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WITHDRAWN

American Standard Safety Code for

Head, Eye, and Respiratory Protection

Sponsors
Department of the Navy
National Bureau of Standards
U.S. Bureau of Mines

Approved November 27, 1959

AMERICAN STANDARDS ASSOCIATION

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Foreword

(This Foreword is not a part of American Standard Safety Code for Head, Eye, and Respiratory Protection, Z2.1-1959.)

The first edition of this code was completed in the fall of 1920 and issued early in 1921. It was prepared with the cooperation of an advisory committee of 19 men who had been selected because of their interest in and knowledge of the subject and as being typical representatives of the interests most closely concerned. The code was developed from a set of safety standards originally prepared in cooperation between the War and Navy Departments and the National Bureau of Standards.

The second edition was issued in 1922, after revision by a sectional committee organized under the procedures of the American Standards Association, and was published as National Bureau of Standards Handbook H2.

The scope of the Z2 project was enlarged to include respiratory protection because of the many processes where simultaneous protection of lungs and eyes was needed, and a revision was published in 1938 as National Bureau of Standards Handbook H24.

In 1946 the sectional committee was reconvened and started work on a revision. A subcommittee on eye protection was organized under the direct supervision of the National Bureau of Standards: a subcommittee on respiratory protection was organized under the supervision of the U.S. Bureau of Mines; and a subcomittee on head protection was organized under supervision of the Department of the Navy. All parts of the standard had to be reviewed and brought up to date in order to include new materials and devices which had been developed since 1938, particularly the use of plastics for eye protection.

Suggestions for improvement gained in the use of this standard will be welcomed. They should be sent to the American Standards Association, Incorporated, 70 East Forty-fifth Street, New York 17, N. Y.

The committee that developed this standard is as follows:

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American Standard Safety Code for

Head, Eye, and Respiratory Protection

1. Purpose and Scope

1.1 Purpose. The purpose of this standard is to provide reasonable and adequate means, ways, and methods for the proper selection and safe use of head, face, neck, eye, and respiratory protective equipment.

1.2 Scope. This standard shall apply to all operations or processes, excluding those relating to (1) communicable air-borne diseases, or (2) x-rays, gamma rays, and high-energy particulate radiations such as alpha, beta, or neutron rays.

2. Exceptions

Variations from the requirements of this standard may be granted by the administrative agency only when it is demonstrated to the satisfaction of the administrative agency that equivalent protection is afforded.

3. Definitions

3.1 General Information

3.1.1 Where the word "approved" is used with qualification, it refers to approval by the administrative agency having jurisdiction over the specific requirement.

3.1.2 In this standard, the use of the word "shall" indicates a mandatory requirement. The word "should" indicates a recommendation.

3.2 Specific Definitions. As used in this standard, the following words shall have the indicated definitions, and all other words shall have meaning according to their common usage.

Abrasive-Blasting Respirator: See Respirator.

Aerosol: A suspension of fine, solid, or liquid particles in air as dust, fume, mist, smoke, or fog.

Air-Line Respirator: See Respirator.

Air-Regulating Valve: An adjustable valve between the air-supply line and the breathing tube of an air-line respirator or an abrasive-blasting respirator whereby the flow of air to the facepiece, helmet, or hood may be regulated.

Air-Supply Device: A hand- or motor-operated blower for the hose mask or a source of respirable compressed air for the air-line respirator and for the abrasive-blasting respirator.

Air-Supply Line: A hose to conduct respirable air from the air-supply device to that portion of a supplied-air respirator carried on the wearer's person.

Auxiliary Magnifier or Enlarger: A single lens or a pair of lenses joined together in a suitable manner to be inserted into the window in a welding helmet or hand shield to magnify or enlarge the area of the point of operation.

Breathing Tube: A flexible tube through which air or oxygen flows to the facepiece of a respirator.

Bridge Size: The distance between lenses on the nose side of each eye, expressed in millimeters.

Canister: A detachable container filled with granular materials that remove gases or vapors from the air that is drawn through the unit; it may also contain mechanical filters to remove dust, mist, and smoke particles.

Cartridge: A small canister.

Cartridge-Type Respirator: See Respirator.

Contaminant: A harmful material that is foreign to the normal atmosphere.

Cover Plate: A removable pane of colorless glass, plastic-coated glass, or plastic that covers the filter plate and protects it from damage.

Crown Strap(s): As applied to protective hats and caps, it is that part of the suspension that supports the shell in proper position on the wearer's head and acts as a shock absorber when the shell is subjected to impact; as applied to helmets and face shields, it is that part of the suspension that supports the device in proper position in front of the wearer's face.

Demand Respirator: See Respirator.

Detachable Coupling: A device by means of which the wearer of an air-line respirator may quickly detach the air-supply line from that part of the respirator worn on the person.

Disinfection: The act or process of destroying organisms that cause disease.

Dispersoid: A colloidal or finely divided substance.

Dust: Finely divided solid particles generated by processing (including handling, crushing, grinding, or pulverizing) materials such as rock, ore, metal, coal, wood, and grain.

Eyepiece: A gastight transparent window in a gas-mask facepiece through which the wearer may see.

Eye Size: A measurement expressed in millimeters and denoting the size of the lens-holding section of an eye frame.

Exhalation Valve: A device that allows exhaled air to leave a respirator and prevents outside air from entering it.

Face Mask: A device worn in front of the eyes and a portion of or all of the face, whose predominant function is protection of the eyes and face.

Facepiece: That portion of a respirator that covers the wearer's nose and mouth and makes a gastight or dust-tight fit with his face; the head harness or headbands and the breathing tube are usually included in the facepiece assembly.

Filter: A device that removes contaminants from air drawn through it or that converts those contaminants into less harmful compounds.

Filter Plate: A removable pane in the window that absorbs varying proportions of the ultraviolet, visible, and infrared rays according to the composition and density of the plate.

Filter Respirator: See Respirator.

Fog: Small liquid particles, condensed from the vapor phase, suspended in a gas such as air.

Full Facepiece: A facepiece that covers the wearer's nose, mouth, eyes, and face and makes a gastight or dust-tight fit with his face. It includes eyepieces, the head harness, and breathing tube.

Fume: Solid dispersoids formed by condensation of vapors, such as those from heated metals.

Gas Mask: See Respirator.

Goggles: A device, with contour-shaped eyecups or facial contact with glass or plastic lenses, worn over the eyes and held in place by a headband for the protection of the eyes and eye sockets.

Half-Mask Facepiece: A facepiece that covers the wearer's nose and mouth but not his eyes, and makes a gastight or dust-tight fit with his face: the headbands are included in the half-mask assembly.

Hand Shield: A device, usually held in the hand or supported on the wearer's chest, designed to protect the eyes and face during welding operations.

Hat: A rigid device that is worn by the operator to provide protection to the head or portions thereof against impact, flying particles, or electric shock, or any combination thereof, and which is held in place by suitable means; brimless caps with peaks are included as hats.

Headband: That part of the suspension consisting of a supporting band that encircles the head.

Head Harness (of Gas Mask): A device for holding the facepiece securely in place on the wearer's face.

Helmet: A device that is worn by a person to shield the eyes, face, neck, and other parts of the head.

Hood: A device that completely covers the head, neck, and portions of the shoulders.

Hose Mask With Blower: See Respirator.

Hose Mask Without Blower: See Respirator.

Infrared Radiation: Electromagnetic energy with wavelengths from 770 to 10^7 millimicrons.

Inhalation Valve: A device that allows respirable air to enter the facepiece and prevents exhaled air from leaving the facepiece through the intake opening.

Interpupillary Distance: The distance in millimeters between the centers of the pupils of the eyes.

Irrespirable: Unfit for breathing.

Lens: The transparent glass or plastic device through which the wearer of the protective goggles or spectacles sees, and which provides protection to the eyes against flying objects, glare, or injurious radiation, or a combination of these hazards.

Lens, Corrective: A lens ground to the wearer's individual corrective prescription.

Lift Front: A type of mounting frame for welding helmets which is made of two connected parts: the front part, which can be removed from the line of vision, contains the high-density filter plate with its cover plate; and the back part, which is fixed to the helmet, contains a low-density impact-resistant plate.

Mist: Suspended liquid droplets generated by breaking up a liquid into a dispersed state.

Mounting Plate or Mounting Frame: The device that holds the filter and cover plate in their proper place on the helmet.

Particulate Matter: Matter occurring in the form of minute separate particles, such as dust, fume, mist, and fog; a dispersoid.

Prefilter: A low-resistance filter pad placed in front of and in series with a regular dispersoid filter to lessen the dust load on the latter by removing the larger dispersoids from the air drawn through it.

Protector: A device that provides head, face, eye, or respiratory protection against the hazards of processes encountered in employment or in the natural environment.

Radiant Energy or Radiation: The energy of electromagnetic waves produced by the movement of molecules excited by the heat of an electric arc, or gas flame, or the passage of an electric current. Three kinds of radiant energy are pertinent to this standard: (1) ultraviolet radiation, (2) visible light, and (3) infrared radiation.

Resistance: Opposition to the passage of air, as through a filter or orifice.

Respirable: Fit to be breathed.

Respirator: A device to protect the wearer from the inhalation of irrespirable atmospheres.

Abrasive-Blasting Respirator: A supplied-air respirator, similar in principle to the air-line respirator, providing respiratory protection against dust and protection for the head and neck of the wearer against impact and abrasion by rebounding material during abrasive blasting operations.

Air-Line Respirator: A supplied-air respirator designed to be connected by a small-diameter hose to a supply of respirable air under positive pressure sufficient to deliver an adequate flow of air to a half-mask facepiece, full facepiece, helmet, or hood.

Chemical-Cartridge Respirator: A non-emergency chemical-filter respirator usually having a half-mask facepiece and one or more cartridges to remove contaminants from the air drawn through them; it is designed for respiratory protection against low concentrations of gases and vapors or a combination of dispersoids, gases, and vapors.

Demand Respirator: An atmosphere-supplying respirator in which air or oxygen is admitted to the facepiece only when the wearer inhales, and in quantities governed automatically by his breathing.

Filter Respirator: A device designed for the wearer to inhale the surrounding atmosphere after it has passed through a filtering medium to remove contaminants. The filtering medium may chemically absorb or mechanically retain or obstruct the impurities.

Gas Mask: A filter respirator having a full facepiece, a canister containing the suitable granular material with or without dispersoid filter, and a canister-carrying harness; it is designed for respiratory protection against gases or vapors or a combination of dispersoids and gases and vapors.

Helmet, Respirator: A rigid device that completely covers the head, neck, and portions of the shoulders of the wearer, and is provided with an air inlet and eyepiece.

Hood, Respirator: A loose-fitting device that covers the head and neck of the wearer. It may be a nonrigid or a combination of a rigid head covering and a nonrigid skirt for the head covering.

Hose Mask With Blower: A supplied-air respirator having a full facepiece to which respirable air is forced through a large diameter hose by a hand- or motor-operated blower, and through which

Respirators (Continued):

the wearer can inhale whether or not the blower is operated.

Hose Mask Without Blower: A supplied-air respirator having a full facepiece to which the supply of air is drawn from an inlet in respirable air through a large diameter hose by the wearer's breathing effort.

Self-Contained Breathing Apparatus: A respirator in which the supply of air, oxygen, or oxygen-generating material is carried by the wearer.

Supplied-Air Respirator: A respirator that makes respirable air available to the wearer through a hose connected to a source of respirable air.

Self-Contained Breathing Apparatus: See Respirator.

Shield: A device to be held in the hand, or supported without the aid of the operator, whose predominant function is protection of the eyes and face.

Side Shield: A device of metal, plastic, or other material hinged or fixed firmly to the spectacle lens frame to protect the eye from side exposure.

Snood: A flexible attachment to the back of a hood for protection against injury to the back of the head and neck.

Spectacle: A device patterned after conventional-type spectacle eyewear but of more substantial construction, either with or without side shields, and with clear, impact-resistant filter or corrective lenses of glass or plastic.

Supplied-Air Respirator: See Respirator.

Suspension: That part of a protective hat, cap, helmet, or face shield that supports the device on the wearer's head; it usually consists of headband and crown strap.

Temple: That part of a spectacle or other protector extending to the ear of the wearer and intended to position the device before the eyes.

Temple Length: The measured length of a temple designated in inches.

Timer: A device, operated by the wearer's respirations, that indicates the approximate length of time that a universal gas mask has been worn.

Toxic Dust: Dust that may be harmful to the respiratory tract or to other parts of the body through passing from the respiratory tract into the blood stream.

Ultraviolet Radiation: Electromagnetic energy with wavelengths from 50 to 390 millimicrons.

Valve: A device that permits the passage of air through it in one direction only.

Vapor: The gaseous state of a substance that is a solid or liquid at ordinary temperature and pressures.

Visible Light: Electromagnetic energy having wavelengths within a range of 390 to 770 millimicrons.

4. General Requirements

4.1 Head, eye, and respiratory protection in a manner provided by this standard shall be required where there is a *reasonable probability* of injury, illness, or disease of the body that can be prevented by such protection.

4.2 In such cases, employers shall furnish protectors of a type suitable for the work to be performed, and employees shall use such protectors.

4.3 No person shall be subjected, without protection, to a hazardous environmental condition.

4.4 Hygienic standards for industrial atmospheric contaminants are published by the American Standards Association, the American Industrial Hygiene Association, and the American Conference of Governmental Industrial Hygienists. All of these values should be used as guides in the control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. They only represent conditions within which it is felt that workers may be exposed continually for 8-hour periods, day after day, without adverse effects on health.

4.5 Protectors shall meet the following minimum requirements:

(1) They shall provide adequate protection against the particular hazards for which they are designed.

(2) They shall be reasonably comfortable when worn under the designated conditions.

(3) They shall fit snugly and shall not unduly interfere with the movements of the wearer.

(4) They shall be durable.

(5) They shall be capable of being disinfected.

(6) They shall be easily cleanable.

4.6 Protectors should be kept clean and in good repair.

4.7 Eye protectors shall be provided where machines or operations present the hazard of flying particles, pieces, or substances.

4.8 Respirators shall be provided where a process presents the hazard of exposure to harmful vapors, gases, dusts, mists, or fumes. Where the process is enclosed or ventilated, a supply of appropriate protectors shall be readily available for use in an emergency.

4.9 Workers whose vision requires the use of corrective lenses in spectacles and who are required by this standard to wear protective goggles shall be provided with goggles of one of the following types:

(1) Goggles whose protective lenses provide optical correction, or

(2) Goggles that can be worn over corrective spectacles without disturbing the adjustment of the spectacles, or

(3) Goggles that incorporate corrective lenses mounted behind the protective lenses

4.10 Every protector shall be distinctly marked to facilitate identification of the manufacturer.

4.11 Only approved protectors shall be used. In such cases where the U.S. Bureau of Mines has issued an approval for a protector, the administrative agency may accept such approval as prima-facie evidence of compliance with this section, provided that the limits within which the Bureau of Mines approval has been granted are not exceeded.

5. Head Protection

5.1 Hats

5.1.1 *Types and Classes.* Protective hats shall be of two types and of the following classes:

Type 1—Hat, full brim

Type 2—Cap, brimless with peak

Class A—General Service. Protection against impact and flying particles; limited dielectric strength

Class B—Utility Service. Protection against impact and flying particles; high dielectric strength

Class C—Special Service. Limited protection against impact; no dielectric strength (particular reference is made to metallic protective hats and caps)

Class D—Firemen Service. Protection against impact and flying particles; limited dielectric strength; Type 1 only

5.1.2 *Materials.* Materials used in the construction of protective hat and cap shells shall be water resistant, acid resistant, and fire resistant, and nonconductors of electricity (except for Class C which possesses no dielectric strength). All materials coming in contact with the wearer's head shall be nonirritating. Class B hats shall contain no metal parts, either in the shell, suspension, or accessories.

