

FirstHAND

CRITICAL GLOVE BARRIER ISSUES

Do the Gloves You Wear Afford Appropriate Barrier Protection for the Task at Hand?

Although gloves manufactured with different materials have comparable leak defect limits when removed directly from the box, their actual on-the-job barrier performance may be extremely different.

Several government agencies have stressed the importance of appropriate glove barrier protection....

CDC – “All health-care workers should routinely use appropriate barrier precautions to prevent skin and mucous-membrane exposure when contact with blood or other body fluids of any patient is anticipated.”¹

OSHA – “Since the reason for wearing gloves is to provide barrier protection from hazardous substances, substitute materials [synthetic or non-latex] must maintain an adequate barrier protection and be appropriate for the hazard.”²

NIOSH – “Use non-latex gloves for activities that are not likely to involve contact with infectious materials (food preparation, routine housekeeping, maintenance, etc.).”³

Protection. For life.

TABLE OF CONTENTS

This publication will review glove barrier issues that are critical to prudent glove selection and end-user practices in the healthcare setting. These issues include:

- Base Glove Material 1
- Physical Performance Standards and Test Methodologies 3
- Viral Penetration 5
- In-Use Barrier Performance Studies 5
- Chemical Barrier Testing 6
- Characteristics of Glove Degradation 7
- Everyday Practices That May Affect Glove Barrier 7
- Glove Barrier Integrity: Evaluation Guideline 10



Base Glove Material

The last decade has been an intense time in glove development laboratories. Several new materials have been introduced and many more are on the horizon. The most prominent base materials currently in the market are listed in Table 1.

Due to the current cost, many synthetic materials are only used in surgical gloves.

Table 1

BASE GLOVE MATERIALS		
Material	Surgical Gloves	Exam Gloves
Natural Rubber Latex (NRL)	X	X
Nitrile (NBR, Nitrile-butadiene rubber)	X	X
Vinyl (PVC, Polyvinyl chloride)		X
Polyurethane (PU)	X	X
Neoprene (CR, Polychloroprene)	X	
Tactylon® (SEBS, Styrene-ethylene-butylene-styrene)	X	
Elastryn (SBR, Styrene-butadiene rubber)	X	

Base Glove Material Strength and Limitations

Information on individual strengths and limitations of base glove materials has been obtained from various sources and is identified in the following charts. Characteristics that had moderate performance in an area were not listed. All chemicals listed represent working (diluted) solutions.

NATURAL RUBBER LATEX	
Strengths	Limitations
• Tensile strength ⁴	• Oils can degrade ⁷
• Tear and puncture resistant ⁵	• Ozone, oxygen & ultraviolet light can deteriorate ⁵
• Performance durability ^{4,6}	• Not to be worn by or used on NRL allergic individuals ^{2,3}
• Tactile sensitivity ⁶	
• Elasticity ⁶	
• Comfortable, supple, low modulus ^{4,6}	

NITRILE	
Strengths	Limitations
• Resistant to oils ^{7,8}	• Ozone, oxygen & ultraviolet light can deteriorate ⁸
• Resistant to glutaraldehyde ^{6,9}	• Can have high modulus, stiffness ⁴
• Resistant to many chemicals ⁴	
• Resistant to punctures ^{10,11}	
• Resistant to abrasion ^{10,11}	
• Comfortable ¹²	

VINYL	
Strengths	Limitations
• Resistant to ozone ¹³	• Durability ⁶
• Resistant to oil ¹⁴	• Not recommended for use in chemotherapy ¹⁵
	• Not recommended for use with glutaraldehyde ⁹
	• Susceptible to breakdown with alcohol ¹⁶
	• Elasticity ⁴
	• Tensile strength ⁶

PU, POLYURETHANE	
Strengths	Limitations
• Resistant to abrasion ¹⁴	• Susceptible to breakdown with alcohol ⁴
• Resistant to oil ¹⁷	• Can be slippery ⁴
• Tensile strength ¹⁷	• Hardens, embrittles at low temperatures ¹⁴

NEOPRENE	
Strengths	Limitations
• Resistant to oil ^{8,17,18}	• Can have high modulus, stiffness ^{4,10}
• Resistant to alcohols ⁴	• Ozone, oxygen & ultraviolet light can deteriorate ¹⁷
• Resistant to many chemicals ⁴	

