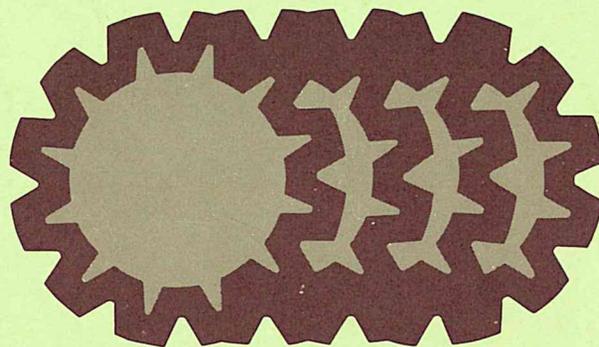


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TECHNICAL INFORMATION

TESTS OF GLASS PLANO SAFETY SPECTACLES



**U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE / Public Health Service
Center For Disease Control / National Institute For Occupational Safety And Health**

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ABSTRACT

The report describes tests of industrial safety spectacles with glass lenses advertised as meeting the requirements of the ANSI Z87.1 standard. A general description of each test is included along with a presentation of the test results. Twenty-two individual models were tested and found to be in general compliance with the ANSI standard.

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INTRODUCTION

Industrial safety spectacles are by far the most frequently used safety device for eye protection in the occupational environment. The Occupational Safety and Health Act of 1970¹ requires that these spectacles comply with the American National Standards Institute (ANSI) standard Z87.1-1968.² This report describes a testing program to determine the extent to which industrial safety spectacles currently available in this country, comply with this standard.

Both corrective and non-corrective (plano) spectacles must comply with the ANSI Z87.1 standard. Corrective industrial safety spectacles must not be confused with ordinary or "street-wear" spectacles. Since 1972, all street-wear spectacles have been required to utilize impact resistant lenses.³ The level of impact resistance is, however, well below that required for industrial safety spectacles. Fortunately, it is not difficult to distinguish between the two types; the lenses of street-wear spectacles are unmarked, while those of industrial safety spectacles are marked with the manufacturer's identification.

Frames of industrial safety spectacles can be either plastic or metal. Lenses can be either glass or plastic, each having advantages and disadvantages. It is generally recognized that the glass lenses provide superior scratch resistance, while plastic lenses are lighter in weight. Glass lenses in plastic frames are considered in this testing program.

In addition to its certification programs, the NIOSH Testing and Certification Branch is developing a body of technical information about personal protective devices currently available to the industrial worker. These devices include safety helmets, safety-toe shoes, linemen's rubber gloves, and eye and face protective devices. This report is one of a series concerning such devices.

SELECTION OF DEVICES

The program described in this report was implemented to survey the quality of glass plano safety spectacles available in the United States and advertised as being in compliance with the ANSI Z87.1 standard.

Unlike street-wear spectacles, the shapes of industrial spectacles are standardized. As a result, the same basic lens is typically used in all the various frame styles available from a particular manufacturer, and since the quality of the lens relates most directly to the safety of the user, no attempt was made to test all of the numerous frame styles available. Instead, one model from each manufacturer was selected for testing. This one model was randomly selected from a tabulation of all models available from each manufacturer.

Models from 22 manufacturers were purchased for testing. To standardize the testing program, all spectacles were ordered with a 48 mm lens size, 22 mm bridge size, 6 diopter base curve, plastic frame, cable temples, clear glass lenses, and sideshields.

TESTING PROGRAM

Twelve specimens of each of 22 spectacle models were tested as outlined in the flow-chart on page 14. The tests and requirements are those of the ANSI Z87.1 standard. A brief explanation of each of these tests follows.

Lens Impact Test

The lens impact test consisted of dropping a 1" steel ball, weighing approximately 2.4 ounces, from a height of 50" onto the center of the outer surface of the lens. The lenses were mounted on a 1/8" thick neoprene gasket having a Shore A durometer reading of 40 ± 5 which was glued to the test block specified in the ANSI standard.⁴ The tests were conducted at increasing "energy steps" until fracture occurred or until the maximum energy was achieved. Each energy step was 20 percent greater than the previous. Only the initial test at the 50-inch height was used as a basis for pass/fail; the high energy impacts were only used to impact for breakage pattern and comparison purposes.

