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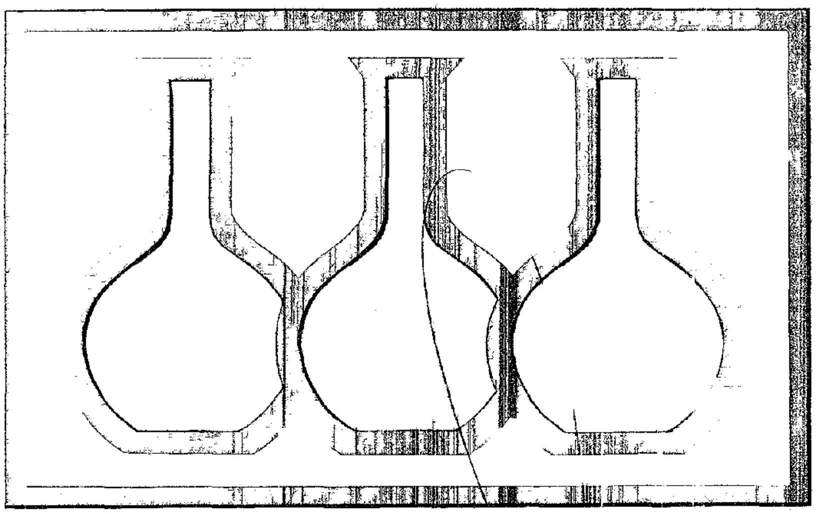

REPORT ON TESTS OF CLASS B INDUSTRIAL HELMETS

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REPORT ON TESTS OF CLASS B INDUSTRIAL HELMETS

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Morgantown, West Virginia
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Mention of company or product names is not to be considered an endorsement by NIOSH.

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Preface

NIOSH wishes to acknowledge the assistance in preparation of this report by several interested groups. A discussion of this report by representatives of NIOSH, OSHA, helmet manufacturers, and labor organizations brought forth the recognition that there is sufficient ambiguity in the ANSI Z89.2 test procedures to warrant further definition for consistency of procedures betwen laboratories.

Mention of company or product names is not to be considered an endorsement or rejection by NIOSH. However, the report does indicate problems in the control of manufacture of industrial helmets.

It should be recognized that many lives have been saved through use of industrial helmets and such devices are a valuable adjunct to the overall protection of workers.

NIOSH expects that, as better and more reproducible testing procedures and improved performance requirements are developed as an outgrowth of this NIOSH study, the protection afforded the worker by industrial helmets will be improved. Until then, workers should continue to wear currently available industrial helmets. NIOSH intends to promulgate regulations in the immediate future to establish the legal basis for a testing and certification program for industrial helmets.

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ABSTRACT

The results of tests on 21 models of randomly selected Class B industrial safety helmets are described. Each model was tested in accordance with American National Standards Institute (ANSI) Standard Z89.2-1971. Of the 21 helmet models tested, 20 were deficient in one or more respects. Helmets failed the impact test more often than any other test.

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INTRODUCTION

A randomly selected group of industrial safety helmets advertised as meeting American National Standards Institute (ANSI) Standard Z89.2-1971 were tested, as specified in that standard, by the National Institute for Occupational Safety and Health (NIOSH) Testing and Certification Laboratory (TCL). The results of those tests are presented in this report for the information of the industrial safety community.

Interest in and use of industrial personal protective devices, such as safety helmets, has increased considerably since the passage of the Occupational Safety and Health Act of 1970. Such devices are frequently advertised as meeting ANSI standards, Occupational Safety and Health Administration (OSHA) requirements, Federal Specifications, or Edison Electric Institute (EEI) standards. The advertisements are usually based upon tests conducted by the manufacturers of advertised devices or upon tests conducted by independent testing laboratories for the manufacturers.

In addition to its certification program, NIOSH's Testing and Certification Laboratory, in Morgantown, West Virginia, is working to develop a body of technical information concerning the personal protective devices offered for use by United States industry. TCL is presently collecting data on safety toe shoes, linemen's rubber gloves, and eye and face protective devices, in addition to the data on safety helmets presented in this report.