5.1.3 *General Requirements.* Each hat or cap shall consist essentially of a shell, a headband, and crown straps for support on the wearer's head. Provision shall be made for adequate ventilation.

5.1.3.1 *Shell.* The shell shall be dome-shaped of one-piece seamless construction, with smooth, hard surfaces. Where reinforcing ribs are used, they shall be so designed as to deflect a falling object. For Class B hats, there shall be no holes in any part of the shell.

5.1.3.2 *Headband.* Unless otherwise specified, the headband shall be genuine vegetable-tanned leather, full grain and soft, or artificial leather conforming to Type II, Class 3 of Federal Specifications CCC-C-418. The headband should be smoothly finished on the surface that will contact the head.

5.1.3.3 *Crown Straps.* Crown straps shall be of closely woven webbing or suitable material with high tensile strength and a low total elongation.

5.1.3.4 *Accessories.* Accessories shall be suitable for the intended purpose. All accessories shall be made of suitable materials and shall show good workmanship.

5.1.3.4.1 Chin Strap. Unless otherwise specified, the chin strap shall be closely woven webbing, genuine leather, or elastic cotton webbing combination.

5.1.3.4.2 Winter Liner. The winter liner, unless otherwise specified, shall consist of two layers of closely woven fabric; if colored, the fabric shall be fast dyed. The outer layer shall be water repellent and the inside layer a non-water-repellent plain woven flannel with nap on the inside surface.

5.1.3.4.3 Lamp Bracket. The lamp bracket shall be plastic or metal; if metal, it shall be insulated from the inside of the shell. The bracket shall be designed for proper beam angle when the hat is worn in the normal position.

5.1.3.4.4 Welding Helmet Combination. When used in conjunction with a cap, the welding helmet shall meet the requirements of 5.2.

5.1.3.4.5 Face Shield. When worn in conjunction with a hat or cap, the face shield or eye shield shall meet the requirements of 5.3.

5.1.3.4.6 Hoods. These are generally classified as acid resistant, heat resistant, and abrasion resistant. They are frequently used in conjunction with protective caps. Hoods used in combination with caps shall be manufactured from an acceptable material suitable for the particular application, and shall be so attached to the cap as to permit good visibility. The hood shall be designed for comfort and safety.

5.1.4 *Detailed Requirements*

5.1.4.1 *Shell.* The Type 1 hat shell shall have a continuous brim as an integral extension of the dome; with the hat held in a horizontal position, the brim shall slope downward; the width of the brim shall be not less than 1¼ inches and not more than 3 inches measured from the inside edge of the shell, except for Class D shells. The Type 2 cap shell shall include a peak or brim extending forward from the crown not less than 1½ inches and shall be not less than 5½ inches in width. The Class B hat or cap shell shall contain no holes, either through the crown portion or the brim portion, for the support of the headgear or for any other purpose; no metal or electrical conducting material shall be permitted either inside or outside the shell for any purpose.

5.1.4.2 *Headband.* The headband may be adjustable or nonadjustable. If adjustable, it shall cover the size range of commercial hat sizes 6⅝ through 7⅝. If nonadjustable, it shall be furnished in the specified head size. The surface of the headband in contact with the wearer's head shall be not less than 1¼ inches in width. Any padding or stiffener strips used shall be secured to the leather or artificial leather of the headband. Headband assemblies intended for use in Class B hats or caps shall contain no metal or electrical conducting material.

5.1.4.3 *Crown Straps.* Crown straps may be adjustable or nonadjustable. These straps when properly laced or assembled shall form a cradle for supporting the hat or cap on the wearer's head. The crown straps shall be designed to permit a clearance between the top of the wearer's head and the shell of not less than 1¼ inches. Crown-strap assemblies intended for use in Class B hats or caps shall contain no metal or electrical conducting material.

5.1.4.4 *Accessories*

5.1.4.4.1 Chin Strap. The adjustable chin strap shall be made of not more than two pieces of webbing, leather, or elastic cotton webbing combination not less than ½ inch in width and not less than 16 inches in length, excluding the attachments to the hat or cap. The means for adjusting the chin strap shall assure a secure hold of the hat or cap on the wearer's head and quick removal of the hat or cap by releasing the strap. The chin strap shall also be adjustable for wearing at the back of the head. The webbing shall have no frayed or loose edges that may unravel. Leather, if used in the chin strap, shall be of suitable thickness, full grained, and smoothly finished on the surface that will be in contact with the chin. All metal parts shall be free from sharp or rough edges or projections. Rivet heads shall be smooth. Chin-strap assemblies intended for use in Class B hats or caps shall contain no metal or electrical conducting material.

5.1.4.4.2 Winter Liner. The winter liner shall be designed to cover the skull, neck, and ears, or the skull and ears only, as specified. The earlug and neck part may be made either in one piece with the skull cap or may be attachable to it. The neck and earlug parts shall be made to fit snugly by means of a lace or chin strap. Winter liners intended for use with Class B hats or caps shall contain no metal or electrical conducting material.

5.1.4.4.3 Lamp Bracket. The lamp bracket shall be so designed as to permit adequate illumination directly in front of the wearer when the hat is positioned properly on the head. Caps for specific use in the mining industry may have metal brackets in place of plastic ones, provided insulating rivets are used to assemble the bracket to the shell.

5.1.4.4.4 Face Shield. Material for face shields or eye shields shall be in accordance with 5.3. The method of attachment to the hat or cap shall be such as to permit easy replacement. A firm, sure fit shall be assured to provide adequate protection. Metal or plastic frames shall be provided to hold the shield firmly to the hat or cap shell. Snap-on or riveted attachments are permitted, provided the shield is held securely. Attachments may be rigid or swiveled; see 5.3.6.6.

5.1.4.4.5 Welding Helmet Combination. The welding helmet shall be attached to the protective cap in such a manner as to permit easy removal, yet offer a firm, positive method of attachment. The attachment shall be such as to permit ready lifting and lowering of the helmet as described in 5.2.4.1.3.

5.1.4.4.6 Hoods

5.1.4.4.6.1 Acid Type. Materials used in this application shall be rubber, synthetic rubber, or plastic. When worn in conjunction with a protective hat or cap, the method of attachment and the design shall be such as to permit ease in movement, adequate visibility, proper ventilation, comfort, and safety. The window shall be attached so as to provide adequate vision with the hat or cap at any angle.

5.1.4.4.6.2 Heat Type. Hoods and masks are available for protection against various degrees of heat. The mask type consists of a plastic- or wire-screen face shield which can be attached by means of a bracket to the brim of a hat or cap. This combination is used where the wearer may come in contact with infrequent splashes of hot materials. Spectacles are frequently worn under the wire-screen mask. The hood shall be made from material such as chrome leather, asbestos, or flameproof duck. The design shall be similar to that of the acid-type hood and shall incorporate the same details as noted therein.

5.1.4.4.6.3 Abrasion Type. Material used for this type of hood shall be heavy rubberized fabric, chrome leather, or similar abrasive-resistant material. The design shall be similar to the acid-type hood and shall incorporate the same details of construction.

5.1.5 *Physical Requirements and Methods of Test*

5.1.5.1 *Preparation of Samples.* All hats or caps shall be prepared in the following manner for the tests described in this section. Using No. 60 grit garnet paper, the entire exterior surface of the shell shall be abraded until the basic material is exposed. All samples shall then be conditioned in an oven for 96 hours at 50 ± 2 C, then cooled in a desiccator and exposed for 96 hours in an atmosphere having 50 percent ± 2 percent relative humidity and a temperature of 25 ± 2 C.

5.1.5.2 *Insulation Resistance (Class A and Class D Hats and Caps).* When tested in accordance with the method specified in 5.1.5.4, Class A and Class D hats and caps shall withstand 2,200 volts, alternating current, 60 cycles per second (root-mean-square value) for 1 minute with leakage current not in excess of 3 milliamperes.

5.1.5.3 *Insulation Resistance (Class B Hats or Caps).* When tested in accordance with the method specified in 5.1.5.4, Class B hats or caps shall withstand 15,000 volts, alternating current, 60 cycles per second (root-mean-square value) for 1 minute with leakage current not in excess of 8 milliamperes. Class B hats and caps when tested to breakdown shall not fail below 20,000 volts. Tests shall be made after first subjecting the hats or caps to the impact resistance test described in 5.1.5.5.

5.1.5.4 *Electrical Proof Test.* The inside of the hat or cap shell (without suspension or accessories) shall be filled with fresh tap water to within ½ inch of the junction of the brim with the crown. If the shell contains holes in the crown near the brim, it shall be filled to within ½ inch of the holes. The hat or cap shall then be submerged in the same type of water to the same level as that of the water inside. One terminal from the current source shall be in contact with the water inside the shell, and the other terminal in contact with the water outside the shell. The circuit shall be provided with a voltmeter of sufficient capacity, and a milliameter of sufficient capacity and accuracy, to measure the specified current. For Class A and Class D hats and caps, 2,200 volts shall be applied for 1 minute and current leakage, if any, noted. For Class B hats or caps, 15,000 volts shall be applied continuously for 1 minute and current leakage, if any, noted; voltage shall then be increased momentarily to 20,000 volts to determine whether breakdown of the shell occurs. Care should be taken to keep the unsubmerged portion of the shell dry so that flashover on application of voltage does not occur. Suitable precaution should be taken to prevent accidental contact by persons with any part of the high-voltage circuit.

5.1.5.5 *Impact Resistance*

5.1.5.5.1 Classes A, B, and D Hats and Caps. When mounted on a standard head form, as described in Federal Specification GGG-H-142, with a crown clearance of 1½ inches, the hat or cap shall not transmit an average force of more than 850 pounds from the impact of an 8-pound spherical steel ball approximately 3.8 inches in diameter dropped onto the center of the crown from a height of 5 feet. The force transmitted shall be determined by mounting the standard head form on a Brinell hardness penetrator apparatus as described in Federal Specification GGG-H-142. See Fig. 1. The impression bar shall be of a metal having a predetermined Brinell hardness of 18-30 as measured with a 500-kilogram load and a 10-millimeter ball, in accordance with the procedures of American Society for Testing Materials Specification E10-54T.

5.1.5.5.2 Class C Hats and Caps. Requirement and test shall be the same as specified in 5.1.5.5.1 except that the height of drop shall be 3 feet.

5.1.5.6 *Penetration Resistance.* Hats and caps of all classes shall be neither dented nor pierced for more than ⅜ inch, nor shall the shell be pushed down so as to touch the standard head form, nor shall the crown straps pull out or break, when mounted as specified in 5.1.5.5.1 and subjected to a 1-pound hardened steel plumb bob with a point having an included angle of 36 degrees dropped squarely onto the center of the crown from a height of 10 feet.

5.1.5.7 *Weight.* Except for Class D, the weight of each hat or cap shall not exceed 15 ounces complete with suspension, but exclusive of winter liner or chin strap.

5.1.5.8 *Flammability.* The thinnest section of the shell shall not burn at a rate greater than 3 inches per minute when tested by inserting one end of a 5-inch x ½-inch strip of the shell material in a blue-flame Bunsen burner. The strip of the shell material shall be inclined at 45 degrees with the 5-inch longitudinal axis horizontal. The burner flame shall be ¾ inch high. After 30 seconds, the burner shall be removed and the strip allowed to burn. Measurement of the rate of burning shall then be recorded.

5.1.5.9 *Water Absorption.* The shell material shall absorb not more than 5 percent by weight of water when subjected to the test specified in 6.2.4.

5.1.5.10 *Edge Strength.* Hats and caps in Classes A, C, and D shall show a deflection under a 40-pound load of not more than ¾ inch and an ultimate strength of not less than 50 pounds when the peak or front brim is clamped in the supported edge position to a T-jig, in accordance with Federal Specification GGG-H-142.

5.1.6 *Selection of Head-Protective Devices*

5.1.6.1 *Class A.* Hats and caps under this classification are intended for protection against impact hazards encountered, for example, in mining, building construction, tunneling, timber work, and manufacturing. Dielectric strength is incorporated as an extra safeguard for protection against voltages not exceeding 600 volts.

5.1.6.2 *Class B.* This class covers safety hats and caps for protection of the wearer's head against electrical contact with exposed conductors of high voltage and against impact hazards.

5.1.6.3 *Class C.* The safety hat or cap in this class is designed specifically for lightweight comfort with some impact protection. This class is usually manufactured from aluminum and offers no dielectric protection.

5.1.6.4 *Class D.* The firemen's helmet covered under this classification is designed for a specific use where additional requirements are: (1) wide brim—to give protection to ears and neck; (2) heavy construction—to provide high-impact resistance and bump protection, with good abrasion qualities; (3) dielectric strength—for protection against voltages not exceeding 600 volts.

5.1.7 *Training Aids*

5.1.7.1 *Crown Lace.* The crown lace, if any, should always be tied with a square knot. This knot should be secure in order for the suspension to provide the required protection when the hat or cap is subjected to impact. If the entire suspension is held in the shell by a lace, this lace shall also be tied in a square knot.

5.1.7.2 *Clearance.* To assure the proper protection when the hat or cap is being worn, the crown straps shall be so designed as to provide a minimum clearance of 1¼ inches between the top of the wearer's head and the crown of the shell. In testing, this distance is measured by placing a shell on a head form in a position similar to that when worn on

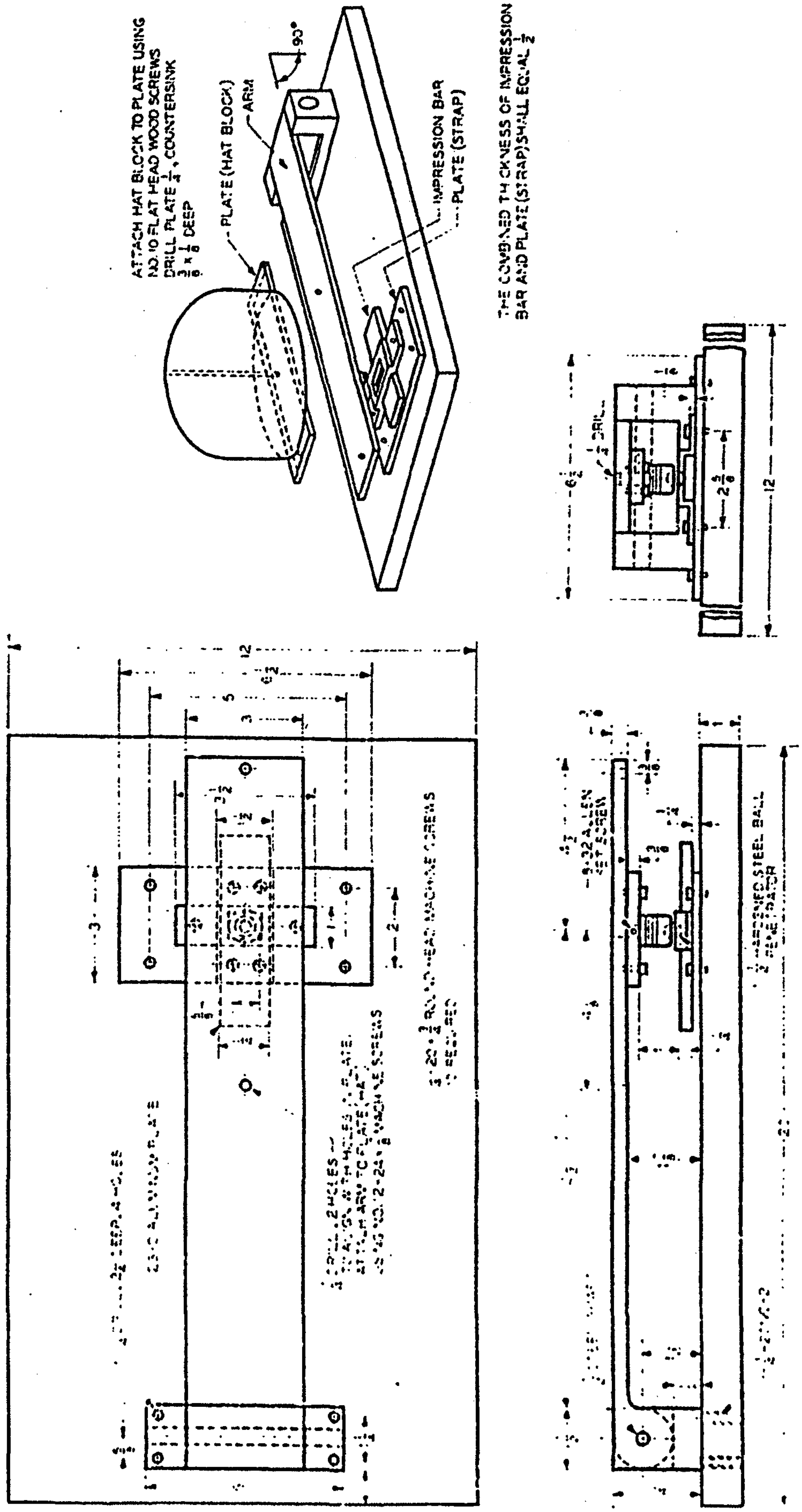

Fig. 1
Brinell Hardness Penetrator Assembly

a man's head. A 25-pound weight is then placed on the shell and the distance between the crown of the test block and the underside of the top of the hat or cap shell may be measured by means of a rod inserted in a hole drilled through the center of the head form.

