Finding the Most Suitable Chemical Resistant Gloves for the Application

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Workers in the chemical processing and handling industry could certainly benefit from the "perfect" glove. The glove would be thick enough for thermal insulation, thin enough to promote dexterity and tough enough to protect workers from cuts and abrasion. It would also protect against all known chemicals and offered at a minimal price.

The problem is that such a glove does not exist. Processors and handlers, therefore, must provide workers with the most suitable, available gloves for the application, considering individual circumstances and how the gloves will be used.

Factors to Consider

The person who selects gloves should know much more than the name of the chemical. If an employee, for example, is working with nitric acid, then PVC (vinyl) and neoprene are the preferred glove materials. Several questions, however, must still be answered.

Is the worker cleaning up spills? If so, the person will require highly chemical-resistant gloves with good storage stability since the gloves may be kept in a spill-control cabinet for several years until they are urgently needed.

Is the person handling sealed bottles, which will require minimal protection unless the bottle breaks? Could a spill be caused by breaking a bottle? If so, the worker will need protection from cuts as well as nitric acid. What is the probable length of exposure? The longer workers are exposed to a certain chemical, the greater the level of protection required.

The chemical concentration must also be considered. Is the compound present only as a trace impurity? Is the employee working with a pure chemical or a dilute solution? If the chemical is diluted, what solvent was used for dilution?

Companies sometimes over-specify gloves, which can be expensive. A chemical company, for example, indicated a need for gloves that would resist "high concentrations" of toluene. When questioned about the application, the company revealed that workers would be exposed to ground water with a toluene concentration of less than 100 parts per million. While this is a high concentration for toluene in groundwater, in this case, gloves that protect against water would be more appropriate and cost effective than gloves that protect against pure toluene.

Glove Types

Gloves are generally categorized according to the materials used and whether they are supported or unsupported (see definitions below). The following glove types are available in a range of lengths, thicknesses and finishes, while some styles are offered with special modifications.

Unsupported and Supported Gloves

Unsupported gloves are made of materials such as natural or synthetic latex, nitrile and neoprene and achieve their glove shape by dipping hand forms directly into the glove compound without a supporting liner or fabric. This type of glove generally provides the dexterity and tactile sensitivity required for many chemical applications.

Unsupported gloves offer a broad spectrum of chemical resistance based on the material used. Nitrile gloves, for instance, are excellent for many chemical processing, oil refining, food processing and petrochemical applications. Gloves made with a neoprene and natural rubber latex blend provide the protection workers need in food processing facilities and chemical and pesticide manufacturing plants.

Supported gloves are made by dipping a knitted or woven cloth liner into a glove compound such as nitrile, with the liner "supporting" the compound and adding strength. Some supported styles have continuous coatings to ensure protection from chemicals.
Cotton and polyester may be used in various combinations as a yarn for woven or knitted products coated with various compounds—including natural latex, neoprene and PVC—to protect against petrochemicals, oils, acids, alcohols and solvents.

Supported gloves with non-continuous coatings are better suited for applications that require comfort and grip. Many supported gloves also offer cut, snag, puncture and abrasion resistance.

Fabric Gloves

This category includes general purpose gloves made with polyester, nylon and cotton; cut-resistant gloves constructed with Kevlar®, Dyneema® and steel; stretch gloves made with small percentages of natural latex and Lycra® yarns added to other fibers; and special purpose gloves with materials such as thermal foam or vibration foam. Special purpose gloves include extra clean gloves and sterile gloves.

General Purpose Gloves
Nylon, polyester and cotton gloves are comfortable and protect against snags, punctures, cuts and abrasion. They do not, however, protect against chemicals and liquids, which is why chemical-resistant gloves may need to be worn as liners in some applications. Nylon is an alternative fabric that may be used in cleanrooms, automotive paint rooms and inspection stations where there is concern about lint contamination.

Cut Resistant Gloves
Gloves made with Kevlar® typically provide the best cut protection based on price, and gloves made with Spectra® or Dyneema® ultra-high molecular weight polyethylene typically offer the best cut protection based on weight. Steel assures the best cut protection based on bulk. None of these materials, however, will protect the hands from liquids unless the fabric is coated with a compound such as nitrile.