SELECTION AND TESTING

Selection of Devices

ANSI Standards Z89.1[1] and Z89.2[2] define three classes of industrial safety helmets. The three classes are distinguished by their dielectric requirements. Class C requires no dielectric protection; Class A requires limited dielectric protection; Class B requires the highest level of dielectric protection (high voltage electricity).

Class B helmets were chosen for investigation, because they, as a class, offer the most comprehensive head protection available to the industrial worker.

All distinct Class B helmet models known to be sold in the United States were identified and listed. A "model" was defined as a distinct shell-suspension combination. Many helmets sold as separate retail units were found to actually be variations of a single basic model. The differences between such retail units typically consisted of the addition of a lamp bracket, a chin strap, or a face shield attachment. In these cases, only the basic model was listed.

Helmets are often sold under a name other than that of the actual manufacturer. In cases where apparently identical helmet models were offered under two or more names, only one model was listed.

Helmet models were included on the list only if a written advertisement claimed conformance to ANSI Z89.2-1971 or an equivalent standard. The final list

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[1] American National Standard Safety Requirements for Industrial Head Protection, American National Standards Institute, 1430 Broadway, New York, New York 10018. Standard No. Z89.1-1969. 1969, 15 pages.

[2] American National Standard Safety Requirements for Industrial Protective Helmets for Electrical Workers, Class B, American National Standards Institute. 1430 Broadway, New York, New York 10018. Standard No. Z89.2-1971. 1971, 15 pages.

identified 29 distinct models offered by 16 manufacturers.

Fifty percent of the eligible helmet models were randomly selected for testing, and, in addition to this initial sampling, one model was selected from each manufacturer not represented in the random selection.

Orders for the test specimens were placed with safety equipment distributors, when possible. If any selected helmet was not available through distributors, the device was purchased directly from the manufacturer. The intended use of the helmets was never concealed. If a supplier inquired, the supplier was told that the helmets were being purchased for testing. Test specimens were purchased between August 21 and September 19, 1974.

Examinations and Tests

The following is a summary of the examinations and tests which were performed on the selected helmets in accordance with ANSI Z89.2-1971.

1. Check-in examination: Each model was examined for characteristics required by ANSI. The characteristics checked were crown clearance, component construction, suspension adjustment instructions, and size range.
2. Weight: Six specimens of each model were weighed and the average reported.
3. Penetration: A 1-pound penetrator with a 35° tip angle was dropped from 10 feet above the helmets. The depth of penetration in each shell was measured and the average for 6 specimens reported.
4. Impact: An 8-pound steel ball was dropped from 5 feet above the

helmets. The force transmitted through the helmets to a headform was measured by use of the Brinell hardness formula, as required by ANSI Z89.2. This test was performed on helmets temperature conditioned for at least 2 hours. Ten helmets were conditioned at 0° F and ten at 120° F.

5. Mechanical proof: An 8-pound steel ball was dropped from 5 feet above helmets which had been temperature conditioned. Three helmets were conditioned at 0° F and three at 140° F. ANSI Z89.2 requires that, by means of carbon paper impressions, the helmet be examined for "substantial" contact between the shell and the suspension. The standard does not, however, describe substantial contact. Due to this undefined performance level, the mechanical proof procedure was not used as a pass/fail indicator. Instead, the mechanical proof procedure was used as a means of conditioning helmets for insulation resistance tests, as required by ANSI Z89.2.
6. Water absorption: Six dry helmet shells were weighed, soaked in tap water for 24 hours, weighed again to determine the amount of water absorbed, and the average absorption was reported.
7. Insulation resistance: Six helmet shells were subjected to voltages of 20 and 30 kilovolts AC as a test of the dielectric properties. Average proof currents and the number of dielectric breakdowns, if any, were reported. Helmets tested for dielectric properties were conditioned by the mechanical-proof and water-absorption procedures.
8. Flammability: Ten specimens cut from helmet shells were tested for

flammability using a Bunsen burner. The rate of burning, in inches per minute, was calculated and the average reported.

Specific considerations concerning test equipment and procedures are discussed in the following section.