5.1.7.3 *Painting.* Caution should be exercised in painting any hat or cap shell as some paints reduce dielectric protection, attack and soften the shell material, and thus reduce impact protection. The manufacturer shall be consulted with regard to the choice of paints for a particular hat or cap.

5.1.7.4 *Insulating Safety Hats.* Unlike rubber gloves, insulating safety hats or caps (Class B) are not normally intended to come into contact with energized conductors or equipment. Nevertheless, periodic visual inspection and occasional electrical tests are considered necessary and are recommended. This is especially desirable in that this equipment is also used as protection against impact hazards, and dielectric strength may be impaired by impact. Insulating safety hats and caps shall be inspected before each usage for cracks, signs of impact, and rough treatment. Shells and suspensions shall be maintained in excellent condition at all times, and defective parts replaced.

5.1.7.5 *Comparative Hat and Cap Sizes.* Comparative hat and cap sizes are shown in Table 1.

5.1.8 *Marking.* Each hat or cap shall be identified on the inside of the shell with the name of the manufacturer and class of protection. For Class B, the hats and caps shall also be marked to indicate that each has been tested to meet the voltage test and breakdown requirements. Each hat or cap shall be accompanied by instructions explaining the proper method of adjusting the suspension.

5.2 Helmets and Hand Shields

5.2.1 ***Function.*** The devices described in this section are designed to provide protection for the eyes, face, ears, and neck against intense radiant energy. Typical operations which require helmets or hand shields include various kinds of arc welding and heavy gas cutting.

5.2.2 ***Types.*** The helmet and the hand shield are the only permissible types for hand welding.

5.2.3 ***Styles.*** The helmet and the hand shield are made to the same basic design and of the same basic materials—a bowl-shaped or modified bowl-shaped device containing a window with filter plate which allows the wearer to see the radiant object, yet prevents harmful intensities of radiation from reaching his eyes. The helmet headgear has an adjustable frame by which it is supported on the head, while the hand shield has a handle attached to the bottom by which it is held in the hand. The basic designs may be modified to provide protection against special hazards, but modified equipment shall meet the same requirements as the basic design.

5.2.4 ***Detailed Requirements***

5.2.4.1 *Rigid Helmet*

5.2.4.1.1 Helmet Body. The helmet body shall be of such size and shape as to protect the face, top of the head, and the neck to a vertical line back of the ears. It shall have an opening or openings in the front for a filter plate. The helmet body shall be attached to the headgear in such a way that it will not come in contact with any part of the head and that it can be lifted up from in front of the face and hold its position in front of the head. The helmet body shall be made of vulcanized fiber, reinforced plastic, or other suitable material which shall be heat and flame resistant, opaque to visible, ultraviolet,

Table 1
Comparative Hat and Cap Sizes

American	6	6⅛	6¼	6⅜	6½	6⅝	6¾	6⅞	
English	5⅞	6	6⅛	6¼	6⅜	6½	6⅝	6¾	
Measurement, inches	19	19⅜	19¾	20⅛	20½	20⅞	21¼	21⅝	
Women's		Small				Medium			
Sizing			20				21		
American	7	7⅛	7¼	7⅜	7½	7⅝	7¾	7⅞	8
English	6⅞	7	7⅛	7¼	7⅜	7½	7⅝	7¾	7⅞
Measurement, inches	22	22⅜	22¾	23⅛	23½	23⅞	24¼	24⅝	25⅛
Women's		Large				Extra Large			
Sizing			22				24		

NOTE: The above measurements are to be made with materials that will not stretch, preferably with a tape measure. In selecting sizes, measure circumference of head where the hat is normally worn. Note nearest corresponding figure on chart for size. These sizes are approximate and vary slightly among different manufacturers. Women's sizes are normally classified as indicated, although the dimensional method could be used.

and infrared radiations, and capable of disinfection. The inside of the helmet body shall have a low light-reflecting finish. Rivets or other metal parts, if terminating on the inside surface, shall be adequately insulated.

5.2.4.1.2 Weight. The helmet or hand shield, exclusive of filter or cover glasses, shall weigh not more than 24 ounces (680 grams).

5.2.4.1.3 Headgear. The helmet shall have a headgear or cradle that shall hold the helmet body comfortably and firmly on the wearer's head, but shall permit the helmet body to be tilted back over the head. The headgear shall be readily adjustable, without the use of tools, for all sizes between commercial hat sizes 6⅝ and 7⅝. The headgear shall be made of materials which are noncombustible or slow burning, resistant to heat, and capable of disinfection. Where required, the headgear shall be fitted with a removable and replaceable sweatband covering at least the forehead portion of the headband. The sweatband shall be made of leather or other suitable material which is slow burning, heat resisting, and nonirritating.

5.2.4.1.4 Headgear Substitutes. The headgear may be replaced by an impact-resistant hat or cap, or other suitable device to which the helmet body is connected, provided that the helmet body can be lifted and adjusted to permit unobstructed vision or lowered to furnish complete protection, as required. The alternative device shall meet the requirements for disinfection and resistance to heat, and, in addition, shall meet the applicable requirements of any additional functions such as protection against falling objects as detailed under 5.1.

5.2.4.1.5 Filter- and Cover-Plate Mounting. The front of the helmet body shall be provided with a light-tight plate-mounting frame or frames made of metal, plastic, or other suitable material, which shall be attached securely to the body of the helmet or shall be an integral part of the helmet. The frame shall provide a window through which the welding or cutting operation may be seen by the wearer; the window shall be not less than 3⅞ inches wide and 1⅝ inches high, or equivalent in area and visual field. The frame shall permit the removal and replacement of filter and cover plates without the use of tools and without damage to the plates or frame. The mounting shall be so designed that the filter plate will be not less than 2 inches (50.8 mm) from the eyes of the wearer.

5.2.4.1.6 Filter Plate. For helmets having only one working window, the filter plate shall be of such dimensions as to fit suitably into the frame and to cover the window; the filter plate shall be not less than 0.08 inch (2 mm) nor more than 0.15 inch (3.8 mm) thick. If auxiliary windows are provided, the dimensions of the main window used for watching the arc shall be as specified in 5.2.4.1.5. If two windows are provided in place of the main window, their equivalent dimensions shall be as specified in 5.2.4.1.5. Filter plates shall be free from striae, waves, or other defects which impair their optical quality. Filter plates shall conform with the radiant-energy transmission requirements shown in Table 2, page 26, and shall be uniform in luminous (visible) transmittance within 20 percent. The dominant line shall be between 490 and 600 millimicrons. Filter-plate surfaces shall be flat and substantially parallel; prismatic effect shall not exceed ⅛ prism diopter (8 minutes of arc).

5.2.4.1.7 Cover Plate. Cover plates, made of plain glass, of glass coated on one or on both sides with plastic, or of a slow-burning solid plastic sheet shall be used to protect the filter plates from damage. The cover plates shall be the same size and shape as the filter plates. They shall transmit not less than 75 percent of the luminous radiation and shall be substantially free from optical imperfections.

5.2.4.2 *Hand Shield.* Hand shields shall be constructed of materials similar to those used for the helmet and in like manner. The materials, lens mounting arrangement, and filter and cover plates shall conform to the requirements for the corresponding parts of the helmet body with headgear. The handle shall be made of a material that is a nonconductor of electricity and is noncombustible or slow burning. It shall be of such size and shape as to be held easily by one hand and shall be firmly attached to the bottom of the shield. Hand shields intended for use by others than welding operators shall have filter and cover plates suitable for the intended use.

5.2.4.3 *Nonrigid Helmet.* Helmets may be made of nonrigid materials where they are to be used in confined spaces or may be collapsible for convenience in carrying or in storage. The helmets may be of the same general shape as the rigid helmet except that a more complete covering of the top of the head is necessary in order to maintain the face, side, and windows in proper position. The requirements for the filter plates, cover plates, and lens-mounting frame are the same as for the rigid helmet. A headgear may be used. The material shall be nonconducting and opaque to ultraviolet, visible, and infrared radiations. It shall withstand the test for resistance to flame described in Federal Specifications for Plastics, Organic; General Specifications Test Methods L-P-406. Stitched seams shall be welted and no stitching shall be exposed.

5.2.4.4 *Attachments and Auxiliary Equipment*

5.2.4.4.1 Lift Front. The lift front shall be fabricated from suitable material, such as thermosetting resin, die-cast aluminum or magnesium alloy, or stamped or drawn metal. A snap hinge shall be provided so that the front part will stay up or down but will not remain in a partially opened position. The lift-front seal against the helmet shall be light-tight. The lift front shall be designed to accommodate three plates: an impact-resisting plate in the back or fixed part, and a filter plate and cover plate in the front part.

5.2.4.4.2 Chin Rest. To avoid contact of the helmet with the face of the wearer, a chin rest should be provided. The chin rest shall be constructed of suitable, rigid material and shall be detachable from the body of the helmet or hand shield.

5.2.4.4.3 Snood. Snoods or back-of-head-and-neck protectors shall be of material that is flame resistant, that is a good insulator of heat and electricity, and that is capable of being disinfected. Such devices shall be designed for easy attachment to the helmet or helmet headgear or cradle.

5.2.4.4.4 Apron. Aprons or bibs for helmets shall be of nonflammable, nonconducting material that is flexible and capable of being disinfected. All joints between the helmet and the bib or apron shall be light-tight.

5.2.4.4.5 Auxiliary Magnifier or Enlarger. This may be made of glass or transparent plastic material of optical quality. If used, it shall be the same size as the filter plate.

5.2.4.5 *Special Protective Devices.* When respiratory protection is needed against airborne contaminants encountered during welding operations, the appropriate respiratory protective device shall be worn in conjunction with a helmet or hand shield.

5.2.4.6 *Flammability.* The thinnest section of the rigid helmet or hand shield shall not burn at a rate greater than 3 inches per minute when tested by inserting one end of a 5-inch x ½-inch strip of the helmet material in a blue-flame Bunsen burner. The strip shall be inclined at 45 degrees with the 5-inch longitudinal axis horizontal. The burner flame shall be ¾ inch high. After 30 seconds, the burner shall be removed and the strip allowed to burn. Measurement of the rate of burning shall then be recorded.

5.2.5 *Marking.* Helmets, shields, and filter plates shall bear a permanent and distinctive marking by which the manufacturer may be readily identified. In addition, all filter plates shall be marked with the shade number; if made of heat-treated glass, they shall be marked with the letter "H."

5.3 Face Shields

5.3.1 ***Function.*** The devices described in this section are designed to provide protection to the face (i.e., the front part of the head including forehead, eyes, cheeks, nose, mouth, chin) and neck, where required, from flying particles and sprays of hazardous liquids and, in addition, to provide antiglare protection where required.

5.3.2 ***Intended Uses.*** Some typical uses for face shields include the following: (1) woodworking operations where chips and particles fly; (2) metal machining causing flying particles; (3) buffing, polishing, wire brushing, and grinding operations where flying particles or objects may strike the face; (4) spot welding; (5) handling hot or corrosive materials.

5.3.3 ***Styles and Types.*** Face shields shall comprise three basic styles: headgear without crown protector; headgear with crown protector; headgear with crown protector and chin protector.

5.3.3.1 *Window.* Each of these styles shall accommodate any of three styles of windows: (1) clear transparent; (2) colored transparent; (3) wire screen.

5.3.4 ***Materials.*** Materials used in the manufacture of face shields shall combine mechanical strength and lightness of weight to a high degree, shall be nonirritating to the skin when subjected to perspiration, and shall be capable of withstanding frequent disinfection. Where metals are used, they shall be resistant to corrosion. Plastic materials shall be slow burning. Clear or colored plastic materials used in windows shall be of an optical grade and shall provide equivalent performance with the applicable optical, physical, and radiant-energy requirements specified in 6.3.2 and 6.3.3.

5.3.5 ***General Requirements***

5.3.5.1 *Assembly.* Face shields shall consist essentially of a detachable transparent plastic window, wire-screen window, or opaque frame with window; a tilting support, an adjustable headgear, and, as required, a crown protector and chin protector.

5.3.5.2 *Window Shape.* The plastic or wire-screen window shall be designed to fit the contour of the window support and to maintain that contour.

5.3.5.3 *Window Support.* There shall be attached to the headgear a window-supporting or window-holding member which shall consist of a band with or without crown protector. The window support shall position the window in front of the face in such a manner as to provide clearance for the nose and eyeglasses of the wearer.

5.3.5.4 *Window Attachment.* The attachment of the window to the window support shall be such as to permit easy removal and replacement. The several sizes and types of windows shall be interchangeable for attachment to the window support.

5.3.5.5 *Headgear.* The headgear shall consist of at least a headband and a crown strap. The headgear shall be made from materials having low heat conductivity. The design shall be such as to hold the window and window support comfortably and firmly in place on the wearer's head, and shall provide for tilting the window away from the face.

5.3.5.6 *Crown Protector.* The crown protector shall be shaped to cover at least the frontal portion of the head and shall extend around each side at least to the edges of the window. It may be designed to be an integral part of the window support, or it may be a separate assembly. The design shall be such as to provide a comfortable clearance over the forehead and head of the wearer.

5.3.5.7 *Chin Protector.* The chin protector shall be shaped to cover at least the chin and upper part of the neck and shall extend at least to the edges of the window. The design shall be such as to provide a comfortable clearance under the chin of the wearer.

5.3.6 *Detailed Requirements*

5.3.6.1 *Window Dimensions.* Plastic or wire-screen windows without frames shall be not less than 9½ inches wide at the top and 8½ inches wide at the bottom, measured over their curved surfaces when attached and in position on the window support, and not less than 6 inches high. Windows, when used in frames, shall be not less than 4 inches wide and 2 inches high, and the frames shall conform to the dimensions specified for windows without frames. Plastic windows shall be not less than 0.040 inch nominal thickness.

5.3.6.2 *Wire-Screen Window.* The exposed borders of wire-screen windows shall be suitably bound or otherwise covered in such a manner as to eliminate any sharp, rough, or unfinished edges. Openings in the wire screen shall not exceed 0.0295 inch (0.75 mm) in the maximum dimension. Bright-finished metal should be used in the window to aid in reflection of radiant energy.

5.3.6.3 *Window Support.* The window support shall be made of vulcanized fiber, plastic, or other suitable material. It shall be frictionally attached to the sides of the headgear to permit easy tilting, either upward or downward, of the supporting member and of the window attached thereto. The window shall be capable of being tilted sufficiently upward so that the center of its bottom edge shall be out of the line of horizontal vision. The tension of the tilting mechanism shall be sufficient to hold the window without slippage in either the up or the down position.