A total of 24 lenses were impact tested for each model. A single failure at the standard height was considered sufficient cause to fail the model.

Frame Impact Test

Spectacles are frame impacted to test the strength of the lens-frame combination.

The test was performed by mounting the spectacles on a test fixture which positions the outer surface of the lenses upward. The spectacles are supported at three points; the bridge rests on a metal support and each temple is clamped at its midpoint. This fixture was selected because it is being considered by the ANSI Z87 committee for possible incorporation in a future revised standard and because of the absence of a workable test fixture in the present standard.

A 1" steel ball, weighing approximately 2.4 ounces, was dropped on each lens from a height of 50". Four specimens were tested. The failure of any one specimen resulted in failure of the model.

Luminous Transmittance Test

Lenses were tested for luminous transmittance using a Gardner model UX-10 hazemeter with a model PG-5500 digital readout. Testing was performed according to Procedure A of the ASTM test method D1003-61T.⁵ Light source A was used.

Clear spectacle lenses are required to transmit at least 89% of the incident luminous light. Eight lenses of each model were tested and their average recorded for the model. An average of less than 89% transmittance resulted in failure of the model.

Flammability Test

Frame-fronts, temples, and sideshields were tested for flammability. Frame-fronts were tested whole with lenses and temples removed. They were mounted in the position in which they are worn, held by the left side, and ignited on the extreme right edge where the temple was attached. The time required for the flame to burn to a line inscribed on the center of the bridge was recorded.

Temples and sideshields were similarly tested by mounting them in a horizontal position and recording the time required for the flame to burn a measured distance. To eliminate their natural curvature, all sideshields were straightened prior to testing. Temples were tested as received; nothing was removed. Sideshields were tested separately from temples, except for the flatfold type which were tested as part of the temple. All samples were tested as outlined in the ANSI Z87.1 standard, and ASTM Test Method D635-72 was consulted to provide details not covered by the ANSI standard.⁶

Samples which burned the entire measured distance were classified as "burning", and a burn rate was computed. If the sample would not ignite or if the flame went out before burning the entire distance, the sample was classified as "self-extinguishing". Testing continued until 5 samples were given the same classification. This classification was recorded for the component. If the component was classified "burning", an average burning rate was calculated to determine failure or compliance with the maximum allowable burning rate of 1.06 mm/sec. In addition, a statistical test, based on the student t distribution, was used to determine the level of confidence.⁷ If the pass/fail rating exhibited less than 90% confidence, the result was considered to be inconclusive. Components classified "self-extinguishing" were considered passing.

Refractive Power Test

The refractive power test is actually four individual tests which measure the optical qualities of prism, sphere, cylinder, and definition. These tests were conducted using NBS Special Publication 374 as a guide.⁸ Sixteen lenses were tested for prism and ten for each of the remaining tests. Each lens was tested by observing a target located 35 ft. away through the lens with a Gaertner model M522 11 power telescope having a 19 mm objective aperture. Each lens was viewed perpendicularly through its geometric center unless a localized defect was present near the center, in which case the target was viewed through the defect.

The prismatic power test measures the extent to which an object being viewed is displaced by the lens under test. Prism in spectacle lenses becomes a problem when two lenses exhibit significant amounts in opposite directions, causing the eyes of the wearer to look in slightly different directions to focus on an object. To prevent this prismatic imbalance, which is significantly more important than pure prism, the ANSI standard requires each lens to exhibit not more than 1/16 diopter of prism, thus setting the maximum difference between any two lenses at 1/8 diopter, an amount easily accommodated by most people.

The prism of an individual lens is meaningful only when the optical axis of the lens is specified. The ANSI standard does not specify the location of the optical axis and it is, therefore, not meaningful to measure the prismatic imbalance between the left and right lens. It is however, possible to measure directly the prismatic imbalance between the left and right lens. If this prismatic imbalance was greater than 1/8 diopter, the spectacles were reported as failing.

