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**NBSIR 76-1109**

# **Architectural Glazing Safety Standard: Survey of Codes and Standards**

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Sanford C. Adler

Building Safety Section  
Center for Building Technology  
Institute for Applied Technology  
National Bureau of Standards  
Washington, D. C. 20234

June 1976

Issued August 1976

Prepared for  
**Consumer Product Safety Commission**  
401 Westbard Avenue  
Bethesda, MD 20014

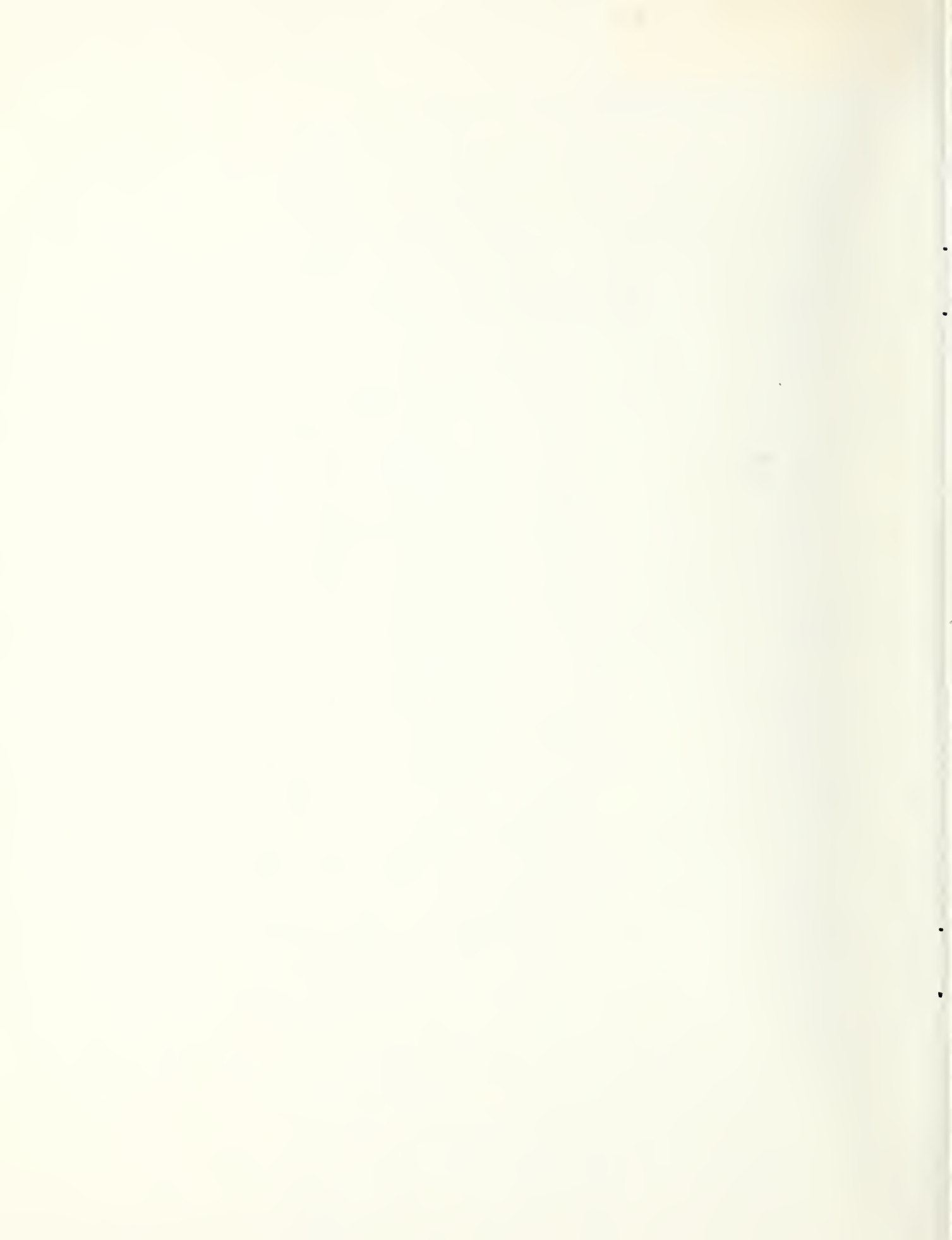
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**ARCHITECTURAL GLAZING SAFETY  
STANDARD: SURVEY OF CODES  
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## I. Introduction

### A. Objective

This survey was carried out as part of the NBS commitment to provide technical support to the Consumer Product Safety Commission in the development of a mandatory national safety glazing standard.

The Commission ranked architectural glazing products (windows, glass doors, sliding glass panels, fixed glass panels, both tubs and shower enclosures, jalousie windows/doors) as the tenth most hazardous group of consumer products.

### B. Summary of Findings

1. There were 97 codes and standards found which contained test methods relating to safety of glazing. An extensive review of these documents identified 34 different test procedures.
2. The most widely recognized standard examined was American National Standards Institute standard Z97.1-1972, "Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings." This standard is included by reference in 33 state laws which collectively cover over 75 percent of the population of the United States.
3. There is no single code or standard which appears to adequately address all of the glazing hazards identified by the Consumer Product Safety Commission.

### C. Survey Procedure

This report is an extensive review of existing standards, codes, specifications, and test methods for architectural and other related glazing products. It is based largely on a search of documents contained in the Standards Information Services Section Library at the National Bureau of Standards. The library contains national, international, and foreign standards from over 57 countries. However, only English language documents were examined. The appendix contains some basic definitions relating to architectural glazing.

## I. Directories

Seventeen directories were searched to identify standards, codes, specifications and test methods relating to architectural glazing.

The following key words were used in searching the directories: glass, glazing, codes, building(s), architecture, windows, doors, panels, tests.

Table I is a descriptive list of these directories.

## 2. Consumer Safety Glazing Committee

In addition to the library search described above, copies of existing state safety glazing laws were obtained with the assistance of the Consumer Safety Glazing Committee (CSGC), an industry supported organization created in 1969 for the expressed purpose of lobbying state legislatures to pass safety glazing legislation.

## II. Report Format

The report is cross-indexed in order to facilitate referencing the materials. The various tables, lists and summary sheets are described below.

### A. Organizations Issuing Standards

Table 2 is a list of organizations which have issued architectural glazing related standards. The list is alphabetical by abbreviation.

### B. Codes and Standards Reviewed

Table 3 is a list of 97 documents examined to locate and identify the test methods described in this report. The list includes:

1. the organization issuing the document,
2. a sequential number for cross-reference identification,
3. the identifying number assigned by the organization issuing the document,



4. the title of the document or a reference to an identical document,
5. number(s) referencing the test methods relating to glass safety which are part of the document and are described in this report.

## C. Test Methods

### I. Types of Tests

- a) Impact tests. Twenty-two of the thirty-four tests described are impact tests. Impact tests differ from one another in the following respects.

- Impactor (size, weight, shape)
- drop height
- total kinetic energy of impact
- horizontal or vertical mounting of specimens
- size of specimen
- temperature range of test
- number of impacts
- material tested
- test criteria (breakage/fragments/penetration/delamination)

The major differences between the impact tests described in this report are summarized in Table 4.

- b) Load Tests. There are four load tests described in this report. Three of these tests use differentials in air pressure to determine the strength of the glass. The fourth test applies a controlled load against the glass using a metal punch.
- c) Other tests. Other tests included stress tests (2), punch test, nondestructive test, hardness test, boil test, weathering test and an elasticity test.

### 2. Summary Description of Test Methods

The 34 test methods described in this report are listed on page 24. For each test method there is a summary sheet which contains the following information.

- a) A descriptive leader, including a test number used for cross-referencing.

- b) Title
- c) Purpose - why the test is used.
- d) Reference - the document(s) which contain the test method.
- e) Procedure - a brief summary of the test procedure.
- f) Test Criteria - how acceptance, or rejection, of the test specimen is determined.
- g) Comments

D. Mandatory Codes and Regulations (copies not included)

1. State Codes.

There are seven states which have mandatory codes which include upgraded safety glazing requirements. They are: Indiana, North Carolina, Ohio, Minnesota, California, Connecticut, and Wisconsin.

2. State Regulations.

Rule No. 47 (New York State) relates to "Transparent Glass Doors in Mercantile Establishments and in Public and Commercial Buildings and Structures." Regulation 43H04 (Maryland) relates to "Transparent Glass Doors in Mercantile Establishments and in Public and Commercial Buildings and Structures."

3. State Glazing Laws.

There are currently 31 states which have safety glazing laws. These laws are based on a "Model Bill" developed by the Consumer Safety Glazing Committee (CSGC). The (CSGC) model bill and most of the state laws include ANSI Z97.1 - 1972 by reference and exclude windows from safety glazing requirements. Table 5 summarizes the salient features of the various state laws, including name of state, population, bill number, effective date, enforcement agency, and differences from the CSGC Model Bill.

4. FHA Minimum Property Standards.

The Federal Housing Administration's Minimum Property Standards required safety glazing material in all sliding glass doors, tub and shower enclosures, shower doors, fixed panels adjacent to entrance doors, and other doors in which glazing is less than 3 feet 6 inches above the floor.

