Selecting a Glove for Protection against Chemicals: Step 2 Selecting the Correct Type of Glove

By Robert N. Phalen, Ph.D., CIH

Once you have identified specific chemical hazards in the workplace that require skin protection, the next step is to identify the type of protective barrier needed to protect the worker. The main types of glove barriers used for chemical protection include rubber elastomers, such as natural latex and nitrile, and plastic polymers, such as vinyl and laminate films.

Always Remember "Like Dissolves Like"

The underlying principle with chemical protective clothing is "like dissolves like." This means that if the glove material is similar to the chemical hazard then it will likely dissolve in the glove and expose the user to the hazard. For example, acrylonitrile is a solvent used in the manufacture of nitrile gloves and thus it will easily dissolve nitrile gloves. It would be unwise to use a nitrile glove for protection against acrylonitrile. In fact, acrylonitrile will dissolve many other elastomer-based materials and typically only a plastic-based laminate material will provide sufficient protection. You need to know that there is no perfect glove for all applications.

Rubber versus Plastic

Most of us have been faced with the decision of paper versus plastic at the grocery store. With gloves it is rubber versus plastic. There are two distinct types of polymers, namely, rubber materials (elastomers) and plastic materials. In general, rubber materials are more flexible and make performing tasks that require hand control and precision easier. Whereas, plastic materials are preferred either for cost reasons or when chemical resistance to a larger number of chemicals is necessary (with the use of laminate films).

There are plastics that are equivalent to rubber materials and vice versa, but each material has its own properties, advantages and disadvantages. The only glove material that provides a broad spectrum protection against many different types of chemicals are the laminate films made of several layers of plastics and/or foils.

Rubber (Elastomers)

Rubber materials are defined by their ability to return to a normal form after being deformed. This makes them perfect for use as a material that can conform to the hand and stretch as the hand moves.

Examples of rubber elastomers include:

- Natural latex
- Chloroprene (or Neoprene)
- Nitrile

- Butyl
- Fluorocarbon (e.g., Viton)

The composition and properties of common elastomers are provided in the table below.

Material	**Primary composition**	**Properties**
Natural latex	*cis*-Isoprene	Highly elastic; degrades in presence of light (UV) and ozone; resistant to alcohols, acids and caustics (bases)
Chloroprene (Neoprene)	Polychloroprene	Similar to natural latex, but more resistant to light and ozone; oil resistant
Nitrile	Acrylonitrile and butadiene	Less elastic than latex; added puncture resistance; more resistant to light and ozone; resistant to oils, fuels, and many solvents
Butyl	Isobutene	Flexible, resistant to light and ozone; poor oil resistance
Fluorocarbon (Viton)	Vinylidene fluoride and Hexafluoropropylene	Less flexible; resistant to chlorinated and aromatic solvents, oils, and heat

Plastic Polymers

The plastic polymers are not typically elastic and are known to hold their shape over a wide temperature range. Most of them are the equivalent of placing a plastic bag over the hand and their performance is often dependent on the strength of the seam. The thin plastic gloves used in food service that look like a flat sandwich bag cut into the shape of a hand are often just that, polyethylene bags in the shape of a hand.

The use of plasticizers (softening agents) has allowed for production of more flexible plastic-type polymers. Vinyl gloves (polyvinyl chloride or PVC) are much more flexible than they used to be. Vinyl gloves are definitely more flexible than a vinyl PVC pipe used in homes and buildings. The drawback is that heavy use of oily plasticizers is likely to make the glove material less resistant to oils and hydrocarbons (e.g., gasoline and toluene). Remember "like dissolves like." An oily glove is more likely to absorb and pass oils and hydrocarbons. This can be the case with some vinyl gloves.

Examples of plastic polymers include:

- Polyethylene
- Poly vinyl chloride (PVC or vinyl)
- Polyvinyl alcohol (PVA)
- Laminate films (multiple layers)

The composition and properties of the plastic polymers are provided in the table below.

