Designation: D7160 – 16

Standard Practice for Determination of Expiration Dating for Medical Gloves[1]

This standard is issued under the fixed designation D7160; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers all surgeon's and examination gloves made from either synthetic or natural rubber latex. The purpose of this practice is to establish methods for testing medical gloves and analyzing the data to determine their shelf life.

1.2 *This standard does not purport to address all of the label claims and safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D573 Test Method for Rubber—Deterioration in an Air Oven

D3078 Test Method for Determination of Leaks in Flexible Packaging by Bubble Emission

D3577 Specification for Rubber Surgical Gloves

D3578 Specification for Rubber Examination Gloves

D5151 Test Method for Detection of Holes in Medical Gloves

D5250 Specification for Poly(vinyl chloride) Gloves for Medical Application

D6319 Specification for Nitrile Examination Gloves for Medical Application

D7161 Practice for Determination of Real Time Expiration Dating of Mature Medical Gloves Stored Under Typical Warehouse Conditions

F88 Test Method for Seal Strength of Flexible Barrier Materials

F1929 Test Method for Detecting Seal Leaks in Porous Medical Packaging by Dye Penetration

F1980 Guide for Accelerated Aging of Sterile Barrier Systems for Medical Devices

2.2 *ISO Standards:*[3]

ISO 2859 Sampling Procedures for Inspection by Attributes

ISO 4074 Natural Latex Rubber Condoms—Requirements and Test Methods

2.3 *Other:*

ICH Q1D Bracketing and Matrixing designs for Stability Testing of Drug Substances and Drug Products[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *accelerated aging*—conducted by storing samples at an elevated temperature for a reduced amount of time to simulate a longer period of real time aging.

3.1.2 *date of manufacture*—date of the final processing step. For sterile products, the last processing step is sterilization.

3.1.3 *real time aging*—the storage of samples under conditions that the product is expected to experience over its shelf life. Storage conditions should include exposure to elevated temperatures that product may experience during shipping.

3.1.4 *real time expiration date*—calculated by adding the shelf life to the date of manufacture.

3.1.5 *shelf life*—determined by the longest storage interval (from time zero) for which there is data demonstrating that the product meets the specifications defined in this practice. The data should be generated utilizing the test plan and methods defined in this practice.

3.1.6 *time zero*—the date of manufacture and the starting point for the shelf life studies.

4. General Information

4.1 The need for an expiration date is primarily based on the potential for a critical aspect of the product to deteriorate,

[1] This practice is under the jurisdiction of ASTM Committee D11 on Rubber and Rubber-like Materials and is the direct responsibility of Subcommittee D11.40 on Consumer Rubber Products.

Current edition approved June 1, 2016. Published December 2016. Originally approved in 2005. Last previous edition approved in 2010 as D7160 – 05 (2010). DOI: 10.1520/D7160-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[4] Available from International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH), ICH Secretariat, 9, chemin des Mines, P.O. Box 195, 1211 Geneva 20, Switzerland, http://www.ich.org.

resulting in a patient/user safety risk. The potential for product deterioration is determined from exposure to the actual or simulated handling and environmental conditions the product would most likely encounter after release for sale.

4.2 Because real time testing is often impractical, accelerated aging techniques must be used. For some medical devices, the Arrhenius equation found in Guide F1980 is an acceptable predictor of real time aging.

4.3 Real time aging of medical gloves that have been marketed prior to the publication of this practice may be performed in accordance with Practice D7161.

5. Materials and Equipment

5.1 Refer to the individual procedures and standards referenced.

6. Tests for Stability and Shelf Life

6.1 Manufacturers shall verify that gloves comply with the requirements of the applicable ASTM standard until the end of the labeled shelf life. Shelf life claims shall not exceed five years.

6.2 A modified glove design is one in which there have been significant changes to the formulation, manufacturing process, or individual sealed containers. Before a new or modified glove design is placed on the market, the following requirements shall be met:

6.2.1 The glove shall be tested for the minimum stability requirements as described in 6.4.

6.2.2 A real time study as described in 6.5 to determine shelf life must be initiated.

6.2.3 Pending completion of the real time study, a provisional shelf life claim shall be substantiated as described in 6.4.