5. Mobile Home Standard.

The American National Standard ANSI-A119.1 for mobile homes requires safety glazing for all hazardous locations in mobile homes. This standard has been adopted by forty-five states.

III. Concluding Observation and Comment.

On June 20, 1973, the Consumer Safety Glazing Committee (CSGC) petitioned the Consumer Product Safety Commission to issue a consumer product safety rule relating to architectural glass.

After a careful review of available data, the Commission granted CSGC's petition. The Commission found that hazards associated with architectural glass presented unreasonable risks of death or injury that no existing standard was adequate.

On May 28, 1974, the Commission published (30 FR 18502) a notice of "Proceeding for Development of Proposed Consumer Product Safety Standard" for architectural glass.

Several organizations, including the CSGC, submitted offers to develop the new standard. In August 1974, the Commission accepted the offer submitted by the Consumer Safety Glazing Committee.

After an extended standard development period, the CSGC submitted a proposed standard to the Commission on January 24, 1975.

The CSGC standard was reviewed by the Commission staff, and changes were made to convert the recommended standard to a performance standard (to the degree practicable) and to modify certain procedures. This activity was completed in early 1976 and a proposed safety standard for architectural glazing materials was published in the Federal Register on February 11, 1976. Subject to changes which might be affected as a result of public review, the standard will become effective August 10, 1976. The standard is basically an extensive revision of ANSI Z97.1-1972.

TABLE I

Directories Used to Identify Architectural Glazing Standards, Specifications and Test Methods

- |   |  |
|---|--|
| <p>D1. <u>(ANSI) American National Standards Institute 1974 Catalog</u>, Published by ANSI, New York, N.Y.</p>                            | <p>Lists ANSI, ISO, IEC, CEE, COPANT and other standards. specifications and recommendations. Includes ISO and IEC cross-references for ANSI standards plus a subject index of ANSI and international standards.</p> |
| <p>D2. <u>1974 Annual Book of ASTM Standards Part 17</u>; Published by American Society for Testing and Materials Philadelphia, Pa.</p>   | <p>Contains all current ASTM standard and tentative test methods, definitions, recommended practices, classifications, specifications, proposed methods and other related material.</p>                              |
| <p>D3. <u>Australian Standards, 1973</u>, Standards Association of Australia, North Sydney, Australian</p>                                | <p>Published annually, lists all Australian standards currently in effect.</p>   |
| <p>D4. <u>British Standards Yearbook, 1973</u>, British Standards Institution London, England</p>   | <p>Lists all British standards and other BSI publications in effect as of December 31, 1972. A brief description of each standard is provided.</p>   |
| <p>D5. <u>Building Standards Index</u> Oct. 1969, Published jointly by CGSB and Dept. of Industry, Trade and Commerce, Ottawa, Canada</p> | <p>An index of codes, standards and specifications used in the building construction industry in Canada.</p>   |
| <p>D6. <u>Catalogue of CGSB Standards, 1974</u> Canadian Government Specifications Board, Ottawa, Ontario</p>                             | <p>Contains numerical and subject of CGSB standards in both French and English languages. Complete through 1973.</p>   |
| <p>D7. <u>Department of Defense (DOD) Index of Specifications and Standards, 1973</u>, Published by DOD, Washington, D.C.</p>             | <p>Provides alphabetical and numerical indexes of military standards and specifications. Issued annually with monthly supplements.</p>   |

Table I (continued)

- |   |   |
|---|---|
| D8. <u>Index of Federal Specifications and Standards</u> , 1973, Published by the General Services Administration, Washington, D. C.  | Provides alphabetical and numerical listing of Federal specifications, standards and qualified products.  |
| D9. <u>Index of International Standards</u> NBS Special Publication 390, March 1974, Sophie J. Chumas, Editor, U.S. Dept. of Commerce, NBS, Washington, D. C.   | A computer-produced index based on the Key-Work-In-Context (KWIC) system and containing titles of over 2,700 standards issued by ISO, IEC, CEE, CISPR, and OIML.  |
| D10. <u>An Index of State Specifications and Standards</u> , NBS Special Publication 375, Issued Sept. 1973, Linda L. Grossnickle, Editor. Published by U.S. Department of Commerce, NBS, Washington, D. C. | Lists more than 6,000 state purchasing specifications and standards issued by 37 state purchasing offices through 1971.   |
| D11. <u>Index of U.S. Voluntary Engineering Standards</u> , NBS Special Publication 329, Issued March 1971, William J. Slattery, Editor. Published by U.S. Department of Commerce, NBS, Washington, D. C.   | A computer-generated index containing the permuted title of over 19,000 voluntary engineering and related standards, specification test methods and recommended practices in effect as of Dec. 31, 1969. 360 U.S. technical societies, professional organizations and trade associations are represented in this index. |
| D12. <u>An Index of U.S. Voluntary Engineering Standards</u> , NBS Special Publication 329, Supplement I, Dec. 1972, William J. Slattery, Editor, U.S. Dept. of Commerce NBS, Washington, D.C.              | Contains permuted titles of over 6,300 standards, specifications, test methods and recommended practices published by 225 U.S. technical societies, professional organizations and trade associations.  |
| D13. <u>ISO Catalogue</u> , 1974, International Organization for Standardization, Geneva, Switzerland   | Contains a list of all ISO standards published up to Dec. 31, 1973. Standards are arranged numerically and by technical committee; subject and UDC indexes are also included. Cumulative supplements are issued every three months.   |

Table I (continued)

- |  |  |
|--|--|
| D14. <u>(SABS) South African Bureau of Standards Yearbook, 1973</u> , Published by the Council of the South African Bureau of Standards, Pretoria, South Africa.   | Complete through December 31, 1972, this annual publication lists all standard specifications, codes of practice, and standard test methods approved by the SABS Council.  |
| D15. <u>(SANZ) Standards Association New Zealand Index, 1974</u> , Published by SANZ, Wellington, New Zealand  | Published annually, includes all standards in national use as of January 31, 1974. Contains numerical cross-references to foreign standards declared or endorsed for use in New Zealand.   |
| D16. <u>Tabulation of Voluntary Standards and Certification Programs for Consumer Products</u> , NBS Technical Note 762, March 1973, Sophie J. Chumas, Editor. U.S. Dept. of Commerce, NBS, Washington, D.C. | Lists over 700 product areas and 1,000 standards titles covering products in and around the home. The product areas are based on those developed for the NEISS. Voluntary national, international and industrial standards are included and information on type of standard (safety, performance) and certification programs is also provided. |
| D17. <u>World Index of Plastics Standards</u> NBS Special Publication 352, Dec. 1971, Leslie H. Breden, Editor. U. S. Dept. of Commerce, NBS, Washington, D. C.  | A computer-produced index of titles of over 9,000 standards on plastics and related materials in effect as of DEcember 31, 1970.   |

TABLE 2

Organizations Issuing Glazing Standards

AAMA	Architectural Aluminum Manufacturers Association 410 North Michigan Avenue Chicago, Illinois 60611	DOC	U.S. Department of Commerce Washington, D. C. 20230
AIA	American Institute of Architects 1735 New York Avenue, N.W. Washington, D. C. 20006	DOD	Department of Defense Address for information on the DOD Index and Standards: Commanding Officer Naval Publications and Forms Center (NPFC 103) 5801 Tabor Avenue Philadelphia, Pa. 19120
(AIA)	American Insurance Association 85 John Street New York, New York 10038		
ANSI	American National Standards Institute 1430 Broadway New York, New York 10018	FGMA	Flat Glass Marketing Association 1325 Topeka Avenue Topeka, Kansas 66612
ASTM	American Society for Testing and Materials 1916 Race Street Philadelphia, Pa. 19103	FHA	Federal Housing Administration Department of Housing and Urban Development Washington, D.C. 20411
BOCA	Building Officials and Code Administrators International, Inc. 1313 East 60th Street Chicago, Illinois 60637	GSA	General Services Administration Federal Supply Service U.S. Government Washington, D. C. 20405
BSI	British Standards Institution 2 Park Street London W1A 2BS, England	GTA	Glass Tempering Association 1325 Topeka Avenue Topeka, Kansas 66612
CGSB	Canadian Government Specifications Board Technical Services Branch Department of Supply and Services 88 Metclafe Street Ottawa, Ontario, Canada	ICBO	International Conference of Building Officials 5360 South Workman Mill Road Whittier, California 90601

Table 2 (Continued)

ISO	International Organization for Standardization Central Secretariat 1, rue de Varembe Case postale 56 CH-1211 Geneva 20 Switzerland	SGAA	Stained Glass Association of America 3600 University Drive Fairfax, Virginia 22030
NWMA	National Woodwork Manufacturers Association 400 West Madison Street Chicago, Illinois 60606	SWI	Steel Window Institute 2130 Keith Building Cleveland, Ohio 44115
SAA	Standards Association of Australia Standards House 80-86 Arthur Street North Sydney-N.S.W. 2060 Australia	UL	Underwriters' Laboratories, Inc. 207 East Ohio Street Chicago, Illinois 60611
SABS	South African Bureau of Standards 191 Private Bag Pretoria, South Africa		
SAE	Society of Automotive Engineers 2 Pennsylvania Plaza New York, New York 10001		
SANZ	Standards Association of New Zealand Private Bag Wellington, New Zealand		
SBCC	Southern Building Code Congress International 3617 Eighth Avenue, South Birmingham, Alabama 35222		
SIGMA	Sealed Insulating Glass Manufacturers Association Suite 209-202 South Cook St. Barrington, Illinois 60010		