The spherical power refers to the maximum refractive power in any meridian, and the cylindrical power refers to the maximum difference in refractive power between any two meridians. The ANSI standard sets a maximum of $\pm 1/16$ diopter for both. These two quantities were measured by observing a target composed of radial lines, eliminating parallax between the crosshairs in the telescope and the target, and recording the two refractive power readings 90° apart. The larger of the two is the spherical power and the difference is the cylindrical power. If an axis of cylinder was observed, one of the crosshairs in the telescope was aligned parallel to the axis prior to taking the reading to eliminate focusing error.

The definition test is a measure of the extent to which the visual acuity of the wearer is affected. This is a "catch-all" because it is sensitive to almost any type of optical defect. In order for a lens to pass, each of the 3 lines on the number 20 pattern of the NBS circular C533 must be individually distinguishable.

Flat and Edge Transverse Tests

The flat and edge transverse tests evaluate the mechanical integrity of the frame. Both tests are conducted with temples removed and lenses in place.

In the flat transverse test, the left half of the frame-front and bridge was secured in a holder such that the outer surface of the lenses faced downward. A 16 ounce weight was attached to the right temple hinge and allowed to stabilize.

In the edge transverse test, the right half of the frame-front and bridge was grasped by the hand and held in a normal wearing position. The left half was then pressed downward against one of the platforms of an equal-arm balance while the other platform contained a five-pound weight. Sufficient downward force was applied to balance the system.

In both tests, the forces were removed as soon as the system stabilized, and the devices were immediately examined. Any permanent deformation was cause for failure. Four specimens were subjected to each test.

Corrosion and Disinfection Tests

The corrosion and disinfection tests require spectacles to demonstrate a minimum level of durability. The corrosion test determines the effects of exposing the device to a salt spray (fog) under controlled conditions. The disinfection test evaluates the extent to which spectacles can withstand routine disinfection without deterioration.

Spectacles were tested for corrosion resistance in a Singleton model SCCH-21 test cabinet according to ASTM test method B117-64.⁹ After being exposed to the fog for 48 hours, the devices were rinsed with distilled water, air dried, and inspected. In order to pass, the spectacles must have been totally usable.

The disinfection test consisted of washing the spectacles in a soap solution, thoroughly rinsing, and immersing them in a hypochlorite solution for 10 minutes at room temperature. Upon completion of the test, the devices were air dried and inspected. Any significant deterioration or discoloration was cause for failure. This procedure was repeated using a phenol solution. Both disinfecting solutions were used at the strengths recommended on their respective labels.

Water Absorption Test

This test measures the tendency of the frames to absorb moisture. Plastic materials used in the construction of safety spectacles must not absorb more than 5 percent water when tested in the following manner.

A section of the frame-front was cut from two different specimens and tested according to Federal Test Method Standard Number 406, Method 7031.¹⁰ Samples were conditioned according to paragraph 4.1.1, and tested as outlined in procedure A. In addition, if the temple material was different from the frame-front, a sample was similarly cut from each of two temples and tested. Sideshields were not tested.

The samples were placed in an oven at 50° C for 24 hours, cooled, and weighed. After immersion in distilled water for 24 hours at 23° C, the samples were reweighed. The percent of water absorbed was calculated from the two weights. This percent was corrected for any water soluble material present.

The percent water absorbed for the component was determined by averaging the results for two samples. If the average was less than or equal to 3 percent, the component passed; otherwise, two additional samples were tested and a new average was computed using all four samples. The new average was then used to determine failure or compliance with the 5 percent requirement.

Design Requirements

The ANSI standard lists several design requirements for safety spectacles. These include such items as manufacturer's markings, lens thickness, and the elimination of eye exposure. At least one specimen from each model was examined for compliance with the design requirements.

TEST RESULTS

Lens Impact Test Results

The lens impact results for standard energy testing are presented in Table 1 along with the other performance test results. The results of the lens impact testing at elevated energies are presented in Table 3.

Glass spectacle lenses performed very well in both normal and higher energy impact tests. All models passed the standard test except the Willson model MS. Even in this model only one of 24 lenses failed at the standard height (impact step 0) with no further fractures occurring until impact step 3.

