Disposable gloves come in all sorts of colours and materials – here we review glove barrier properties and ask: Can you give your gloves the thumbs up?

As the physical properties of glove materials are critical for determining barrier effectiveness, details on tensile strength and elongation are also provided in Table 1. Perhaps surprisingly, measurement of physical properties is not a requirement for “Protective gloves against chemicals and micro-organisms” (as defined in EN374-1: 2005 Terminology & Performance Requirements). Accordingly details of the nearest appropriate European standard (EN455-2: 2000 covering examination gloves and before accelerated ageing) are provided, as are the ASTM equivalents.

Council Directive 90/679/EEC dated 26 November 1990 is the original version of the regulation covering protection of workers from risks related to exposure to biological agents. It has been substantially revised over the years and Council Directive 2000/54/EC appears to be the latest version. This Directive classifies biological agents into four groups, which determines the level of risk and the containment level.

Containment level may be described as the barriers for managing hazardous biological agents in the laboratory environment. Its objective is to reduce the risk to laboratory workers, those in the vicinity of the laboratory and the wider community from potentially hazardous biological agents. There are four containment levels, which are aligned with the biological agent group. Containment typically

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**Table 1: Summary of main features of glove materials**

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Tensile Strength</th>
<th>Elasticity</th>
<th>Durability</th>
<th>Fit &amp; Comfort</th>
<th>Chemical resistance (incidental exposure)</th>
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<tbody>
<tr>
<td>Latex (Natural Rubber Latex from the rubber tree Hevea brasiliensis)</td>
<td>Excellent with a minimum tensile strength of 9N per EN455-2 and 14 MPa per ASTM D3578.</td>
<td>High level of memory, elasticity, and elongation. Minimum requirement for elongation is 650% per ASTM D3578.</td>
<td>Highly resistant to tears and punctures, with in-use failure rates reported to be 0% to 9%.</td>
<td>Excellent, conforms to hand.</td>
<td>Fair protection especially with water-based chemicals, alcohols and aromatics. Good protection against organic chemicals, oils and greases.</td>
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<tr>
<td>Nitrile (Acrylonitrile-butadiene, a synthetic co-polymer)</td>
<td>Excellent strength and puncture resistance. Minimum tensile strength of 3.6N per EN455-2 and 14 MPa per ASTM D6319.</td>
<td>Medium to high, conforming to the user’s hand and use. Minimum requirement for elongation is 500% per ASTM D6319.</td>
<td>Highly resistant to punctures and tears. Once punctured tear is visible and quickly spreads. Reported in-use failure rates range from 1% to 3%.</td>
<td>Good to excellent, conforms to hand. Sometimes has high modulus or stiffness.</td>
<td>Good protection to a broad range of chemicals including alcohols, fuels, many solvents, greases, animal fats etc. Poor protection against ketones, aromatics and chlorinated solvents.</td>
</tr>
<tr>
<td>Vinyl (Poly-vinyl chloride, a synthetic co-polymer)</td>
<td>Limited strength, with minimum tensile strength of 3.6N per EN455-2 and 11MPa per ASTM D5250 (NB: ASTM differentiates between nitrile &amp; vinyl).</td>
<td>Low to medium, with moderate flexibility. Minimum requirement for elongation is 300% per ASTM D5250.</td>
<td>In applications requiring long term or rigorous use, in-use failure rates range from 26% to 61%.</td>
<td>Fair, but not usually offering the snug qualities of latex or nitrile.</td>
<td>Generally poor, but offering some protection to petroleum-based products and animal fats. Contact with chemicals can release phthalates (often used as a softener in vinyl), which may damage DNA. DEHP is the most commonly used phthalate and is classified as a toxicant in the EU.</td>
</tr>
<tr>
<td>Neoprene</td>
<td>Excellent strength properties. Minimum tensile strength of 3.6N per EN455-2 and 14MPa per ASTM D6977.</td>
<td>Generally higher elasticity than nitrile and closer to latex in elasticity properties. Minimum requirement for elongation is 500% per ASTM D6977.</td>
<td>Fair puncture resistance.</td>
<td>Good, although sometimes has high modulus or stiffness.</td>
<td>Resistant to many chemicals including oils, acids, &amp; large range of solvents. Poor protection to organic solvents.</td>
</tr>
</tbody>
</table>
covers three elements: facility design, laboratory practices and safety equipment. The latter addresses the question of what personal protective equipment (PPE) is to be used for each containment level.