TABLE 3

List of Architectural Glass Standards, Codes,  
Specifications, and Test Methods<sup>1</sup>

<u>Identification No.</u>	<u>Title</u>	<u>Test Methods<sup>2</sup></u>
<u>Architectural Aluminum Manufacturers Association</u>		
1. AAMA 302.8-72	See ANSI A134.1-1972	19,25,32,33
2. AAMA 402.8-72	See ANSI A134.2-1972	19,25,32,33
3. AAMA 1002.8-72	See ANSI A134.3-1972	19,25,32,33
4. AAMA 1102.6-72	See ANSI A134.4-1972	19,25,32,33
<u>American Institute of Architects</u>		
5. AIA K215(1964)	Guide Specifications for Metal and Glass Entrances	
6. AIA K231 (1962)	Guide Specifications for Glass and Glazing	
<u>American Insurance Association, BOCA International, ICBO, and SBCC</u>		
7. AIA, BOCA International, ICBO & SBCC 1971	One and Two Family Dwelling Code, Sections R-208 and R-209	19,32,33
<u>American National Standards Institute</u>		
8. ANSI A119.1-1972	Mobile Homes: Body and Frame Design and Construction Requirements and the Installation of Plumbing, Heating and Electrical Systems (NFPA No. 501B-1971)	
9. ANSI A134.1-1972	Specifications for Aluminum Windows	19,25,32,33
10. ANSI A134.2-1972	Specifications for Aluminum Sliding Glass Doors	19,25,32,33
11. ANSI A134.3-1972	Specifications for Aluminum Combination Vertically-Sliding or Horizontally-Operating Storm Windows for External Application	19,25,32,33
12. ANSI A134.4-1972	Specifications for Aluminum Storm Doors	19,25,32,33
13. ANSI SE4.5-1972	Burglary Resisting Glazing Material	11,12,15

<sup>1</sup>Includes English language standards issued by foreign organizations.

<sup>2</sup>Includes only test methods related to the safety of architectural glazing products.

<u>Identification No.</u>	<u>Title</u>	<u>Test Methods</u>
14. ANSI Z26.1-1973	Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways, Safety Code for, including Supplement Z26.1a-1973	1,5,7,9,10,13,14,18,20,21,22
15. ANSI Z97.1-1972	Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings	19,32,33

American Society for Testing and Materials

16. ASTM C 158-72	Flexure Testing of Glass (Determination of Modulus of Rupture)	28
17. ASTM C 162-71	Standard Definitions of Terms Relating to Glass and Glass Products	
18. ASTM C 336-69	Standard Method of Test for Annealing Point and Strain Point of Glass	
19. ASTM C 338-73	Standard Method of Test for Softening Point of Glass	
20. ASTM C 598-72	Test for Annealing Point and Strain Point of Glass by Beam Bending	
21. ASTM C 623	Tentative Method of Test for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance	34
22. ASTM C 730-72	Knoop Indentation Hardness of Glass, Test for	31
23. ASTM E 330-70	Standard Test for Structural Performance of Exterior Windows, Curtain Walls, and Doors Under the Influence of Wind Loads	25
24. ASTM F 218-72	Analyzing Stress in Glass	30

Building Officials and Code Administrators International, Inc.

25. BOCA International 1970	The BOCA Basic Building Code, Section 858.46	19,32,33
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<u>Identification No.</u>	<u>Title</u>	<u>Test Methods</u>
<u>British Standards Institution</u>		
26. BS CP 145 1969	Part 1: Patent Glazing	
27. BS CP 151 1957	Part 1: Wooden Doors	
28. BS CP 152 1972	Glazing and Fixing of Glass for Buildings	
29. BS CP 153 1969	Part 1: Cleaning and Safety (of Windows and Rooflights)	
30. BS CP 153 1970	Part 2: Durability and Maintenance (of Windows and Rooflights)	
31. BS 459 1954	Part 1: Panelled and Glazed Wood Doors	
32. BS 857 1967	Safety Glass for Land Transport	5,13,27,32
33. BS 952 1964	Classification of Glass for Glazing and Terminology for Work on Glass	
34. BS 3925 1965	Toughened Safety Glass for Ships, Windows	23,30
<u>Canadian Government Specifications Board</u>		
35. BGSB 12-GP-1b 1971	Glass; Safety	2,5,17,32
36. CGSB 12-GP-2a 1970	Glass; Flat, Clear Sheet	
37. CGSB 12-GP-3b 1970	Glass; Flat, Polished Plate or Float	
38. CGSB 12-GP-4a 1971	Glass; Flat, Heat Absorbing, Transparent, Building Construction	
39. CGSB 12-GP-8 1966	Glazing (Double) Units, Factory-Sealed	
40. CGSB 12-GP-9 1972	Glass, Spandrel, for Building Construction	24,30
41. CGSB 12-GP-10 1972	Glass, Light and Heat Reflecting, for Building Construction	
42. CGSB 12-GP-11 1973	Glass, Wired, Safety, for Building Construction	19

<u>Identification No.</u>	<u>Title</u>	<u>Test Methods</u>
43. CGSB 12-GP-12 1973	Performance of Plastic Safety Glazing Material	19,33
44. CGSB 82-GP-1 1964	Glass Door, Aluminum Frame, Sliding, Standard Duty	
45. CGSB 82-GP-2 1964	Glass Door, Aluminum Frame, Sliding, Medium Duty	
46. CGSB 82-GP-3 1966	Doors, Aluminum, Combination Storm and Screen	
<u>Department of Commerce</u> <sup>3</sup>		
47. GS 163 1964	Ponderosa Pine Windows, Sash and Screens (Using Single Glass and Insulating Glass)	
48. CS 190-64	Wood Double-Hung Window Units	
49. CS 204 1964	Wood Awning Window Units	
50. CS 205 1964	Wood Casement Window Units	
51. CS 264 1964	Wood Horizontal-Sliding Window Units (all Sash Operating)	
52. CS 265 1964	Wood Horizontal-Sliding Window Units (one or more Non-Operating Sash )	
53. CS 266 1964	Wood Single-Hung Window Units	
<u>Department of Defense</u>		
54. MIL-G-2857A 1968	Glass, Heat-Treated, Glazing, Rectangular (For Bridge Windows)	6,30
55. MIL-G-3787F 1972	Glass, Laminated, Flat (except aircraft)	10,13,22
56. MIL-G-5485C 1971	Glass, Laminated, Flat, Bullet Resistant	16
57. MIL-G-25667B 1971	Glass, Monolithic, Aircraft Glazing	29,30

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<sup>3</sup>The commercial standards listed here are being withdrawn. For standards covering these products, see those issued by the National Woodwork Manufacturers Association.

<u>Identification No.</u>	<u>Title</u>	<u>Test Methods</u>
<u>Flat Glass Marketing Association</u>		
58. FGMA XYZ1 1965	Acrylic Plastic Panels Used for Commercial Glazing	
59. FGMA XYZ5 1965	Glazing Flat Glass Curtain Walls-Steel or Aluminum	
<u>Federal Housing Administration</u>		
60. FHA #300 1966	Minimum Property Standards for One and Two Family Living Units, (and 55 revisions) Section 711 (Revised in 1973)	5
61. FHA #2600	Minimum Property Standards for Multi-Family Housing, Section M611 (Revised in 1973)	19,32,33
<u>General Services Administration</u>		
62. Federal Specification DD-G-451c 1972	Glass, Plate, Sheet Figured (Float Flat, for Glazing, Corrugated, Mirrors and other uses)	
63. Federal Specification DD-G-1403B 1972	Glass, Plate (Float), Sheet, Figured, and Spandrel (Heat Strengthened and Fully Tempered)	19,27,32,33
64. Federal Standard L-P-505B 1964	Plastic Sheet, Corrugated, Translucent, Glazing	
65. Federal Test Method Standard No. 406 (1961)	Plastics - Methods of Testing	8,16
<u>Glass Tempering Association</u>		
66. GTA 61-1-20	Flat or Bent Tempered Glass for Television Receiver Safety Windows	4,27,30
67. GTA 62-8-7	Safety Windows for Laminating to Television Tubes	30
68. GTA 64-3-16 Rev #2	Tempered Safety Glass for General Construction Usage	19,27
69. GTA 65-5-13 1966	Tempered Glass for Use in Appliances	27,30
70. GTA 66-9-20 1969	Specifications for Spandrel Glass - Ceramic Enameled, Tempered or Heat - Strengthened	26