At impact step 1, two American Optical lenses fractured, and at impact step 2, a single lens fracture occurred in the American Industrial, Safeline, and Pulmo-san models. Each of twelve additional models suffered initial fractures at impact steps 3, 4, and 5, four models at each step. The remaining five models, Aden, Jackson, Safeside, Watchemoket, and Wilkie Optical did not fracture during this test. Thus, no fractures were observed in 23 percent of the models when subjected to impact energies 2 1/2 times greater than the ANSI standard requires. Even more impressive is that 88.4 percent of the 528 lenses tested survived the 250 percent increase in impact energy. Ninety-nine percent survived impact step 2.

At least 50 percent of the lenses in all models survived the tests. In eighteen of the 22 models tested, 75% of the lenses survived.

The stress pattern of each lens was photographed with crossed polarizing filters before impact in an attempt to correlate the pattern with fracture energy. The observed patterns divided into two groups, one with a clear cross pattern and the other with a distorted cross superimposed on a circle. Neither group could be clearly identified as better than the other. No fractures occurred in at least two models in both groups. There was no apparent correlation between the patterns and the fracture energy.

Frame Impact Test Results

All models passed the frame impact test. There were a few individual frames that fractured; however, it was determined that these fractures resulted from the frame striking the sharp corner on the test fixture. These fractures are considered to indicate a defect in the fixture rather than the spectacles. A headform with facial features and the texture of a human face would be a more realistic test fixture.

Luminous Transmittance Test Results

No failures occurred in the Luminous Transmittance Test. All of the 168 lenses tested were well above the 89 percent minimum required. The values ranged from 92.1 percent to 92.4 percent. No results are shown for the Pulmosan model G-6300-S. Because this model was received with green tinted lenses, it was not tested.

Flammability Test Results

Four of the 22 models tested failed the flammability test. In each case, failure occurred because the burning rate of the sideshields exceeded the maximum allowable rate of 1.06 mm/sec. Burning rates for fronts ranged from 0.51 to 0.75 mm/sec with an average rate of 0.58 mm/sec. Three fronts were self-extinguishing. Burning rates for temples ranged from 0.34 to 0.88 mm/sec with an average rate of 0.63 mm/sec. Two temples were self-extinguishing. Because flatfold sideshields were tested attached to the temples, sideshields were tested separately in only 11 models. Four of these failed with burn rates of 1.13, 1.14, 1.14, and 1.19 mm/sec. The range for sideshields was 0.54 to 1.19 mm/sec. One sideshield was self-extinguishing.

Refractive Power Test Results

All models passed the four individual tests collectively called the Refractive Power Tests. As expected, the results of these tests are much better than those obtained from testing the plastic windows in flexible fitting goggles.

It is important to point out that the two lenses in each pair of spectacles were tested together for prism. Since there is more than one lens design in use today, it would be possible to have a pair of spectacles with two lenses that were properly manufactured but of different design. Tested individually, these two lenses would satisfy the maximum 1/16 diopter requirement, while the prismatic imbalance between them could be significantly greater. Since prismatic imbalance is more important than pure prism, testing should always be done in pairs. For the same reason, replacement lenses should be purchased in pairs.

Flat and Edge Transverse Test Results

All models passed the flat and edge transverse tests. There were no failures in either test. As expected, the plastic frames deformed slightly under load but returned to their original shape when the load was removed.

Corrosion and Disinfection Test Results

All models except one passed the corrosion test. The Jackson model's wire-mesh sideshields rusted until approximately 1/3 of the screen was clogged, thus reducing ventilation capacity and peripheral vision. Of the five other models with wire-mesh sideshields, one had some discoloration over 5% of its surface and the other four showed almost no effects from the test.

All models passed the disinfection test. The Jackson model's wire-screen sideshields which failed the corrosion test, rusted over 25-50 percent of its surface; however, the rust was in the form of discoloration and did not clog the

holes in the screen. Although this model was totally usable after the test, the degree of discoloration indicates that, future disinfection or even general use could lead to deterioration that would affect the usability of the device. The other five wire screen sideshields showed almost no effects from the test.

Water Absorption Test Results

All models passed the Water Absorption Test. Fourteen frame-fronts absorbed 1-2 percent water, six fronts absorbed 2-3 percent, and two fronts absorbed just over 3 percent water. Two temples were also tested because they appeared to contain plastic different from that used in the frame-fronts. One absorbed less than 1 percent, and the other between 2 and 3 percent water. Since none of the water absorption rates was close to the 5 percent maximum allowed, the results are not included in the table.