TACTYLON® (SEBS, STYRENE-ETHYLENE-BUTADIENE-STYRENE)	
Strengths	Limitations
• Resistant to ozone, oxygen ⁵	• Breaks down with uncured methacrylate (e.g. bone cement) ⁴
• Resistant to glutaraldehyde ¹⁹	
• Comfortable, supple, low modulus ¹⁰	
• Tactile sensitivity ¹⁰	

ELASTRYN (SBR, STYRENE-BUTADIENE RUBBER)	
Strengths	Limitations
• Comfortable, supple, low modulus ¹⁰	• Ozone, oxygen & ultraviolet light can deteriorate ⁴
• Tactile sensitivity ¹⁰	• Breaks down with uncured methacrylate (e.g. bone cement) ⁴
	• Susceptible to oil ¹⁷

The molecular structure of the base material from which a glove is made is one of the primary determinants of barrier performance.⁵¹ As challenges to barrier integrity change (snag, tear, material fatigue, chemical contact), so too may the appropriate glove choice.

To aid in the prediction of glove performance, many different tests have been developed. A discussion of these test methodologies and associated standards follows.

Physical Performance Standards and Test Methodologies



Glove materials have different stretch capabilities. This difference can affect in-use barrier performance. Glove materials from top to bottom: Natural Rubber Latex, Nitrile, Vinyl.

The American Society of Testing and Materials (ASTM), a non-governmental, not for profit agency, develops voluntary glove standards. Members of ASTM medical glove working groups include representatives from glove manufacturers, testing laboratories, government agencies and healthcare. The physical performance standards they develop establish minimum acceptable strength, elongation, thickness, dimension and modulus requirements for natural rubber latex (NRL) and synthetic gloves. Test methodologies including viral penetration and chemical permeation have been developed to further characterize barrier performance; however, manufacturers are not required to perform these specific evaluations.

Relevant Test Methods

Some of the more relevant test methods include, but are not limited to:

Water leak (ASTM D5151): This test is performed by placing an unused glove over the end of a vertical cylinder and filling it with 1,000 milliliters of water. After a two-minute period, the glove is observed for leaks.²⁰ Values are stated as Acceptable Quality Levels (AQL), which is roughly the percent failure rate allowed.

Relevance: Holes, rips and/or very weak areas that rupture in the leak test indicate that barrier protection is compromised.

Thickness (ASTM D3767): The thickness of a single layer of glove is measured in millimeters (mm) utilizing a micrometer at specified locations on the upper finger, palm and cuff.²¹

Relevance: Thickness is an important component of barrier protection consistency for both durability and chemical permeation.

Strength or Tensile Strength (ASTM D412):

Strength is measured in megaPascals (MPa) to assess the amount of force applied to a glove until it breaks. The calculation is adjusted to normalize for thickness.²²

Relevance: The lower the tensile strength, the more easily materials of the same thickness can break when snagged or pressure is applied. For example, fingernails exert a tremendous amount of concentrated pressure at glove fingertips.

Ultimate Elongation (ASTM D412): The ability to stretch is determined by extending a strip of glove until it breaks. The percentage the strip is stretched until the break is the ultimate elongation.²²

Relevance: This stretchability is very important at the microscopic level where the glove material must be able to give rather than break when stressed or snagged by instruments, fingernails, ridges on caps, twisting stop cocks on IV sets, snapping off enclosures or any tasks performed with gloved hands.

Relevant Test Methods (continued)

Modulus, resistance to movement or stress at 500% elongation (ASTM D412):²² This is determined by the amount of force (effort) required to stretch the glove. The lower the modulus, the less effort required for movement.

Relevance: This measurement enables one to predict the effort wearers will have to exert to perform tasks. This has an indirect impact on barrier performance as hand fatigue may lead to accidents (e.g., puncture, tearing and/or ripping glove material) during procedures.

Since the physical properties of synthetic materials differ from each other and from NRL, one standard cannot be applied to all gloves. Tables 2 and 3 specify the minimally acceptable ASTM physical performance standards of unused gloves made of different materials. It is important to emphasize that these are minimal standards. Manufacturers vary in the rigorousness of their internal requirements. For instance, some manufacturers have standards that are more stringent than those of ASTM requirements (e.g., an AQL of 1.5 instead of the more lenient 2.5 for exam glove leaks).