<u>Identification No.</u>	<u>Title</u>	<u>Test Methods</u>
71. GTA XYZ1 1969	Specifications for Tempered Glass Where Temperature Resistance is Required	
72. GTA XYZ2 1966	Tempered Glass for Telephone Booths	3,27
<u>International Conference of Building Officials</u>		
73. ICBO UBC 54-1 1970	Glass	
74. ICBO UBC 54-2 1970	Safety Glazing	19,32,33
<u>International Organization for Standardization</u>		
75. ISO 614 1973	Shipbuilding - Non-destructive, strength testing of toughened safety glasses for ships, side scuttles and rectangular windows - punch method	23
76. ISO 1226 1970	Recommendation for Symbolic Designation of Direction of Closing and Faces of Doors, Windows and Shutters - Part 1.	
<u>National Woodwork Manufacturers Association</u>		
77. NWMA IS 1-73	Wood Doors	
78. NWMA IS 2-69	Wood Windows	25
79. NWMA IS 3-70	Wood Sliding Patio Doors	25
80. NWMA IS 5-73	Ponderosa Pine Doors	19,32,33
<u>Standards Association of Australia</u>		
81. CA26-1957	Code of Recommended Practice for the Glazing and Fixing of Glass for Buildings (out of print, under revision)	
<u>South Africian Bureau of Standards</u>		
82. SABS 727-1962	Steel Windows and Steel Doors	
<u>Society of Automotive Engineers</u>		
83. SAE J938 (1968)	Drop Test for Evaluating Laminated Safety Glass for Use in Automotive Windshields	13

<u>Identification No.</u>	<u>Title</u>	<u>Test Method</u>
<u>Standards Association of New Zealand</u>		
84.	NZS 2258-1969                      Recommendations for Glass and Glazing	
<u>Southern Building Code Congress, International, Inc.</u>		
85.	SBCC 1973                              Southern Standards Code Section 2703.1	19,32,33
<u>Stained Glass Association of America</u>		
86.	SGAA XYZ1 1968                      Specifications for Stained Glass Windows	
<u>Sealed Insulating Glass Manufacturers Association</u>		
87.	SIGMA 65-7-2 1971                      Glazing Specification for Sealed Insulating Glass Units	
88.	SIGMA 70-7-1 1970                      Glazing Specification for Sealed Insulating Glass Units	
89.	SIGMA XYZ1 1967                      Certification Program for Sealed Insulating Glass Units Including License Agreement Certification Affidavit	
<u>State Governments</u>		
90.	Illinois 3 1971                          Standard Specification for Glass, Flat for Glazing	19,32,33
91.	New York 31806-0313 1971                              Specification for Glass, Flat (for Glazing Purposes)	
92.	Oregon 64-200-9010 1969                              Standard Specification for Plate and Sheet Glass	
93.	Oregon 64-575-9010 1969                              Standard Specification for Plastic Panels; Glass Fiber Reinforced Polyester (Structural and Glazing Purposes)	
94.	Pennsylvania G-4 1971                              Specification for Flat and Corrugated Glass (for Glazing Purposes)	
95.	Rhode Island 1-004A 1969                              Specification for Steel Bookcase; Sliding Glass Doors (Office Furniture)	
<u>Steel Window Institute</u>		
96.	Steel Window Institute Recommended Specifications for Steel Windows (reissued annually)	
<u>Underwriters' Laboratories, Inc.</u>		
97.	UL 972 (1972)                              See ANSI SE4.5-1972	11,12,15

Table 4  
SUMMARY OF IMPACT TESTS  
(Numbers in Body of Table Refer to Test Method Number)

IMPACTING OBJECT	WEIGHT (lbs)	MAXIMUM DROP (ft)	MAXIMUM KINETIC ENERGY (ft-lbs)	TEST CRITERIA (b)	SIZE OF SPECIMEN (inches)	TYPE OF GLAZING MATERIAL TESTED				MULTI-GLAZED UNITS	
						ALL GLASS	TEMPERED GLASS	LAMINATED GLASS	WIRE GLASS		PLASTIC
Steel Ball	.5	10	5.0	B	12 x 12	1	2				
	.5	10	5.0	B	12 x 12		3	2			
	1.0	5	5.0	B	--		4				
	1.18	4.3	5.1	B	--		5				
	.5	11+	5.5	F	12 x 12		6				
	.5	12	6.0	B	--						
	.5	18	9.0	F	12 x 12				7		
	2.0	4.5	9.0	B	12 x 12				8		
	.5	30	15.0	F	12 x 12			10			9
	.5	30	15.0	P	12 x 12						
	5.0	8	40.0	P	24 x 24	11					
	5.0	10	50.0	P	24 x 24	12					
	5.0	12	60.0	P	12 x 12	13					
	5.0	20	100.0	D	--				14		
	5.0	40	200.0	P	24 x 24	15			16		
Bag	.5	Not Specified	Not Specified	D	--						
	11	4	44	B, F	12 x 12	17					
	11	8	88 (a)	B	12 x 12	18					
Dart	100	4	400 (a)	B, F	Varies	19					
	7 oz.	10	4.4	F	12 x 12				20		
	7 oz.	18	7.9	F	12 x 12					21	
	7 oz.	30	13.1	P	12 x 12			22			

(a) Vertically mounted specimen is impacted by a 100 lb. bag dropped through a pendulum arc. (ANSI Z97.1-1972). All other tests are vertical drops on to horizontally mounted specimens.

(b) Abbreviations for Test: B = Breakage/ F = Fragmentation/ D = Delamination/ P = Penetration.



TABLE 5

Summary of State Safety Glazing Legislation<sup>1/</sup> (All States Listed)

<u>State</u> <u>(Population<sup>2/</sup>)</u>	<u>Bill No.</u>	<u>Effective</u> <u>Date</u>	<u>Authorized</u> <u>Enforcement</u> <u>Agency</u>	<u>Difference from CGSC 1973 Model Bill</u> <sup>3/</sup>
Alabama (3,444,165)	Pending			
Alaska (302,173)	HB 205			Differs from 1973 Model Bill
Arizona (1,772,482)	HB 2161	July 1, 1974	None	Defines fixed panel as 18" to 48" in width and less than 18" above floor.
Arkansas (1,923,295)	SB 34	Jan. 1, 1974	Com. of Labor	Excludes residential construction of not more than two families that was in existence before Jan. 1, 1974.
California (19,953,134)	SB 601	Nov. 1971	None	Defines fixed panel as: 18" to 48" in width; Less than 18" above floor. Labeling: permanent labeling not required.
Colorado (2,207,259)	HB 1110	July 1, 1971	Industrial Com.	Primary residential entrance & exit doors not covered.
Connecticut (3,032,217)	HB 8501	Jan. 1, 1974	Com. of Public Works	Primary residential entrance & exit doors not covered.
Delaware (548,104)	SB 23	Jan. 1, 1972	Co. Bldg. Inspectors	Permanent label on wire glass not required Primary residential entrance & exit doors not covered.
District of Columbia (756,510)				
Florida (6,789,443)	SB 417	July 1, 1970	None	Defines fixed glazed panels as: more than 24" width; more than 6' height; less than 2' above floor. Defines glass doors as: more than 18" width; more than 4' height. Louvered glass doors with screens excluded.

<u>State (Population)</u>	<u>Bill No.</u>	<u>Effective Date</u>	<u>Authorized Enforcement Agency</u>	<u>Difference from CGSC 1973 Model Bill</u>
Georgia (4,589,575)	HB 412	July 1, 1970	Dept. of Labor	Same as 1973 Model Bill.
Hawaii (769,913)	HB 379	May 28, 1971	Dept. of Health	Primary residential entrance & exit doors not covered.
Idaho (713,008)	Pending			
Illinois (11,113,976)	SB 101	Jan. 1, 1973	Dept. of Labor	Primary residential entrance & exit doors not covered.
Indiana (5,193,669)				
Iowa (2,825,041)	Pending			
Kansas (2,249,071)	SB 332	Jan 1, 1975	None	Excludes single family dwellings. Defines fixed panels as: 18" or more above finished floor, first fixed-glazed panel not more than 48" or less than 18" in width. Permanent labeling not required.
Kentucky (3,219,311)	HB 353	Jan 1, 1971	Dept. of Public Safety	Same as 1973 Model Bill.
Louisiana (3,643,180)	SB 460	Jan 1, 1973	State Fire Marshall	Primary residential entrance & exit doors not covered.
Maine (993,663)	HP 465	Jan 1, 1974	Dept. Public Safety	Primary residential entrance and exit doors not covered.
Maryland (3,922,399)	HB 7	July 1, 1973	Dept. of Economic & Community Development	Jalousie doors excluded. Defines fixed panels as less than 18" from floor and 18" or more in width. Permanent labeling of wired glass, laminated glass & plastic which are further fabricated after manufacturing is not required.

<u>State (Population)</u>	<u>Bill No.</u>	<u>Effective Date</u>	<u>Authorized Enforcement Agency</u>	<u>Difference from CGSC 1973 Model Bill</u>
Massachusetts (5,689,170)	SB 1401 HB 5324	Jan. 1, 1973	None	Primary residential entrance & exit Doors not included.
Michigan (8,875,083)	HB 5740	July 1, 1973	None	Primary residential entrance & exit doors not covered. Required label "Non Safety Glazing Materials over 300 sq.in. are not to be used in doors or other hazardous locations."
Minnesota (3,805,069)	HF 874	June 1, 1974	None	Same as 1973 Model Bill.
Mississippi (2,216,912)	HB 1218	Jan 1, 1975	None	Primary residential entrance & exit doors not covered if less than 50 percent exposed glass with panel less than 60" in height and 24" in width.
Missouri (4,677,399)	Pending			
Montana (694,409)				
Nebraska (1,483,791)				
Nevada (488,738)				
N. Hampshire (737,681)	Pending			
N. Mexico (1,016,000)				
N. Jersey (7,168,164)	Assem. 496	Mar. 28, 1972	Dept. of Community Affairs	Same as 1973 Model Bill
New York (18,190,740)	Assem. 11456 SB 9580	July 1, 1973	None	Primary residential entrance & exit doors not covered. Permanent labeling of wire glass, laminated glass & plastic not required.