The purpose of the water absorption test is not clear. We are not aware of how a water absorption rate in excess of 5 percent would lessen the degree of protection spectacles are intended to provide.

Design Requirement Results

Table 2 lists the results of the more important design requirements and includes all failures except two: Temple ends were not secure on the Fibre-Metal model, and the measured bridge size was just outside of the required range (18-26 mm) on the Aden model at 26.5 mm.

A summary of Table 2 shows that 5 models failed the manufacturer marking requirements, three on the fronts and 2 other models on the temples. Two models also failed the length marking requirement on the temples. Three models had adjustable temples, but only one of them had the different positions identified by length markings. The other 2 were not failed, however, because temple length markings are not as important on adjustable temples where a change in temple length requires only a very minor adjustment. Adjustable temples will fit most individuals, and the proper length can be determined easily; however, on fixed-length temples the size must be known so that the proper length can be attached to the front initially to avoid a trial and error process.

One unexpected finding was the failure of one model to permit the interchangeability of temples. Over 50 percent of the time, the screws on the Watchemoket model broke off in the hinge, making it impossible to remove the temple. This is a significant failure, since damaging a temple could well result in the need to replace the entire frame.

Fifteen of the models had universal bridges. Of the remaining seven, one failed the requirement that the bridge size marked on the frame front be within 1 mm of the actual size. This was the Aden model for which the bridge size, as previously mentioned, was outside of the required range.

No sideshields are shown as failing the design requirements in table 2. Eleven of the 22 models had full sideshields and are listed as passing. The other eleven models had flatfold sideshields, a more recent design not specifically covered in the standard. While these models comply with the requirements for spectacles without sideshields, they do not provide the protection from projectiles approaching from above and below the eye which is required of models with

full sideshields. Accordingly, they are identified in table 2 with an "S" to indicate that they provide protection from the side only. Some manufacturers are including a statement to this effect with each pair of spectacles. We believe that all manufacturers of this type of spectacles should clearly state, in advertisements and in instructions accompanying the product, that they do not provide the protection of full sideshields. Of the five models with full perforated plastic sideshields, all passed the requirement that the holes exclude a 1.5 mm diameter particle.

There were no failures in the lens thickness requirement, which specifies that a lens must be in the range 3.0 to 3.8 mm. The range for the models tested was 3.23 to 3.66 mm with an average of 3.48 mm.

CONCLUSIONS AND RECOMMENDATIONS

Industrial safety spectacles with glass lenses were found to be in general compliance with the primary requirements of the ANSI Z87.1 standard and are considered to be high quality safety devices. Most areas of non-compliance were minor. The only exception was a single failure in the lens impact test.

All models were found to have lenses of high optical quality. There was not a single failure in the optical quality tests, and even though some aspects of the ANSI optical requirements are somewhat subjective, we consider the overall optical quality to be definitely above the ANSI requirements. This is especially significant since non-corrective safety spectacles are worn by individuals who do not normally wear spectacles and who may be unaccustomed to their use. Optical imperfection could cause discomfort or, even worse, discourage the worker from using safety spectacles.

The primary function of safety spectacles is to protect the eye from direct impact. The three tests which directly measure how well spectacles provide this protection are lens impact, frame impact, and the design requirement for elimination of eye exposure. All models passed the lens and frame impact tests with the single exception noted above, and all models with full sideshields met the eye exposure requirement. Only spectacles with full sideshields are required to eliminate eye exposure. This last point deserves further discussion.

We consider the elimination of direct eye exposure to be one of the most important features of any eye protective device. Accordingly, it is important to emphasize that spectacles without sideshields offer virtually no protection to the eye from projectiles approaching from the side. Failure to adequately consider this obvious limitation, when selecting spectacles, could result in a hazard to the user. The choice between the two styles specified in the ANSI standard is difficult to make, but very important. The style with no sideshields offers limited protection while the full sideshield model, because of its appearance and restriction of peripheral vision, may not be readily accepted by some workers. We are concerned that this choice may be based more on worker acceptance than the degree of protection needed. Safety equipment manufacturers are apparently concerned with the problem and have attempted to deal with it by introducing a third spectacle style, the so-called "flatfold" design. This design is not specifically considered by the ANSI standard, but is representative of several models encountered in this testing program. The flatfold design offers a useful alternative. Such spectacles reduce restriction to peripheral vision and are more acceptable in appearance than spectacles with full sideshields. They also provide significantly more protection than models without sideshields. Therefore, we encourage the use of the flatfold design in place of spectacles without sideshields.

