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SUPERSEDED ANSI Z89.1-1969

American National Standard

safety requirements for industrial head protection

ANSI
Z89.1-1969
Partial Revision
of Z2.1-1969

American National Standard Safety Requirements for Industrial Head Protection

Sponsor

United States Department of the Navy

Approved December 17, 1969

American National Standards Institute, Inc

American National Standard

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Foreword

(This Foreword is not a part of American National Standard Safety Requirements for Industrial Head Protection, Z89.1-1969.)

This standard is a partial revision of American National Standard Safety Code for Head, Eye, and Respiratory Protection, Z2.1-1959. In 1962 the Safety Standards Board approved the division of the Z2 Committee into three separate projects: Z87 — Industrial Eye Protection, Z88 — Respiratory Protection, and Z89 — Industrial Head Protection.

In August 1962, the Safety Standards Board approved the scope of the Z89 Standards Committee: "Safety requirements for the protection of the heads of occupational workers from impact and electrical shock." Soon after the first organizational meeting in October 1963, the task of developing a standard for industrial head protection was assigned to a Specifications Subcommittee.

After a careful review of the first draft standard, which included all the types and classes of protective helmets under consideration, it was decided that the interests of all concerned would best be served by developing two separate standards — one for general head protection, Z89.1, and one for electrical (high-voltage) protection, Z89.2.

After consideration of a draft of Z89.1 at a meeting of the full committee in June 1968, revised drafts were submitted to two letter ballots, and American National Standard Z89.1-1969 was approved on December 17, 1969.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

At the time it approved this standard, the Z89 Committee had the following members:

Robert W. Webster, *Chairman*

Organization Represented	*Name of Representative*
American Federation of Labor and Congress of Industrial Organizations	C. F. Moran Lloyd D. Utter Walter J. Feltz *(Alt)*
American Gas Association	J. P. Carroll J. F. McGuigan
American Insurance Association	Robert Conroy
American Society of Mechanical Engineers	E. L. Davison J. L. Ryan, Jr. *(Alt)*
American Mutual Insurance Alliance	Edward J. Baxa Frederick H. Deeg *(Alt)*
American Society of Safety Engineers	Raymond I. Pfeifer Edward N. Deck *(Alt)*
Associated General Contractors of America	Henry V. Carvill
Association of American Railroads	W. C. Laraway
Canadian Standards Association *(Liaison)*	D. P. Russell
Edison Electric Institute	G. W. Elg A. T. Higgins *(Alt)*
General Services Administration	Ralph M. Greene
Industrial Medical Association	W. Garret Hume
Industrial Safety Equipment Association	H. A. Raschke R. G. Tressler M. F. Shields *(Alt)*
International Association of Fire Chiefs	Harley N. Trice *(Alt)* Joseph M. Redden Donald M. O'Brien *(Alt)*
International Association of Governmental Labor Officials	Craig H. Haaren
National Fire Protection Association	Paul R. Lyons
National Safety Council	F. M. Livingston, Jr. C. S. Wolff *(Alt)*
Society of the Plastics Industry	Harley N. Trice
The Telephone Group	W. E. Bray
United Mine Workers of America	Lewis E. Evans
U. S. Department of the Army	Edward R. Gloyd
U. S. Department of Labor, Bureau of Labor Standards	F. A. Van Atta Patrick F. Cestrone *(Alt)*
U. S. Department of the Navy	J. N. Cornette

The Specifications Subcommittee, which developed this standard, had the following members:

P. W. O'Donnell, *Chairman* †

R. G. Tressler, *Chairman*

W. G. Bush
J. R. Cambron
G. W. Elg
H. A. Raschke
M. F. Shields
R. W. Webster

Contents

American National Standard Safety Requirements for Industrial Head Protection

1. Scope

This standard establishes specifications for industrial protective helmets for the protection of heads of occupational workers from impact and penetration from falling and flying objects and from limited electric shock and burn. This standard does not include high-voltage protective helmets, Class B.