6.3 The product to be considered for storage stability testing is categorized into family groupings that represent a worst or limit case for a given set of common characteristics to the gloves within that family group of gloves. These groupings are formed with consideration to the type of latex formulations used, types of processing such as chlorination or coatings, packing methods, sterilization, and the product's intended use. Typical groups or product family categories are summarized in Annex A1.

6.4 *Accelerated Stability Test:*

6.4.1 A minimum of three discrete finished product lots must be tested. ICH Q1D may be used for bracketing and matrixing designs. Only lots meeting the requirements of the applicable ASTM standard at time zero shall be included in this test. Data from formal stability studies should be provided on lots manufactured by using the actual method of manufacture and procedure used for production lots.

6.4.2 A sufficient number of samples shall be incubated at the applicable conditions listed in Table 1. Samples must be incubated in the final packaging configuration. Alternative methods for accelerated aging studies are described in 9.1.3.

6.4.3 At the end of the incubation periods, test the gloves per Section 7. Note that the measurement of physical properties should be performed no earlier than 16 h and no later than 96 h from the time of removal from the oven in accordance with Test Method D573. During this period, the oven-aged gloves should be conditioned at room temperature.

TABLE 1 Incubation Conditions

Time Interval	Temperature
Time Zero (control group, no aging, all materials)	Ambient
72 ± 2 h (vinyl only)	70 ± 2°C
166 ± 2 h (except vinyl)	70 ± 2°C
90 ± 1 day (all materials)	50 ± 2°C

6.5 *Real Time Stability Studies:*

6.5.1 Real time studies of gloves sampled from the same three lots should be initiated at the same time as the accelerated studies.

6.5.2 Sufficient samples shall be stored under conditions that are representative of the actual storage conditions the product is expected to experience over its shelf life. Storage conditions should be monitored and recorded. Testing shall be performed no sooner than 24 h from date of manufacturing at the initiation of the study and, at a minimum, tested at yearly intervals up to five years. Testing may occur at more frequent intervals if desired. The samples must be incubated in the final packaging configuration and be representative of the finished product.

6.5.3 Testing shall be performed at each interval on each of three lots per Section 7.

6.5.4 If the real time data indicates a shorter shelf life than that established by accelerated aging, the manufacturer shall change the shelf life for the product to that which is supported by the real time study. The shelf life shall not exceed five years regardless of supporting data.

7. Test Program for Accelerated and Real Time Aging

7.1 *All Gloves*—Each of the three (3) lots of finished product must be tested in accordance with Table 2 and documented according to appropriate procedures.

8. Acceptance Criteria for Real Time and Accelerated Aged Gloves

8.1 Glove samples aged at less than 50 °C must meet the requirements of the appropriate ASTM product type specification with respect to water leak testing and "before aging" physical properties.

8.2 Glove samples aged at 50 ± 2 °C or greater must meet the requirements of the appropriate ASTM product type specification with respect to water leak testing and "after accelerated aging" physical properties.

8.3 If a 25 % or greater change in physical properties from the initial value is observed, an investigation should be initiated to determine if the change is an indication of an increased rate of degradation. If an increase in the rate of degradation of physical properties is confirmed, then the previous test interval should be used to determine the shelf life.

NOTE 1—The percent change of physical properties between two intervals is based on the average values of the samples tested.

8.4 Sterile product packaging must demonstrate predetermined requirements for seal strength and the ability to maintain sterility (package integrity).