5.3.6.4 *Headgear.* The headgear shall be adjustable, without the use of tools, for all commercial hat sizes 6⅝ and 7⅝. Adjusting devices shall be positive and shall hold firmly in place after being so adjusted. The crown strap or band shall be attached to, and extend between, the front and rear centers or from the middle sides of the headband. It shall form an arc over the head to assist in positioning and holding the headgear in place. Adjusting devices, if used, shall be positive and shall hold firmly in place after being so adjusted. All mechanisms and movements shall be protected so that the wearer's hair cannot catch in the adjusting devices. Not less than the forehead portion of the headband shall be provided with a removable and replaceable cushioned sweatband that shall be nonirritating and nontoxic.

5.3.6.5 *Crown Protector and Chin Protector.* The crown protector and chin protector shall be made of vulcanized fiber, plastic, or other suitable material having an impact resistance not less than that of the plastic window. When the crown protector is used in conjunction with the chin protector for protection against sprays of hazardous liquids, the assembly of the crown protector and window support and the assembly of the chin protector and window shall be splash-proof, i.e., shall not allow liquids to pass through any openings in the assembly and reach the face, forehead, or chin of the wearer.

5.3.6.6 *Headgear Substitutes.* For additional protection, the headgear may be replaced by an impact-resistant hat or cap or other suitable device to which the window support is connected. The attachment may be either rigid or swiveled. If swiveled, the design shall be such as to permit lifting and adjusting of the window to permit unobstructed vision or lowering to furnish protection, as required. The substitute device shall meet the requirements for low-heat conductivity and disinfection, and, in addition, shall meet the applicable requirements of any additional functions such as protection against falling objects, as detailed under 5.1.

5.3.7 *Marking.* Each headgear and each plas window shall bear a permanent and legible marking by which the manufacturer may be readily identified. In addition, each window offered for protection against glare shall bear its shade designation.

5.3.7.1 *Marking for Special Operating Conditions.* When face shields are to be used in atmospheres or working areas requiring special conditions of nonconductivity or nonsparking, then all materials used shall meet these requirements. Face shields shall be plainly and permanently labeled, identifying them as "nonconductive face shield" or "nonsparking face shield."

5.3.8 ***Physical Requirements and Methods of Test***

5.3.8.1 *Impact Resistance, Plastic-Window Face Shield.* The face shield shall be mounted on a holder consisting of a standard wooden hat block, size 7, mounted vertically on a wooden support fastened securely to a base. The face shield shall be so mounted that the headband fits snugly around the periphery of the base of the block and the crown strap is in contact with the crown portion of the block. An additional supporting block, approximately 1 inch wide and curved to conform to the shape of the plastic window, shall be provided as a support for the window at its lower end or, if the face shield is provided with a chin rest, as a support under the chin rest. The face shield will then rest in a position such that the axis of the cylindrical window is horizontal and the outer surface of the window is uppermost. The impact test shall be made at room temperature (65 F to 85 F) under normal humidity conditions. A ⅞-inch-diameter steel ball, weighing approximately 1.56 ounces, shall be freely dropped from a height of 50 inches onto the apex of the window at a point approximately 3 inches below the top edge of the window. The window shall not be fractured nor separated nor removed from any of its points of fastening to the headgear by the impact of the steel ball.

5.3.8.2 *Penetration Resistance, Plastic-Window Face Shield.* The face shield shall be mounted in the manner described in 5.3.8.1 and shall be tested under similar conditions. A pointed projectile of suitable size, consisting of a new Singer number 135 x 17 size 25 needle fastened into a holder, weighing approximately 1.56 ounces, shall be freely dropped, needle point downward, from a height of 50 inches onto the apex of the window at a point approximately 3 inches below the top edge of the window. The projectile may be guided, but not restricted, in its fall by dropping it through a tube extending to within approximately 4 inches of the face-shield window. The window shall not be fractured nor pierced through by the impact of the projectile.

5.3.8.3 *Visible Transmittance, Plastic Windows.* The total visible (luminous) transmittance of clear or colored windows shall be determined by any standard method recognized as suitable by the National Bureau of Standards. A suggested method is described in 6.3.4.6.2. Clear windows shall transmit not less than 85 percent of the incident visible radiation. Colored windows shall transmit as follows:

Shade	*Percent Transmittance*
Light	50 ± 7
Medium	23 ± 6
Dark	14 ± 6

5.3.8.4 *Flammability, Plastic Windows.* The clear or colored plastic window shall burn at a rate not greater than 3 inches per minute when tested by inserting one end of a 5-inch x ½-inch strip of the material in a blue-flame Bunsen burner. The strip shall be inclined at 45 degrees with the 5-inch longitudinal axis horizontal. The burner flame shall be ¾ inch high. After 30 seconds, the burner shall be removed from the strip and the strip allowed to burn. Measurement of the rate of burning shall then be recorded.

5.3.8.5 *Disinfection.* All face-shield materials shall be such as to withstand, without visible deterioration, washing in detergents and warm water, rinsing to remove all traces of detergent, and disinfection by one of the following methods:

(1) Immersion for 10 minutes in a solution of formalin made by placing one part of 40 percent formaldehyde solution in 9 parts of water at a room temperature of 68 F.

(2) Subjection to a moist atmosphere of formaldehyde for a period of 10 minutes at room temperature of 68 F.

(3) Immersion for 10 minutes in a solution of modified phenolics, hypochlorite, or quaternary ammonium compounds in strength specified by the manufacturer at a room temperature of 68 F.

6. Eye Protection

6.1 Styles and Functions of Protectors

6.1.1 ***Goggles, Eyecup***

6.1.1.1 *Basic Types.* Eyecup goggles shall comprise two basic types as follows:

Cup-Type Goggles designed to be worn by individuals who do not wear corrective spectacles.

Cover-Cup-Type Goggles designed to fit over corrective spectacles

6.1.1.2 *Models.* The two basic types of eyecup goggles shall be subdivided into the following classes:

Chipper's Models providing protection against flying objects.

Dust and Splash Models providing protection against relatively fine dust particles or liquid splashes.

Welder's and Cutter's Models providing protection against glare and injurious radiations. The basic designs may be modified to provide more protection against special hazards, but the modified equipment shall meet the same requirements as the basic design.

6.1.1.3 *General Requirements.* Eyecup goggles shall consist of two eyecups, with lenses and lens retainers, connected by an adjustable bridge, and a replaceable and adjustable headband or other means for retaining the eyecups comfortably in front of the eyes. Specific applications for the use of eyecup goggles will be found in Table 3. (See page 27.)

6.1.1.4 *Detailed Requirements*

6.1.1.4.1 Eyecup Material. Eyecups shall be made from a plastic or other material of such composition as to withstand the heat deformation test outlined in 6.1.1.5 and the disinfection, water absorption, and flammability tests outlined in 6.2.

6.1.1.4.2 Vision and Fit. Eyecups shall be right and left in pairs and shall permit an effective angle of vision not less than 105 degrees, assuming that the pupil of the eye is located 17 millimeters behind the inner surface of the lens. The edge of the eyecup which bears against the face shall have a smooth surface free from roughness or irregularities which might exert undue pressure or cause discomfort to the wearer. The eyecups shall be of such shape and size as to cover completely the entire eye sockets, and the depth of the eyecup shall be such that the lenses will not interfere with the eyelashes of the wearer. The eyecups of cover-cup-type goggles shall be designed so that they provide ample clearance and will not interfere with the spectacles of the wearer.

6.1.1.4.3 Ventilation

Chipper's Models. Eyecups shall be ventilated in a manner to permit circulation of air. Ventilation openings shall be such as to exclude a spherical particle 0.04 inch in diameter.

Dust and Splash Models. Eyecups shall be ventilated in a manner to permit circulation of air. The ventilation openings shall be baffled or screened to prevent the direct passage of dust or liquids into the interior of the eyecups.

Welder's and Cutter's Models. Eyecups shall be ventilated in a manner to permit circulation of air. The ventilation openings shall be baffled to prevent the passage of light rays into the interior of the eyecups.

6.1.1.4.4 Lens Retainers. Each eyecup shall be provided with a lens retainer bearing evenly on the lens with sufficient pressure effectively to retain fragments in the event of lens breakage. The design shall be such as to permit the ready removal or replacement of lenses. Lens retainers for welder's and cutter's models shall be such as to accommodate a filter lens, fiber gasket, and cover lens.

6.1.1.5 *Heat Deformation Test.* Goggles shall be tested for heat deformation by mounting the eyecup on a wooden block with a weight as shown in Fig. 3, and by placing the whole assembly in an oven at 150 F for one hour. After one hour the assembly shall be removed from the oven and allowed to cool, after which the dimensions (A), (B), and (D) shown in Fig. 2 shall be measured. The maximum deviation from the original dimensions shall not exceed the following: For dimensions (A) and (B), ½ percent, and for dimension (D), 5 percent. After testing, the retaining ring and the cup of the eyecup shall fit in a snug but not tight manner. The eyecup shall be mounted on the wooden block as follows: With the facial edge of the cup down and the lens horizontal, the bridge side fastened to the block by means of a piece of wire, with the eyecup resting on the edge of the block, which has a 3/16-inch radius, and the 680-gram weight suspended from the eyecup by means of a piece of wire, one end of which is attached to the weight and the other end fastened in the temple-side headstrap hole.

6.1.2 *Spectacles, Metal or Plastic Frame*

6.1.2.1 *Description.* Spectacles shall consist of two lenses and two lens frames, of suitable size and shape for the purpose intended, connected by a nose bridge and supported on the face by temples or other suitable means. Where required, cable-type temples shall be adequately insulated over that portion in contact with the ears or head of the wearer. The spectacles shall be furnished with or without side shields, depending upon their intended use. The frames and side shields when provided shall be made of metal or slow-burning plastic material.

6.1.2.2 *Protection.* Spectacles shall provide protection to the eye from flying objects and, where required, from glare and injurious radiations. Spectacles without side shields are intended to provide frontal eye protection only. Where side as well as frontal eye protection is required, the spectacles shall be provided with side shields. The edge

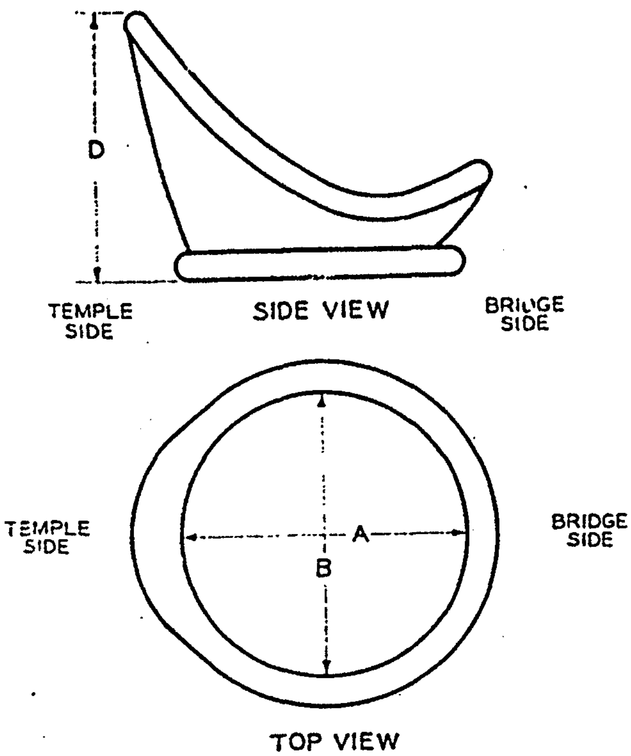

Fig. 2
Dimensions To Be Measured in Heat Deformation Test

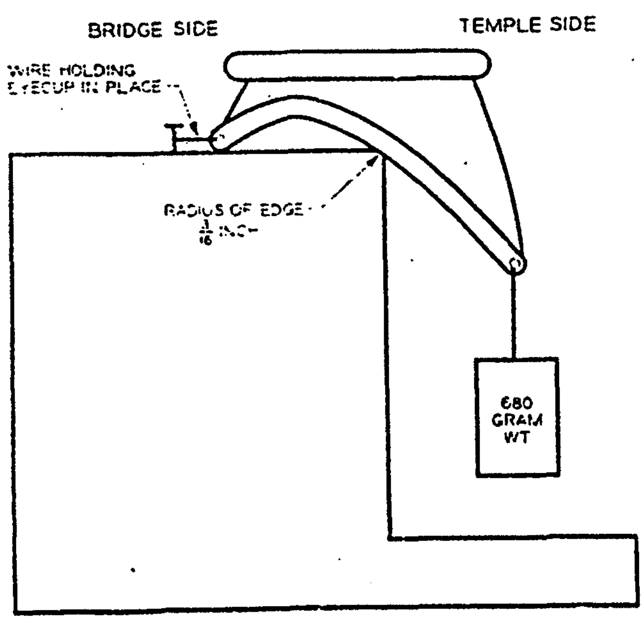

Fig. 3
Apparatus for Heat Deformation Test

of the side shield shall have a smooth finish or shall be padded.

6.1.2.3 *Marking.* These frames shall be designed for industrial exposure and shall bear a trade-mark identifying the manufacturer. Specific application for use will be found in Table 3. (See page 27.)

6.1.2.4 *Materials and Methods of Test*

6.1.2.4.1 General. In addition to the specific requirements outlined hereafter, materials used shall be capable of withstanding the disinfection, corrosion resistance, water absorption, and flammability tests outlined in 6.2.

6.1.2.4.2 Strength of Lens Containers. That portion of the frame which supports the lenses shall be of sufficient strength to withstand, without breakage and without dislodging the lens, the fracture-resistance test for lenses specified in 6.3.4.2.

6.1.2.4.3 Strength of Soldered Joints (Metal-Frame Spectacles). The soldered or brazed joints shall be given the following tests to demonstrate their strength and durability. The lens containers with lenses in place shall be gripped one in each hand, with the thumbs bearing on the outer surface near the bridge and the fingers on the inner surface of the lenses near the junction of the bridge and the lens container. The frames shall then be bent, the direction of motion being in a plane perpendicular to surface of the lenses, until the outer surfaces of the lenses face each other, the outer ends of the frames touching. The frames shall then be bent back to their original shape and a careful inspection made for failure in the joints. All frames tested shall pass this test without developing visible joint fracture.

6.1.2.4.4 Flat Transverse Test (Metal-Frame Spectacles). The right-lens container of each frame tested shall be laid flat, with the outer surface of the lens downward, on a firm, level support so that the left lens and one half of the bridge project beyond the edge of the support, and it shall be held in this position. A spring balance shall be attached to the outermost portion of the frame of the left lens, and a downward force of 8 ounces shall be applied while the right-lens frame is rigidly held. After removal of the load no permanent deformation shall be apparent in the frame.

6.1.2.4.5 Edge Transverse Test (Metal-Frame Spectacles). The right-lens container of each frame tested shall be held vertically in one hand and the lower edge of the left-lens container, as worn, shall be pressed against one of the platforms of an equal-arm balance having a weight of 3 pounds on the other platform. The pressure shall be increased until the weight is balanced, whereupon the frame shall be removed and examined. No permanent deformation shall be apparent in the frame.

6.1.3 *Goggles, Flexible Fitting*

6.1.3.1 *Description.* Goggles shall consist of a frame (composed of a flexible, chemical-resistant, nontoxic, nonirritating, and slow-burning material, forming a lens holder), lenses, and a positive means of support on the face such as an adjustable headband of suitable material to retain the frame comfortably and snugly in place in front of the eyes. The lens holder shall be such that the lenses are held firmly and tightly and may be removed or replaced without the use of tools. The goggles may be ventilated or not, as required by their intended use. Where chemical goggles are ventilated, the openings shall be such as to render the goggles splashproof.

6.1.3.2 *Protection.* Goggles shall provide eye protection from fine dusts, fumes, liquids, splashes, mists, and spray.