Table 2

ASTM MINIMUM REQUIRED PHYSICAL STANDARDS FOR EXAMINATION GLOVES ^{23,24,25}							
Material	ASTM Standard	AQL [a]	Modulus	Thickness		Strength [b]	Elongation [b]
				Finger	Palm		
NRL Type I [c]	D3578-01	2.5	5.5MPa	0.08mm	0.08mm	18MPa	650%
NRL Type II [c]	D3578-01	2.5	2.8MPa	0.08mm	0.08mm	14MPa	650%
Nitrile	D6319-00a	2.5	NS	0.05mm	0.05mm	14MPa	500%
Vinyl	D5250-00	2.5	NS	0.05mm	0.08mm	9MPa	300%

[a] Acceptable Quality Level [b] Before Aging [c] Type I Natural Rubber Latex has higher strength requirements than Type II material NS: Not Specified

Table 3

ASTM MINIMUM REQUIRED PHYSICAL STANDARDS FOR SURGICAL GLOVES ²⁶						
Material	ASTM Standard	AQL	Modulus	Thickness	Strength [a]	Elongation [a]
NRL Type 1	D3577-00	1.5	5.5MPa	0.10mm	24MPa	750%
Synthetic Type 2	D3577-00	1.5	7.0MPa	0.10mm	17MPa	650%

[a] Before Aging

Viral Penetration

The viral penetration test is not required but is performed by some manufacturers. ASTM F1671-97b is a standardized test method used to assess the ability of protective clothing to resist viral penetration.²⁷ A single layer of glove is placed between two halves of a test chamber. A liquid suspension of the challenge virus, Phi X 174, is placed in one side of the chamber. The other half of the chamber is filled with receiving media. Samples are pulled from the receiving chamber at various times throughout the challenge period. Detection of any virus in the receiving media indicates breakthrough and thus failure of the glove material.

In-Use Barrier Performance Studies

Although test results identify basic physical capability differences between glove material types and establish minimal acceptable standards, the real relevance to the healthcare professional is whether or not the glove is protective in use. Both simulated in-use studies and actual clinical studies have been performed to evaluate glove durability. NRL and vinyl have been the primary materials used in the medical glove industry and thus constitute the bulk of independent research testing to date. Data summaries of several studies are provided in Table 4.



Provide appropriate barrier protection for the task.

Table 4

PHYSICAL BARRIER PERFORMANCE STUDIES						
Author	Date	Durability Challenge		Leakage Percentage Rates (ab)		
		Simulated Use	Clinical	Vinyl	Latex (NRL)	Nitrile (f)
Rego ²⁸	1999	X		30% (c)	2%	2%
Douglas ²⁹	1997		X	26% (c)	8%	–
Korniewicz ³⁰	1994	X		51%	4%	–
Korniewicz ³¹	1993		X	85%	18%	–
Olsen ³²	1993		X	43%	9%	–
Merchant ³³	1992		X	83%	21%	–
Klein ¹⁶	1990	X		22% (d)	1% (d)	–
				56% (e)	1% (e)	–
Korniewicz ³⁴	1990	X		63%	7%	–
Korniewicz ³⁵	1989	X		53%	3%	–

(a) All percentages were rounded to the nearest whole number. (b) When more than one brand of a particular material was evaluated, failure rates were averaged. (c) There did appear to be a difference in performance between standard and stretch vinyl. • Rego study: Standard vinyl exhibited failure rates ranging from 26-61%; stretch vinyl failed at 12-20%. • Douglas study: Standard vinyl failed at 25-32%; stretch vinyl failed at 22-27%. (d) Without first contacting ethanol. (e) After contact with 70% ethanol. (f) Additional barrier studies on this fairly new medical glove material are anticipated.

Chemical Barrier Testing

While general medical gloves do not require chemical permeation or degradation testing, chemotherapy gloves do. The following is a discussion of relevant chemicals and test methodologies.

Chemotherapy/Cytotoxic Drug Testing

Gloves sold for chemotherapy use must pass chemical permeation challenges with numerous chemotherapeutic drugs. The test protocols and results must be reviewed and cleared by the FDA. It is advisable that hospital materials managers require clearance documentation.