Test Methods and Equipment

The tests described in ANSI Z89.2-1971 are the generally recognized or accepted performance standard for industrial helmets. A complete description of the test methods are presented in ANSI Z89.2-1971. There are, however, several specifications in Z89.2 which are subject to interpretation. The interpretations applied in this series of tests are discussed below.

The check-in examination included a check on the dimensions of the nape strap, headband, and sweatband. Packages were checked for the presence of suspension adjustment instructions. The helmets were examined for proper labeling. The shell was checked for seams and holes.

The impact resistance test specified by ANSI Z89.2 requires that an 8-pound steel ball be dropped on the helmets. The drop was performed using an 8-pound shot dropped from an electromagnet. The shot was not guided during its fall.

ANSI Z89.2 requires the use of aluminum bars as the impact force-measuring medium. The bars are required to have an average Brinell hardness between 21 and 24. The standard does not, however, impose any requirements on the allowable variation in hardness of individual bars. TCL established a maximum allowable variation of 0.88 Brinell units between the two ends of a bar 7 inches long. A variation of that amount will limit error due to hardness variation to less than 2.5 percent.

The penetrator required by ANSI Z89.2 weighs 1 pound and has an included tip angle of 35°. In the tests conducted by TCL the penetrator was released from an electromagnet at a height of 10 feet above the helmets being tested.

Insulation resistance tests were conducted after the helmet had been impacted as prescribed by the mechanical proof procedure. This was in accord with the ANSI stipulation that all helmets tested for insulation resistance must first have passed the mechanical proof test. As discussed earlier, the helmets were not evaluated for pass or fail under the mechanical proof test. All helmets which were subjected to the mechanical proof impacts were tested for insulation resistance. Helmets which had open holes or cracks caused by the mechanical proof impact were recorded as failing the insulation resistance test.

The flammability tests were conducted in accord with ASTM D 635-74, Standard Test Method for Flammability of Self Supporting Plastics. That is the latest version of the ASTM standard referenced by ANSI Z89.2.

RESULTS

Pass/Fail Criteria

The ANSI Z89.2 tests were divided into two classifications for analysis. The first classification is comprised of those tests which result in measurements on a continuous scale. The second classification is comprised of those tests for which there is not a continuous scale of measurements (Component Construction, Size Range and Marking, Suspension Adjustment Instructions, Number Failing Dielectric Breakdown, and Number Transmitting more than 1,000 Pounds Force) and Crown Clearance.

The results of the tests in the first classification were subjected to a pass/fail analysis based on the requirements of ANSI Z89.2 followed by an analysis based on the Student t test described in Apendix A. The results of the tests in the second classification were examined only for conformance to ANSI Z89.2.

The Student t test was used to determine the significance of the test data collected. In this study, a 0.10 level of significance was used for the pass/fail decision. This provides 90 percent confidence in the reported results. If the helmet model failed to meet the ANSI Z89.2 requirements or failed the Student t test, where applicable, it was reported as failing (F). If the helmet model satisfied the ANSI requirements and the Student t test, where applicable, it was reported as passing (P). The 0.10 level of significance was selected after consideration of recognized acceptable quality levels, acceptable consumer risks, and quantities required for testing.

Summary of Results

Most of the Class B industrial helmet models tested did not conform to the

ANSI standard; the results of those tests are presented in Tables 2 to 5. Ninety-five percent of the models tested failed to conform with at least one of the requirements of ANSI Z89.2. Additionally, nearly 67 percent of the models failed to meet more than one requirement. Only one model, the Willson 66JC, met all the requirements. Examination of the test results indicates that three models (Erb 906, Goodall GYC-E, and MSA 454704) failed only check-in inspection items.

Impact Test

Most of the models failed to satisfy the impact resistance requirements. The results of these tests are presented in Tables 2a, 2b, and 5.

The test results indicate that helmets with woven crown straps have a performance advantage over those with molded crown straps, but there are individual exceptions in both categories. Probably the most significant exception is that of the Safety Supply of Canada 9650 which, even though it has molded crown straps, passed the impact resistance test by a wide margin while all the other helmets with molded crown straps failed.