2. Definitions

brim. An integral part of the shell extending outward over the entire circumference to protect the face, neck, and shoulders.

chin strap. An adjustable strap, attached directly or indirectly to the shell, and fitting under the chin to secure the helmet to the head.

crown straps. That part of the suspension which passes over the head.

headband. That part of the suspension which encircles the head.

helmet. A rigid device that is worn to provide protection for the head, or portions thereof, against impact, flying particles, or electric shock, or any combination thereof; and which is held in place by a suitable suspension.

nape strap. An adjustable strap, attached directly or indirectly to the shell, and fitting behind the head to secure the helmet to the head.

peak. An integral part of the shell extending forward over the eyes only.

shell. A helmet less suspension, accessories, and fittings.

suspension. The internal cradle of the helmet which holds it in place on the head and is made up of the headband and crown straps.

sweatband. That part of the headband, integral or replaceable, which comes in contact with at least the wearer's forehead.

winter liner. A snug-fitting cover worn under the helmet to protect the head, ears, and neck from the cold.

3. Types and Classes

Protective helmets shall be of the following types and classes:

Type 1 — Helmet, full brim
Type 2 — Helmet, brimless, with peak
Class A — Limited voltage protection
Class C — No voltage protection
Class D — Limited voltage protection, Fire Fighters' Service, Type 1, only.

4. Materials

Materials used in helmet shells shall be water-resistant and slow-burning. All materials coming in contact with the wearer's head shall be non-irritating to normal skin. Materials used in Class D helmets shall be fire-resistant (self-extinguishing when tested in accordance with *Test for Flammability of Self-Supporting Plastics* D635-68, published in Philadelphia by the American Society for Testing and Materials in 1968) and shall be non-conductors of electricity.

5. General Requirements

Each helmet shall consist essentially of a shell and suspension. Provision shall be made for ventilation between the headband and shell.

5.1 Shell. The shell shall be dome-shaped, of one-piece seamless construction. There shall be no holes in the shell except those for mounting suspensions or accessories.

5.2 Headband. Headbands shall be of leatherette, plastic, or other suitable materials that are comfortable.

5.2.1 *Sweatband.* Sweatbands shall be made of leatherette, plastic, or other suitable materials that are comfortable.

5.3 **Crown Straps.** Crown straps should be made of plastic, closely-woven webbing, or other suitable material, and conform comfortably to the shape of the wearer's head.

5.4 **Accessories**

5.4.1 *Chin Strap and Nape Strap.* The chin strap and nape strap shall be adjustable and made of closely-woven webbing, leather, elastic-webbing combination, plastic, or other suitable material not less than ½ inch in width.

5.4.2 *Winter Liners.* Winter liners should be made of fabric, plastic, or other suitable material. Colored materials shall be fast-dyed. The outer surface may be water-resistant.

5.4.3 *Face Shields and Welding Helmets.* When worn in conjunction with industrial protective helmets, face shields and welding helmets shall meet the requirements set forth in the current American National Standard Practice for Occupational and Educational Eye and Face Protection, Z87.1-1968, or the latest revision thereof. When so worn, helmets may be without peaks or brims.

5.4.4 *Lamp Bracket.* The lamp bracket, if supplied, shall be plastic or other suitable material to hold the lamp properly. The bracket shall be designed to provide proper beam angle when the helmet is worn in the normal position.

5.5 **Instructions.** Each helmet shall be accompanied by instructions explaining the proper method of adjusting the suspension and headband.

5.6 **Marking.** Each helmet shall be identified on the inside of the shell in letters not less than ⅛ inch high, with the name of the manufacturer, the American National Standard designation and class. For example:

Manufacturer
ANSI Z89.1-1969
Class A

6. Detailed Requirements

6.1 **Shell.** Type 1 helmet shells shall have a continuous brim not less than 1¼ inches wide. Type 2 shells shall include a peak extending forward from the crown.