<u>State (Population)</u>	<u>Bill No.</u>	<u>Effective Date</u>	<u>Authorized Enforcement Agency</u>	<u>Difference from CGSC 1973 Model Bill</u>
N. Carolina (5,082,059)	Pending			
N. Dakota (617,761)				
Ohio (10,652,017)	HB 9 HB 1172	Jan. 1, 1973	None	Law applies only to residential construction. Excludes glass in primary doors & sidelights over 42" above floor.
Oklahoma (2,559,253)	HB 1350	Jan. 1, 1972	State Health Dept.	Primary residential entrance & exit doors not covered.
Oregon (2,091,385)	HB 1771	July 1, 1970	State Board of Health	Minimum requirements for entrance & exit doors, fixed panels, storm doors & sliding glass doors.
Pennsylvania (11,793,909)	SB 29	Jan. 1, 1972	Dept. of Labor and Industry	Primary residential entrance & exit doors excluded.
Rhode Island (949,723)	HB 5030	July 8, 1973	Dept. Public Works	Defines fixed panels as less than 18" from floor and 48" or less in width. Labeling of safety glazing material not required. Primary residential entrance & exit doors not covered.
S. Carolina (2,590,516)	HB 1433	July 1, 1974	None	Same as 1973 Model Bill
S. Dakota (666,257)	SB 53	July 1, 1974	None	Excludes glass lights with larger dimension not greater than 18". Fixed panels - excludes glass lights not less than 18" above floor, and 48" or less in width.
Tennessee (3,924,164)	SB 178	Jan. 1, 1972	Dept. Public Health	Primary residential entrance & exit doors not covered.

<u>State (Population)</u>	<u>Bill No.</u>	<u>Effective Date</u>	<u>Authorized Enforcement Agency</u>	<u>Difference from CGSC 1973 Model Bill</u>
Texas (11,196,730)	Pending			
Utah (1,059,273)				
Vermont (444,732)				
Virginia (4,648,494)	SB 656 Repealed	Jan. 1, 1974 May, 1974	None	Same as Model Bill
Washington (3,409,169)	HB 137	Jan 1, 1974	Dept. of Labor	Defines fixed panels as: 18" or more above finished floor. Permanent labeling of wire glass not required.
W. Virginia (1,744,237)	HB 504	July 1, 1971	Dept. of Labor	Excludes residential construction of not more than two families that was in existence before July 1, 1971.
Wisconsin (4,417,933)	Pending			
Wyoming (332,416)				

1/ As of May 1974, 32 states, representing over 75% of the U.S. population have safety glazing laws. If legislation is passed in the states where it is pending, over 90% of the U.S. population will be included.

2/ Population based on 1970 Census data. Total U.S. Population was 203,184,772.

3/ The consumer safety glazing committee's Model Bill requires permanently labelled glazing material meeting ANSI Z97.1-1972 to be installed in the following "Hazardous Locations" of residential, commercial, industrial and Public Buildings; Interior and exterior entrance and exit doors and adjacent flat fixed glazed panels, sliding glass door units and adjacent glazed panels, storm or combination doors, and shower and bathtub enclosures. Windows are Not covered by the Model Bill.

#### IV. List of Test Methods Described in This Report

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1. IMPACT TEST (Breakage/ 1/2 lb. Ball - 10 ft./All)

TITLE: IMPACT TEST

PURPOSE:

Made to determine whether safety glass has a certain minimum strength under impact.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways. (Test No. 6)

PROCEDURE:

A 1/2 pound steel ball is dropped 10 feet to the center of a horizontally mounted specimen 12" x 12" at a temperature between 70°F and 85°F.

TEST CRITERIA:

Not more than two of the twelve specimens may crack or break as a result of this impact.

2. IMPACT TEST (Breakage-Delamination/ 1/2 lb. Ball - 10 ft./  
Tempered-Laminated)

TITLE: IMPACT TEST

PURPOSE:

Covers impact resistance of glass and laminated glass to breakage and spalling on impact and, in the case of laminated glass, resistance to separation of the glass from the plastic laminating materials.

REFERENCE:

Canadian Government Specification Board: 12-GP-1b-1971 Standard for Glass: Safety, for Guilding Construction.

PROCEDURE:

A 1/2 pound steel ball is dropped 10 ft. on the center of a horizontally mounted specimen 12" x 12". Laminated glass is tested at 0°F and 120°F. Tempered glass is tested at 73°F.

TEST CRITERIA:

(a) For laminated glass - At the point immediately opposite the point of impact the small fragments of glass that leave the specimen must expose less than 1 square inch of the laminating material whose surface must always be well covered with tiny particles of tightly adhering glass. Total separation of glass from the reinforcing material must not exceed 3 square inches on either side.

(b) For tempered glass - Not more than three specimens, when five are tested, shall fracture.



3. IMPACT TEST (Breakage/1 lb. Ball - 5 ft./Tempered)

TITLE: IMPACT TEST

PURPOSE:

To determine the resistance to breakage of the impacted glazing material.

REFERENCE:

GTA XYZ2, Tempered Glass for Telephone Booths (1966).

PROCEDURE:

Randomly selected sheets are used in the impact test. The specimen to be tested is placed horizontally on a rectangular wooden frame and a 1 pound ball is dropped so as to strike the glass with approximately five foot pounds of energy.

TEST CRITERIA:

If the first glass tested fails (breaks), three additional sheets of glass are tested and all must pass.

4. IMPACT TEST (Breakage/1.18 lb. Ball - 4.3 ft./Tempered)

TITLE: IMPACT TEST

PURPOSE:

To determine whether the glazing material being tested has a certain minimum strength.

REFERENCE:

GTA 61-1-20, Flat or Bent Tempered Glass for Television Receiver Safety Windows.

PROCEDURE:

The glass specimen is placed in a horizontal position for the test. Flat glass samples are supported on the two short sides, while bent glass is mounted on four pads with the convex side up. A 1.18 pound steel ball is then dropped onto the approximate center of the glass surface, striking it with about five foot pounds of energy.

TEST CRITERIA:

When impacted as described above, the glass shall not break.

5. IMPACT TEST (Fragments/ 1/2 lb. Ball - 11 ft./Tempered)

TITLE: FRACTURE TEST

PURPOSE:

To determine the fracturing characteristics of safety glass when broken.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways. (Test No. 7) See also standards nos. 32, 35 and 60 on list.

PROCEDURE:

A temperature-stabilized (70°-85°) flat specimen (12" x 12") is supported horizontally in a hardwood frame. A 1/2 pound steel ball is dropped from 11 ft., (or higher in 1 ft. increments) until the glass is broken.

TEST CRITERIA:

No individual fragments obtained three minutes after the test may weigh more than 0.15 ounces.

6. IMPACT TEST (Breakage/ 1/2 lb. Ball - 7, 9, 12 ft./Tempered)

TITLE: IMPACT TEST

PURPOSE:

To determine whether the glazing material possesses a certain minimum strength under impact.

REFERENCE:

MIL-G-2857A (1968), Glass, Heat-Treated, Glazing, Rectangular (for bridge windows).

PROCEDURE:

The test specimen is placed on a rectangular frame and impacted near its center. Since heat-treated glass cannot be cut, sheets are used as received. Each specimen is impacted once with a 1/2 pound steel ball from 7, 9 or 12 feet depending on whether glass is 1/4, 11/32 or 12/32 inch thick.

TEST CRITERIA:

Glass shall not crack or show any visible change.

7. IMPACT TEST (Fragments/ 1/2 lb. Ball - 6 to 18 ft./Plastic)

TITLE: IMPACT TEST

PURPOSE:

Made to determine whether the plastic has a certain minimum strength and whether it is properly made.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways. (Test No. 13)

PROCEDURE:

A 1/2 pound solid, smooth, steel sphere is dropped once from a height determined by the thickness of the plastic, ranging from 6 ft. (.125" or less) to 18 ft. (.250" or more), onto the center of a horizontally mounted specimen 12" x 12" at a temperature between 70°F and 85°F.

TEST CRITERIA:

The impact may produce cracks in the plastic; not more than two of the specimens shall break into separate large pieces, nor shall more than two of the remaining specimens develop a fracture which can be described as a hole through the body of the specimen.

At the point immediately opposite the point of impact, small fragments of plastic may leave the specimen, but if laminated, the small area thus affected shall expose less than 1 square inch of reinforcing or strengthening material, the surface of which shall always be well covered with particles of tightly adhering plastic. Total separation of plastic from the reinforcing or strengthening material shall not exceed 3 square inches on either side.

8. IMPACT TEST (Breakage/2 lb. - 4.5 ft./Plastic)

TITLE: SHATTERPROOFNESS TEST

PURPOSE:

To determine the susceptibility of plastics to shattering under impact.

REFERENCE:

Fed. Test Method Std. No. 406, Method 1073.