Material	**Primary composition**	**Properties**
Polyethylene	Polyethylene foils punched or welded	Thin material; stiff plastic film; good chemical resistant properties, but strength of seam often a limiting factor
Vinyl (PVC)	Polymer of vinyl chloride	Good resistance against water and aqueous (water) solutions, detergents, and dilute acids and bases; poor oil and hydrocarbon resistance
Polyvinyl alcohol (PVA)	Polymer of vinyl alcohol	Often a thicker material; good organic chemical resistance (oils and hydrocarbons); poor water resistance
Laminate film (Silver Shield/4H)	Foil-laminate (multiple layers)	Resistance to wide range of chemicals; less elastic; thick plastic sheeting, which makes it more difficult to use and perform tasks

General Guidelines to Selection of Glove Material

The table below is a general guideline to aid with the selection of a glove material. It is a starting point, but not the ultimate source on which a final selection should be made. Notice that the table is color coordinated and organized with nitrile gloves near the middle. This is because nitrile provides mixed resistance to organic solvents, oils, alcohols, acids, and caustics (bases). This is why nitrile is often a choice in many industrial or hospital setting, because it is resistant to a wider range of chemicals and it often performs similar natural latex. Vinyl is somewhere between natural latex and nitrile, but not well suited for many organic solvents because of the often high plasticizer (oil) content, as mentioned earlier. Remember like dissolves like.

The laminate films are not listed, because they offer a broad spectrum of chemical resistance, but are often an expensive choice used only when protection is critical, such as with high hazard exposures or spill response activities. They are typically recommended when the other choices are ruled out.

<table>
<tr><th>Glove Material</th><th>Resistant to</th><th>Not recommended</th></tr>
<tr><td>Natural latex</td><td>Alcohols, ketones, acids, and caustics</td><td rowspan="3">Hydrocarbons: aliphatic, aromatic and halogenated solvents</td></tr>
<tr><td>Neoprene</td><td>Alcohols, peroxides, petroleum (oils), organic acids, and caustics</td></tr>
<tr><td>Butyl</td><td>Alcohols, peroxides, ketones, and esters</td></tr>
<tr><td>Vinyl</td><td>Alcohols, acids, and caustics</td><td>Ketones, acetate and hydrocarbons:</td></tr>
</table>

		aliphatic, aromatic and halogenated solvents
Nitrile rubber	Organic solvents (aliphatic and aromatic hydrocarbons), oils, alcohols, and weak acids/caustics	Ketones, strong oxidizers, amines, and halogenated hydrocarbons
Viton	Hydrocarbons: aliphatic, aromatic and halogenated solvents	Ketones, acetates, and amines
PVA		Aqueous solutions, inorganic acids, and alcohols

Examples of Glove Choices for Common Chemicals

Below are some common glove choices one should look at for common chemicals. For other chemicals you may need to go to the MSDS or chemical label to determine what type chemical hazard you have.

Acetone – this is a ketone and both natural latex and neoprene would be good choices to start with.

Ammonium hydroxide – this is a caustic/base and natural latex, neoprene and vinyl would be likely choices worth investigation.

Chloroform – this is a chlorinated solvent thus Viton and PVA would be likely choices

Ethanol – this is an alcohol, which means natural latex, neoprene, vinyl and nitrile would likely work well

Hydrochloric acid – this is an acid thus natural latex, neoprene, vinyl and nitrile may all well be good starting choices to select from

Isopropyl alcohol – this is an alcohol thus natural latex, neoprene, vinyl and nitrile would likely work well

Methyl ethyl ketone (MEK) – this is a ketone thus natural latex and butyl would be more obvious choices

Toluene – this is an aromatic hydrocarbon thus nitrile, Viton and PVA would be possible choices

Xylene - similar to toluene this is an aromatic hydrocarbon thus nitrile, Viton and PVA would be possible choices

So You Say You are Not a Chemist – That is Okay

How can you identify which glove type may be best without knowing the chemical classification. The answer is somewhat easy: Go directly to the chemical resistance charts. Later we will cover how to interpret these charts, but most have a simple coding system that allows you to easily identify the right glove type. Most are coded as:

E= Excellent

G = Good

F = Fair

P = Poor

NR = Not Recommended

In some cases it may be a simple color coded system that identifies recommended and not recommended classifications.

Unfortunately, not every chemical will be listed in these chemical resistance charts, so you may have to rely on chemical classifications and properties, as we looked at earlier.

