposed to cold temperatures. The plasticisers allow them to remain flexible down to -20°C and usable down to -40°C. However productivity will begin to suffer as the glove stiffens.

PVC IN THE HEAT

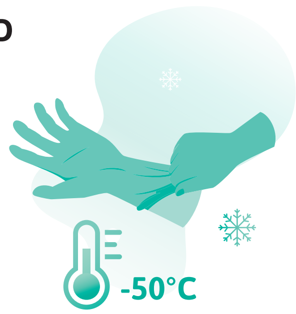
Whilst PVC is flame-resistant and will not set alight, applying heat will result in the production of hydrogen chloride gas which is very toxic when inhaled. PVC gloves should not be used with contact heat applications where the temperature is over 100°C.

Natural Rubber Latex (NRL) Gloves

As the name suggests, natural rubber gloves are made by processing natural rubber harvested from rubber trees. The natural properties of this latex imbue gloves with high elasticity. However, many end users are moving away from using these gloves due to the potential allergic reactions to the natural proteins within the latex.

NRL IN THE COLD

The natural elasticity of NRL helps the glove retain its properties when exposed to cold temperatures. The glove will remain flexible down to -50°C.



NRL IN THE HEAT

Given its natural properties NRL does not perform well when it comes to contact with high heat. When accompanied with a suitable liner, NRL has an operating temperature of up to ~120°C whereby passing this temperature the natural rubber will begin to melt.

Neoprene (Polychloroprene) Gloves

Neoprene is a synthetic man-made rubber polymer whereby its production process imbues the polymer with a robust set of properties. However, there are several caveats with using neoprene.

NEOPRENE IN THE COLD

Neoprene performs very well in the cold, maintaining its flexibility down to -50°C. When paired with an appropriate supported internal liner, neoprene is a suitable choice for working in cold environments where there is a liquid/chemical risk.

NEOPRENE IN THE HEAT

When paired with a supported internal liner which will manage the heat transfer, neoprene performs well against contact heat. Within EN 407, sufficiently supported neoprene gloves are able to pass the contact heat level 2 test, 250°C. However even though it can pass the test in laboratory conditions, neoprene may start to show physical changes at temperatures above 180°C.

There are several other aspects which need to be considered when it comes to neoprene:

1. To achieve consistent heat resistance, neoprene often needs to be thick and bulky. This reduces the level of dexterity and tactility that the gloves can offer.

2. Neoprene is **not** a food contact approved material within the EU, after being banned in France. The gloves themselves are not specifically designed for direct food contact however, many food manufacturing sites insist on food contact approval even if the gloves are only used in secondary applications such as moving packaged food.

Nitrile Gloves

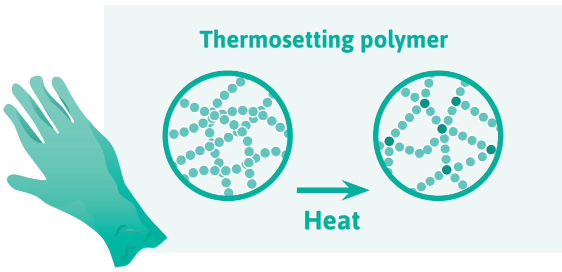
Nitrile is also a synthetic man-made polymer, however it is very different to neoprene. Nitrile rubber (in the gloves) is a copolymer of acrylonitrile and butadiene. The proportion of components have a drastic impact of the gloves fit, feel and performance.

NITRILE IN THE COLD

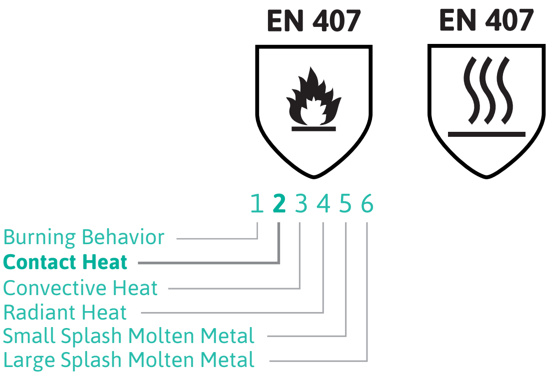
Nitrile is a polymer which does not perform well in the cold. Down to temperatures of around 5°C the glove is usable. However any temperature below this, the gloves physical properties will start to be compromised. Between 0°C and -15°C the gloves will become very stiff and impede dexterity, tactility, and productivity. Below -15°C the gloves will become brittle and become a penetration risk due to the polymer cracking, causing holes.

NITRILE IN THE HEAT

When accompanied by a suitable supported liner, nitrile will comfortably perform in temperatures up to 100°C. As the exposure temperature increases, nitrile will begin to thermoset. This is a process whereby the glove will begin to harden and then not return to its soft state even after the polymer has cooled down. Constant exposure to higher temperatures will begin to degrade the polymer.



How is contact heat protection measured?