It should be emphasized that flatfold sideshields are not to be considered a substitute for full sideshields. Unfortunately, the advertisements of some

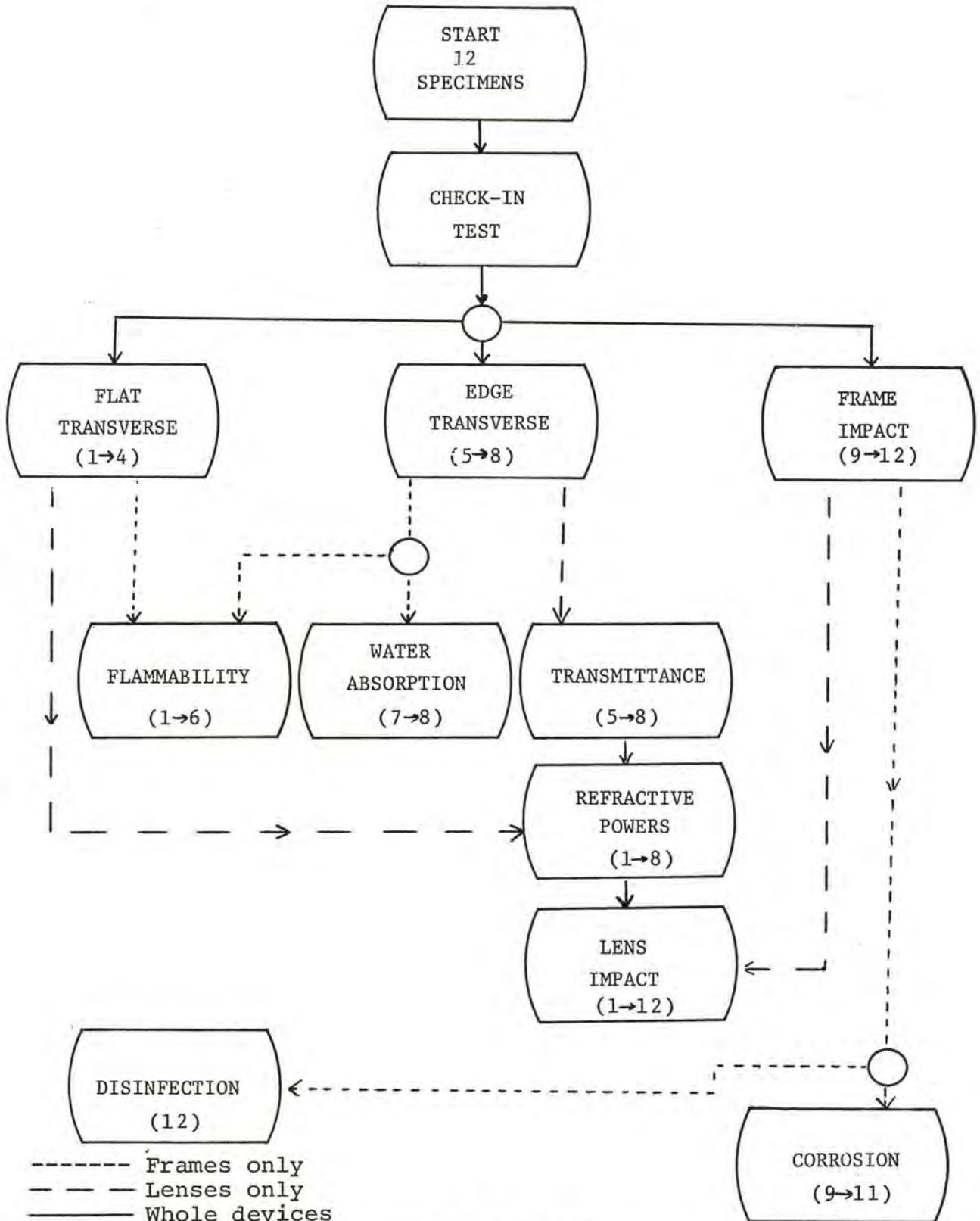
manufacturers improperly lead the reader to believe that the flatfold design provides protection equivalent to that provided by full sideshields.