6.2 **Headband.** The headband shall be adjustable in ⅛-size increments. The size range of commercial helmet sizes, from at least 6½ to 8 inclusive, shall be accommodated by one or more headbands. The size range and adjustment shall be marked on the headband in a permanently legible manner. When the headband is adjusted to the maximum designated size, there shall be sufficient clearance between the shell and headband to provide ventilation. The surface of the headband, in contact with the wearer's head, shall not be less than one-inch nominal width. Headbands (or sweatbands) shall be removeable and replaceable.

Comparative Helmet Sizes:

Headband Size	*Circumferential Measurement (Inches)*
6½	20½
6⅝	20⅞
6¾	21¼
6⅞	21⅝
7	22
7⅛	22⅜
7¼	22¾
7⅜	23⅛
7½	23½
7⅝	23⅞
7¾	24¼
7⅞	24⅝
8	25

NOTE: The above measurements are to be made with materials that will not stretch, preferably with a tape measure. In selecting sizes, measure the circumference of the head where the helmet is *normally worn. Note* the nearest corresponding figure on the chart for size. Allowable tolerance of circumferential measurement shall be ± ⅛ inch. Nothing in this standard shall be construed as prohibiting larger or smaller headband sizes as specified. Headbands that incorporate an integral nape strap will not necessarily conform to the circumferential measurements tabulated above; however, they must accommodate the required head sizes.

6.2.1 *Sweatband.* The sweatband may be of the removeable-replaceable type or may be integral with the headband. The sweatband shall cover at least the forehead portion of the headband.

6.3 Crown Straps. The crown straps, when assembled, shall form a cradle for supporting the helmet on the wearer's head, so that the distance between the top of the head and the underside of the shell cannot be adjusted to less than 1- 1 ¼ inches as measured under test conditions in 8.3.2.

7. Physical Requirements

7.1 Insulation Resistance. Class A and D helmets, when tested in accordance with the method specified in 8.2 shall withstand 2200 volts, AC, 60 hertz (root-mean-square value) for one minute, with leakage current not in excess of 3 milliamperes. This test is not applicable to Class C.

7.2 Impact Resistance. When tested in accordance with the method specified in 8.3, helmets shall transmit an average force of not more than 850 pounds, and no individual specimen shall transmit a force of more than 1000 pounds.

7.3 Penetration Resistance. When tested in accordance with the method specified in 8.4, Classes A and D helmets shall not be pierced more than ⅜ inch and Class C helmets not more than 7/16 inch, including the thickness of the shell material.

7.4 Weight. The weight of each helmet, complete with suspension and headband, but exclusive of accessories, shall not exceed 15.0 ounces for Class A or C helmets or 30.0 ounces for Class D helmets.

7.5 Flammability. For Class A helmets, when tested in accordance with the method specified in 8.5, the thinnest section of the shell shall burn at a rate not greater than three inches per minute. For Class D helmets, the thinnest section of the shell shall be self-extinguishing when tested according to ASTM D635-68. This test is not applicable to Class C.

7.6 Water Absorption. When tested in accordance with the method specified in 8.6, helmet shells shall not absorb more than 5.0 percent of water.

8. Methods of Test

8.1 Preparation of Samples (Insulation Resistance and Water Absorption Tests). Where it is evident that the sample helmets have a protective coating over the basic material, the exterior surface of the shell shall be abraded until the basic material is exposed using a No. 60 grit garnet paper. Tests shall be made at room temperature (23 ± 2C or 73.4 ± 3.6°F). Controlled relative humidity of 50 ± 5 percent shall be used only in cases of disagreement. The temperatures specified in the various test procedures shall be interpreted as the temperature of the specimen.

8.2 Insulation Resistance Test

8.2.1 *Apparatus.* The test apparatus shall consist of the following:

(1) A vessel, containing fresh tap water, of sufficient size to submerge an inverted helmet shell to within ½ inch of the junction of the brim with the crown.

(2) A wire frame for suspending the test specimen in the water.