Stretch Gloves
Most fabric gloves today are made from knitted fabric rather than woven fabric because knits have a natural tendency to stretch and fit closely. Natural rubber latex is used to make the least expensive additive yarn for making tighter-fitting gloves and cuffs. Workers who need a tighter fit and know or suspect they have a latex allergy should consider switching to gloves made with a synthetic alternative such as spandex.

Special Purpose Gloves

Specialty gloves include those made with thermal foam for protection from heat or cold, vibration-absorbing foam for workers handling power tools and other vibrating machinery, or products with radiation-absorbing additives such as lead or bismuth. This category also includes extra-clean gloves for electronics cleanrooms and sterile gloves for pharmaceutical facilities.

Chemical Barrier Glove Materials

Descriptions of glove materials that may be used with various chemicals follow, with advantages and disadvantages listed. Gloves are listed in order by degree of specialized use.

Natural Rubber (Latex)

Natural rubber latex gloves are generally unsupported and available in many styles, including cleanroom and sterile styles. These gloves provide excellent protection from bases, alcohols, and dilute water solutions of many chemicals, with fair protection against aldehydes and ketones.

Advantages: low cost, good physical properties, high resistance to cuts, excellent dexterity.

Disadvantages: poor protection against oils, greases and organics; risk of protein allergies. Some manufacturers use quality-reducing shortcuts that result in a poor quality product.

Poly Vinyl Chloride (PVC or Vinyl)

Gloves made with PVC are generally available in heavy supported or lightweight disposable styles and protect against strong acids, strong bases, salt solutions and some heavy organic chemicals. Many PVC or vinyl gloves offer good abrasion and cut resistance—although some styles may be susceptible to cuts.
Advantages: low cost, fair physical properties, minimal risk of allergic reactions.

Disadvantages: organic solvents can wash plasticizers out, leaving "holes" in the glove polymer on the molecular level that may allow rapid chemical permeation; gloves from some manufacturers are poor quality.

Nitrile (Buna, NBR)

Nitrile gloves are generally available as disposable, mediumweight unsupported, or lightweight supported styles. They protect against oils and greases (including animal fats); xylene, perchloroethylene and aliphatic solvents. They also protect against most agricultural pesticide formulations, chemical and biological weapons of mass destruction (WMDs) and other chemicals.

Advantages: low cost, excellent physical properties, dexterity, excellent resistance to snags, puncture, abrasion and cuts.

Disadvantages: poor protection against many ketones, some aromatic chemicals, and medium-polar compounds.

Neoprene

Neoprene is available in disposable, mediumweight unsupported, mediumweight supported and heavy supported styles. Neoprene protects against a broad range of oils, oxidizing acids (nitric and sulfuric), polar aromatics (phenol and aniline), glycol ethers, oils, greases and many other chemicals. Other types of gloves may offer better protection against some of these chemicals.

Advantages: medium cost, medium physical properties, medium but broad-ranging chemical resistance.

Disadvantages: less resistant to snags, punctures, abrasion and cuts than nitrile or natural rubber.

Butyl

This compound is used only in mediumweight unsupported gloves.

Advantages: dexterity and outstanding resistance to moderately polar organic compounds such as aniline and phenol, glycol ethers, ketones and aldehydes.

Disadvantages: poor protection against non-polar solvents, including hydrocarbons, chloro and fluoro carbons; expensive

Poly Vinyl Alcohol (PVA)

PVA is used for mediumweight supported gloves that provide a high level of resistance to many organic chemicals such as aliphatics, aromatics, chlorinated solvents, fluorocarbons and most ketones (except acetone), esters and ethers.

Advantages: very rugged and highly chemical-resistant; good physical properties with resistance to snags, puncture, abrasion and cuts.

Disadvantages: will quickly break down when exposed to water and light alcohols, less flexible than many other types of chemical resistant gloves, expensive.

Viton

This compound is used primarily in mediumweight unsupported gloves to protect against aromatics, chlorinated solvents, aliphatics and alcohols.

Advantages: dexterity, outstanding resistance to many organic compounds.

Disadvantages: poor resistance to certain solvents, including ketones, esters and amines; poor physical properties; extremely expensive.

Sealed-Film (Laminate) Gloves

Laminate is one of the most chemical-resistant materials available and protects against almost anything, including most chemicals and biological WMDs. Gloves made with this material are excellent for hazmat applications. Laminate gloves are often used as liners, which takes advantage of their thinness and is often the best way to address their disadvantages.