The chemotherapy drug challenge test study is not standardized. However, the method most frequently used is ASTM F739³⁶ for continuous contact permeation studies of any chemicals on thin film protective materials. Physical testing may also be conducted on the glove after the permeation study is completed to determine if the physical properties have degraded. Because not every chemotherapeutic drug or combination of drugs can be anticipated, the drugs are divided into chemical families. Representatives from each of the drug families are used as the chemical test challenge. Basically, one layer of the glove is placed between two chambers. The drug being evaluated is placed on one side and a receiving fluid on the other. Samples are taken from the receiving fluid over several hours to determine if breakthrough has occurred.

It is important to note that chemotherapy glove clearance [510 (k)] from the government is based only on the resistance to permeation. It is up to each facility to review guidelines published by professional associations in establishing their own chemotherapy and general hazardous drug (HD) glove usage policies.



Top: The toxicity of chemotherapeutic drugs demands the protection provided by gloves cleared for chemo use.

Above: Chemicals can penetrate gloves and put the wearer at risk. Select gloves that resist chemical penetration.

Considerations when addressing chemotherapy/cytotoxic guidelines may be:

- Use of chemotherapy qualified gloves (when, where, how)
- Use of powder-free gloves to reduce the potential for powder absorption and aerosolization of cytotoxic drugs
- Length of glove cuff for forearm protection*
- Use of double glove when appropriate
- Use of sterile versus non-sterile gloves
- Frequency of glove change (e.g., immediate if torn or punctured)
- Use of gloves when disposing of contaminated linens
- Proper removal and disposal of gloves

*If single gloving, tuck the clean glove over the cuff of the gown. If double gloves are worn, one glove is inserted under the cuff, and one glove goes over the cuff.

Antiseptic, Disinfectant and Liquid Sterilant Penetration Testing

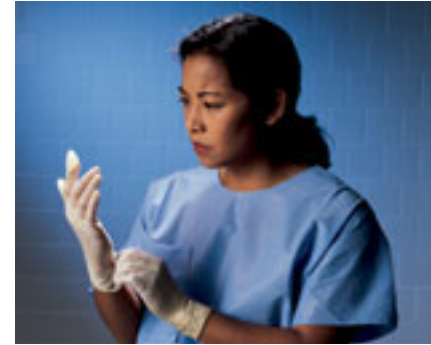
Gloved hands may routinely come in contact with numerous antiseptics, disinfectants and/or liquid sterilants. Thus, it is important to know the quality of chemical protection the glove provides.

Although no requirements exist for gloves, some manufacturers may choose to use the ASTM F739 method to evaluate the resistance of their gloves to specific chemicals. Information regarding chemical permeation must be requested directly from the manufacturer. Facilities will vary, of course, but frequently used chemicals include gluteraldehyde, isopropyl alcohol and formalin.

Characteristics of Glove Degradation

There are general characteristics of glove degradation that may indicate a breakdown in the glove barrier integrity. It is important to recognize these general indicators to help ensure the selection and maintenance of optimal glove protection. These indicators of degradation include:

- *Hardening or embrittlement*
- *Softening (may see extending of fingertips)*
- *Tackiness*
- *Cracking*
- *Loss of strength*
- *Loss of tear resistance*
- *Loss of elasticity*



Glove materials are degraded by different substances. Note the elongation of the thumb and fore-finger of this glove after a task that required sustained contact with an oil-based product.

Everyday Practices That May Affect Glove Barrier

The barrier protection of any glove may be further compromised by everyday practices that include storage conditions, skin care, personal habits and the inability to rapidly identify type of base material. Several of these practices are identified as follows.

Glove Specific:

Selection of Powder-Free versus Powdered Gloves. Powder can defeat the intent of glove barrier protection by functioning as a vehicle for the transport of infectious microorganisms and interfering with the local resistance to infection in wounds where powder is deposited. Glove powder may cause dermatitis with cracks and open lesions on the hands. This break of the natural skin barrier may enhance microbial access into the body. Powder can also absorb and aerosolize disinfectants, drugs and other chemicals with which the powdered glove comes in contact – again by-passing the protective intent of the glove.