Insulation Resistance

The only failures recorded in the insulation resistance test were models which for one reason or another failed to satisfy the breakdown voltage requirements. All of the models satisfied both the ANSI requirements and those of the Student t test in the proof test. Most of the failures in the breakdown test were caused by shells which cracked during the mechanical proof conditioning procedure. As noted earlier, if a shell was shattered or had a crack which was obviously open, that shell was not subjected to the insulation resistance test but was reported as failing. If the cracks, when present, did not appear to extend completely through the shell, the shell was tested. The only model which failed the insulation resistance test but did not have any evident cracks in the shell was the Safety Supply of Canada 9650. This model failed at approximately the same point in both of the shells reported as failing. The point of failure was about 1 inch ahead of the injection point and on the edge of a ridge. It is possible that there may have been a thin spot in that area of the shell.

Penetration Resistance

None of the models failed either criteria. In fact, the average depth of penetration was only 3/16 inch--one-half the maximum allowable depth.

Flammability

None of the models tested failed the flammability test. Of the models tested, the Fibre Metal TF-2, MSA 454721, MSA 455811 and Welsh 4265 were self-extinguishing. That is, the flame did not burn 100 mm on the test specimens.

Size Range and Marking

The Goodall GYC-E does not allow suspension adjustment over the required range, and none of the three MSA models had the size adjustment marked on the headband. The standard does allow the use of more than one suspension to accommodate the required size range, but mention is not made in the manufacturers' literature of the availability of additional sizes. This test is considered to have no direct bearing on the performance of the device.

Suspension Adjustment Instructions

Over one-third of the models were not furnished with instructions for adjusting the size of the headband. This item is considered to have no direct bearing on the performance of the device.

Crown Clearance

Only one model, the Welsh 4265, failed to meet this criterion. This model also gave the worst performance of all models in the impact test at 0° F.

Water Absorption

None of the models failed the water absorption test. Varying quantities of label residue on the shells resulted in a relatively wide variation in the percentage of water absorbed by the models.

OBSERVATIONS AND CONCLUSIONS

Observations

The transmitted force recorded during the impact resistance test showed more variation within the models than any other performance factor. Some models evidenced very good control over the variability in transmitted force while, in a few cases, the standard deviation of the test results exceeded 38 percent of the average force.

Tables 2a and 2b list seven models with standard deviations in transmitted force greater than 300 pounds. The large values of standard deviation in five of these seven models are most likely due to contact between the helmet shell and the headform. Examination of the shells of these helmets revealed evidence of contact in the form of crown strap impressions in the shells.

A comparison of the relative performance of woven and molded suspensions in the impact test (presented in Table 6) seems to indicate that the suspension type has a definite bearing on the performance of the model. Of the 21 models tested, five (Apex E2-A, Fibre-Metal TF-2 and E-2, Safety Supply of Canada 9650, and Schuberth Ber/PL) had molded crown straps. Of these five, only one, the Safety Supply of Canada 9650, passed the impact attenuation requirements of ANSI Z89.2. That model has a crown strap design which appears to be quite different from those seen in the other four models in this category, and outperforms many of the models with woven type crown straps in the impact test.

It should be noted that even though the average performance of helmets with woven crown straps appears to satisfy the requirements of ANSI Z89.2, the standard deviation associated with this mean is too large to allow a reasonable level of confidence in that average value.

Further, it was observed that models with crown clearances of 1.25 inches or less tended to perform more poorly in the impact resistance test at 120° F conditioning temperature. There were not enough models with failing or minimally acceptable measurements in this test to form any definite conclusions, but from the limited data available, it appears that 1.25 inches minimum clearance may not be sufficient and that perhaps it should be increased slightly. This would have the effect of both raising the center of gravity of some helmets and, also increasing the level of protection afforded the wearer if all other factors remain constant. The effect of raising the center of gravity would be negligible if the minimum clearance were increased by about 1/8 inch, but the level of protection should be significantly improved in those models with borderline clearances. Increasing the crown clearance could also have the effect of reducing the variation in transmitted force by reducing the number of shells which bottom on the headform during the impact test.