Here are two general chemical resistance charts for different glove and/or clothing materials:

Source	Title / Link
Forsberg and Mansdorf (2007)	Quick Selection Guide to Chemical Protective Clothing, 5th Edition (Wiley) http://www.wiley.com/WileyCDA/WileyTitle/productCd-0470146818.html
NIOSH (online)	Recommendations for Chemical Protective Clothing: A Companion to the NIOSH Pocket Guide to Chemical Hazards: Database http://www.cdc.gov/niosh/ncpc/ncpc1.html

Here is a partial list of links to glove manufacturer chemical resistance charts for different glove products:

Manufacturer	Link
Ammex	http://www.glovesbyweb.com/gloves-chemical-resistance-chart
Ansell	http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf
Mapa	http://www.mapaglove.com/ChemicalSearch.cfm?id=0
North	http://www.northsafety.com/ClientFormsImages/NorthSafety/CorpSite/E8D15F2E-1F59-454F-B8F0-147FA2B9D81D.pdf
Microflex	http://www.microflex.com/Products/~/media/Files/Literature/Microflex%20Chemical%20Resistance%20Guide.ashx
ShowaBest	http://www.chemrest.com/chemrest/hazards

Chemical Mixtures

There is no easy solution to complex chemical mixtures. One approach is to try and find a glove material that will work with all the chemical components. Sometimes this is possible, because "like dissolves like" and a mixture of different solvents should have similar properties. They would not be able to be dissolved in each other if they were not similar. There are always exceptions, but most of the time there should be some similarity between the chemicals in a mixture.

Another alternative is to look at the MSDS for the chemical mixture, if one exists, and see if there is a specific recommendation regarding glove type. However, if it states "use a rubber glove" then by now you should know that this does not necessarily mean a natural latex rubber glove. Many times the MSDS will state "wear gloves" or "wear appropriate protective gloves." Always be cautious with information that seems vague. There are many different types of gloves and on one glove is perfect for all situations.

One other alternative is to select two to three likely choices based on the information you have and then do some chemical compatibility testing. This concept will be covered in more detail later. One simple test that can be done is to get samples of three or more different glove materials and then expose them to the chemical mixture in question for 24 hours. After the exposure remove the samples, wipe off or blot the excess chemical, and then compare the changes that may have occurred. Place the exposed samples next to the original material and look for physical signs of swelling, color change, cracking, wrinkling, aging, or a change in shape. Any significant changes would be an indication of an interaction or degradation (breakdown of the material). You would not want to use gloves affected in such a manner.

This simple test can help you eliminate a glove material from your choices. In critical situations where workers are exposed to highly hazardous or toxic chemicals never rely on such simple observational tests. Instead, laboratory tests using more sophisticated analytical methods may be necessary. These will be discussed later.

Select at Least Two Glove Materials to Decide From

For each application or worker exposure, you should determine at least two best glove material choices, based on the charts and information sources above. For example, if natural latex looks like the best option, then also consider neoprene as an option. If vinyl seems best, then maybe nitrile, natural rubber or neoprene may be worth investigating as alternatives. These choices become more important when other factors come into play, such as cost, user comfort, or protection against multiple chemicals in the workplace.

References and Additional Reading:

1. Anna, Ed. (2003) *Chemical Protective Clothing, Second Edition.* AIHA Press, Falls Church, VA.

2. Boman, Estlander, Wahlberg, and Maibach, Eds. (2005) *Protective Gloves for Occupational Use, Second Edition.* CRC Press, Boca Raton, FL.
3. Forsberg and Mansdorf (2007) *Quick Selection Guide to Chemical Protective Clothing, Fifth Edition*. Wiley-Interscience, Hoboken, NJ.
4. Occupational Safety and Health Administration (OSHA) *Chemical Protective Clothing* in *OSHA Technical Manual.* Accessed online (July 30, 2012) at http://www.osha.gov/dts/osta/otm/otm_viii/otm_viii_1.html.
5. Plog, Niland, and Quinlan, Eds. (2001) *Fundamentals of Industrial Hygiene*, Fifth Edition. National Safety Council, Itasca, IL.