(3) A source of 60-hertz alternating current with 2200 volts (root-mean-square).

(4) Wiring and terminals for application of voltage across the crown of the test specimen.

(5) A volt meter of sufficient capacity.

(6) A millimeter of sufficient capacity and accuracy to measure the specified currents.

8.2.2 *Mounting of Specimens.* The inside of the helmet shell (without suspension or accessories) shall be filled with fresh tap water to within ½ inch of the junction of the brim and crown. If a Class A or D shell contains holes in the crown near the brim for mounting suspension, it shall be filled to within ½ inch of the holes. The shell shall then be submerged in the same type of water to the same level as the water on the inside of the shell. The volt meter and milliammeter shall be attached to the circuit.

8.2.3 *Test Procedures.* Care should be taken to keep the unsubmerged portion of the shell dry so that flashover on application of voltage does not occur. The voltage shall be applied and increased to 2200 volts, held there for one minute, and the current leakage noted.

8.2.4 *Reporting.* For each specimen, the leakage current, or evidence of breakdown, shall be reported.

8.3 Impact Resistance Tests

8.3.1 *Apparatus.* The test apparatus shall consist of the following:

(1) A standard head form. The standard head form mentioned throughout this standard is the model head known as "A.M.L. Head Size Standard" medium size.[1]

Test-block forms which simulate the standard head form may be employed. The head form may be low resonance magnesium K-1A, aluminum, or wood. For protection from damage, wood head forms may be provided with a steel insert in the crown.

(2) A Brinell penetrator assembly as shown in Fig. 1. The impression bar shall be of 1100-0 aluminum ½ × 1⅛ inch, having a predetermined Brinell hardness of 21 to 24, as measured with a 500 kilogram load using a ten millimeter ball. The Brinell penetrator used in the impact test shall be a hardened steel ball ½ inch in diameter.

(3) A steel ball approximately 3¼ inches in diameter and weighing 7.8 to 8.0 pounds.

(4) A Brinell microscope, or other suitable microscope, accurate to 0.05 millimeters.

8.3.2 *Mounting of Specimens.* For the impact-absorption and penetration-resistance tests, the specimen, with adjustment lace (if any) removed, and the headband adjusted to size 7¼, shall be mounted on the medium size (size 7) standard head form so that the drop ball, head form, and the penetrator ball are center-aligned by means of a plumb bob. The center of the crown of the specimen shall be as nearly centered as possible. The specimen shall be mounted with the back toward the fulcrum of the test equipment. To determine the clearance, the shell, minus suspension, shall be placed on the head form and a dimensional reading taken, as shown in Fig. 2. The suspension shall then be installed, and another dimensional reading taken with a 25-pound weight, having a flat surface of not less than two inches in diameter, applied to the crown of the shell. The difference in dimensional readings shall be the clearance.

8.3.3 *Test Procedures.* The Brinell penetrator assembly, with head form attached, shall be placed on a substantially level concrete floor and located beneath the drop ball so that the center of the head form is aligned with the center of the drop ball by means of a plumb bob. Specimens shall be tested at 0°F and 120°F. All specimens shall be subjected to the test temperature for at least two hours prior to impact tests. The impact test should be conducted within 15 seconds after the removal of the specimen from the temperature-conditioning apparatus. The ball shall be dropped vertically on the crown from a height of 60 inches measured from the bottom of the ball to the top of the shell. The ball shall not be allowed to strike the specimen more than once. Impressions shall be spaced at least 2½ diameters apart, edge to edge, and not less than 2½ diameters from the edge of the bar. Elliptical impressions shall be disregarded if the difference between the minimum and maximum axis exceeds 0.3 millimeter. All impressions from double blows shall be disregarded. The minimum diameter of the impression produced on the impression bar shall then be measured to the nearest 0.1 millimeter with the Brinell microscope. For each test the average Brinell hardness number of the impression bar used shall be recorded.