Conclusions

With only 3 of the 21 helmet models tested by TCL satisfying the performance related portions of ANSI Z89.2, most of the Class B industrial helmets offered for sale today appear to be mislabled as meeting the ANSI requirements. The manufacturers' incorrect labeling could result from misinterpretation of test results or failure to perform tests. The only remedy for this problem is improved conformance surveillance.

Poor impact attenuation is considered to be the most serious deficiency in the helmets tested. The large values of standard deviation in this test may, in part, be caused by variability in the manufacturing process. More often however, the large standard deviations are probably due to marginal helmet designs which allow the shell to bottom out during the impact test. If this is indeed the situation, the only thing which can be done is to redesign the helmets involved to provide more impact attenuation capability. The potential for design improvement is clearly demonstrated by the superior impact performance of several of the models tested.

Finally, the results reported herein have indicated a need to further define the test recommended by ANSI Z89.2. As discussed earlier, TCL found it necessary to apply interpretations to several specifications. The impact, penetration, insulation resistance, and flammability tests are in need of revision or further definition.

APPENDIX A

In this study, the Student t test was used to test a hypothesis concerning one mean. The method of application of this test is well recognized and can be found in most books concerned with statistical methods. The null and alternative hypothesis (H_0 and H_A respectively) were chosen to correspond to the position taken by a consumer who questions the performance of a helmet model until that performance is proven at a chosen confidence level. That is, the helmet model is assumed to be failing unless proven otherwise. This assumption results in hypotheses of the form

$$H_0: \quad \overline{X} = \overline{X}'$$

$$H_A: \quad \overline{X} < \overline{X}'$$

where $\overline{X}'$ is the maximum average value allowed by ANSI Z89.2 for that test. The test of the hypothesis H_0: $\overline{X} = \overline{X}'$ is thus a single tail test and care must be taken when using tables of the Student t distribution that the probability on the table is chosen to correspond with that of a single tail test and not a double tail test.

The test of the hypothesis H_0: $\overline{X} = \overline{X}'$ is based on the statistic

$$t = \frac{\overline{X} - \overline{X}'}{s / \sqrt{n}}$$

where $\overline{X}$ is the measured mean of the helmet model, $\overline{X}'$ is the maximum allowable value, n is the number of samples tested, and s is defined by

$$s^2 = \frac{\Sigma (\overline{X_i} - \overline{X})^2}{(n - 1)}$$

where X_i represents the test result for an individual helmet.

The above choice of H_0 and H_A corresponds to the null hypothesis representing failure of the helmet model to satisfy the ANSI requirements while the alternative hypothesis corresponds to satisfaction of the ANSI requirements by the helmet model. Use of the Student t test results in rejection of H_0 if the calculated value of t satisfies

$$t < - t_c$$

where t_c is the tabulated[1] value of t at the chosen level of significance. Values of t not satisfying the above relationship result in acceptance of the null hypothesis H_0: $\overline{X} = \overline{X}'$, and thus a report that the helmet model failed the requirements.

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[1] Experimental Statistics, NBS Handbook No. 91, M. G. Natrella, August 1, 1963. Available from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 for $8.45.

TABLE 1: ANSI Z89.2-1971 Requirements for Class B Industrial Helmets

Test	Requirements
Impact Resistance	The average force at each test temperature must not be greater than 850 pounds with no individual force exceeding 1000 pounds.
Insulation Resistance	The average proof current at an applied potential of 20 KV-AC must not exceed 9 ma; the device must withstand a momentary application of 30 KV-AC.
Penetration Resistance	The average depth of penetration must not exceed 3/8 inch.
Flammability	The average rate of burning must not exceed 3 inches per minute.
Component Construction	The shell must not have any holes through it; the headband must be at least one inch wide; no metal parts are allowed; a sweatband must be provided; the shell must be marked to indicate the manufacturer and ANSI classification.
Size Range and Marking	The headbands must be adjustable from the size 6 1/2 to 8 in 1/8 size increments; size range and adjustment must be permanently marked on the headbands.
Suspension Adjustment Instructions	Instructions must be supplied with each helmet.
Crown Clearance	The clearance must be at least 1.25 inches.
Weight	No complete helmet can exceed 15.5 ounces.
Water absorption	The shell must not absorb more than 0.5 percent water.