Rapid Identification of Base Material (e.g., label, glove ID, color). When you or your staff grab a glove, is it readily apparent which type of material you are donning? Is the base glove material labeled generically as "synthetic" or does it specify vinyl, nitrile or other synthetic material? It does little good to understand the differences in barrier capability among glove materials if the material of the glove you are grabbing is not readily apparent. Is the color such that vinyl gloves, for instance, can be differentiated from NRL gloves? Mistaken identity can lead to the use of a latex colored vinyl glove when the barrier protection quality of an NRL was the intended selection. Or, an NRL allergic individual may mistakenly grab an NRL glove, which may result in an adverse reaction. The same thought process applies to brightly colored NRL and NRL/synthetic blends where natural rubber latex and synthetic materials can be confused.

Selection of Glove Size. There should be a full range of glove sizes to accommodate all personnel. Glove length, width, finger contour and thumb position are among the factors to consider when evaluating appropriate glove fit. Gloves should conform to the hands, yet allow ease of movement (low modulus) to minimize fatigue. Poor fitting gloves can interfere with the optimal performance of procedures. "Baggy" gloves can cause wearers to execute procedures awkwardly. If infectious agents or hazardous chemicals are used, accidental spills can put staff at personal risk.

Check for the Sticking of Adhesives to the Glove. If the glove is to be used for tasks that require tape or adhesive label contact, check to see if the adhesive material adheres to the glove. Consider an alternate glove if adherence occurs, as forced removal may cause microscopic tears in the material.

Observe for Clumps and Debris. A "halo effect" may be seen around debris imbedded in the glove material. The halo may indicate a weakened area that can fracture during use. This effect can occasionally be seen at glove fingertips where a drop of the liquid glove material can solidify during production.

Everyday Practices That May Affect Glove Barrier (continued)



It is important to prevent the development of dermatitis. The open sores and cracks that result from dermatitis provide entry routes for microorganisms.

Glove Specific (continued):

Donning Techniques. Poor donning techniques can result in glove rips and tears. Healthcare personnel should take care to don gloves correctly and avoid excessive stretching. Thoroughly dry hands before sliding them into gloves.

Double Gloving. Double gloving has been documented to significantly reduce the penetration of contaminated sharps through to the skin surface and should be considered when the risk of exposure to highly pathogenic organisms is present or as dictated by facility policies.^{37,38}

Length of Glove Wear. The longer a glove is worn the more vulnerable it is to barrier compromise. The rate of fatigue can be compounded by many factors that include, but are not limited to, rigorous manipulations, contact with various chemicals and quality of the film glove layer in areas that are difficult to coat (e.g., the saddle between the fingers). During extended surgeries, the practice of changing to a new pair of gloves prior to a critical procedure has been noted to reduce bacterial contamination.

Glove Removal. Infectious organisms may contaminate the exterior surface of gloves during use. It is important to follow proper glove removal techniques. The gloves should then be dropped, not tossed, into the appropriate disposal container. A perfect barrier is meaningless if the contamination on the outside of the glove is spread throughout the environment as a result of poor removal technique.

Storage Conditions. Heat, light, moisture and ozone can all degrade glove materials. Various types of electrical equipment such as generators, ultraviolet or fluorescent light and X-ray machines create ozone. To avoid material degradation due to these factors, gloves should be stored in a cool, dry place away from direct light and electrical generating equipment.

Other:

Dermatitis. If the glove barrier is breached, the wearer must depend on the integrity of the skin to prevent infectious substances from gaining passage into the body. Cases of transferring infectious organisms from or to the hands have occurred. For example, occupationally acquired HIV has been traced to the contact of soiled materials on chapped hands.³⁹ The transfer of Herpes Simplex (Herpetic Whitlow) and Staphylococcus (MRSA) from the patient to the hands of the healthcare worker has been documented.^{7,40} Many cases of Hepatitis B Virus (HBV) from healthcare providers to patients have been reported.⁷ Similar transfers of Hepatitis C Virus (HCV) are now being reported.⁴¹ Also, dermatitis is painful and may prevent adequate hand scrubbing thus leaving residual organisms on the hand.

Healthy Skin. Healthy intact skin is an essential factor in reducing the risk of cross-contamination. Choose gloves with low potential for causing irritant or allergic contact dermatitis. Similarly, avoid direct contact with surface disinfectants, sterilants or other strong chemicals with unprotected hands. Select mild soaps and lotions that are less likely to cause dermatitis.