TABLE 2 Tests Required

Gloves	Sample Size and Specification
Test Method D5151	Sample Size: per ISO 2859, Inspection Level S-3, but not less than 32 gloves. AQL = 1.50 (Surgeon's) AQL = 2.50 (Exam)
Test Methods D412	Sample Size: per ISO 2859, Inspection Level S-3, but not less than 32 gloves. Specified values for physical requirements per appropriate ASTM standard. (Specifications D3577, D3578, D5250, D6319, and so forth.) AQL = 4.00
Sterile Packaging	**Sample Size and Specification**
Impermeable Package—Test Method D3078	Sample Size: per ISO 2859, Inspection Level S-4, but not less than 50 packages. AQL = 0.65 (Surgeon's) AQL = 1.50 (Exam)
Permeable Package—Test Method F1929	Sample Size: per ISO 2859, Inspection Level S-4, but not less than 50 packages. AQL = 0.65 (Surgeon's) AQL = 1.50 (Exam)
All Package Types—Test Method F88	Sample Size: per ISO 2859, Inspection Level S-4,but not less than 50 packages. AQL = 0.65 (Surgeon's) AQL = 1.50 (Exam)

9. Expiration Date Determination

9.1 *Accelerated Stability:*

9.1.1 Pending the completion of real time studies, accelerated stability studies shall be used to estimate shelf life.

9.1.2 A maximum shelf life of three (3) years shall be assigned based on accelerated studies. The shelf life may be extended as real time data is generated.

9.1.3 In addition to the Accelerated Stability Test method outlined in 6.4, there are several accelerated aging models that may be used. A model using Arrhenius shift factors is included in ISO 4074, Annex L "Guidance on Conducting and Analyzing Accelerated Aging Studies." Alternatively, the shift factor can be verified and the shelf life estimated using the method described in this practice in Annex A2. Another method based on activation energy is included in this practice as Annex A3. Manufacturers may chose other accelerated aging models that can be validated with real-time data. As manufacturers, standard developing groups, and regulatory agencies accumulate data, a consensus method will be developed.

9.2 *Real Time Aging*—The maximum shelf life for medical gloves is five years. The shelf life of a test lot is determined by selecting the longest test interval from time zero for which all requirements are met at the end of the entire test interval as well as for each intermediate test interval. The shelf life of the product is the shortest shelf life obtained for the three test lots.

10. Keywords

10.1 expiration date; medical gloves; shelf life

ANNEXES

A1. POSSIBLE GROUPINGS FOR TYPICAL MEDICAL GLOVE PRODUCT FAMILIES

NOTE 1—Factors to consider include glove thickness, chlorination levels, and coatings or surface treatments.

Material Type	Chlorinated	Coating	Packaging Type	Sterile
NRL Latex Compound				
Neoprene				
Nitrile				
Vinyl				
Other				

FIG. A1.1 Possible Groupings for Typical Medical Glove Product Families

A2. VERIFICATION OF THE ACTIVATION ENERGY AND ESTIMATING SHELF LIFE USING SHIFT FACTORS

A2.1 Introduction

A2.1.1 An accelerated aging guidance for natural rubber latex condoms that is based on the Arrhenius equation suggests that a constant activation energy of 83 kJ/mol will provide a conservative estimate of shelf life for that product (see ISO 4074, Annex L, Guidance on Conducting and Analyzing Accelerated Ageing Studies). While there are similarities between natural rubber latex gloves and condoms, an activation energy of 83 kJ/mol may not be appropriate for all gloves, whether made from latex or synthetic materials. In fact, it is likely that the activation energy necessary to cause degradation of the product may change over a large temperature range. The following method, also based on the Arrhenius equation, may be used to determine the actual activation energy for each product family (including each latex formulation) and for each pair of temperatures in the accelerated aging study. Once this is completed, an estimate of the shelf life can be made based on the actual shift factors.

A2.1.2 In order to use this approach, a statistically appropriate sample of finished product should be randomly selected from each of three production lots. (See 7.1 for recommended sample sizes.) Gloves, in their original packaging, should be aged at a minimum of four elevated temperatures, including 50 °C and 70 °C. The maximum temperature should be 80 °C or less. Testing of the properties of interest should be performed at multiple time intervals for each elevated temperature, until a predetermined threshold value is reached. At least 5 time points will be needed for each temperature.

NOTE A2.1—For tensile strength, the recommended threshold value is 75 % of the original tensile strength.