8.3.4 *Reporting.* The average force and the greatest individual force for at least three specimens tested under one group shall be computed and reported. The forces shall be computed from impression diameter using Table 1 or the following Brinell formula:

$$F = 2.2 \cdot H \cdot \frac{\pi D}{2} \cdot (D - \sqrt{D^2 - d^2}) \quad \text{(Eq 1)}$$

where

F = transmitted force in pounds
H = average Brinell hardness number of the impression bar
D = diameter of the impression ball in millimeters
d = diameter of the impression in millimeters

8.4 Penetration Resistance

8.4.1 *Apparatus.* The apparatus shall consist of the following:

[1] The standard head form may be obtained from the National Bureau of Standards, Washington, D.C. 20324; Aero-Medical Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio 45433; or Nondestructive and Tool Testing Division, Laboratory Branch, Quality Assurance Section, Philadelphia Naval Shipyard, Philadelphia, Pa 19112.

Table 1
Transmitted Forces in Pounds

Diameter of Impression, millimeters	Brinell Hardness Number												
	18	19	20	21	22	23	24	25	26	27	28	29	30
3.9	485	515	540	565	595	620	650	675	700	730	755	785	810A
4.0	510	540	570	600	625	655	680	710	740	765	795	825	850
4.1	540	570	600	630	660	690	720	750	775	810	835	865	895
4.2	565	600	630	660	690	720	755	785	815	850	880	910	940
4.3	595	625	660	695	725	760	790	825	860	890	925	955	990B
4.4	625	660	690	725	760	795	830	865	900	935	970	1000	1040
4.5	650	690	725	760	795	835	870	905	940	975	1015	1050	1085
4.6	680	720	760	795	835	870	910	950	985	1025	1060	1100	1135
4.7	715	755	790	830	870	910	950	990	1030	1070	1110	1150	1190
4.8	745	785	825	870	910	950	990	1035	1075	1115	1155	1200	1240
4.9	780	820	865	905	950	995	1035	1080	1125	1165	1210	1255	1295
5.0	810	850	900	945	990	1040	1080	1130	1175	1220	1265	1310	1355
5.1	A845	895	940	985	1035	1080	1130	1175	1220	1270	1315	1365	1410
5.2	880	930	980	1030	1080	1125	1175	1225	1275	1325	1370	1420	1470
5.3	920	970	1020	1070	1120	1175	1225	1275	1325	1375	1430	1480	1530
5.4	955	1005	1060	1115	1165	1220	1270	1325	1380	1430	1485	1535	1590
5.5	B990	1045	1100	1155	1210	1265	1320	1375	1430	1485	1540	1595	1650
5.6	1030	1085	1140	1200	1255	1310	1370	1425	1480	1540	1600	1655	1710

NOTE 1: Values below line A exceed or are equal to the specified average force.
NOTE 2: Values below line B exceed or are equal to the specified individual force.

(1) A standard head form as specified in 8.3.1.1.

(2) A one-pound plumb bob of steel with a point having an included angle of 35 ± 1 degrees and a maximum point radius of 0.010 inch.

8.4.2 *Mounting of Specimens.* Specimens shall be mounted as specified in 8.3.2.

8.4.3 *Test Procedures.* The head form should be placed on a substantially level concrete floor beneath the plumb bob. The plumb bob shall be dropped ten feet to strike the shell within a three-inch diameter circle, the center of which will be the geometric center of the shell. The plumb bob shall not fall on any ridges or injection points. Test shall be conducted at room temperature. Penetration shall be measured along the side of the point of the plumb bob and shall include the thickness of the shell.

8.4.4 *Reporting.* The depth of penetration shall be reported as the average for three specimens.

8.5 Flammability. Test method ASTM D635-68 shall be employed to determine conformance to 7.5. Three strips shall be used in lieu of the ten specimens required in ASTM D635-68.

8.5.1 *Preparation of Specimens.* At least three specimens, ½ inch wide and five inches long, shall be cut from a shell, so as to give as flat a section as practicable. Each specimen shall be marked by scribing lines at ½-inch intervals starting from one end of the specimen.