Advantages: moderate cost, thin, outstanding resistance to almost all organic compounds.

Disadvantages: no grip finish, poor physical properties (very low resistance to physical damage), not as form-fitting as dipped gloves.

Chemical-Resistant Glove Tests

Chemical-resistant gloves typically are tested for degradation, permeation breakthrough times, and final permeation rates.

Degradation is a deleterious change in the physical properties of a glove due to the effects of a chemical. It is commonly evaluated by measuring weight or dimension changes upon exposure. Currently, no widely used standard degradation test exists for gloves—although several groups have tried to develop one. The problem is that during actual use, only the outside of a glove is exposed to chemicals, and it is difficult to test the outside of a multi-layer glove without having the results distorted by the properties of the inner layers.

Permeation is the process by which a chemical moves into and through a chemical-resistant glove film by adsorption on the outside, diffusion through, and then desorption on the inside. Measurements commonly tabulated include breakthrough time (for example, how long after exposure was the permeation "valve" opened?) and permeation rate (e.g., how wide was it opened?).

Both degradation and permeation result from a chemical being absorbed and diffused into the film. The amount of chemical absorbed and the rate of transport, however, are independent variables, which means that neither property can be predicted based on the test results for the other property. A simple degradation test, therefore, cannot be used to extrapolate the results expected from a more complex and time-consuming permeation test.

ASTM F 739 is the permeation test most commonly used and represents the original permeation standard—although a substantial amount of data has been accumulated since it was first issued. European standards writers adopted ASTM F 739 with minor modifications as EN 388. During testing, permeation test cells are filled once and remain filled. The results typically provide the time delay until the chemical breaks through and the flow rate through the material, which increases to a final constant value.

Method F 739 does not realistically simulate most end uses for chemical-resistant gloves. During actual use, gloves are likely to be warmed by the wearer's hands to higher temperatures than those used in testing, which will make chemicals permeate more rapidly. Gloves will be flexed and squeezed rather than held in place in a test cell, which will also make chemicals permeate more rapidly.

Gloves, however, are typically worn to protect against possible splashes—not continuous liquid contact. Chemicals, therefore, will permeate through more slowly during actual use than in a standard permeation test. Breakthrough times and permeation rates from F 739, therefore, should not be considered as absolute constants of nature. The data is useful only to compare gloves and obtain a general indication of how well they can be expected to perform.

ASTM F 739-07 is the newest version of ASTM F 739 and uses 27C as the standard temperature since gloves are generally warmer than room temperature during use. Much older data and European data were obtained at room temperature, which is 21C. Europeans decided that a consistent established method is more important than a somewhat more realistic method, which is why they use 21C as the test temperature. When selecting gloves, it is important to compare products that were tested at the same temperature.

ASTM F 1383 can be used to simulate intermittent contact applications—although the test focuses on permeation only. During F 1383 tests, permeation test cells are filled and emptied repeatedly on a schedule developed to match the intended end use. Air or nitrogen is blown through the chemical compartment during the entire "empty" cycle, with evaporation away from and diffusion into the sample occurring simultaneously. The ASTM F1383 Intermittent-Contact Permeation Test, therefore, may provide a more realistic permeation measurement of real-world breakthrough times.

Breakthrough ratings indicate how long a glove may be safely worn after a splash occurs. Final permeation rates show how much of a chemical permeates the glove barrier during continuous exposure. While lower ratings are better, there is still no allowable skin contact threshold limit value (TLV) for any chemical. Most people who select gloves tend to pay more attention to the breakthrough time.

Conclusion

Since the "perfect" glove does not exist to protect workers in every chemical application, gloves should be selected that provide the appropriate level of protection for the specific chemical handled. Questions should be considered regarding the chemical concentration and length of exposure, dexterity, tactile sensitivity and cut protection required.

Many glove manufacturers offer hand protection products that protect workers from a variety of chemicals. In general, natural rubber latex is the least expensive alternative for tight-fitting gloves that resist bases, acids, alcohols and the diluted aqueous solutions of most chemicals. Unsupported gloves offer a broad spectrum of chemical resistance—depending on the material used. Supported styles are often used for general purpose, chemical-resistant or cut-resistant applications.

For more information about hand protection products that protect against chemicals, call 800.800.0444 or visit www.ansellpro.com.