Handwashing. There is no substitute for handwashing. It should be an absolute habit for healthcare providers. Suggestions to minimize dermatitis sometimes associated with handwashing include the use of mild soaps and tepid (not hot) water, the addition of water to your hands before applying soap, thorough rinsing, jewelry removal and complete drying.⁴²

Everyday Practices That May Affect Glove Barrier (continued)

Other (continued):

Long Fingernails. Long fingernails can tear and rip gloves by placing a tremendous amount of pressure in a tiny area. As the majority of microorganisms on the hand are found under and around the fingernails, short nails are advised.⁴² Short nails provide a smaller area for microorganisms to hide under and access for scrubbing is improved. Moderation in fingernail length should be standard practice while wearing gloves.

Artificial Fingernails. Artificial fingernails present several problems.⁴² Of primary concern is the harboring of fungi and bacteria that cannot be effectively removed even with nailbrushes. Microorganisms can dwell and even thrive between the natural and artificial nail. This situation may be compounded by the fact that the moist, warm, occlusive environment under a glove supports microbial growth. Of somewhat less importance, but noteworthy nonetheless, artificial nails tend to cling to the glove surface (especially powder-free gloves), making donning more difficult.

Jewelry. Jewelry may snag, tear and puncture gloves. Microorganisms may collect under bracelets and rings potentially jeopardizing the health of the wearer, patient or family members. Jewelry may also trap soap, disinfectants and other substances that may contribute to irritation or a Type IV chemical allergy.⁴²

Hand Sanitizers. Hand sanitizers are frequently used in acute, long-term and home healthcare situations. To perform their function of killing microorganisms, hand sanitizers (usually alcohol or urea formaldehyde based) must be allowed to dry on the hands before proceeding. This is not only critical to ensure efficacy of antimicrobial activity, it is also important in preventing glove barrier compromise.⁴³ If the alcohol is still liquid when the glove is donned, most glove materials will be susceptible to rapid degradation.

Lotions. Lotions and barrier creams containing oils, petrolatum and other petroleum-based products should not be worn under gloves. These products may weaken the glove material.

Contact. Stay conscious of what contaminated gloves may be touching. Straightening of the hair, touching one's face and/or clothing may leave behind microorganisms that can be transferred to others.

Summary

Out-of-the-box failure rates (AQLs for water leaks) are important for immediate risk reduction, but they are not predictive of in-use glove barrier protection once the glove is challenged with rigorous, prolonged or chemically incompatible procedures. The determinants of glove barrier protection are complex. The base material of the glove, manufacturing quality requirements and various on the job practices can adversely alter assumed barrier efficacy. Although the base material of a glove presents certain performance capability limits, there are significant variations among gloves made of the same material from different manufacturers.

Prior to purchase and use, obtain data from the manufacturers on testing performed by independent laboratories for the gloves under evaluation. Make certain the test data represent the actual gloves to be purchased. Perform inspections for glove defects as well as in-use tests to see if the gloves can maintain protection during the tasks for which they are being selected. Table 5 incorporates issues that have been reviewed in this document and may be beneficial when evaluating gloves for barrier integrity.

Table 5

GLOVE BARRIER INTEGRITY: EVALUATION GUIDELINE

- What is the base glove material? Important: If it is a synthetic material, ask for the specific base glove material.
- Is the base material clearly displayed on the glove or packaging?
- Is the color confusing in the distinction between the natural rubber latex (NRL) and synthetic gloves?
- What is the manufacturer's AQL specification for water leaks in unused gloves?
- What is the tensile strength?
- What is the ultimate elongation?
- Is the glove easy to double don?
- Does the glove come in enough sizes to comfortably fit all personnel well?
- Is the glove (NRL or synthetic) powder-free?
- Obtain the permeation data on alcohol, gluteraldehyde and other commonly used chemicals.
- Obtain government clearance documentation [510 (k)] for gloves used in preparing or administering chemotherapy drugs.
- Obtain viral penetration test data.
- Inspect the glove by trapping air within, pinching the cuff closed and looking for thin areas, clumps and debris anywhere on the glove, especially looking at the fingertips and between the fingers.
- Ask if the test data supplied represents the gloves to be received or if the gloves are actually purchased from others and thus a mixed bag, rendering data received not necessarily applicable.
- When evaluating gloves, grade the fit and feel. Then, perform rigorous tasks for the longer durations encountered. Fill the used gloves with water to see if they leak.
- Obtain data on residual chemical levels to select gloves that present less of a risk for developing hand dermatitis.