In summary, glass safety spectacles were found to be good quality safety devices. The level of protection provided the user will be determined primarily by the style of spectacles selected for use.

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SAFETY SPECTACLES - FLOWCHART [plastic frame, glass lens]



The ()'s indicate the specimen numbers that are available for each test

TABLE 1.--PERFORMANCE TEST RESULTS***

Manufacturer Model	Lens+ Impact	Frame** Impact	Transmittance (Min=89%)	Flammability+++ (Max=1.06 mm/Sec)			Refractive Powers			
				Front	Temples	Sideshields	Prismatic**	Definition*	Spherical*	Cylindrical*
Aden 4000		8	92.1	0.54	0.72	0.90	8	10	10	10
American Ind. 474S	2	8	92.3	0.64	0.34		8	10	10	10
American Opt. F9800B-14051	1	8	92.3	SE	0.69	1.14F	8	10	10	10
Babbitt 8500	3	8	92.2	0.52	0.72		8	10	10	10
Bouton 5901	3	8	92.2	0.63	0.69	SE	8	10	10	10
Cam-Hi 323	4	8	92.2	SE	0.65	1.19F	8	10	10	10
Cesco 318	3	8	92.4	0.68	0.76	0.72	8	10	10	10
Fibre Metal 3481	5	8	92.2	0.75	SE	0.78	8	10	10	10
Glendale 7400	5	8	92.2	0.54	0.68	0.54	8	10	10	10
Jackson 0760-0603		8	92.2	0.52	0.75	1.14F	8	10	10	10
MSA 7600	3	8	92.1	0.53	0.51	0.64	8	10	10	10

* Number passing out of 10 tested.

** Number passing out of 8 tested.

*** All Failures are indicated by F.

+ The number shown is the "impact step" at which fracture occurred. The impact energy, E, is given by $E = E_0 [1.20]^m$, where m is the impact step and E_0 is the ANSI pass/fail energy corresponding to a 1" steel ball dropped from 50" (m=0 for the ANSI pass/fail test). Absence of a number indicates no fractures occurred.

++ Clear lenses were not available at the time of testing.

+++ Absence of a burn rate under sideshields indicates the flatfold type. SE indicates self-extinguishing.

TABLE 1.--continued***

Manufacturer Model	Lens+ Impact	Frame** Impact	Transmittance (Min=89%)	Flammability+++ (Max=1.06 mm/Sec)			Refractive Powers			
				Front	Temples	Sideshields	Prismatic**	Definition*	Spherical*	Cylindrical*
Morse 334S	5	8	92.2	0.62	SE		8	10	10	10
Pulmosan G-6300-S	2	8	++	0.59	0.57		8	10	10	10
Safeline 2700	2	8	92.3	SE	0.57	1.13F	8	10	10	10
Safeside 302		8	92.3	0.51	0.62		8	10	10	10
Sellstrom 700 CS	4	8	92.3	0.63	0.45		8	10	10	10
Thermacote 40-07080	4	8	92.2	0.54	0.49		8	10	10	10
91 U. S. Safety 78	4	8	92.3	0.56	0.47		8	10	10	10
Watchemoket 848 SS		8	92.2	0.53	0.88		8	10	10	10
Welsh 2200	5	8	92.3	0.71	0.64		8	10	10	10
Wilkie Opt. WO-61		8	92.4	0.53	0.80		8	10	10	10
Willson MS	OF	8	92.3	0.53	0.52	0.98	8	10	10	10

* Number passing out of 10 tested.

** Number passing out of 8 tested.

*** All Failures are indicated by F.

+ The number shown is the "impact step" at which fracture occurred. The impact energy, E, is given by $E=E_0[1.20]^m$, where m is the impact step and E_0 is the ANSI pass/fail energy corresponding to a 1" steel ball dropped from 50" (m=0 for the ANSI pass/fail test). Absence of a number indicates no fractures occurred.