Table 2a: Results of Impact Tests on Class B
Industrial Helmets conditioned at 0° F

Mfr./Model	Ave.Force	Max.Force	No.>1000#	Std.Dev.	n	P/F[1]
American Optical BX-18	699	786	0	50.5	9	P
Apex E2-A	910	968	0	46.6	10	F
Bullard 302DMY	849	944	0	58.7	10	F[2]
Cam-Hi CH-71	836	921	0	57.8	10	F[2]
Eastern TUF-E	920	1151	1	121	10	F
Erb 906	749	1000	0	149	7	P
Fibre-Metal TF-2	966	1108	3	115	7	F
Fibre-Metal E-2	990	1159	3	88.2	9	F
Glendale 9500	1056	1949	3	414	10	F
Goodall GYC-E	747	842	0	84.5	7	P
Jackson SC-4	713	764	0	37.3	10	P
MSA 454704	771	845	0	29.1	10	P
MSA 455811	694	1016	1	174	10	F
MSA 454721	750	1038	1	136	8	F
Safety Supply of Canada 2650	692	962	0	146	10	P
Schuberth Ber/PL	995	1093	5	92.1	10	F
US Safety 806Y	769	968	0	115	10	P
Welsh 4315	839	879	0	22.4	10	P
Welsh 4265	1423	2546	5	714	10	F
Welsh 4375	793	875	0	46.8	10	P
Willson 66JC	740	774	0	27.5	10	P

[1] P - pass; F - fail.
[2] This model did not meet the statistical requirements described on p. 9.

Table 2b: Results of Impact Tests on Class B Industrial Helmets conditioned at 120° F

Mfr./Model	Ave.Force	Max.Force	No.>1000#	Std.Dev.	n	P/F[1]
American Optical BX-18	817	1301	3	328	9	F
Apex E2-A	1648	2075	10	270	10	F
Bullard 302DMY	644	698	0	36.6	9	P
Cam-Hi CH-71	661	832	0	68.8	10	P
Eastern TUF-E	1414	2008	10	277	10	F
Erb 906	572	633	0	31.3	10	P
Fibre-Metal TF-2	796	985	0	115	7	F[2]
Fibre-Metal E-2	776	937	0	84.3	10	P
Glendale 9500	676	782	0	41.1	10	P
Goodall GYC-E	490	875	0	137	10	P
Jackson SC-4	544	573	0	21.7	10	P
MSA 454704	746	836	0	49.2	9	P
MSA 455811	697	748	0	54.3	10	P
MSA 454721	752	1443	2	312	9	F
Safety Supply of Canada 2650	672	897	0	86.6	10	P
Schuberth Ber/PL	732	1437	2	288	10	F
US Safety 806Y	943	1393	5	367	10	F
Welsh 4315	654	769	0	89.7	10	P
Welsh 4265	891	1519	2	341	10	F
Welsh 4375	797	1933	1	435	9	F
Willson 66JC	612	787	0	93.6	10	P

[1] P - pass; F - fail.
[2] This model did not meet the statistical requirements described on p. 9.

TABLE 3: Results of Insulation Resistance, Penetration, and Flammability Tests on Class B Industrial Helmets