6.1.3.3 *Application.* Specific application for use of flexible fitting goggles will be found in Table 3.

6.1.3.4 *Materials and Methods of Test.* Plastic lenses used in flexible fitting goggles shall be not less than 0.050 inch in thickness. Materials used shall be capable of withstanding the disinfection, corrosion resistance, water absorption, and flammability tests outlined in 6.2.

6.1.4 *Goggles, Plastic Eyeshield*

6.1.4.1 *Description.* The goggles shall consist of a frame of plastic material, lens or lenses, and a means of support such as an adjustable headband to retain the goggles in front of the eyes. The frame and lens need not be of the same material. The lens need not be an integral part of the goggles. The frame may be translucent, clear, or opaque, and may be ventilated or not, as required by its intended use. The edge of the frame which bears against the face shall have a smooth surface free from roughness or irregularities which might cause discomfort to the wearer.

6.1.4.2 *Protection.* The goggles shall provide protection against flying objects and, where required, against glare and injurious radiations. Where the goggles are used for protection against injurious light radiation, the lenses and frames shall meet the requirements of Table 2 (see page 26) and the frames shall prevent the passage of injurious light rays.

6.1.4.3 *Application.* Specific application for use of plastic eyeshield goggles will be found in Table 3. (See page 27.)

6.1.4.4 *Design.* Goggles shall be so designed as to cover completely the eye sockets and the facial area immediately adjacent to and surrounding the eyes of the wearer to protect the eye from side exposure. Where required, the design shall be such that the goggles will fit over ordinary spectacles worn by the wearer. Goggles shall be so designed as to afford an effective angle of vision of not less than 105 degrees, assuming that the pupil of the eye is located 17 millimeters behind the inner surface of the lens. When lenses are not an integral part of the frame, the method of attachment of lens to frame shall be such that the lens will not be inwardly dislodged from its seat when it is subjected to the fracture-resistance tests specified in 6.3.4.2.

6.1.4.5 *Materials and Methods of Test.* Where plastic lenses are used in plastic eyeshield goggles, they shall be not less than 0.050 inch in thickness. If glass lenses are used, they shall be not less than 3.0 millimeters nor more than 3.8 millimeters in thickness. Materials used shall be capable of withstanding the disinfection, corrosion resistance, water absorption, and flammability tests outlined in 6.2.

6.1.5 *Spectacles, Plastic Eyeshield*

6.1.5.1 *Description.* Spectacles shall consist of a frame of metal, fiber, or plastic material, plastic lens or lenses, and temples or other suitable means of support to retain the frame before the eyes. The lens or lenses need not be an integral part of the frame. The spectacles shall have side shields, if required by their intended use.

6.1.5.2 *Protection.* Spectacles shall provide protection to the eye from flying objects and, where required, from glare and injurious radiation. Spectacles without side shields provide frontal eye protection only. Where side as well as frontal eye protection is required, the spectacles shall be provided with side shields.

6.1.5.3 *Application.* Specific application for use of plastic eyeshield spectacles will be found in Table 3. (See page 27.)

6.1.5.4 *Materials and Methods of Test.* Plastic lenses used in plastic eyeshield spectacles shall be not less than 0.050 inch in thickness. Materials used shall be capable of meeting the applicable requirements and withstanding the tests outlined in 6.2 and 6.3.

6.1.6 *Goggles, Foundrymen's*

6.1.6.1 *Description.* Goggles shall consist of a mask made of a flexible, nonirritating, and noncombustible or slow-burning material, such as leather or flexible plastic, metal lens holders attached thereto, lenses, and a positive means of support on the face, such as an adjustable headband, to retain the mask comfortably and snugly in place in front of the eyes.

The edge of the mask in contact with the face shall be provided with a binding of corduroy or other suitable material. The lens holders shall be so designed that the lenses are held firmly and tightly and may be readily removed or replaced. The lens holders shall be ventilated to permit circulation of air. Ventilation openings shall exclude a spherical particle 0.04 inch in diameter. For protection against heavy concentrations of dust, the use of a fine-mesh screen lining (e.g., 100-mesh screen) is recommended. Such lining shall be suitably and permanently fastened to the inside surface of each lens holder assembly.

6.1.6.2 *Protection.* The goggles shall provide protection against impact and hot-metal splash hazards encountered in foundry operations such as melting, pouring, chipping, babbitting, grinding, and riveting. Where required, they shall also provide protection against dusts.

6.1.6.3 *Application.* Specific application for use of foundrymen's goggles will be found in Table 3. (See page 27.)

6.1.6.4 *Materials and Methods of Test.* Materials used shall be capable of withstanding the disinfection, corrosion-resistance, water-absorption, and flammability tests outlined in 6.2.

6.2 Materials and Methods of Test of Protectors

6.2.1 *Materials.* Materials used in the manufacture of eye protectors shall combine mechanical strength and lightness of weight to a high degree, shall be nonirritating to the skin when subjected to perspiration, and shall withstand frequent disinfection by the methods hereinafter prescribed. Where metals are used they shall be inherently corrosion resistant.

6.2.2 *Disinfection.* All materials shall be such as to withstand, without visible deterioration or discoloration, washing in detergents and warm water, rinsing to remove all traces of detergent, and disinfection by the following methods:

(1) Immersion for 10 minutes in a solution of formalin made by placing one part of 40 percent formaldehyde solution in 9 parts of water at a room temperature of 68 F.

(2) Subjection to a moist atmosphere of formaldehyde for a period of 10 minutes at a room temperature of 68 F.

(3) Immersion for 10 minutes in a solution of modified phenolics, hypochlorite, or quaternary ammonium compounds in strength specified by the manufacturer at a room temperature of 68 F.

6.2.3 *Corrosion Resistance.* Metal parts shall be tested for corrosion resistance by placing them in a boiling aqueous 10-percent (by weight) solution of sodium chloride for a period of 15 minutes. The parts upon being removed from this solution shall be immediately immersed in a 10-percent (by weight) aqueous solution of sodium chloride at a room temperature of 68 F. They shall then be removed from this solution and, without wiping off the adhering liquid, allowed to dry for 24 hours at room temperature. The metal parts shall then be rinsed in lukewarm water and allowed to dry. On visual inspection, the metal parts shall show no signs of roughening of the surface resulting from corrosion.

6.2.4 *Water Absorption.* Plastic parts shall be tested for water absorption and the results calculated in accordance with Test Method No. 7031 of Federal Specification L-P-406 (see Appendix). The amount of the water absorbed shall not exceed 5 percent.

6.2.5 *Flammability*

6.2.5.1 *Eyecup Goggles.* Eyecup goggles shall be tested for flammability by use of a ⅝-inch-diameter Bunsen burner, adjusted for a ¾-inch-high nonluminous flame of commercial natural gas (1,000-1,200 British thermal units). The temple side of the specimen shall be held at the tip of this flame in a draft-free room and the time (in seconds) required to ignite the material so that it will remain burning after the flame is removed shall be determined. The time required to ignite the specimen in the manner described shall be not less than 4 seconds.

6.2.5.2 *All Other Types.* Where plastic materials are used, such materials shall be slow burning. Cellulose nitrate, or materials having flammability characteristics approximating those of cellulose nitrate, shall not be used. Flammability of the materials shall be no greater than that exhibited by cellulose acetate or acetate butyrate.

6.3 Lenses

6.3.1 *Types of Lenses.* Lenses intended for use in protectors covered by this code shall comprise three basic types as follows:

(1) *Clear Lenses.* Impact resisting, providing protection against flying objects

(2) *Filter Lenses.* Impact resisting, providing protection against

(a) Flying objects, glare, and injurious radiation

(b) Flying objects and glare

(3) *Protective-Corrective Lenses,* either clear or filter, as specified, for persons having defective vision.

6.3.2 *General Requirements*

6.3.2.1 *Optical Quality.* All lenses shall be made of material suitable for ophthalmic use and both surfaces of the lenses shall be well polished and free from visible surface defects. The lenses shall be free from striae, bubbles, waves, and other visible defects and flaws which would impair their optical quality.

6.3.2.2 *Prismatic and Refractive Power.* The prismatic effect of a noncorrective lens shall not exceed 1/16 prism diopter (2 minutes angular deviation). The refractive power, in any meridian, of any noncorrective lens shall not exceed plus or minus 1/16 diopter. The difference in refractive power of any two meridians shall not exceed 1/16 diopter.

6.3.2.3 *Size Tolerances.* Circumferential tolerances of lenses shall be held sufficiently close to permit interchangeability or replacement in their respective frames.

6.3.2.4 *Edges.* The edges of the lenses shall be smooth and, where required, lenses shall be bevelled and such bevelled edges shall be dull finished.

6.3.2.5 *Haze.* Lenses of all types shall exhibit not more than 6 percent haze when tested in accordance with the requirements of Federal Specification L-P-406 (see Appendix).

6.3.2.6 *Lenses for Persons Having Defective Vision.* Employees whose vision requires the use of corrective lenses in spectacles and who are required by these rules to wear protective goggles shall be provided with goggles of one of the following types:

(1) Goggles whose protective lenses provide the proper optical correction and withstand the drop test specified in 6.3.4. (Such lenses are exempted from the requirements for parallelism of surfaces. Minimum thickness of prescription lenses shall be 3.0 millimeters, except in the case of lenses of strong plus power, when the edge thickness may be reduced to 2.5 millimeters, provided they meet the impact test specified in 6.3.4.)

(2) Goggles which can be worn over corrective spectacles without disturbing the adjustment of the spectacles.

(3) Goggles which incorporate corrective lenses mounted inside the protective lenses.

6.3.3 *Detailed Requirements*

6.3.3.1 *Lens Thickness.* Glass or plastic lenses for use in eyecup goggles, metal- or plastic-frame spectacles, or foundrymen's goggles shall be not less than 3.0 millimeters, nor more than 3.8 millimeters in thickness.

Plastic lenses for use in flexible-fitting goggles, plastic-eyeshield goggles, or plastic-eyeshield spectacles shall be not less than 0.050 inches in thickness.

6.3.3.2 *Marking.* Each lens shall be distinctively marked in a manner by which the manufacturer may be identified. Such marking shall be clear and permanent and so placed as not to interfere with the vision of the wearer. In addition, each filter lens shall be marked with the shade number.

6.3.3.3 *Transmittance*

6.3.3.3.1 Filter Lenses. Filter lenses shall meet the radiant-energy-transmission requirements hereinafter specified (see Table 2, page 26), and shall be uniform in luminous (visible) transmittance within 20 percent. The dominant line shall be between 490 and 600 mu (millimicrons). Filter lenses shall be supplied in pairs. For shades 1.5 to 2, inclusive, both lenses of a pair shall have the same visible transmittance within 10 percent; for shades 2.5 and darker, both lenses of a pair shall have the same luminous transmittance within 20 percent.

6.3.3.3.2 Clear Lenses. Clear lenses shall transmit not less than 89 percent of the incident luminous radiation.

6.3.3.4 *Lens Strength.* All lenses shall be capable of withstanding the fracture resistance tests specified in 6.3.4.2.

6.3.4 ***Methods of Test and Examination of Lenses***

6.3.4.1 *Tests for Prismatic and Refractive Power and for Definition.* Lenses of all types shall be tested for prismatic and refractive power and for definition by any standard methods which are of sufficient accuracy for the purpose and are equivalent to the following National Bureau of Standards' methods: (See note below.)

6.3.4.1.1 Prismatic Power. The lenses may be tested for prismatic power with an 8-power telescope which has an effective aperture of 0.75 inch and is equipped with cross hairs in the focal plane of the ocular. The telescope is to be focused on an illuminated target at a distance of 35 feet from the telescope objective, comprising a central dot and a concentric circle 1 inch in diameter. The telescope is to be so aligned that the image of the central dot falls on the intersection of the cross hairs in the focal plane of the ocular. The lens is to be held in front of the objective lens of the telescope and, if the intersection point of the cross hairs falls without the image of the circle, the prismatic power of the goggle lens exceeds 1/8 prism diopter.

NOTE: Lenses may be checked for heat strengthening by means of a polariscope.

6.3.4.1.2 Refractive Power. The lenses may be tested for refractive power by any suitable instrument such as a vertometer, lensometer, or telescope. The lenses may be tested for refractive power with an 8-power telescope which has an effective aperture of 0.75 inch and is focused at a distance of 35 feet on an illuminated test chart. As a test chart, the resolving power chart pattern 20 of National Bureau of Standards Miscellaneous Publication M166 and National Bureau of Standards Circular C533 may be used. An advantage in adopting this chart is that by its use it becomes possible to provide all inspectors with identical charts, whereas if charts are improvised at different places they are likely to be different. The lens to be tested shall be placed in front of the telescope objective which is then brought to the sharpest possible focus. The pattern marked 20 should be clearly resolved with the target placed at a distance of 35 feet from the telescope objective used for testing lenses. The telescope is calibrated by successively locating the position of best focus with first a standard lens of plus 1/16 diopter in front of the objective and then with a standard lens of minus 1/16 diopter in front of the objective. These positions are marked by scratches on the draw tube or by other suitable index marks. The lens is to be held in front of the calibrated telescope and if the position of the best focus falls outside the index marks, the refractive power is in excess of 1/16 diopter.

6.3.4.1.3 Definition. The lenses may be tested for definition with an 8-power telescope which has an effective aperture of 0.75 inch and is focused at a distance of 35 feet on an illuminated test chart. As a test chart the resolving power chart pattern 20 of National Bureau of Standards Miscellaneous Publication M166 and National Bureau of Standards Circular C533 may be used. An advantage in adopting this chart is that by its use it becomes possible to provide all inspectors with identical charts, whereas if charts are improvised at different places they are likely to be different. The lens to be tested shall be placed in front of the telescope objective, which in turn is then brought to the sharpest possible focus. The pattern marked 20 should be clearly resolved with the target placed at a distance of 35 feet from the telescope objective used for testing lenses.

6.3.4.2 *Fracture Resistance—Lenses of All Types*

6.3.4.2.1 Lens in Frame. The frame with lens shall be supported on a wooden block of such size and shape as to fit the frame securely but not to touch the lens. A 7/8-inch-diameter steel ball, weighing approximately 1.56 ounces, shall be freely dropped from a height of 50 inches onto the horizontal upper surface of the lens. The edge of the lens shall not chip from the shock nor shall the lens be displaced from the frame.

6.3.4.2.2 Lens on Block. The lens shall be removed from the frame and placed horizontally on the end of a hardwood tube having an upper periphery conforming in shape and size to the lens to be tested and a wall thickness not greater than 3/16 inch. A washer of rubber packing not more than 1/8 inch thick and of the same shape and size as the end of the tube shall be placed between the lens and the tube. The rubber washer shall be of the quality required for a grade A gasket in Federal Specification HH-G-156. The 7/8-inch steel ball shall be freely dropped from a height of 50 inches onto the horizontal outer surface of the lens. The lens shall not fracture from the impact of the steel ball.

6.3.4.2.3 Breakage Pattern. As a test to determine the type of breakage pattern exhibited by a lens when subjected to a force sufficient to break it, a lens may be broken by increasing the height of drop of the 7/8-inch steel ball or by employing a heavier ball. If made of glass, the lens shall break predominately with radial cracks with a minor tendency toward concentric cracks. Any tendency to break with lines of cleavage parallel to the surface indicates an unsatisfactory heat treatment; and the lenses represented by that sample shall be considered as not conforming to these requirements.

6.3.4.3 *Penetration Resistance for Plastic Lenses.* The frame and lens shall be supported on a wooden block of such size and shape as to fit the frame securely. A pointed projectile of suitable size, consisting of a new Singer number 135 x 17 size 25 needle, fastened into a holder weighing approximately 1.56 ounces, shall be freely dropped, point downward, from a height of 50 inches onto the horizontal outer surface of the lens. The projectile may be guided, but not restricted, in its fall by being dropped through a tube extending to within approximately 4 inches of the lens. The lens shall not be pierced through from the impact.