References and Authors

Wava Truscott, PhD

Received her Doctorate in Comparative Pathology from the University of California at Davis, her MBA from the University of LaVerne, CA and her BS from Brigham Young University, UT. She is the Director of Scientific Affairs and Clinical Education for Kimberly-Clark Health Care in Roswell, GA.

Kathleen B. Stoessel, RN, MS

Commander USN (retired) received her Bachelor's degree in nursing from Salve Regina University, RI and her master's degree in education from Memphis State University, TN. She is the Manager of Clinical Education for Kimberly-Clark Health Care in Roswell, GA.

1. CDC, Recommendations for prevention of HIV transmission in health-care settings, MMWR 36(SU02);001, 1987.
2. OSHA Technical Information Bulletin: Potential for Allergy to NRL Gloves and other Natural Rubber Products; 1999.
3. National Institute for Occupational Safety and Health. Preventing Allergic Reactions to Natural Rubber Latex in the Workplace (DHHS [NIOSH] Publication No. 97-135), June 1997.
4. Hirsch, M, "Selecting Surgical Gloves," Surgical Services Management, V 6, No 4, April 2000.
5. Korniewicz, D, Rabussay, D; "Surgical Glove Failures in Clinical Practice Settings," AORN Journal, V 66, No 4, October 1997.
6. ICNA, Glove Use Guidelines, UK, September 1999.
7. Mellstrom, G,Wahlberg, J, Maibach, H, Protective Gloves for Occupational Use, CRC Press, 1994.
8. Morton, M, Rubber Technology, Third Edition, Chapman & Hall, 1995.
9. AAMI, "Safe use and handling of gluteraldehyde-based products in health care facilities," American National Standard, 1996.
10. ECRI, "Synthetic Surgical Gloves," Health Devices, V29, No 2-3, Feb-March 2000.
11. Huggins, K, "A Hand in the Glove: Lessons Learned About Glove Selection," Infection Control Today, V 3, No 2, 1999.
12. Francis, A, "Glove Me Tender," The Scientist, V14, No 10, 2000.
13. Fisher, A, "Standard and Special Testes for the Barrier Integrity of Medial Gloves: Part I: The Use and Abuse of Vinyl Gloves by Health Care Workers Allergic to Latex," Current Content News, V 59, February 1997.
14. Lewis, R, Hawley's Condensed Chemical Dictionary, Twelfth Edition, Van Nostrand Reinhold Company, 1993.
15. Johnson, F, "Disposable gloves: research findings on use in practice," Nursing Standard, V 11, No 16, January 8, 1997.
16. Klein, R, Party, E, Gershey E, "Virus Penetration of Examination Gloves," BioTechniques, V 9, No 2, August 1990.
17. Ohm, R, The Vanderbilt Rubber Handbook, Thirteenth Edition, R. T. Vanderbilt Company, 1990.
18. Guin, J, Hamann C, Sullivan K, "Natural and Synthetic Rubber," Occupational Skin Disease, Third Edition, W.B. Saunders Company, 1999.
19. Lehman, P, Franz, T, Guin, J, "Penetration of gluteraldehyde through glove material: Tactylon ' versus natural rubber latex," Contact Dermatitis 1994, V 30, No 176.
20. ASTM Designation: D5151-99, Standard Test Method of Detection of Holes in Medical Gloves, approved May 1999, published June 1999.
21. ASTM Designation: D3767-96, Standard Practice for Rubber – Measurement of Dimensions, approved November 1996, published December 1996.
22. ASTM Designation: D412-98, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension, approved July 1997, published April 1998.
23. ASTM Designation: D3578-01, Standard Specification for Rubber Examination Gloves, approved August 2001, published October 2001.
24. ASTM Designation: D6319-00a, Standard Specification for Nitrile Examination gloves for Medical Application, approved December 2000, published January 2001.
25. ASTM Designation: D5250-00, Standard Specification for Polyvinyl chloride Gloves for Medical Application, approved January 2000, published February 2000.
26. ASTM Designation: D3577-00, Standard Specification for Rubber Surgical Gloves, approved January 2000 published February 2000.