++ Clear lenses were not available at the time of testing.

+++ Absence of a burn rate under sideshields indicates the flatfold type. SE indicates self-extinguishing.

TABLE 2.--DESIGN REQUIREMENTS***

Manufacturer Model	Frame-Front		Temples			Sideshields		Lens Thickness (3.0 - 3.8 mm)
	Manufacturer Marking	1 mm Bridge Tolerance*	Markings Manufacturer	Inter- Length Changeable	Inter- Changeable	Eyes Protected	1.5 mm Hole Tolerance**	
Aden 4000	P	F	P	P	P	P	P	P
American Ind. 474S	F		P	P	P	S		P
American Opt. F9800B-14051	P	P	P	P	P	P		P
Babbitt 8500	P	P	P	P	P	S		P
Bouton 5901	P	P	P	P	P	P		P
Cam-Hi 323	F		P	P	P	P		P
Cesco 318	P		P	P	P	P	P	P
Fibre-Metal 3481	P		P	P	P	P	P	P
Glendale 7400	P		F	F	P	P	P	P
Jackson 0760-0603	P		P	P	P	P		P
MSA 7600	P	P	P	P	P	P	P	P

P = Pass

F = Fail

S = Side protection only due to flatfold design.

* Not applicable to universal bridge.

** Applies to perforated plastic sideshields only.

*** All failures are indicated by F.

TABLE 2.--continued***

Manufacturer Model	Frame-Front		Temples			Sideshields		Lens Thickness (3.0 - 3.8 mm)
	Manufacturer Marking	1 mm Bridge Tolerance*	Markings Manufacturer	Inter- Length Changeable	Eyes Protected	1.5 mm Hole Tolerance**		
Morse 334S	F		P	P	P	S	P	
Pulmosan G-6300-S	P		P	P	P	S	P	
Safeline 2700	P	P	P	P	P	P	P	
Safeside 302	P		P	P	P	S	P	
Sellstrom 700 CS	P	P	P	F	P	S	P	
Thermacote 40-07080	P		F	P	P	S	P	
U. S. Safety 78	P		P	P	P	S	P	
Watchemoket 848 SS	P		P	P	F	S	P	
Welsh 2200	P		P	P	P	S	P	
Wilkie Opt. WO-61	P		P	P	P	S	P	
Willson MS	P		P	P	P	P	P	

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P = Pass

F = Fail

S = Side protection only due to flatfold design.

* Not applicable to universal bridge.

** Applies to perforated plastic sideshields only.

*** All failures are indicated by F.

TABLE 3.--Lens Impact Test Results

Manufacturer/Model	Cumulative Number of Lenses Failing at each Impact Step*					
	m=0	m=1	m=2	m=3	m=4	m=5
Aden 4000	0	0	0	0	0	0
American Ind. 474S	0	0	1	4	4	10
American Opt. F9800B-14051	0	2	2	2	5	9
Babbitt 8500	0	0	0	1	1	3
Bouton 5901	0	0	0	1	1	1
Cam-Hi 323	0	0	0	0	1	3
Cesco 318	0	0	0	1	1	1
Fibre-Metal 3481	0	0	0	0	0	1
Glendale 7400	0	0	0	0	0	1
Jackson 0760-0603	0	0	0	0	0	0
MSA 7600	0	0	0	1	3	7
Morse 334S	0	0	0	0	0	2
Pulmosan G-6300-S	0	0	1	1	2	3
Safeline 2700	0	0	1	3	6	9
Safeside 302	0	0	0	0	0	0
Sellstrom 700 CS	0	0	0	0	1	1
Thermacote 40-07080	0	0	0	0	2	2
U.S. Safety 78	0	0	0	0	2	2
Watchemoket 848 SS	0	0	0	0	0	0
Welsh 2200	0	0	0	0	0	1
Wilkie Opt. WO-61	0	0	0	0	0	0
Willson MS	1	1	1	2	3	5

*The number shown is the "impact step" at which fracture occurred. The impact energy, E, is given by $E = E_0 [1.20]^m$, where m is the impact step and E_0 is the ANSI pass/fail energy corresponding to a 1" steel ball dropped from 50" (m = 0 for the ANSI pass/fail test).

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