PROCEDURE:

The 12 x 12 inch test specimen is mounted horizontally in a supporting frame. A steel ball weighing 2 lbs. is released magnetically from a height of 4.5 ft. so as to strike the specimen once at its approximate center.

TEST CRITERIA:

Specimen must sustain the impact without shattering.

COMMENTS:

For detailed discussion of the sampling procedure and reporting of test results, see Fed. Test Method Std. No. 406.

9. IMPACT TEST (Fragments/ 1/2 lb. Ball - 30 ft./Multiple Glazed Unit)

TITLE: IMPACT TEST

PURPOSE:

To determine strength and breakage characteristics of multiple glazed units.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways. (Test No. 14)

PROCEDURE:

A 1/2 pound steel ball is dropped repeatedly from 30 feet onto the center of a horizontally mounted specimen 12" x 12" at a temperature between 70°F and 85°F until all component layers are damaged. If necessary, the weight of the ball or the height of the drop may be increased.

Twenty-four specimens of multiple-glazed units, nonsymmetrical in construction rather than in shape, are tested on both sides, using a separate sample for impacting opposite sides.

TEST CRITERIA:

No single fragment of glazing material free from cracks or separated from reinforcing or strengthening material shall exceed 2 square inches in area.

10. IMPACT TEST (Penetration/ 1/2 lb. Ball - 30 ft./Laminated)

TITLE: IMPACT TEST

PURPOSE:

Made to determine whether the safety glass has a certain minimum strength and whether it is properly made.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways. (Test No. 12)  
See also standard #55.

PROCEDURE:

A 1/2 pound steel ball is dropped once from 30 feet onto the center of a horizontally mounted 12" x 12" specimen at a temperature between 70°F and 85°F. Twelve specimens are stuck on the side of the specimen which would be glazed to the outside.

TEST CRITERIA:

The impact may produce a large number of cracks in the glass; not more than two of the specimens may break into separate large pieces. In no more than two of the remaining specimens shall the ball produce a hole or fracture at any location in the specimen through which the ball will pass.

At the point immediately opposite the point of impact, small fragments of glass may leave the specimen, but the small area thus affected shall expose less than 1 square inch of reinforcing or strengthening material, the surface of which shall always be well covered with tiny particles of tightly adhering glass. Total separation of glass from the reinforcing or strengthening material shall not exceed 3 square inches on either side.

Spalling of the outer glass surface opposite the point of impact and adjacent to the area of impact is not to be considered failure.



11. IMPACT TEST (Penetration/5 lb. Ball - 8 ft./All)

TITLE: THERMAL CONDITIONING TEST FOR OUTDOOR USE

PURPOSE:

To determine the penetration resistance of the glazing material upon impact following extreme temperature conditioning.

REFERENCE:

ANSI SE4.5-1972, Burglary Resisting Glazing Material (UL 972-1972).

PROCEDURE:

Twenty flat 24 x 24-inch specimens are tested. Prior to testing, ten samples are conditioned at a temperature of 120°F for at least 4 hours, and the remaining ten are conditioned at a temperature of minus 14°F for the same length of time. Immediately upon removal from the conditioning chamber the specimen is mounted horizontally and the 5 pound steel ball is released from 8 feet so as to strike the sample successively at five different locations within a 5-inch diameter circle centered on the test specimen.

TEST CRITERIA:

The steel ball shall not penetrate the glazing material on any one of the five impacts on 9 of the 10 samples tested. Penetration occurs when the ball passes completely through the glazing material.

## 12. IMPACT TEST (Penetration/5 lb. Ball - 10 ft./All-Temp Range)

TITLE: THERMAL CONDITIONING TEST FOR INDOOR USE

PURPOSE:

To determine the penetration resistance of thermally conditioned glazing material upon impact.

REFERENCE:

ANSI SE4.5-1972, Burglary Resisting Glazing Material (UL 972-1972).

PROCEDURE:

The glazing material shall be capable of withstanding five 50 foot-pound impacts, as produced by dropping a steel ball, weighing 5 pounds, through a vertical distance of 10 feet following thermal conditioning of the material.

The test shall be conducted on 10 samples of the material conditioned at a temperature of 29°C (95°F), and on 10 additional samples conditioned at a temperature of 17°C (55°F). All samples shall be conditioned at the specified temperatures for at least 4 hours prior to this test.

TEST CRITERIA:

The steel ball shall not penetrate the glazing material on any one of the five impacts on 9 of the 10 samples tested. Penetration occurs when the ball passes completely through the glazing material.

### 13. IMPACT TEST (Penetration/5 lb. Ball - 12 ft./Laminated)

TITLE: PENETRATION RESISTANCE

PURPOSE:

To determine whether the glazing material has satisfactory penetration resistance.

REFERENCE:

ANSI Z26.1-1966 Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways (Test No. 26). See also standards 32, 55 and 83.

PROCEDURE:

Ten 12 x 12 inch specimens at 70-85°F are tested by dropping a 5 pound steel ball from a height of 12 feet onto the center of each specimen. The specimens are mounted horizontally in a wooden frame.

TEST CRITERIA:

The ball may not pass through more than two of the specimens within 5 seconds after impact. Cracks in the glass, tears in the reinforcing interlayer material, or a substantial permanent deformation in the shape of the specimen is not reason for failure.

14. IMPACT TEST (Delamination/5 lb. Ball - 20 ft./Laminated)

TITLE: IMPACT TEST (Bullet Resistant Glass)

PURPOSE:

To determine whether the bullet resistant glass plies are satisfactorily bonded together.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways (Test No. 29).

PROCEDURE:

A 12" x 12" horizontally mounted specimen at  $0^{\circ} \pm 10^{\circ}F$  is impacted by a 5 pound steel ball from a height of 20 feet onto the approximate center of the test specimen. If all glass plies are not broken on the first ball impact, the specimen shall be reversed and the same test repeated on the opposite glass surface. Any impact not occurring in the approximate center of the assembly shall be considered unfair and shall be disregarded and another assembly tested. The impact or impacts, shall cause all glass plies to fracture. Two specimens shall be tested.

TEST CRITERIA:

A specimen shall be considered to fail the ball impact test when delamination occurs between any adjacent glass or plastic plies along any crack or fracture line which extends over 1/8" normal to such crack or fracture line. The spalling off of a cone shaped mass in the area opposite the point of impact shall be disregarded.

15. IMPACT TEST (Penetration/5 lb. Ball - 40 ft./A11)

TITLE: HIGH-ENERGY IMPACT TEST

PURPOSE:

To determine the penetration resistance of the glazing material to an impacting object of high energy.

REFERENCE:

ANSI SE4.5-1972, Burglary Resisting Glazing Material (UL 972-1972).

PROCEDURE:

A steel ball weighing five pounds is dropped onto the approximate center of the horizontally mounted test specimen from a vertical distance of 40 feet. Three flat 24 x 24-inch specimens are used, with each specimen being impacted only once at its approximate center. Specimens are maintained at room temperature (70°80°F).

TEST CRITERIA:

The steel ball shall not penetrate the glazing material. Penetration occurs when the ball passes completely through the glazing material.

16. IMPACT TEST (Delamination/ 1/2 lb. Ball-Breakage Height/Laminated)

TITLE: IMPACT TEST FOR BULLET-RESISTANT GLASS

PURPOSE:

In test resistance to delamination of bullet-resistant glass.

REFERENCE:

U.S. Dept. of Defense, Military Specification MIL-G-5485C, 1971  
Glass, Laminated, Flat, Bullet-Resistant. See also standard no. 65.

PROCEDURE:

A 1/2 pound smooth steel sphere is dropped from a sufficient height to cause breakage at the center of a specimen. If all the glass plies are not broken, the specimen is reversed and the impact repeated until all the glass plies are broken.

TEST CRITERIA:

The specimen is rejected if the glass separates from the laminating material.

17. IMPACT TEST (Breakage-Fragments/11 lb. Bag - 4 ft./Laminated-Tempered)

TITLE: IMPACT TEST

PURPOSE:

Test resistance to impact by a heavy soft object.

REFERENCE:

Canadian Government Specification Board: 12-GP-1b-1971 Standard for Glass: Safety, for Building Construction.

PROCEDURE:

An 11 pound shot bag is dropped from a height of 4 feet onto a 12" x 12" flat specimen supported in a wooden frame at 68-78°F.

TEST CRITERIA:

For laminated glass - The specimen glass may crack and lose its rigidity but no single detached fragment may exceed 1 gram in weight.

For tempered glass - The specimen must not fracture.

18. IMPACT TEST (Breakage/11 lb. Bag - 8 ft./All)

TITLE: IMPACT TEST

PURPOSE:

Made to determine whether the safety glass has a certain minimum strength under impact by a large yielding object.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways. (Test No. 8)

PROCEDURE:

Five 12" x 12" flat, horizontally mounted specimens at a temperature between 70°F - 85°F are impacted once by an 11 pound shot bag dropped from 8 feet.

TEST CRITERIA:

Not more than one specimen may crack or break as a result of the impact.



19. IMPACT TEST (Breakage-Fragments/100 lb. Bag, 1-1.5-4 ft./A11)

TITLE: IMPACT TEST

PURPOSE:

Made to determine the resistance of the glass to impact when struck by a heavy, relatively soft object.