8.5.2 *Mounting of Specimen.* The specimen shall be clamped in a support at the end farthest from the first ½-inch mark with its longitudinal axis horizontal and its transverse axis inclined 45°.

8.5.3 *Test Procedure.* The alcohol lamp, or gas burner, with a neutral blue flame ½ to ¾ inch in height, shall be placed under the free end of the strip and adjusted so that the flame tip is just in contact with the material. At the end of 30 seconds the flame shall be removed, and the specimen allowed to burn. A stopwatch shall be started when the flame reaches the first mark, and the time observed when the flame reaches the 3½-inch mark. In the case of specimens that are self-extinguishing, the burner shall be placed under the free end for a second period of 30 seconds. Immediately upon removal of the burner, the stopwatch shall be started, and the time of after-flaming observed.

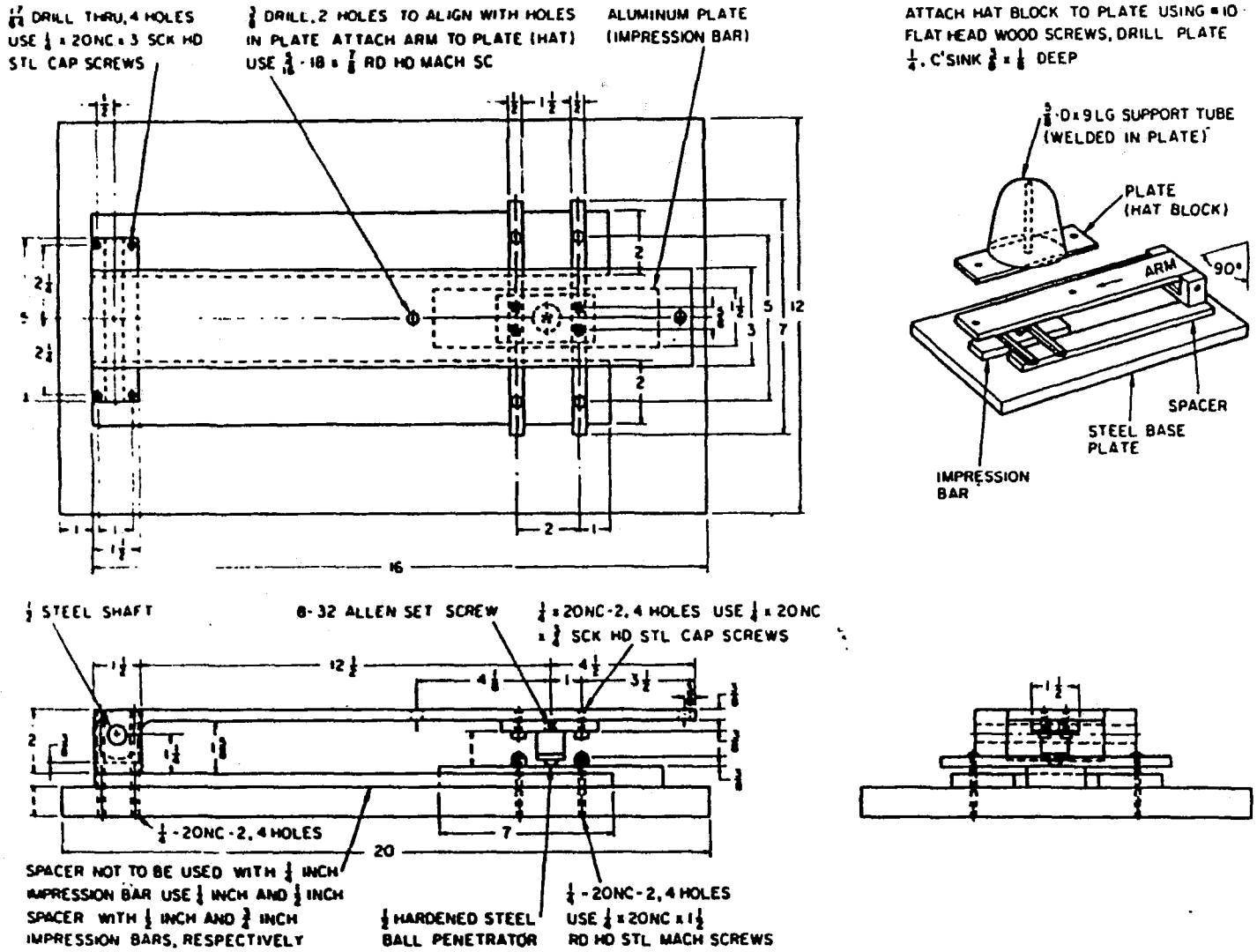

Fig. 1
Brinell Hardness Penetrator Assembly

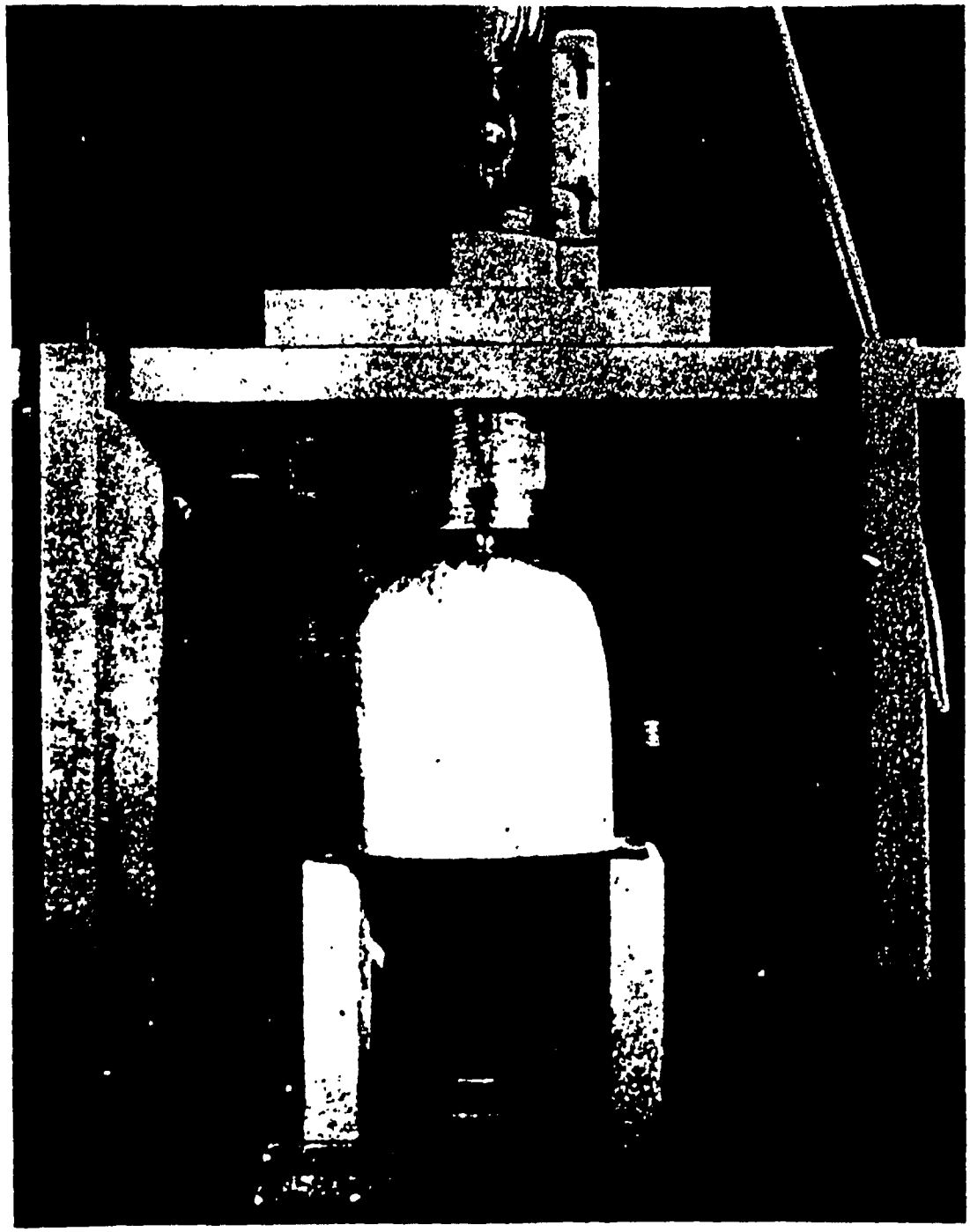

Fig. 2
Suggested Apparatus for Measurement of Crown Clearance

8.5.4 *Reporting.* For Class A shells, the burning rate, in inches per minute, shall be reported as the average for three specimens. For Class D shells, the length of time, in seconds, that the material continues to burn, shall be reported as the average for three specimens.

8.6 Water Absorption

8.6.1 *Apparatus.* The test apparatus shall consist of the following:

(1) An oven of sufficient size where an even and consistent temperature of 120°F can be maintained for at least four hours.