A2.2 Background

A2.2.1 According to the Arrhenius equation,

$$k = A\exp\left[-\frac{E_a}{RT}\right] \quad \text{(A2.1)}$$

where:

k = rate constant,
A = a constant related to the property of interest,
E_a = activation energy,
R = the universal gas constant (8.314×10^{-3} kJ mol^{-1} K^{-1}), and
T = temperature of interest (in degrees Kelvin).

A2.2.2 The shift factor, a_T, is the ratio of two different rates of reaction. It can be expressed as

$$a_T = \frac{k_2}{k_1} \quad \text{(A2.2)}$$

where:

k_1 = the rate constant at T_1, and
k_2 = that at T_2 ($T_1 < T_2$).

A2.2.3 Combining Eq A2.1 and Eq A2.2 yields:

$$a_T = \exp\left[\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right] \quad \text{(A2.3)}$$

A2.2.4 Experimentally, a_T can be determined by

$$a_T = \frac{t_1}{t_2} \quad \text{(A2.4)}$$

where:

t_1 = time the product dwells at T_1 until the property threshold is reached, and
t_2 = that at T_2 ($T_1 < T_2$).

A2.3 Verification of the Activation Energy

A2.3.1 Calculate the actual shift factor, a_T, for at least 3 pairs of accelerated aging temperatures (for example, 50 °C and 60 °C, 60 °C and 70 °C, 70 °C and 80 °C) using the experimental data and Eq A2.4.

A2.3.2 Calculate the actual activation energy, E_a, for each accelerated temperature pair using the shift factors calculated in A2.3.1 and Eq A2.3. Compare the actual activation energies with the estimated value of 83 kJ/mol. If the actual and estimated values are similar (that is, within ±2 kJ/mol) for all temperature ranges, then it is appropriate to use the shift factor associated with activation energy of 83 kJ/mol. These values are tabulated in Annex L of ISO 4074. Proceed to A2.4.

A2.3.3 If the actual and estimated activation energies are not similar, calculate the shift factor, a_T, for the storage temperature (for example, $T_{storage}$ = 30 °C) using Eq A2.3, where $T_1 = T_{storage}$, T_2 = the lowest accelerated aging temperature, and E_a is that calculated in A2.3.2 for the lowest temperature pair. Proceed to A2.4.

A2.4 Estimation of Shelf Life

A2.4.1 Calculate the expected storage time, $t_{storage}$, at the storage temperature (for example, $T_{storage}$ = 30 °C) using Eq A2.4, where $t_1 = t_{storage}$, t_2 = the time at the lowest accelerated aging temperature, and a_T is that obtained in A2.3.2 or A2.3.3. The time, $t_{storage}$, is the estimated shelf life.

A3. CONDUCTING AND ANALYZING ACCELERATED SHELF LIFE PREDICTION FOR RUBBER PRODUCT USING THE AVERAGE ACTIVATION ENERGY APPROACH OR ACTIVATION ENERGY APPROACH

A3.1 Average Activation Energy Approach

A3.1.1 The Activation Energy procedure needs a minimum of three sets of test temperatures. A plot of the measure of the reaction rate (log scale) against the reciprocal of the absolute temperature is constructed. The average of the slope of the lines connecting the data points is used to extrapolate and predict the shelf life (see Fig. A3.1).

A3.1.2 Consider five data points at 50, 60, 70, 80, and 90 °C (minimum are three data points). The slope between these five data points is calculated. Then with four slopes predict the next slope by taking the average of the above four slopes. Take an equispaced temperature point and using the 5^{th} slope, the 5^{th} data point can be calculated. This data point is the first predicted data point. Then with the actual five data points plus one predicted data point, follow the same procedure until the equidistant projection lower shelf temperature is reached.

A3.2 Principle

A3.2.1 At a chosen temperature, the variation in the numerical value of a chosen property, for example, a mechanical or viscoelastic property, are determined as a function of time. Refer to Fig. A3.1. The testing is continued until the relevant threshold value of that property has been exceeded. Further tests are performed at two other temperatures.

