Chemical Protective Gloves
In-Use Protection Time
VS.
Standard Breakthrough Time

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Skin Contact despite Gloves

- Contamination of inner side
- Penetration - through holes
- **Permeation** - on molecular level
- Degradation - chemical destruction
- "Resistance"
- Re-use next day

- Contamination of inner side of glove by bad hygienic habits.
- Penetration is transfer of liquids or solids through macroscopic holes etc.
- Permeation is invisible and happens on the molecular level.
- Degradation is the irreversible change of barrier and other properties by chemical agents, visible in nearly all cases.
- Resistance is no clear term although used widely. Resistance should always be defined precisely - it might mean resistance to penetration, or permeation, or degradation or to all of these.
- Re-use next day is happening commonly but is not always acceptable practice - reliable information is lacking in many cases.
This work is based on a research project which was carried out by MILJÖ-CHEMIE.

Other participating labs were BIA (St. Augustin / Germany) and KCL (Fulda / Germany).

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More information at the homepage of German Work Insurance (Berufsgenossenschaften), www.hvbg.de
• Permeation test cell according to EN 374-3 and ASTM F739.
• A test specimen is cut from a sample glove and fixed between two compartments,
  one of these is filled with the challenge chemical
  the other one if flushed with air or water with then is analysed
  for permeants.
Solid collection media may be glass fibre filters, silicon rubber discs and other material.
A test specimen is cut from a sample glove and pressed tightly against the disc.
The disc is sent to analysis which gives the medium permeation during exposure.
Permeation - Breakthrough Time

- Period until permeation of 1 µg / 0.1 µg substances per minute through 1 cm² glove area is reached (EN / ASTM)

- Precision / variation:
  - ± 5 - 30 % within a lab
  - ± 23 - 50 % between labs
  - ± 8 - 25 % between trained labs

- Breakthrough is defined as normalised breakthrough time - this allows comparison of test data from different labs.

- Permeation rate is not used in Europe because it is said that no criteria exist for which amount of a chemical agent on skin is acceptable and which is not.

- The precision of testing is controlled by round robin tests.

- The variation is given both by inhomogeneous material and by variation of testing.

- In Europe, breakthrough time is reported in rough bands which reflects the variation of testing results.
Breakthrough Time = Protection Time ???

- Conditions of testing
- Selection of test method
- Pure substances / preparations
- Validity of results / databases

- conditions of testing:
  - temperature inside glove
  - stretching of glove
  - duration of exposure

- selection of test method:
  - select proper collection medium
  - select proper detection technique
  - else you get "no breakthrough" just because breakthrough was not possible to be seen

- In many cases, the permeation behaviour of mixtures cannot be predicted from test data of the ingredient when these were tested as single substances

- Test results and test data in databases shall be assigned to the glove brand in test only, not to other glove brands of similar polymer type and thickness
"It is emphasised that the test does not represent conditions likely to be found in service,

and the use of test data should be restricted to comparing materials chiefly on a relative basis in broad categories of breakthrough times."

• conditions of testing:
  • temperature inside glove
  • stretching of glove
  • duration of exposure
Temperature and Stretching

Conditions of testing:

- Temperature inside glove: 35 °C
- Stretching of gloves
  - Length stretching - typically 20 % at finger knuckle
  - Interval stretching or continuous stretching

• conditions of testing:
  • temperature inside glove
  • stretching of glove
Device for length stretching, tension frame.
### Temperature and Stretching

35 not 23 °C, 20 % Length stretching

<table>
<thead>
<tr>
<th>Glove</th>
<th>Chemical</th>
<th>Reduction of Breakthrough Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type Nitrile</td>
<td>non polar</td>
<td>by 0 - 50 %</td>
</tr>
<tr>
<td>Type Butyl</td>
<td>different</td>
<td>by 50 - 70 %</td>
</tr>
<tr>
<td>Type Chloropren</td>
<td>polar</td>
<td>by 30 - 50 %</td>
</tr>
</tbody>
</table>

- conditions of testing:
  - temperature inside glove
  - stretching of glove
Short-term Exposure

- Exposure of small areas only
- Occasional splashes
- Only temporary exposure
  - e.g. once a day
  - in intervals several times a day

**Volatility** determines the period of the agent remaining on glove and its impairment

- conditions of testing:
  - duration of exposure
Mixtures, Preparations

- Normally NO prediction possible from single substance data to behaviour of mixture
- Special case: Solutions of large molecules: the solvent determines breakthrough
- "Opening" effect by change of glove properties

• In many cases, the permeation behaviour of mixtures cannot be predicted from test data of the ingredients when these were tested as single substances
Latex does not equal Latex, Nitrile does not equal Nitrile

Significant differences in:

- Thickness
- Raw materials, polymer mixtures
- Vulcanising technique, cross-bonding
- Polymer layers within glove

Each test is valid only for the glove brand, not for the generic type of polymer!

• Test results and test data in databases shall be assigned to the glove brand in test only, not to other glove brands of similar polymer type and thickness.
Re-Use of Gloves next Day

<table>
<thead>
<tr>
<th>Case No</th>
<th>1st day</th>
<th>2nd day</th>
<th>3rd day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; 8 h</td>
<td>&gt; 8 h</td>
<td>&gt; 8 h</td>
</tr>
<tr>
<td>2</td>
<td>2 h</td>
<td>1 h</td>
<td>1 h</td>
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<tr>
<td>3</td>
<td>1:20 h</td>
<td>1 h</td>
<td>1 h</td>
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<td>4</td>
<td>1:40 h</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td>1:30 h</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>6</td>
<td>0:50 h</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

- 6 gloves were tested.
- no 1: no problem with re-use
- no 2: re-use possible, but shorter protection time
- no 3: re-use possible, almost the same protection time as on first day
- no 4, 5, 6: re-use not possible, gloves were untight next morning
Testing for real Applications

- 3 out of 5 cases: gloves in use and recommended by supplier: untight
- 4 out of 5 cases: detailed recommendations, cheaper than proposals from most databases
- Laminate gloves (4H, Barrier): very good in all tested cases, but bad acceptance (low wearing comfort)

- Several gloves were tested for 5 applications of chemical agents, considering the real-life use patterns.
- In 3 out of 5 cases: The gloves which were in use and had been recommended by the supplier - were untight
- In 4 out of 5 cases: detailed recommendations for proper gloves could be derived from the new test data, and most of these gloves were cheaper than proposals which had been read from databases
- Laminate gloves (4H, Barrier): These were very good in all tested cases, but they showed bad acceptance of the workers (due to limited wearing comfort)
Avoid skin contact

Define specifications for the glove (exposure, duration, use patterns, re-use)

Ask glove supplier

Assess testing method
- possibly re-calculate to real conditions
- possibly do realistic testing

Decide, buy and use the gloves
Future

- Trade specific recommendation of glove brands
- Suppliers of hazardous chemicals inform about good glove brands for typical use patterns
  - in MSDS / technical data sheet / example risk assessment
- Do all this on the basis of realistic testing (35 °C, possibly 20 % stretching, adapted duration of test)

- It is not possible that every user of gloves has find out which glove is doing its job well enough.
- In the future it is expected that recommendations are given by trade associations etc. for typical applications, such as indoor painting, road paving, metal degreasing etc.
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For more detailed information:
www.miljo-kemi.com