6.3.4.4 *Haze.* Haze of all types of lenses shall be determined by test method No. 3021 of Federal Specification L-P-406, Plastics, Organic, General Specifications, Test Methods.

6.3.4.5 *Flammability.* Where plastic materials are used in lenses, such material shall be slow burning. Cellulose nitrate, or materials having flammability characteristics approximating those of cellulose nitrate, shall not be used.

6.3.4.6 *Ultraviolet, Luminous, and Infrared Transmittance.* The ultraviolet, luminous (total visible), and infrared transmittance of lenses of all types shall be determined by any standard method recognized as suitable by the National Bureau of Standards. The following methods are suggested:

6.3.4.6.1 Ultraviolet Transmittance. The source of radiant energy for determining the ultraviolet spectral transmittance shall be a quartz mercury arc or other source emitting an intense and preferably discontinuous spectrum. The intense emission lines of the quartz mercury arc at 313 mu, 334 mu, 365 mu, and 405 mu are conveniently distributed and well adapted for making these measurements. If other sources are used, the wavelengths closest to the above values of the mercury arc may be used.

6.3.4.6.2 Luminous Transmittance. The standard source of radiant energy used in the measurement of the luminous transmittance of filter lenses shall be a Projection Type Lamp No. T-8 (or other high-powered gas-filled tungsten filament incandescent lamp) operated at the color temperature (2854 K) corresponding to CIE[1] Source A. The luminous transmittance shall be determined by one of the following means:

(1) Photometrically by an observer having normal color vision, as determined by recognized color vision chart tests such as those employing pseudo-isochromatic plates;

(2) With a physical photometer consisting of a thermopile (or other radiometer) and a luminosity solution having a spectral transmittance curve which coincides closely with the luminous-efficiency curve of the average eye;

(3) By measuring the spectral transmittance and calculating the luminous transmittance through the use of published data on the spectral radiant energy of CIE Source A and the relative luminous efficiency of the average eye.

The standards of luminous transmittance maintained by the National Bureau of Standards are based on the latter method.

6.3.4.6.3 Infrared Transmittance. The same standard source of radiant energy used in determining the transmittance of luminous radiation shall be used also in the measurement of the transmittance of the total infrared radiation. One of the following methods shall be used for determining the total infrared transmittance:

(1) By observing the infrared spectral-energy distribution curves of a gas-filled lamp, with and without the lens placed before the entrance slit of the spectrometer, and integrating the area under each of the two curves between the spectral limits of 700 mu and 4000 mu.

(2) By observing the integrated transmittance with a physical radiometer (e.g., a thermopile) covered with a deep red filter (e.g., Corning 2404) which has a high and uniform transmittance through the infrared spectrum and transmits less than 0.5 percent of the luminous radiation.

The latter method is employed at the National Bureau of Standards in the test of welding glass for government purchase.

[1] International Commission on Illumination

Table 2

Transmittances and Tolerances in Transmittance of Various Shades of Filter Lenses

Shade Number	Optical Density			Luminous Transmittance			Maximum Infrared Transmittance	Maximum Spectral Transmittance in the Ultraviolet and Violet			
	Maximum	Standard	Minimum	Maximum	Standard	Minimum		313 mu	334 mu	365 mu	405 mu
				Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
1.5	0.26	0.214	0.17	67	61.5	55	25	0.2	0.8	25	65
1.7	0.36	0.300	0.26	55	50.1	43	20	0.2	0.7	20	50
2.0	0.54	0.429	0.36	43	37.3	29	15	0.2	0.5	14	35
2.5	0.75	0.643	0.54	29	22.8	18.0	12	0.2	0.3	5	15
3.0	1.07	0.857	0.75	18.0	13.9	8.50	9.0	0.2	0.2	0.5	6
4.0	1.50	1.286	1.07	8.50	5.18	3.16	5.0	0.2	0.2	0.5	1.0
5.0	1.93	1.714	1.50	3.16	1.93	1.18	2.5	0.2	0.2	0.2	0.5
6.0	2.36	2.143	1.93	1.18	0.72	0.44	1.5	0.1	0.1	0.1	0.5
7.0	2.79	2.571	2.36	0.44	0.27	0.164	1.3	0.1	0.1	0.1	0.5
8.0	3.21	3.000	2.79	0.164	0.100	0.061	1.0	0.1	0.1	0.1	0.5
9.0	3.64	3.429	3.21	0.061	0.037	0.023	0.8	0.1	0.1	0.1	0.5
10.0	4.07	3.857	3.64	0.023	0.0139	0.0085	0.6	0.1	0.1	0.1	0.5
11.0	4.50	4.286	4.07	0.0085	0.0052	0.0032	0.5	0.05	0.05	0.05	0.1
12.0	4.93	4.714	4.50	0.0032	0.0019	0.0012	0.5	0.05	0.05	0.05	0.1
13.0	5.36	5.143	4.93	0.0012	0.00072	0.00044	0.4	0.05	0.05	0.05	0.1
14.0	5.79	5.571	5.36	0.00044	0.00027	0.00016	0.3	0.05	0.05	0.05	0.1

Table 3

Selection of Eye- and Face-Protective Devices

Hazard Involved	Part To Be Protected	Permissible Protective Devices	
		Type	Reference
Relatively large flying objects	Eyes, Face	Goggles	6.1.1, 6.1.4, and 6.1.6
		Spectacles	6.1.2, 6.1.5
		Face shields	5.3.3
Dust and small flying particles	Eyes, Face	Goggles	6.1.1, 6.1.4, and 6.1.6
		Spectacles	6.1.2, 6.1.5
		Face shields	5.3.3
Dust and wind	Eyes	Goggles	6.1.1, 6.1.4
		Spectacles	6.1.2, 6.1.5
Molten metal	Eyes, Face	Goggles	6.1.1, 6.1.4, and 6.1.6
		Spectacles	6.1.2, 6.1.5
		Face shields	5.3.3
Gases, fumes, and smoke	Eyes, Face	Goggles	6.1.3, 6.1.4
Liquids	Eyes, Face	Goggles	6.1.3, 6.1.4
		Face shields	5.3.3
Reflected light or glare	Eyes	Goggles	6.1.4
		Spectacles	6.1.2, 6.1.5
Injurious radiant energy (moderate)	Eyes	Goggles	6.1.1
		Helmets	All described in 5.2
		Hand shields	All described in 5.2.4.2
		Face shields	5.3.3 (must include crown protector and chin protector)
Injurious radiant energy (intense)	Eyes, Face	Helmets	All with spectacles described in 6.1.2
		Hand shields	All with spectacles described in 6.1.2.

7. Respiratory Protection

7.1 Classification of Hazards. Hazardous atmospheres fall into the following broad groupings:

- Oxygen deficiency
- Gaseous contaminants:
  - Immediately dangerous to life
  - Not immediately dangerous to life
- Particulate contaminants (dusts, fumes, mists, fogs)
- Combination of gaseous and particulate contaminants
  - Immediately dangerous to life
  - Not immediately dangerous to life

7.1.1 ***Oxygen Deficiency.*** The oxygen content of normal air is about 20.9 percent by volume. Atmospheres in confined spaces such as wells, mines, holds of ships, tanks, and burning buildings may contain a lower percentage of oxygen because of dilution or displacement of the air by other gases or vapors, or because of the loss of oxygen by its reaction with, or absorption by, other substances. When the oxygen content of the air is about 16 percent, the flame of a safety lamp will be extinguished. Below this concentration, a person breathing the air exhibits symptoms ranging from increased volume of breathing and acceleration of pulse rate to unconsciousness and death, depending on the oxygen content of the air and the degree of his physical activity.

7.1.2 ***Gaseous Contaminants.*** Gaseous contaminants may be classified into two broad groups as follows: toxic and inert. The toxic or poisonous gases may produce harmful or objectionable response in man in relatively low concentrations, whereas the inert gases produce undesirable effects primarily by displacement of oxygen. The term "gases" as used here applies equally to gaseous substances (such as nitrogen, carbon monoxide, and carbon dioxide) and the vapors of volatile substances (such as benzene and carbon tetrachloride).

The toxicity of gases and vapors for man varies over a wide range. For instance, a 10-minute exposure to a concentration of 120 parts per million (ppm) of phosgene may be fatal, whereas one may safely breathe 1,000 ppm of dichlorodifluoro-methane (freon) throughout a working day.

7.1.2.1 *Gaseous Contaminants Immediately Dangerous to Life.* Gaseous contaminants immediately dangerous to life are gases present in concentrations that would endanger the life of a person breathing them for even a short period of time. For example, 400 to 500 parts of sulfur dioxide per million parts of air (0.04 to 0.05 percent) by volume is considered to be dangerous for a short exposure.

7.1.2.2 *Gaseous Contaminants Not Immediately Dangerous to Life.* Gaseous contaminants not immediately dangerous to life are gases present in concentrations that could be breathed for a short period without endangering the life of a person breathing them, but which might produce discomfort and possible injury after a prolonged single exposure or repeated short exposures. For instance, the threshold limit value for sulfur dioxide has been set at 5 ppm, based primarily on the irritating effect of this gas on the nose, eyes, and throat.

7.1.3 *Particulate Contaminants (Dusts, Fumes, Smokes, Mists, Fogs).* Particulate contaminants may be classified, according to their mode of action, into three broad groups as follows: (1) Toxic particulate contaminants that may pass from the lungs into the blood stream and are carried to the various parts of the body to exert their injurious effects. These effects may be chemical irritation, systemic poisoning, neoplasms (tumors), or such effects as hay fever, asthma, or simple febrile reactions. (2) Fibrosis-producing dust, such as asbestos and free silica, or other pneumoconiosis-producing dusts that are not taken up by the blood stream but remain in the lungs and may cause significant pulmonary impairment. (3) Nontoxic and nonfibrosis-producing particles (so-called nuisance dusts and mists) that may dissolve and pass directly into the blood stream or may remain in the lungs producing neither local nor systemic effects.

Particulate contaminants may be classified according to their physical properties into three broad groups as follows: (1) solid, such as dusts and fumes; (2) liquid, such as mists and fogs; and (3) a combination of solid and liquid, such as silica-water sprays and paint sprays.

The majority of particulate contaminants are not immediately dangerous to life; that is, days, weeks, or even years of exposure may transpire before harmful effects are noted. Notable exceptions are dusts and mists containing the organic phosphorus insecticides which, if present in high concentrations, may incapacitate or even kill a man in a very short time. Other exceptions to this generalization are certain radioactive particulates and the toxic war smokes such as diphenylchloroarsine (DA) and diphenylaminechloroarsine (DM).

7.1.4 *Combination of Gaseous and Particulate Contaminants.* In addition to atmospheres containing gaseous or particulate contaminants, there are those in which both types occur simultaneously. The contaminants may be entirely different substances, such as carbon monoxide and oxides of nitrogen produced by blasting and the dust from the blasted material, or they may be the same substance in the liquid and in the vapor form, such as slightly volatile liquids that are atomized. The simultaneous occurence of both gaseous and particulate contaminants in an atmosphere complicates the procedure for providing adequate respiratory protection against them.

7.2 Classification of Respiratory Protective Devices. Respiratory protective devices fall into the following broad groupings on the basis of their mode of functioning:

- Atmosphere-supplying respirators
  - Self-contained type
  - Hose type
- Air-purifying respirators
  - Gas masks or chemical cartridge respirators
  - Self-rescue-type respirators
  - Dispersoid (dust, fume, mist) respirators
  - Combination gas and dispersoid respirators

A more detailed classification, brief description, and the limitations of the various types of respirators follow:

7.2.1 *Atmosphere-Supplying Respirators.* Atmosphere-supplying respirators provide a respirable atmosphere to the wearer independent of his immediate atmospheric environment. They may be divided into two main subgroups: self-contained breathing apparatus and hose-type respirators.

7.2.1.1 *Self-Contained Breathing Apparatus.* A self-contained breathing apparatus is a respirator by means of which the user may obtain respirable air or oxygen from a supply of air, oxygen, or oxygen-generating material which is an integral part of the respirator as worn. Self-contained breathing apparatus may be divided into two main subgroups: recirculating-type and demand-type.

7.2.1.1.1 Recirculating-Type Self-Contained Breathing Apparatus. Recirculating-type self-contained breathing apparatus may furnish respirable oxygen to the wearer from either (1) a cylinder of compressed oxygen or (2) a canister containing an oxygen-generating material.

(1) *Compressed Oxygen Type.* The mode of functioning of the compressed-oxygen type is as follows: High-pressure oxygen from the cylinder passes through a pressure-reducing-and-regulating valve and an admission valve into a breathing bag from which the wearer inhales through a corrugated breathing tube connected to a mouthpiece or facepiece through a one-way check valve. The wearer's exhaled breath passes through another check valve and corrugated breathing tube to a container of chemical which removes the exhaled carbon dioxide. It then passes through a cooler and enters the breathing bag. In normal use, oxygen enters the breathing bag from the supply cylinder only when the volume of gas in the bag has decreased sufficiently to allow a pressure plate to act upon the admission valve which then admits oxygen until the wearer exhales. In the event that the pressure-reducing-and-regulating valve or the admission valve does not function properly, oxygen may be admitted directly from the oxygen cylinder to the bag through a manually operated by-pass valve. Suitable pressure-release and saliva traps are provided.

(2) *Self-Generating Type.* The mode of functioning of the self-generating type is as follows: Water vapor in the wearer's exhaled breath reacts with the granular chemical fill of the canister to liberate oxygen which then enters the breathing bag from which the wearer inhales through a corrugated breathing tube connected to a facepiece. Check valves maintain a unidirectional flow of gases in the closed system. The rate of evolution of oxygen is governed by the volume rate of breathing of the wearer. Exhaled carbon dioxide is removed by the canister. A suitable manually operated pressure-relief valve is provided.

7.2.1.1.2 Demand-Type Self-Contained Breathing Apparatus. Demand-type self-contained apparatus is designed to supply air or oxygen to the wearer. These gases are not to be used interchangeably; that is, oxygen should never be used in an apparatus designed for compressed air, and vice versa.

The mode of functioning of the demand-type self-contained breathing apparatus is as follows: Oxygen or air is admitted to the facepiece from a cylinder of the compressed gas through a two-stage pressure-reducing mechanism only when the wearer inhales, and in quantities governed by his breathing. The wearer's exhaled breath escapes to the surrounding atmosphere.

7.2.1.1.3 Limitations of Self-Contained Breathing Apparatus. The self-contained breathing apparatus has no limitation as to the concentration of gas or particulate matter or as to a deficiency of oxygen in the atmosphere in which it is worn. However, many gases are very irritating to the skin and to mucous membranes when present in high concentrations; and hydrocyanic acid gas can be absorbed in dangerous amounts through the unbroken skin. The wearer has complete freedom of movement, and may leave the work area through any available exit. The length of time that he may remain in the irrespirable atmosphere is dependent upon the amount of oxygen or air made available to him by the apparatus and upon his activity. Self-contained breathing apparatuses are rated according to whether they will protect for two hours, one hour, three quarters of an hour, or one-half hour while doing heavy work. If this type of respirator is to be used safely and with confidence, rather extensive training is required not only in its care and use but also in an understanding of its limitations.

7.2.1.2 *Hose-Type Atmosphere-Supplying Respirators.* Hose-type atmosphere-supplying respirators make air available to the wearer through a hose connected to a supply of respirable air. They may be divided into four main subgroups: (1) hose mask with blower, (2) hose mask without blower, (3) air-line respirator, and (4) abrasive-blasting respirator.

7.2.1.2.1 Hose Mask with Blower. The hose mask with blower (Type A supplied-air respirator) consists of a full facepiece to which respirable air is forced through a large-diameter flexible hose by a hand or motor-operated blower, and through which the wearer can inhale whether or not the blower is operated. Check valves allow air flow only toward the facepiece. The hose is attached to the wearer's body by means of a rugged safety harness which has provision for the attachment of a safety line; with this harness and line the wearer may be drawn to safety in an emergency. Usually, the hose mask with blower is designed so that two facepiece-harness-and-hose assemblies may be attached to a single, double-outlet blower.