A3.2.2 For the Arrhenius procedure, the measures of the reaction rate obtained are plotted as a function of the reciprocal of temperature and the straight line obtained is extrapolated back to the temperature of use (refer to Fig. A3.1). Regression analysis gives a best straight line fit through the experimental data points. In general, it is suggested that if the correlation coefficient (R^2) is less than 0.90, the activation energy approach, as explained below, should be used (refer to Fig. A3.2). For the average activation energy procedure, the reaction rates obtained are plotted as a function of the reciprocal of the temperature and by taking the successive average of the slopes between equally spaced data points at different temperature reciprocals. Back extrapolation is done to the shelf temperature (refer to Fig. A3.3).

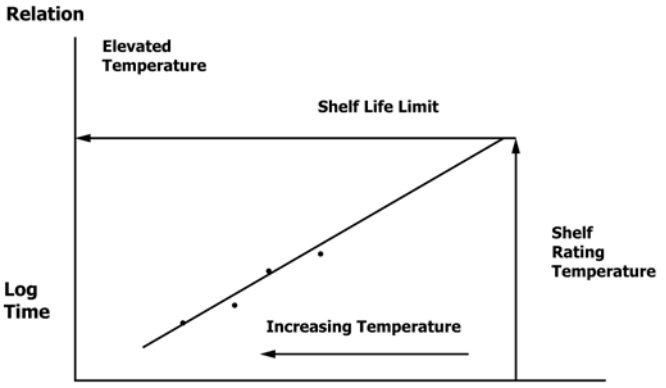


FIG. A3.2 Use of the Arrhenius Procedure

A3.3 Test Selection

A3.3.1 Tensile strength in accordance with Test Method D412 shall be used.

A3.4 Selection of Threshold Values

A3.4.1 The threshold is chosen at the point where the degree of degradation approaches the minimum acceptable value for the property being tested, as per product specification. The test should be continued until the threshold value is reached. Although it is possible to extrapolate to a greater degree of degradation, this is not recommended.

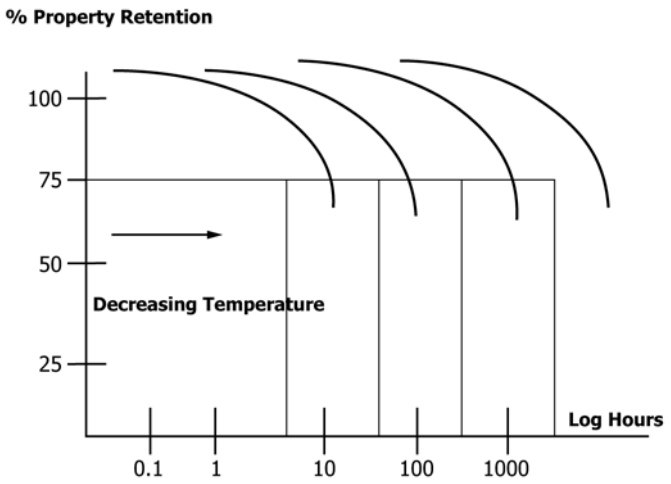
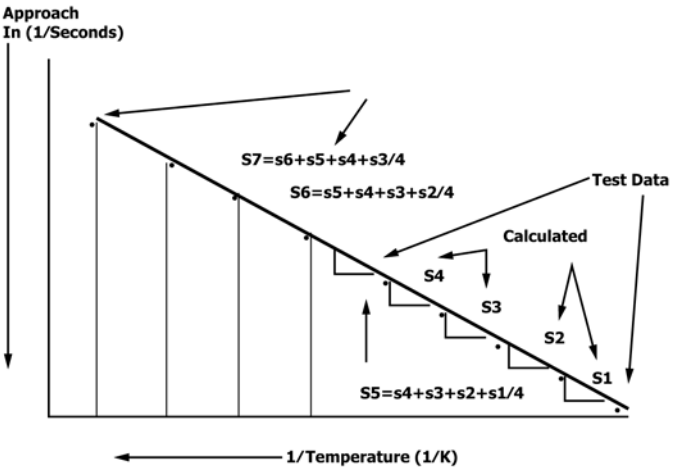


FIG. A3.1 Material Property versus Time



NOTE 1—Predicted Equispaced Data

FIG. A3.3 Use of the Average Activation Energy Procedure

A3.5 Test Specimens

A3.5.1 The dimensions and methods of the preparation of the test pieces shall be in accordance with Test Method D412. The minimum number of test pieces required (N) for a destructive test method depends on:

A3.5.1.1 The number of test pieces (a) required for one test in accordance with the test method,

A3.5.1.2 The number of tests (b) necessary to obtain the property/time/relation at one temperature.