REFERENCE:

ANSI Z97.1-1972 Performance Specification and Methods of Test for Safety Glazing Materials Used in Buildings. See also standards 1, 2, 3, 4, 7, 9, 10, 11, 12, 25, 42, 43, 61, 63, 68, 74, 80 and 90.

PROCEDURE:

A vertically mounted specimen is impacted at its center by a 100 pound shot bag swinging in a pendulum arc from a height of 12", 18", and 48" or until breakage occurs.

TEST CRITERIA:

The glazing material passes the test if each of four specimens meets any one of the following criteria:

(1) When breakage occurs, numerous cracks or fissures may appear but no opening should develop through which a 3-inch diameter sphere can freely pass.

(2) When disintegration occurs, the 10 largest crack-free particles obtained 3 minutes after the test can weigh no more than the equivalent weight of 10 square inches of the original specimen.

(3) When breakage occurs and results in several separate pieces, none shall be of such a nature or shape that could be described as "sharp-edged, pointed, or dagger-like".

(4) The specimen remains intact after one 48-inch drop test, though not necessarily remaining within the frame.

20. IMPACT TEST (Fragments/7 oz. Dart - 10 ft./Wire)

TITLE: IMPACT TEST

PURPOSE:

To determine the behavior of wire glass under impact from a small, hard object.

REFERENCE:

Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways. (Test No. 11)

PROCEDURE:

Five 12" x 12" flat, horizontally mounted specimens between 70°F - 85°F are each struck at the center by a 7 ounce dart dropped from 10 feet.

TEST CRITERIA:

The dart may crack the glass and may puncture the test specimen and small particles may disengage themselves from both sides of the specimen at and immediately around the point of impact, but no loose or detached pieces shall leave any area of the specimen exclusive of the area punctured by the dart. The glass on adjacent sides of each crack extending from the area punctured by the dart must be held in place by the reinforcing or strengthening material, and no glass shall be freed from reinforcing or strengthening material for a distance greater than 1-1/2 inches from a crack.

21. IMPACT TEST (Fragments/7 oz. Dart - 6 to 18 ft./Plastic)

TITLE: IMPACT TEST

PURPOSE:

To determine the behavior of plastic under impact from a small hard object.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways (Test No. 10).

PROCEDURE:

Five 12" x 12" flat, horizontally mounted specimens between 70°F - 85°F are each struck at the center by a 7 ounce dart dropped once onto the center of the specimen. The drop height is determined by the thickness of the plastic, ranging from 6 feet (.125" or less) to 18 feet (.250" or more).

TEST CRITERIA:

The dart may crack or puncture the test specimen but not more than one specimen shall break into separate large pieces.

At the point immediately opposite the point of impact, small fragments of plastic may leave the specimen, but if laminated, the small area thus affected shall expose less than 1 square inch of reinforcing or strengthening material, the surface of which shall always be well covered with particles of tightly adhering plastic. Total separation of plastic from the reinforcing or strengthening material shall not exceed 3 square inches on either side.

## 22. IMPACT TEST (Penetration/7 oz. Dart - 30 ft./Laminated)

TITLE: IMPACT TEST

PURPOSE:

To determine resistance to penetration under impact from a small, hard object.

REFERENCE:

ANSI Z26.1-1966 (R-1973) Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways (Test No. 9). See also standard no. 55.

PROCEDURE:

Five 12" x 12" flat specimens, horizontally mounted, at a temperature between 70°F - 85°F, are each struck at the center by a 7 ounce steel dart dropped once from 20 feet.

TEST CRITERIA:

The dart may crack the glass and may puncture the test specimen. However, the hole so produced must not be sufficiently large to permit passage of the body of the dart completely through the specimen. Small particles may disengage themselves from both sides of the specimen at and immediately around the point of the impact, but no loose or detached pieces may leave any area of the specimen exclusive of the area punctured by the dart. The glass on adjacent sides of each crack extending from the area punctured by the dart must be held in place by the reinforcing or strengthening material, and no glass shall be freed from reinforcing or strengthening material for a distance greater than 1-1/2 inches from a crack. Spalling of the outer glass surface opposite the point of impact and adjacent to the area of impact is not to be considered a failure. Not more than one specimen shall break into separate large pieces.

23. LOAD TEST (Breakage/Punch-Load to Max/Tempered)

TITLE: PROOF LOAD (PUNCH) TEST

PURPOSE:

To determine non-destructively the resistance to breakage of glass.

REFERENCE:

ISO 614-1973, Shipbuilding - Non-Destructive Strength Testing of Toughened Safety Glasses for Ships' Side Scuttles and Rectangular Windows - Punch Method. See also standard no. 34.

PROCEDURE:

The test specimen is placed in a horizontal position with a pad interposed between the glass and the punch. The test load is then applied to the punch and increased steadily until the specified load is attained. This load is held for five seconds, then gradually removed (see standard for details).

TEST CRITERIA:

Specimen must withstand proof load found in Table 2 of standard. Number of specimens and test trials, provisions for failures, sampling procedure, etc. are not discussed.

24. LOAD TEST (Breakage/Vacuum Load to Break/Spandrel)

TITLE: UNIFORM LOAD STRENGTH TEST

PURPOSE:

To determine whether the glazing material possesses a certain minimum strength under pressure.

REFERENCE:

CGSB 12-GP-9, Glass, Spandrel, for Building Construction (1972).

PROCEDURE:

A Rectangular sample at least 75% in each dimension of the maximum size normally furnished is mounted in a vacuum chamber with all edges supported by a soft material. The chamber pressure is reduced at a sufficient rate to produce a .1 in. deflection each minute. The mean average breaking pressure for 8 specimens is recorded.

TEST CRITERIA:

The average load strength of the eight samples tested shall meet the minimum value in Table 3 of the standard.

## 25. LOAD TEST (Breakage/Air Pressure Difference to Max or Break/All)

TITLE: LOAD TEST

PURPOSE:

To determine the structural performance of exterior windows, curtain walls, and doors under static air pressure differences representing wind loads.

REFERENCE:

ASTM E330-70, Structural Performance of Exterior Windows, Curtain Walls, and Doors under the Influence of Wind Loads. See also standards 1, 2, 3, 4, 9, 10, 11, 12, 78, and 79.

PROCEDURE:

"This method consists of sealing the test specimen into or against one face of a test chamber, supplying air to or exhausting air from the chamber at the rate required to maintain the test-pressure difference across the specimen, and measuring and observing the deflection, deformations, and nature of any failures of principal or critical members." Windows, doors, and other test specimens consist of the entire assembled unit, including frame and anchorage. "The outer side of the specimen shall face the higher pressure side for positive wind loads; the indoor side shall face the higher pressure side for negative wind loads." Two separate procedures are described - one for use when a specific test load is to be supplied and the other for use in determining the ultimate load, or point at which failure of the specimen occurs. These procedures are discussed in detail in ASTM E330-70.

TEST CRITERIA:

Two successive failures (breakages) of specimens determine that the glass is inappropriate for a given test pressure. (See Appendix of ASTM E330-70 for details.)

26. LOAD TEST (Breakage/Vaccum Load to Max/Spandrel)

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TITLE: LOAD TEST

PURPOSE:

To determine the behavior of spandrel glass when subjected to heavy loads.

REFERENCE:

GTA 66-9-20, Specifications for Spandrel Glass-Ceramic Enameled, Tempered or Heat-Strengthened (1969).

PROCEDURE:

Differential pressure loads are applied to a horizontally mounted specimen by evacuating the area underneath the specimen. The required differential pressure load is determined by applicable highest wind loads determined by National Weather Service charts or as specified by an architect.

TEST CRITERIA:

The sample must sustain a specified load equivalent to subjection to a certain high wind velocity for a period of one minute without breaking or showing excessive deflection. The ultimate load which the specimen can support is also determined.

COMMENTS:

See also PPG Technical Service Report No. 101 for wind velocity equivalents of various loads.



27. PUNCH TEST (Fragments/Spring-Loaded Punch/Tempered)

TITLE: PUNCH PRICK TEST

PURPOSE:

To determine whether heat strengthened or fully tempered glass breaks in a safe break pattern.

REFERENCE:

General Services Administration, Federal Specification, FS-DD-G-1403 B (1972), Glass, Plate (Float), Sheet, Figured, and Spandrel (Heat Strengthened and Fully Tempered). See also standards 32, 66, 68, 69, 72.

PROCEDURE:

A horizontally supported specimen stabilized at 70°-85°F is broken by the use of a spring loaded carbide tipped center punch, or a center punch struck by a hammer, applied within 1/2" of any two edges of the specimen.

TEST CRITERIA:

No crack-free particle taken from the specimen at any place, except from an area of 2" radius about the center punch mark, shall weigh more than 4.5 grams.

COMMENTS:

Other references are Glass Tempering Association "Engineering Standards Manual" Specification No. 64-3-16, Rev. #1; Libby-Owens-Ford Company Bulletin 8.26 Li (1974) "Glass and Glazing".

28. STRESS TEST (Modulus of Rupture/Single Bend/All)

TITLE: DETERMINATION OF MODULUS OF RUPTURE

PURPOSE:

To determine the stress of which a glass specimen breaks during a flexure (bending) test.

REFERENCE:

ASTM Test Method C-158 Determination of Modulus of Rupture.