7.2.1.2.2 Limitations of Hose Mask With Blower. The hose mask with blower (Type A supplied-air respirator) has no limitations as to concentration of gas or particulate matter or a deficiency of oxygen in the atmosphere in which it is worn. However, many gases are very irritating to the skin and mucous membranes when present in high concentrations; and hydrocyanic acid gas can be absorbed in dangerous amounts through the unbroken skin. The wearer is limited by the length of the air-supply hose to travel within 150 feet of the blower which must be in respirable air. He must return to fresh air by retracing his route in the contaminated atmosphere, otherwise the air-supply hose would become entangled. It provides respiratory protection for an unlimited period.

7.2.1.2.3 Hose Mask Without Blower. The hose mask without blower (Type B supplied-air respirator) consists of a full facepiece to which a supply of respirable air may be drawn through a large-diameter flexible hose by the wearer's breathing effort. Check valves allow air flow only toward the facepiece. The hose is attached to the wearer's body by a suitable harness. The air-inlet end of the hose is provided with a fine-mesh screen to prevent entrance of coarse particulate matter and with a means of anchoring the inlet in respirable air.

7.2.1.2.4 Limitations of Hose Mask Without Blower. The hose mask without blower (Type B supplied-air respirator) is limited to use in any atmosphere from which the wearer can escape unharmed without the aid of the respirator. The wearer is limited by the length of the air-supply hose to travel within 75 feet of an assured source of respirable air in which the air-inlet end of the hose must be placed. It provides respiratory protection for an unlimited period.

7.2.1.2.5 Air-Line Respirator. Air-line respirators (Type C supplied-air respirators) consist of a half-mask facepiece, full facepiece, or a loose-fitting helmet or hood to which respirable air is supplied through a small-diameter hose. They may be divided into two classes: (1) continuous-flow class and (2) demand class.

7.2.1.2.5.1 Continuous-Flow Class Air-Line Respirator. Continuous-flow class air-line respirators (Type C and CE supplied-air respirators) supply a continuous flow of respirable air to the facepiece, helmet, or hood through a small-diameter hose. The wearer's exhaled air and the excess air entering the facepiece, helmet, or hood covering escapes to the surrounding atmosphere. Provision is made for attaching the air-supply hose to the wearer and for detaching the air-supply hose rapidly in an emergency. The respirator is designed to allow at least 4 cubic feet of air per minute to enter the facepiece and at least 6 cubic feet of air per minute to enter the helmet or hood.

7.2.1.2.5.2 Abrasive-Blasting Respirator. The principle of operation of the abrasive-blasting respirator (Type CE supplied-air respirator) is the same as that of the continuous-flow class air-line respirator. However, it is constructed so that it will protect the head and the neck of the wearer and the eyepiece of the respirator from the rebounding abrasive. The respirator is designed to allow at least 4 cubic feet of air per minute to enter the facepiece and at least 6 cubic feet of air per minute to enter the helmet or hood. Only a full facepiece or hood and helmet is used with this respirator.

7.2.1.2.5.3 Demand-Class Air-Line Respirator. Demand-class air-line respirators (Type C supplied-air respirators) supply respirable air to the facepiece only when the wearer inhales, and at a rate governed by his volume rate of breathing. A source of respirable air, either an air compressor or a container of compressed air, is attached by a small-diameter hose to a demand valve which is actuated by a slight negative pressure created when the wearer inhales. Upon actuation, it allows air to flow to the facepiece through a flexible corrugated breathing tube. Upon exhalation, the demand valve closes and permits no air to flow to the respirator. The exhaled breath escapes to the surrounding atmosphere through an exhalation valve or valves. The demand valve is attached to the wearer so as to allow the air-supply line to be dragged behind the wearer without exerting a pull on the facepiece. Provision is made for detaching the air-supply hose rapidly in an emergency. Helmets or hoods are not used with this respirator.

7.2.1.2.6 Limitations of Air-Line Respirators. The air-line respirator (Type C supplied-air respirator) and the abrasive-blasting respirator (Type CE supplied-air respirator) are limited to use in concentrations of gases or vapors that are not immediately harmful or from which the wearer can escape unharmed without the aid of the respirator. They are not to be worn in an oxygen-deficient atmosphere. The wearer's travel is limited by the length of the air-supply hose, and he must retrace his route in the contaminated atmosphere to return to fresh air while wearing the respirator. These respirators shall be used within the limits set by the manufacturer for air-supply hose length and range of air pressure applied to the inlet of the air-supply hose. They provide respiratory protection for an unlimited period.

7.2.2 *Air-Purifying Respirators.* Air-purifying respirators remove gaseous or particulate contaminants, or both, from otherwise respirable air that is inhaled by the wearer. They may be divided into three classes: (1) chemical-filter type, (2) mechanical-filter type, and (3) combination chemical- and mechanical-filter type.

7.2.2.1 *Chemical-Filter Respirators.* Chemical-filter respirators such as gas masks, chemical-cartridge respirators (non-emergency gas respirators), and self-rescue-type respirators remove toxic gases and vapors from inspired air by sorption, chemical reaction, or oxidation by the granular fill of the canister or cartridge. The exhaled breath escapes to the surrounding atmosphere.

7.2.2.1.1 Gas Masks. Gas masks consist of a canister, containing the appropriate granular fill, a full facepiece, and a body harness to hold the canister securely in place on the body of the wearer. The inspired air is drawn through the canister and enters the facepiece in such a manner as to inhibit the accumulation of moisture on the eyepieces. A check valve prevents exhaled breath from entering the canister and allows it to be forced out through an exhalation valve in the facepiece to the surrounding atmosphere. The facepiece is held securely to the wearer's face by an elastic head harness. Universal gas masks have an indicator or timer which shows when the canister should be changed for protection against carbon monoxide.

Gas masks are designed to provide respiratory protection against a single specific gas such as chlorine, a single class of gases or vapors such as organic vapors, or a combination of two or more classes of gases or vapors such as acid gases and organic vapors or all gases and vapors. The canisters of many types of gas masks are manufactured in two sizes, namely, regular or "industrial size," and the large or "supersize" canisters. Everthing else being equal, the large canister provides a longer service time than the regular size between changes of canisters, but the limitations of both in regard to maximum concentration of gas against which they will protect are the same. In most cases, a canister designed for a single gas or a single class of gases and vapors will afford respiratory protection for a considerably longer period than will a canister of the same size designed for protection against a multiplicity of gases and vapors.

Gas-mask canisters manufactured in the United States of America are marked in bold letters with the name of the atmospheric contaminants for which the canister is intended or with the words "UNIVERSAL GAS-MASK CANISTER" in capitals, as well as being given a distinctive color in accordance with the American Standard Safety Code for Identification of Gas-Mask Canisters, K13.1-1950. These colors serve as an aid to rapid identification of canisters. The table from 6.1 of the above code is reproduced here for ready reference (see Table 4).

Table 4

Color Code for Gas-Mask Canisters

Canister, Type Letter	Atmospheric Contaminants To Be Protected Against	Color Assigned[1]
A	Acid gases	White[2]
A	Hydrocyanic acid gas	White with ½-inch green stripe around the canister near the botton
A	Chlorine gas	White with ½-inch yellow stripe around the canister near the bottom
B	Organic vapors	Black[2]
C	Ammonia gas	Green
D	Carbon monoxide	Blue
AE, etc	Dust, fumes, mists, fogs, and smokes in combination with any of the above gases or vapors	½-inch contrasting black or white stripe around the canister near the top
AB	Acid gases and organic vapors	Yellow
ABC	Acid gases, organic vapors, and ammonia gas	Brown
N	All of the above atmospheric contaminants	Red. Filters are included in this canister, but stripes to indicate them are unnecessary.

NOTE 1: Gray shall not be assigned as the color for any gas-mask canister.

NOTE 2: Canisters for a single gas or vapor other than ammonia or carbon monoxide shall have a ½-inch colored stripe around the canister near the bottom.

7.2.2.1.2 Limitations of Gas Masks. The gas mask is limited to use in atmospheres containing at least 16 percent of oxygen and not more than 2 percent of most toxic gases (3 percent of ammonia). Many gases are very irritating to the skin and to the mucous membranes when present in these maximum concentrations; and hydrocyanic acid gas can be absorbed in dangerous amounts through the unbroken skin, its effects depending mainly upon the concentration of the gas and the duration of the exposure. The wearer has complete freedom of movement. A gas mask provides respiratory protection for a period that depends on the type of canister, the concentration of the gas, and the activity of the wearer. A gas mask with canister for protection against carbon monoxide should have an indicator to show when the canister is to be replaced. No practicable method is available to warn the wearer of leakage of relatively odorless gases through the canister. It is important that the proper gas-mask canister be used for the intended purpose. For instance, an ammonia gas-mask canister will not afford respiratory protection against acid gases, organic vapors, or carbon monoxide.

7.2.2.1.3 Chemical-Cartridge Respirators. Chemical-cartridge respirators (non-emergency gas respirators) consist of a half-mask facepiece to which is attached one or two cartridges. Like canisters, the cartridges are filled with granular materials that remove gases or vapors from the air drawn through them. Check valves prevent exhaled breath from entering the cartridges and allow it to be forced out through an exhalation valve in the facepiece to the surrounding atmosphere. The facepiece is held securely to the wearer's face by elastic headbands. The cartridges are usually designed to provide respiratory protection against single gases or vapors or against single classes of gases and vapors. They are easily removed and replaced.

7.2.2.1.4 Limitations of Chemical-Cartridge Respirators. The chemical-cartridge respirator (non-emergency gas respirator) is limited to use in atmospheres that are not immediately dangerous to life; hence, it shall not be worn in an atmosphere deficient in oxygen. The wearer has complete freedom of movement. A chemical-cartridge respirator provides respiratory protection for a period that depends on the type of cartridge used, the concentration of the gas or vapor, and the wearer's activity. Its use is limited to low concentrations of certain gases and vapors such as a maximum of 0.1 percent (1,000 ppm) of organic vapors. It should not be used for protection against (1) harmful gases or vapors that cannot be detected by the sense of smell; (2) gases or vapors that are highly toxic in low concentration, such as phosgene and arsine; or (3) concentrations of gases and vapors that are highly irritating to the eyes. It is important that the proper chemical cartridge be used for the intended purpose; for instance, an organic vapor cartridge will not afford respiratory protection against ammonia. Knitted cotton covers for the face-contacting surface of the facepiece should not be used since they are not gastight.

7.2.2.1.5 Self-Rescue-Type Respirators. The self-rescue-type respirator is designed to provide the greatest possible respiratory protection consistent with the practicability of carrying the device at all times so that it is always available for use during escape in the event of a catastrophe. It consists essentially of a small filter element, a mouthpiece, a nose clip, and a means of carrying the device conveniently on the body or storing it near the work location. Most filter elements are similar to chemical cartridges made for protection against specific gases or vapors, but particulate filters are also available. One self-rescue-type respirator offers protection against carbon monoxide present in the atmosphere following an explosion or fire in a mine. The filter cartridge for this type shall be protected from moisture to keep the chemical fill active.

7.2.2.1.6 Limitations of Self-Rescue-Type Respirators. Self-rescue-type respirators should never be used as a working tool, but only as a means during escape from a contaminated area to enhance the possibility of reaching a safe atmosphere or a more positive type of respiratory protective equipment. The magnitude of protection afforded usually falls between that provided by gas masks and by chemical-cartridge respirators. For example, the self-rescue-type respirator for protection against carbon monoxide will provide at least 30 minutes service in an atmosphere containing 1 percent by volume of carbon monoxide.

7.2.2.2 *Mechanical-Filter Respirators.* Mechanical-filter respirators such as dust, fume, or mist respirators remove particulate matter from the inspired air by capture on the filter, which is usually a fibrous pad. These respirators consist of a full or half-mask facepiece to which are attached one or two filters through which the inspired air is drawn. Check valves, present in most mechanical-filter respirators, prevent exhaled breath from passing through the filters and allow it to be forced out through an exhalation valve in the facepiece to the surrounding atmosphere. The facepiece is held securely to the wearer's face by elastic headbands. Knitted cotton covers are sometimes used to cover the face-contacting surface of the facepiece to absorb perspiration and to prevent irritation of the skin when the respirator is worn in hot places or in air containing certain irritating dusts such as lime.

Mechanical-filter respirators are designed to provide respiratory protection against a single specific dust, fume, or mist, a single class such as toxic dusts, or a combination of several classes of particulate matter such as dusts, fumes, and mists.

The filters may be of the single-use or re-usable type. *Single-use* filters cannot be cleaned and re-used, but should be discarded after they have served their purpose. Re-usable filters, cleaned mechanically according to the manufacturer's instructions, may be re-used. They should never be washed or treated with solvents.

7.2.2.3 *Limitations of Mechanical-Filter Respirators.* There is a practical limit for the concentrations in which a mechanical-filter respirator should be used. This is determined by the time required to plug the filter. For example, if the concentration is so high that the filter must be changed several times an hour in order that the wearer can inhale without undue resistance, a more suitable type of respiratory protective device should be selected. Mechanical-filter respirators should not be used in sand- or shot-blasting operations in which one might be exposed to heavy concentrations of particulate matter and to rapidly rebounding particles of the abrasive. For such conditions, the abrasive-blasting respirator shall be used.

Mechanical-filter respirators do not protect against gases and vapors or against an atmosphere deficient in oxygen. The wearer has complete freedom of movement. The useful life of the filters is limited by the build-up of resistance to inhalation as the contaminant is removed by the filter. The higher the concentration of contaminant in the air drawn into the filter and the greater the wearer's activity, the more rapidly the resistance to inhalation increases. This applies particularly to dusts and fumes. Hence, the use of dust and fume respirators in high concentrations of these contaminants requires frequent replacement of disposable filters or frequent cleaning of re-usable filters.

7.2.2.4 *Combination Chemical-and-Mechanical-Filter Respirators.* Combination chemical-and-mechanical-filter respirators remove toxic gases and vapors and particulate matter from inspired air. Some gas-mask canisters contain special filters which provide respiratory protection against particulate matter, in addition to the respiratory protection against gases and vapors furnished by their granular fill. Some chemical-cartridge respirators contain filters for the same purpose. Others have filters attached so that the filters may be changed one or more times before the cartridges are changed. The type of protection afforded by the filters in gas-mask canisters and chemical-cartridge-respirator cartridges is stated on their labels.

7.2.2.5 *Limitations of Combination Chemical-and-Mechanical-Filter Respirators.* The limitations of combination chemical-and-mechanical-filter respirators generally are the same as for each type of respirator given in the preceding sections. However, the limitation of dust filters in regard to protection against gases and vapors given in 7.2.2.3 obviously is modified by the type of protection afforded by the chemical-filter respirator (gas-mask or chemical-cartridge respirator) against gases and vapors.

7.3 Requirements for Respirators. Respirators of all types should be capable of providing an adequate degree of respiratory protection against given atmospheric contaminants when the proper type has been chosen and when it is maintained and used correctly. Specific requirements for most of the types of respirators used in industry in the United States of America have been set up by the Federal Bureau of Mines. These requirements are published as Bureau of Mines Schedules, a list of which follows:[2]

Bureau of Mines, Procedure for Establishing a List of Permissible Self-Contained Mine Rescue Breathing Apparatus; Fees, Character of Tests, and Conditions Under Which Mine Rescue Breathing Apparatus Will Be Tested: Schedule 13, March 5, 1919, 13 pp; Schedule 13A (revision of Schedule 13), January 21, 1930, 12 pp; Schedule 13B (revision of Schedule 13A), August 12, 1935, 12 pp; Schedule 13C (revision of Schedule 13B), July 9, 1946, 11 pp; Schedule 13D (revision of Schedule 13C), September 22, 1956, 12 pp. (Code of Federal Regulations reference: 30 CFR Part 11.)