Whilst most reputable glove manufacturers have available extensive chemical permeation data, we need to appreciate the limitations of this data:

• Chemical permeation is the process by which chemicals flow through the glove material at the molecular level. A breakthrough takes place when the chemical is detected on the other side of the sample.

• EN374-3: 2003 (Determination of resistance to permeation by chemicals) is the standard method for evaluating the chemical barrier performance of a glove. Here one layer of the glove is placed between two chambers. The chemical being tested is placed on one side and a receiving fluid on the other. Breakthrough occurs when a permeation rate of 1µg/cm²/min is noted and is reported in minutes.

• EN374-3: 2003 is a total immersion test and may not be representative of the laboratory environment, where the emphasis is on incidental chemical exposure.

• The tests are done on unused gloves under laboratory conditions. The test methodology does not take into account the stresses and strains to which disposable gloves are subjected whilst being worn in the laboratory. Similarly a glove in-use is likely to be significantly warmer than an unused glove and the higher level of surface heat may accelerate chemical permeation.

To compensate for the potential shortcomings in EN374-3:2003, several glove manufacturers now provide data on degradation. The latter relates to the deleterious change in one or more physical properties of a glove material due to contact with a chemical. In the presence of a chemical, glove materials may become stiff, discoloured or brittle. Likewise they may become weaker, softer and become swollen. Degradation is important as a glove materials permeation resistance can be substantially reduced.

There is currently no internationally recognised test for degradation, thereby making it difficult to validate manufacturers’ claims. However as part of EN374, a test for degradation is under development and may address the need for a universal standard to measure chemical degradation.

Table 1 provides some guidance on which glove materials perform best with certain chemical classes. Specific breakthrough data from glove manufacturers will also be helpful as part of the overall risk assessment. It is important to appreciate that under Council Directive 89/686/EEC it is the duty of the employer to audit the risk and provide appropriate PPE. Therefore the suitability of a glove for a specific task in the laboratory must be determined by making a risk assessment.

Finally as has been noted for biohazard protection, EN374-1: 2003 stipulates a minimum length of 26cm for size 10 gloves (XL).

How do I know if my gloves fulfil the criteria for being microorganism resistant?

The above pictogram is the standard biohazard sign and is also used on gloves that have fulfilled the criteria for being microorganism resistant, according to the latest version (2003) of the penetration test (EN374:2).

The article focuses on disposable gloves, as this is the most common form of hand protection in the laboratory. However, it should be noted that disposable gloves only offer limited protection to chemicals. Typically this does not extend beyond beyond incidental exposure to chemical splashes. The limitations of disposable gloves are now recognized in EN374:2003 Protective gloves against chemicals & micro-organisms. As few as any standard laboratory gloves would be able to achieve the required class 2 (a breakthrough time of <30 minutes) from three of the twelve chemicals listed in EN374:1:2003, most disposable gloves that are certified as protecting against chemicals and micro-organisms will show the following pictogram:

The question mark in the middle of the square-shaped glass beaker reminds those of us engaged in risk assessments in the laboratory that we are referring to “low chemical resistant” or “water proof” gloves. It should also encourage us to seek additional information from the glove manufacturer on the chemical permeation time for specific chemicals that are being used in the laboratory.

As most disposable gloves are of one size, this would mean that all disposable gloves used for protection against chemical splashes and biohazards should have a minimum length of 26cm. However, few of the gloves routinely used in laboratories would satisfy this requirement. This seems strange given that the rationale for longer cuff gloves is for protection of the wrist from chemical splashes and biohazards.

This article has taken a closer look at the barrier properties of disposable gloves, when used in the laboratory. Particular attention has been given to protection from chemical splashes and biohazards. The value of long cuffed gloves for protection of the wrist has been noted, although it would appear that few manufacturers are to date complying with the minimum length required for conformity with EN374-1: 2003 (“Protective Glove against chemicals and micro-organisms-Terminology & Performance Requirements”). Similarly the limitations of EN374-2: 2003 (determination of resistance to penetration) was discussed in so far as it does not appear to offer protection against viruses. In this context it was suggested that for protection of biological agents from groups 2 to 4, it may be advisable to use gloves that have proven viral penetration resistance. Whilst ASTM F1671 is not a European standard, it may be a temporary solution.

REFERENCES


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18/02/2012 12:48:49