PROCEDURE:

Specimens having cut edges shall be broken with the cutter marks on the side under compression. The permissible initial load shall not exceed that corresponding to a stress of approximately 4000 psi. The specimen shall be bent until fractured under a constant loading rate such that the rate of increase of stress is  $10,000 \pm 1,000$  psi per min. No specimen may be rejected during test because of low flexural strength.

TEST CRITERIA:

The maximum, minimum and average of the modulus of rupture for each group of similar specimens is recorded along with the values of the stress due to the initial load, and the rate of increase of stress.

29. STRESS TEST (Modulus of Rupture/Cyclic Bending/Tempered)

TITLE: STRESS TEST-MODULUS OF RUPTURE

PURPOSE:

To determine whether semitempered or tempered glass specimens have a minimum average strength.

REFERENCE:

U.S. Dept. of Defense, Military Specification MIL-G-25667B, 1970, Glass, Monolithic, Aircraft Glazing.

PROCEDURE:

The specimens are subjected to a specified number of cycles of stress or until fracture occurs using a rotating beam fatigue machine of the R. R. Moore type capable of operating speeds of 3,450 or 10,000 revolutions per minute.

TEST CRITERIA:

The following results are reported:

- (1) The constant-stress flexural fatigue strength in pounds per square inch at the number of cycles specified.
- (2) The stress in pounds per square inch to which each specimen was subjected and the number of cycles of stress required to break the specimen.
- (3) The constant stress at which the specimens were subjected to the flexure stress cycle.
- (4) Curve of stress as ordinate versus the logarithm of the number of cycles required for fracture as abscissa on semilogarithmic graph paper.
- (5) The type of specimen, notched or unnotched.
- (6) The operating speed of the machine in revolutions per minute.

COMMENT:

The test method is fully described in Federal Test Method Standard 406, Method 1062 "Constant-Stress Flexural Fatigue Strength".

30. NON-DESTRUCTIVE TEST (Internal Stress/Polariscope/Tempered)

TITLE: POLARISCOPIIC COMPARISON

PURPOSE:

To determine whether semitempered or tempered glass specimens have a minimum average strength as compared to a reference sample.

REFERENCE:

U.S. Dept. of Defense, Military Specification MIL-G-25667B, 1970, Glass, Monolithic, Aircraft Glazing. See also standards, 24, 34, 40, 54, 66, 67 and 69.

PROCEDURE:

Specimen is compared optically with a polariscope to a reference sample of the same glass which is of known strength.

TEST CRITERIA:

Specimen must indicate strength equal to the reference specimen.

COMMENTS

Glass manufacturers used non-destructive testing as part of their quality control procedures. It may be feasible to develop a portable device which would permit non-destructive testing of installed glass. A portable device could detect stresses caused by improper installation as well as defects due to the manufacturing processes.

### 31. HARDNESS TEST (Hardness/Knoop Indentation/Tempered)

TITLE: KNOOP INDENTATION HARDNESS TEST

PURPOSE:

To determine the relative hardness of specimens in a batch of glass or the change in hardness caused by thermal or chemical treatment of glass.

REFERENCE:

ASTM Test Method, C-730 Tentative Method of Test for Knoop Indentation Hardness of Glass.

PROCEDURE:

A predetermined test load is applied to the indents of the hardness apparatus which bears on the glass specimen. The load is removed and the length of the diagonals of the indentations made in the glass by the applied load bearing on the indents is measured with a microscope. This length is related to the hardness of the glass. The instrument may be calibrated with standard glasses available from the National Bureau of Standards.

TEST CRITERIA:

Not applicable.

COMMENTS:

Attempts have been made to relate Knoop Indentation Hardness to tensile strength, grinding speeds, and other hardness scales, but no generally accepted methods are available. Such conversions are limited in scope and should be used with caution, except for special cases where a reliable basis for the conversion has been obtained by comparison tests.

32. BOIL TEST (Delamination/Boiling Water - 2 hrs./Laminated)

TITLE: BOIL TEST

PURPOSE:

To determine the probable effect of exposure to tropical temperatures and conditions on safety glazing.

REFERENCE:

ANSI Z97.1-1972 Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings. See also standards 1, 2, 3, 4, 7, 9, 10, 11, 12, 25, 32, 35, 61, 63, 74, 80 and 90.

PROCEDURE:

Three 12 x 12 inch flat specimens are immersed, vertically on edge, in water at 150°F for 3 minutes and then, quickly transferred to and similarly immersed in boiling water where they are held for 2 hours and then removed.

TEST CRITERIA:

There shall be no bubble or other defects develop more than 1/2 inch from the **outer** edge of the specimen or from any crack that may develop.

33. WEATHERING TEST (Strength Loss/Carbon-Arc Lamp-2000 hrs./Plastic)

TITLE: WEATHERING TEST

PURPOSE:

To determine whether the plastic will successfully retain its safety characteristics after exposure to simulated weathering conditions for an extended period of time.

REFERENCE:

ANSI Z97.1-1972 Performance Specifications and Methods of Test for Safety Glazing Materials Used in Buildings. See also standards 1, 2, 3, 4, 7, 9, 10, 11, 12, 25, 43, 61, 63, 74, 80 and 90.

PROCEDURE:

The specimen is exposed 2000 hours to a twin enclosed carbon-arc lamp apparatus in accordance with ASTM D-1499 requirements.

TEST CRITERIA:

Specimens are evaluated before and after exposure by the Charpy Unnotched Impact Test with the weather-side of the specimens subject to tension in the test. The material is acceptable if the impact strength has not been reduced more than 25% during the 2000 hour exposure. There shall be no bubbles or noticeable decomposition occur during the 2000 hour exposure.

34. ELASTICITY (Young's Modulus-Shear Modulus-Poisson's Ratio/Vibration/  
All)

TITLE: TEST FOR YOUNG'S MODULUS/SHEAR MODULUS/POISSON'S RATIO

PURPOSE:

To determine the elastic properties of glass and glass-ceramic materials.

REFERENCE:

ASTM Test Method C-623 Tentative Method of Test for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance.

PROCEDURE:

Specimens of these materials possess specific mechanical resonance frequencies which are defined by the elastic moduli, density, and geometry of the test specimen. Therefore the elastic properties of a material can be computed if the geometry, density, and mechanical resonance frequencies of a suitable test specimen of that material can be measured. Young's modulus is determined using the resonance frequency in the flexural mode of vibration. The shear modulus, or modulus of rigidity is found using torsional resonance vibrations. Young's modulus and shear modulus are used to compute Poisson's ratio the factor of lateral contraction. For details of procedure, see referenced test methods.

TEST CRITERIA:

Not applicable.



## APPENDIX

### Basic Definitions Relating to Architectural Glazing

#### ANNEALED GLASS

Glass which has been subjected to a controlled, relatively slow cooling process to prevent or remove objectional stresses. Annealed glass is used for a wide variety of products, including windows and doors. When broken, annealed glass characteristically breaks into long, sharp, dagger-like pieces.

#### ARCHITECTURAL GLAZING

Architectural glazing as defined by the CPSC includes:

- (a) entrance and exit doors, including storm doors and sliding glass panels
- (b) windows
- (c) glazed panels adjacent to doors
- (d) bathtub and shower enclosures

#### COATED GLASS

Glazing consisting of a piece of glass coated and bonded on one or both sides with an applied plastic coating, sheeting, or film. The strength and breakage pattern is similar to annealed glass, but the coating holds the broken pieces together.

#### LAMINATED GLASS

Glazing which is a composite of two or more pieces of annealed glass held together by an intervening layer or layers of plastic material. If broken, the pieces of glass tend to adhere to the plastic. The plastic interlayer also makes it difficult to penetrate the glazing.

#### PLASTIC

Glazing which consists of a sheet of plastic material, a combination of two or more plastic sheets laminated together, or a combination of plastic material with reinforcing fibers or flakes. Acrylic, polycarbonate, and polystyrene plastics are commonly used for glazing. Plastic materials are strong and flexible, and if impacted, tend to pop out of their frames rather than crack. When broken, the edges are usually not sharp, although they may be pointed.

### SAFETY GLAZING

Glazing material constructed, treated, or combined with other materials such that in comparison to ordinary annealed glass, the likelihood of lacerative injury due to its breakage is significantly decreased. Safety glazing includes laminated glass, tempered glass, wire safety glass, coated glass, and plastics.

### TEMPERED GLASS

Glass which has been thermally or chemically treated to significantly increase its mechanical strength. When broken, tempered glass disintegrates into innumerable small fragments of more or less cubical shape.

### WIRE SAFETY GLASS

Glass with a layer of wire mesh completely imbedded within the sheet. When the glass is broken, the wire mesh tends to hold the broken pieces together. Safety wire glass is so constructed as to withstand higher impacts than normal wire glass, which is used for fire safety applications.

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16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)  The report describes 34 test procedures extracted from 97 codes and standards identified in an extensive library search of English language codes and standards relating to architectural glazing. The report also contains summaries of existing state laws relating to safety glazing. Test descriptions include procedures, kinetic energy levels, purpose of tests, and acceptance/rejection criteria. Test methods, codes and standards, and sources are cross-referenced.				
17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Architectural glazing; codes; Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; state law; standards				
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