A3.5.1.3 The number of exposure temperatures (c).

A3.5.2 The minimum number of test pieces is:

$$N = a \cdot b \cdot c + a \quad \text{(A3.1)}$$

A3.5.3 It is recommended that additional test pieces be aged at each temperature in case problems occur after several weeks or months of aging, or an extra exposure temperature is required to improve precision. The minimum number of test pieces for a non-destructive test method is normally: $N = a \cdot c$. It may be necessary in addition to make trial tests to determine the temperature of the test and the number of test points required at each temperature.

A3.6 Temperature Ranges

A3.6.1 The selection of the test temperatures involves knowing beforehand the approximate aging characteristics of the material under test. With no previous knowledge of the material, exploratory tests must be made. This information will assist in selecting the test temperatures best suited for the evaluation of the material.

A3.6.2 The test pieces shall be tested at not fewer than three temperatures, covering a range necessary to establish the lifetime estimation by extrapolation with the required degree of accuracy. The lowest test temperature shall be chosen so that the time taken to reach the threshold value is at least 8 to 10 weeks. Likewise, the highest temperature shall be chosen in order to make sure that necessary threshold value is reached. A typical time temperature-aging matrix for thin latex rubber products is shown in Table A3.1.

A3.7 Test Intervals

A3.7.1 The intervals between sets shall be such as to adequately characterize the measure of reaction rates chosen. In many cases, a linear progression will be satisfactory.

A3.8 Test Methodology

A3.8.1 At a chosen test temperature, the variation in tensile strength is determined as a function of time.

A3.8.2 The testing is continued until the relevant threshold value has been exceeded.

A3.8.3 Further tests are performed at different temperatures.

A3.8.4 For the Arrhenius procedure, the measures of the reaction rates obtained are plotted as a function of the reciprocal of temperature and the straight line obtained is extrapolated to the temperature of use. Refer to Fig. A3.2.

NOTE A3.1—If the data deviate from a straight line, it indicates that different reactions are taking place at the different temperatures and the Arrhenius extrapolation of the data is invalid. If the data are not following the straight line fit, then use the average activation energy technique.

A3.8.5 For the average activation energy procedure, the measures of the reaction rates obtained are plotted as a function of the reciprocal of temperature; however, the linear extrapolation is not done, instead an average of the change in the activation energy is taken, which is in effect the slope between the data points obtained. In this way, a back extrapolation or interpolation yields the shelf life of the rubber product. Refer to Fig. A3.3.

A3.9 Limitations

A3.9.1 Although in principle the extrapolation can be made over a larger span of temperatures and hence to extremely long times, consideration must be given to the increase of uncertainty with the degree of extrapolation and the possibility that the chemical reaction at high temperatures is gradually replaced by a different reaction at lower temperatures, especially where both scission and cross-linking reactions take place. Because of these considerations, extrapolations are generally limited 30 to 40 °C beyond the last data point. It is recommended that an estimate of the uncertainty of the results be made. Caution must also be used when the results are being analyzed because thermal oxidative aging is diffusion controlled and thus different results can be achieved when comparing thin and thick film pieces. The test conditions in the laboratory may also differ from service conditions where other causes of deterioration, such as light aging and ozone attack, may be involved.

TABLE A3.1 Typical Time-Temperature Matrix for Thin Latex Rubber Products

Temperature, °C	30 min	2 h	4 h	8 h	7 days	14 days	28 days	42 days	56 days	70 days	168 days
80	X	X		X	X	X					
70			X	X	X	X	X				
60				X	X	X		X		X	
50							X	X	X	X	X