EN 407 is the EU standard which covers the performance of materials when exposed to contact heat, amongst others. This contact heat test introduces the sample material to a hot plate at a set temperature and then measures the temperature increase on the inside of the material. It is measured by how long it takes for the inside of the material to increase by 10°C.

If the temperature inside the glove takes longer than 15 seconds to increase by 10°C, then the glove passes the level it was tested against.

The flame icon on the left can be used when the flame resistance test has met minimum level one, irrelevant if any of the other parts of the test were carried out. Whereas the contact heat symbol on the right is to be used when only contact heat has been tested. EN 407 test levels are broken down in the below table:

TEMPERATURE TESTED	CONTACT HEAT LEVEL
100°C	**1**
250°C	**2**
350°C	**3**
500°C	**4**

Another prerequisite to pass the EN 407 contact heat test is to ensure that the glove does not degrade during the test. The samples are visually checked after the test to determine its performance against 2 key areas:

Melting **Holes**

If any signs of these 2 types of degradation are present the sample will **not** pass the test, **even if it achieves the > 15 seconds requirement.**

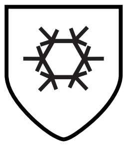
Key things to note with EN 407 contact heat

As with all EN tests, the tests are designed to allow for comparisons between materials in a laboratory conditions and do not necessarily relate to real word applications. There are some key considerations to consider when viewing EN 407 contact heat performance scores:

1. It is a single test against the required test temperature and does not take into account heat buildup over repeated contact with a heat source.
2. The test only looks for an increase in 10°C between the inside and the outside of the material after 15 seconds. A glove which passes with 16 seconds will still be allowed to show the EN shield the same as a glove which passes with 40 seconds.

How is contact cold protection measured?

EN 511



a b c

(a) Resistance to Convective Cold
(performance level 0-4)
Based on the thermal insulation properties of the glove, which are obtained by measuring the transfer of cold via convection.

(b) Resistance to Contact Cold
(performance level 0-4)
Based on the thermal resistance of the glove material when exposed to contact with a cold object.

(c) Penetration by Water *(0 or 1)*
0 = water penetration
1 = no water penetration

PERFORMANCE LEVEL	THERMAL INSULATION (R) IN M2°C/W
Level 1	0.025 R < 0.050
Level 2	0.050 R < 0.100
Level 3	0.100 R < 0.150
Level 4	0.150 R

Similar to the EN 407 contact heat test, the contact cold test is designed about repeatability in a laboratory setting.

In this test, 2 samples from the fingers of the glove are placed between metal plates which are at different temperatures and the temperature drop across the sample is measured to determine its thermal insulative value.

Again, there are a number of key points to take into account when reviewing this test and the results it can give.

How to interpret performance scores on EN 511

Given that the performance levels stated on product which pass EN 511 relate to their thermal insulation level in a lab setting, there are a number of key considerations which need to be taken into account when looking at applying these scores into real world applications as a products performance score does not correlate to a working temperature. For example, level 2 does not mean its suitable to -20°C.

1. **Environmental temperature** – Convective cold can affect the hand temperature even before contact has been made with a surface

2. **Wind speed** – High winds will increase the effect of convective cold

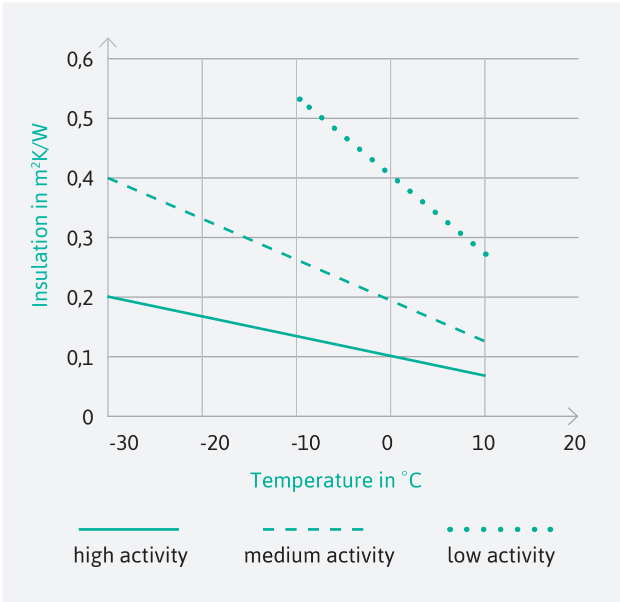
3. **Time of exposure** – Longer exposure and repeated contact can affect the gloves' thermal insulation

4. **Activity level** – The amount of activity the wearer is carrying out will affect the heat they generate and the thermal insulative properties of the glove

5. **Dexterity requirement of the application** – Thicker gloves may keep the hands warmer but may impede the wearer from carrying out their application safely

6. **Water** – Contact with wet items can affect the gloves thermal properties after contact with the object has finished

Below is a graph which shows an indicative view on the level of insulation needed when comparing different activity levels across different temperatures:



As you can see, the higher the activity level carried out by the wearer, the lower the insulative value the glove needs to be.

Taking these points into consideration can aid in the selection of appropriate PPE.

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