27. ASTM Designation: F1671-97b, Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System, approved December 1997, published February 1998.
28. Rego, A, Roley, L, "In-use barrier integrity of gloves: Latex and nitrile superior to vinyl," American Journal of Infection Control, V 27, No 5, October, 1999.
29. Douglas, A, Simon, R, Goddard, M, "Barrier Durability of Latex and Vinyl Medical Gloves in Clinical Settings," American Industrial Hygiene Association Journal, V58, pp 672-676, 1997.
30. Korniewicz, D, Kirwin, M, Cresci, K, Tian Sing, S, Tay Eng Choo, J, Wool, M, Larson, E, "Barrier protection with examination gloves: Double versus single," APIC, American Journal Infection Control, 1994.
31. Korniewicz, D, Kirwin, M, Cresci, K, Larson, E, "Leakage of Latex and Vinyl Exam Gloves in High and low risk clinical settings," Am Ind Hyg Assoc Journal, V 54, No 1, pp 22-26, 1993.
32. Olsen, R, Lynch, P, Coyle, M, Cummings, J, Bokete, T, Stamm, W, "Examination Gloves as Barriers to Hand Contamination in Clinical Practice," JAMA, V 270, No 3, July 21, 1993.
33. Merchant, V, Molinari, J, Pickett, T, "Microbial penetration of gloves following usage in routine dental procedures," American Journal of Dentistry, V 5, No 2, April 1992.
34. Korniewicz, D, Laughon, B, Cyr, W H, Lytle, C D, Larson, E, "Leakage of Virus through Used Vinyl and Latex Examination Gloves," Journal of Clinical Microbiology, V 28, No 4, April 1990, pp 787-788.
35. Korniewicz, D, Laughon, B, Butz, A, Larson, E, "Integrity of Vinyl and Latex Procedure Gloves," Nursing Research, V 38, No 3, May/June 1989.
36. ASTM Designation: F739-99, Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact, approved June 10, 1999, published August 1999.
37. Gerberding, J, Littell, C, Tarkington, A, Brown, A, Schecter, W, "Risk of exposure of surgical personnel to patients' blood during surgery at San Francisco General Hospital," The New England Journal of Medicine, V 322, No 25, June 21, 1990.
38. Matta, H, Thompson, AM, Rainey, JB, "Does wearing two pairs of gloves protect operating theatre staff from skin contamination?," BMJ, V 297, September 3, 1988.
39. CDC, "Update: Human Immunodeficiency virus Infections in Health-Care Workers Exposed to Blood of Infected Patients," Morbidity and Mortality Weekly Report, Epidemiologic Notes and Reports, V 36, No 19, May 1987.
40. Kotilainen, H, Brinker, J, Avato, J, Gantz, N, "Latex and Vinyl Examination Gloves, Quality Control Procedures and Implications for Health Care Workers," Arch Intern Med, V 149, December 1989.
41. Rabussay, D, Korniewicz, D, "The Risks and Challenges of Surgical Glove Failure," AORN Journal, V 66, No 5, November 1997.
42. Larson, E, "Hand Washing and Skin Preparation for Invasive Procedures," APIC Infection Control and Applied Epidemiology, Principles and Practice, Chapter 19, Mosby-Tear Book, Inc., 1996.
43. Pitten, F, Herdemann, G, Kramer, A, "The Integrity of Latex Gloves in Clinical Dental Practice," Infection Control and Hospital Epidemiology, V 21, No 2, Feb. 2000, pp 105.



Commitment to Excellence

If, for any reason, our products do not meet your expectations, please let us know your comments or suggestions for improvement. Your input will result in a concerted effort on our part to meet your requirements. Our goal is to provide quality products that completely meet your needs time after time.

For more information, please call 1-800-KCHELPS in the United States, or visit our web site at www.kchealthcare.com.

* Registered Trademark or Trademark of Kimberly-Clark Corporation, Roswell, GA 30076 or its affiliates. Manufactured for Kimberly-Clark Corporation by SAFESKIN Group (Thailand), a wholly owned subsidiary of Kimberly-Clark Corporation, Roswell, GA USA. © 2001 KCC. All rights reserved.

KL 3498 X3915

Protection. For life.