Mfr./Model	Insulation Resistance			Penetration		Flammability	
	Proof Current, ma	Number failing breakdown	P/F[1]	depth, inches	P/F[1]	burn rate, in./min.	P/F[1]
American Optical BX-18	3.8	0	P	3/16	P	1.01	P
Apex E2-A	5.3	0	P	1/8	P	1.87	P
Bullard 302DMY	4.0	0	P	3/16	P	.75	P
Cam-Hi CH-71	4.0	0	P	1/4	P	.69	P
Eastern Tuf-E	3.0	0	P	3/16	P	.77	P
Erb 906	4.0	0	P	3/16	P	.77	P
Fibre Metal TF-2	6.4	1	F	3/16	P	SE[2]	P
Fibre-Metal E-2	4.5	0	P	3/16	P	2.07	P
Glendale 9500	3.7	0	P	3/16	P	2.00	P
Goodall GYC-E	4.0	0	P	1/4	P	.69	P
Jackson SC-4	5.0	3	F	3/16	P	.70	P
MSA 454704	5.0	0	P	3/16	P	1.94	P
MSA 455811	7.9	0	P	1/8	P	SE[2]	P
MSA 454721	6.1	0	P	1/8	P	SE[2]	P
Safety Supply of Canada 2650	5.0	2	F	3/16	P	.82	P
Schuberth Ber/PL	4.4	0	P	3/16	P	.99	P
US Safety 806Y	3.5	0	P	3/16	P	.63	P
Welsh 4315	4.0	2	F	3/16	P	.46	P
Welsh 4265	7.2	0	P	1/8	P	SE[2]	P
Welsh 4375	4.0	1	F	3/16	P	.75	P
Willson 66JC	3.4	0	P	3/16	P	.76	P

[1] P - pass; F - fail.
[2] Self-extinguishing.

TABLE 4: Results of Check-in Inspection, Weight and Water Absorption Tests on Class B Industrial Helmets

Mfr./Model	Check-In Inspection			Crown Clearance		Weight		Water Absorption	
	Component Construction	Size Range & Marking	Susp. Adj. Instr.	in.	P/F[1]	Oz.	P/F[1]	%	P/F[1]
American Optical BX-18	P	P	P	1.50	P	12.6	P	.11	P
Apex E2-A	P	P	P	1.42	P	12.9	P	.01	P
Bullard 302DMY	P	P	P	1.50	P	12.0	P	.27	P
Cam-Hi CH-71	P	P	F	1.38	P	12.1	P	.19	P
Eastern TUF-E	P	P	F	1.75	P	14.0	P	.21	P
Erb 906	P	P	F	1.50	P	12.4	P	0	P
Fibre-Metal TF-2	P	P	P	1.50	P	13.5	P	.02	P
Fibre-Metal E-2	P	P	P	1.50	P	12.9	P	0	P
Glendale 9500	P	P	P	1.67	P	14.7	P	.17	P
Goodall GYC-E	P	F	F	1.67	P	12.0	P	.21	P
Jackson SC-4	P	P	P	1.50	P	13.0	P	.20	P
MSA 454704	P	F	P	1.50	P	12.8	P	.15	P
MSA 455811	P	F	P	1.59	P	11.7	P	.18	P
MSA 454721	P	F	P	1.50	P	11.9	P	.38	P
Safety Supply of Canada 2650	P	P	F	1.75	P	11.6	P	.07	P
Schuberth Ber/PL	P	P	F	1.75	P	12.8	P	0	P
US Safety 806Y	P	P	P	1.25	P	13.4	P	.06	P
Welsh 4315	P	P	P	1.38	P	14.7	P	.09	P
Welsh 4265	P	P	P	1.08	F	12.0	P	.36	P
Welsh 4375	P	P	F	1.25	P	12.7	P	.30	P
Willson 66JC	P	P	P	1.50	P	14.8	P	.22	P

[1] P - pass; F - fail.

TABLE 5: Summary of ANSI Z89.2-1971 Test Results by Test

Test	Percent of Models Passing
Impact Resistance	33.3
Insulation Resistance	76.2
Penetration Resistance	100.0
Flammability	100.0
Component Construction	100.0[1]
Size Range and Marking	81.0[1]
Suspension Adjustment Instructions	66.7[1]
Crown Clearance	95.2[1]
Weight	100.0
Water Absorption	100.0

[1]Student t test not applicable; see text

TABLE 6: A Comparison of Impact Performance versus Crown Strap Construction

Crown Strap Construction	No. of Models	0° F Cond. temp.		120° F Cond. temp.	
		Ave.Force,[1] lbs.	Std.[2] Dev.	Ave.Force,[1] lbs.	Std.[2] Dev.
Woven	16	840	182	759	216
Molded	5	905	127	933	407

[1]Average force of all the helmets tested.

[2]Standard Deviation of the average forces in Tables 2a and 2b.

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