(2) A vessel containing fresh tap water of sufficient size to completely submerge a helmet shell.

8.6.2 *Mounting of Specimens.* A helmet shall be placed in the oven to heat for at least four hours at 120°F.

8.6.3 *Test Procedures.* After heat conditioning for at least four hours at 120 °F, the shell shall be weighted, then submerged in fresh tap water for 24 hours at atmospheric pressure and room temperature. After removal from the water, the shell shall be wiped lightly to remove surface moisture with an absorbent cloth, or paper towel, and reweighed.

8.6.4 *Reporting.* The difference in weight (before and after immersion) multiplied by 100, and divided by the initial weight, equals the percent water absorption. The percent-water absorption shall be reported as the average for three specimens.

Appendix

(This Appendix is not a part of American National Standard Specifications for Industrial Head Protection, Z89.1-1969, but is included for information purposes only.)

A1. Recommendations Concerning Equipment

A1.1 Laces. Laces, if any, should always be tied securely with a square knot.

A1.2 Painting and Cleaning. Caution should be exercised if shells are to be painted, since some paints and thinners may attack and damage the shell and reduce protection. The manufacturer should be consulted with regard to paints or cleaning materials for their particular products. A common method of cleaning and sterilization of shells, is dipping them in hot water (approximately 140°F) containing a good detergent, for at least a minute. Shells should then be scrubbed and rinsed in clear water (approximately 140°F). After rinsing, the shell should be carefully inspected for any signs of damage.

A1.3 Periodic Inspection. All components, shells, suspensions, headbands, sweatbands, and any accessories should be visually inspected daily for signs of dents, cracks, penetration, or any other damage due to impact, rough treatment, or wear that might reduce the degree of safety originally provided. Any industrial protective helmet that requires replacement, or replacement of any worn, damaged, or defective part, should be removed from service until the condition of wear or damage has been corrected.

A1.4 Limitation of Protection. Industrial protective helmets, in accordance with this specification, are designed to provide optimum protection under average conditions. Users are cautioned that if unusual conditions prevail (such as higher or lower extremes of temperature than described, or other unusual conditions), or if there are signs of abuse or mutilation of the helmet or any component, the margin of safety may be reduced.

A1.5 Sizes. Provisions may be made by the manufacturers of industrial protective helmets for extra-small or extra-large sizes.

A1.6 Precautions. Industrial protective helmets should not be stored or carried on the rear-window shelf of an automobile, since sunlight and extreme heat may adversely affect the degree of protection. Also, in the case of emergency stops or accident, the helmet might become a hazardous missile.

The addition of accessories to the helmet may adversely affect the original degree of protection.

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