Bureau of Mines, Procedure for Establishing a List of Permissible Gas Masks; Fees, Character of Tests, and Conditions Under Which Gas Masks Will Be Tested: Schedule 14, May 22, 1919, 13 pp; Supplement to Schedule 14, January 6, 1920, 4 pp;

[2] Copies of the most recent Bureau of Mines Schedules and List of Respiratory Protective Devices Approved by the Bureau of Mines may be obtained from the Publications Distribution Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

Schedule 14A (revision of Schedule 14), August 25, 1923, 15 pp; Schedule 14B (revision of Schedule 14A), August 7, 1930, 13 pp; Schedule 14C (revision of Schedule 14B), August 20, 1934, 17 pp; Schedule 14D (revision of Schedule 14C), May 9, 1935, 17 pp; Schedule 14E (revision of Schedule 14D), December 24, 1941, 19 pp; Schedule 14F (revision of Schedule 14E), April 23, 1955. (Code of Federal Regulations reference: 30 CFR Part 13.)

Bureau of Mines, Procedure for Testing Hose Masks for Permissibility: Schedule 19, April 28, 1927, 8 pp; Supplement to Schedule 19, August 20, 1934, 3 pp. Procedure for Testing Supplied-Air Respirators for Permissibility: Schedule 19A (revision of Schedule 19 and supplement, enlarged to include special hose masks without blowers, air-line respirators, and abrasive-blasting helmets, hoods, or masks), August 9, 1937, 21 pp; Schedule 19A as amended in the Federal Register on March 13, 1948, to include Type C, demand-class supplied-air respirators; Schedule 19B (revision of Schedule 19A), April 19, 1955. (Code of Federal Regulations reference: 30 CFR Part 12.)

Bureau of Mines. Procedure for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility: Schedule 21. August 20. 1934, 14 pp; Schedule 21A (revision of Schedule 21), April 19, 1955. (Code of Federal Regulations reference: 30 CFR Part 14.)

Bureau of Mines, Procedure for Testing Nonemergency Gas Respirators (Chemical Cartridge Respirators) for Permissibility: Schedule 23, November 13. 1944. 10 pp; Schedule 23A (revision of Schedule 23), April 23. 1955. (Code of Federal Regulations reference: 30 CFR Part 14A.)

Each respirator that has been approved by the Bureau of Mines has met the requirements of the pertinent schedule that was in effect at the time of the approval. In general, each revision of a Bureau of Mines schedule makes these requirements more severe. A Bureau of Mines approval on a respirator remains in effect even though the schedule under which it was approved has been revised one or more times since then. Hence, if the user wishes to check on the minimum performance that he may expect from the respirator, he should consult the schedule or revision thereof, which is shown in the list of schedules as being in effect when the approval was granted.

The Bureau of Mines performance requirements for a respirator are based on its field of use and upon three fundamental requirements for a satisfactory device: (1) It must provide adequate protection for a satisfactory period; (2) It must be reasonably comfortable and convenient to wear; and (3) It must be constructed of durable materials. If no Bureau of Mines schedule applies to a respirator being considered for use, it should be examined to see that it fulfills these three requirements. Further judgment might be based on its compliance with the performance requirements of the most closely related respirator approved by the Bureau of Mines.

7.4 Selection of Respirators

7.4.1 *General Considerations.* In choosing a respirator to be used for respiratory protection in any given situation, the following factors should be considered: (1) the nature of the hazard; (2) the severity of the hazard; (3) the type of contaminant; (4) the concentration of the contaminant; (5) the period for which respiratory protection must be afforded; (6) the location of the contaminated area with respect to a source of respirable air; (7) the expected activity of the wearer; and (8) the operating characteristics and limitations of the available respirators.

Table 5 lists the hazards and the respirators that are designed specifically to afford respiratory protection against them. By reference to this table, and by considering the foregoing factors, the user can determine the type of respirator that should be used. The self-contained breathing apparatus and the hose mask with blower would give respiratory protection against any of the hazards listed, but these devices are not included in the list of respirators that could be used in the less hazardous situations because their use would amount to "over-engineering."

Even though most of the factors in 7.4.1 are interrelated, a brief discussion of each follows:

7.4.1.1 *Nature of the Hazard.* The user should determine whether or not the atmosphere is deficient in oxygen, and whether the contaminant is gaseous or particulate, or a combination of the two.

7.4.1.2 *Severity of the Hazard.* The user should determine whether or not the atmosphere is immediately dangerous to life. This is discussed under Classification of Hazards in 7.1.

7.4.1.3 *Type of Contaminant*

7.4.1.3.1 Gaseous Contaminant. Where the contaminant is gaseous, the user should determine whether it is an acid gas, an organic vapor, ammonia, carbon monoxide, or a mixture of two or more of these gaseous contaminants. This information is essential to the choice of the proper gas mask or chemical-cartridge respirator because the different

Table 5
Selection of Respiratory Protective Device

Hazard	Respirator
Oxygen deficiency	Self-contained breathing apparatus Hose mask with blower
Gaseous contaminant Immediately dangerous to life	Self-contained breathing apparatus Hose mask with blower Gas mask
Not immediately dangerous to life	Air-line respirator Hose mask without blower Chemical-cartridge respirator
Particulate contaminant	Dust, mist, or fume respirator Air-line respirator Abrasive-blasting respirator
Combination gaseous and particulated contaminant Immediately dangerous to life	Self-contained breathing apparatus Hose mask with blower Gas mask with special filter
Not immediately dangerous to life	Air-line respirator Hose mask without blower Chemical-cartridge respirator with special filter

types of gases require different absorbents or combinations of absorbents to remove them from the inspired air.

7.4.1.3.2 Particulate Contaminant. Where the contaminant is particulate, the user should know its physical form; that is, whether it is a dust, fume, or mist. Furthermore, he should know whether it is a toxic type (containing, for instance, arsenic, antimony, cadmium, or lead), a pneumoconiosis-producing type (containing, for instance, asbestos or free silica), or a type having a low order of toxicity and being nonfibrosis producing (containing, for instance, flour or wood). This information is essential to the choice of the proper dispersoid respirator, as a respirator designed to protect against one type of particulate matter does not necessarily afford adequate protection or service life against the other types.

7.4.1.4 *Concentration of Contaminant*

7.4.1.4.1 Gaseous Contaminant. Where the contaminant is gaseous, the maximum expected concentration of the gas should be known. Where this is above 3 percent by volume of ammonia gas, or 2 percent by volume of other gases, a gas mask is not adequate and should not be used. If it is above 0.1 percent by volume (1,000 ppm) of organic vapors, an organic-vapor chemical-cartridge respirator is not adequate and should not be used.

7.4.1.4.2 Particulate Contaminant. Where the contaminant is particulate, the proper type of dispersoid respirator may give an adequate degree of protection, yet its service life may be too short to be practicable or economical. That is, the filter may plug too readily with a rapid increase in the inhalation resistance, thus necessitating frequent changing or cleaning of the filter material. Where practicable, an air-line respirator should be used in high concentrations of particulate matter.

7.4.1.5 *Period of Required Respiratory Protection.* The period of respiratory protection required has considerable bearing on the decision about which type of respirator to use in any given situation. The self-contained breathing apparatus, the gas mask, and the chemical-cartridge respirator provide respiratory protection for a limited period, whereas the hose mask with blower, the air-line respirator, and the abrasive-blasting respirator do so for an unlimited period; thus, for protracted periods of use, the latter types offer some advantages.

7.4.1.6 *Location of Contaminated Area with Respect to Source of Respirable Air.* This is a factor that is frequently overlooked when choosing a respirator. In using a hose mask, air-line respirator, or abrasive-blasting respirator, the distance that the wearer can go into a contaminated atmosphere is limited by the length of the hose connected to the source of respirable air. Furthermore, the presence of the hose requires that he enter and leave the area by the same route. When wearing a self-contained breathing apparatus or a gas mask, a person may leave the contaminated area by another exit, but he should make certain that the device will afford protection for a period adequate for him to reach fresh air, taking into account possible delays. For instance, in mine-rescue work, the maximum distance from fresh air that a crew wearing 2-hour self-contained breathing apparatus should cover is 1,000 feet (2,000 feet round trip) under ideal conditions. This distance is decreased to not more than 50 feet from fresh air if the crew has to crawl in a low passage.

7.4.1.7 *Activity of the Wearer.* In many instances, the respirator that would be first choice from the standpoint of respiratory protection or period of protection cannot be used because it would limit the activity of the wearer. For instance, a hose mask would not be practicable for use where the wearer has to weave in and out of a series of obstructions such as pipes because of the difficulty of pulling the heavy hose after him and his inability to escape quickly to fresh air in event of danger. An air-line respirator would likewise be rather impracticable for use where the wearer must be moving about constantly in the contaminated area, or going from one room to another, because of the inconvenience and tripping hazard of the air-supply hose.

The activity of the wearer has a marked effect on the life to be expected from a self-contained breathing apparatus, gas mask, chemical-cartridge respirator, or dispersoid respirator. The volume of air breathed by a man walking at a rate of 4 miles per hour is more than three times that breathed when he is standing still. Hence, the supply of oxygen in a self-contained breathing apparatus is used up faster, the absorbent capacity of a gas-mask canister or a chemical cartridge is exhausted faster, and the filter of a dispersoid respirator would be plugged faster while the wearer is exercising than when he is at rest.

7.4.1.8 *Operating Characteristics and Limitations of the Available Respirators.* The operating characteristics and limitations of respirators have been discussed in 7.2.

7.5 Use and Maintenance of Respirators

7.5.1 *General Considerations.* Respirators are used to supplement other methods of control of airborne contaminants rather than to substitute for them. Every effort should be made to prevent the dissemination of contaminants into the breathing zones of the workers. In some instances, it is necessary to use respirators only until these control measures have been taken; in others, such measures are impracticable, and the continued use of respirators is necessary.

7.5.2 *Precautions To Be Taken in the Use of Respirators*

7.5.2.1 *Precautions To Be Taken in the Use of a Self-Contained Breathing Apparatus*

(1) The wearer of a self-contained breathing apparatus should be physically sound and fit and should be thoroughly trained in the construction, testing, use, care, and limitations of the apparatus before he attempts to wear such apparatus in a hazardous situation.

(2) Make certain that the self-contained breathing apparatus is in good operating condition.

(3) Make certain that the apparatus is capable of supplying air or oxygen for the period that the wearer must remain in the contaminated area.

(4) Adjust the apparatus to the wearer and test for tightness according to the manufacturer's instructions.

(5) If the wearer is to enter a confined space containing an atmosphere that is extremely hazardous, connect a strong life line to his body. This will serve (a) as a means of guiding him to the exit; (b) as a means of transmitting prearranged signals between him and the men at the fresh-air base; and (c) as a means of aiding in rescue operations in case of an accident or emergency. This life line should be held by two attendants, at least one of whom is wearing a similar apparatus.

(6) Enter the contaminated area cautiously, and, if the contaminant is detected by odor, taste, or eye, nose, or throat irritation, return to fresh air immediately and ascertain the cause.

(7) Bear in mind the time limitations of the apparatus and allow an adequate margin of time for the return to fresh air.

(8) The mouthpiece and nose clip, or the facepiece, should not be removed until the wearer is certain that he is in respirable air.

7.5.2.2 *Precautions To Be Taken in the Use of a Gas Mask*

(1) Make certain that the gas mask is in good operating condition.

(2) Adjust the canister harness on the body so that, when the facepiece is put on, there is some slack in the breathing tube when the wearer's head is in the normal position.

(3) Adjust the facepiece to make a gastight fit on the wearer's face. There are two means of testing a facepiece for a gastight fit: (a) Close off the exhalation valve and exhale gently into the facepiece. If a slight positive pressure can be built up in the facepiece without any ind[illegible]ation of outward leakage of

air between the facepiece and the face, it is adjusted properly. (b) Close off the breathing tube, inhale so that the facepiece starts to collapse, and hold the breath for about ten seconds. If the facepiece stays in its partially collapsed condition and no inward leakage of air is detected, it is adjusted properly.

(4) Test the complete gas mask for gas-tightness by closing off the air-intake at the bottom of the canister, either with the palm of the hand or with the bottom canister seal, and inhaling as in (3) (b) above.

This test checks the gastightness of the canister or timer gaskets and of the connection between the breathing tube and the canister or timer.

(5) Make certain that the contaminated atmosphere is not deficient in oxygen.

(6) Enter the contaminated area cautiously. If the odor of the contaminant is noted, return to fresh air immediately and ascertain the cause of the leakage.

(7) Make certain that the canister has enough residual life to give respiratory protection for the period that the wearer expects to be in the contaminated area. It is good practice to attach a fresh canister to the mask before entering an extremely hazardous atmosphere, especially one containing a gas that has poor warning properties, such as methyl bromide.

(8) The facepiece should not be removed or fresh canisters attached until the wearer is certain that he is in respirable air.

(9) After leaving the contaminated area, replace the bottom seal on the canister to prevent deterioration of the canister contents. This is particularly important in the case of universal gas-mask canisters.

(10) Where the contaminant is a single gas or vapor, or a mixture of two or more gases or vapors of the same type, longer service time will be obtained if a canister is used that is designed especially for protection against the contaminant than would be obtained if a universal gas-mask canister were used. Firemen generally use the universal gas-mask canister because they are never certain what gases they might encounter.

7.5.2.3 *Precautions To Be Taken in the Use of a Hose Mask With Blower*

(1) Make certain that the hose mask is in good operating condition.

(2) Set the blower in an assured source of respirable air.

(3) Connect the proper length of hose (not over 150 feet) to the blower and to the facepiece, making sure that all gaskets are in place and that the connections are tight. Where more than one hose line is to be used, each should originate at the blower.

(4) Before entering a confined space such as a tank or sewer containing an atmosphere that is extremely hazardous, connect a strong life line to the D-ring of the body harness. This life line should be held by two attendants so that the wearer can be removed from the contaminated atmosphere in case of accident or emergency.

(5) Operate the blower for a minute or two at a rapid rate to blow any dust out of the hose and to make sure that air is being delivered to the facepiece.

(6) Adjust the body harness securely to the wearer.

(7) Adjust the facepiece to the wearer so that it makes a gastight fit with his face. There are two means of testing for a satisfactory facepiece fit: (a) Close off the exhalation valve and exhale gently into the facepiece. If a slight positive pressure can be built up in the facepiece without any indication of outward leakage of air between the facepiece and the face, it is adjusted properly. (b) Close off the breathing tube or tubes, inhale so that the facepiece starts to collapse, and hold the breath for about 10 seconds. If the facepiece stays in its partially collapsed conditions and no inward leakage of air is detected, it is adjusted properly.

(8) Operate the blower, and adjust the flow of air to the wearer's satisfaction. The blower should be operated continuously during the use of the mask.

(9) Check on the prearranged signals between the wearer and the blower operator.

(10) Enter the contaminated area cautiously.

(11) Be careful that the hose is not endangered by sharp edges or falling objects, and remember that the wearer must retrace his steps and leave by the same route that he entered.

(12) If the continuous flow of air to the facepiece is interrupted, the wearer should return to fresh air and ascertain the cause.

(13) The facepiece should not be removed until the wearer is certain that he is in respirable air.

7.5.2.4 *Precautions To Be Taken in the Use of a Hose Mask Without Blower*

(1) Make certain that the hose mask is in good operating condition.

(2) Securely fasten the air-intake of the respirator in an assured source of respirable air.

(3) Connect the proper length of hose (not over 75 feet) to the air-intake and to the facepiece, making sure that all gaskets are in place and that the connections are tight.

(4) Adjust the body harness to the wearer.

(5) Adjust the facepiece to the wearer so that it makes a gastight fit with his face.

There are two means of testing for a satisfactory facepiece fit: (a) Close off the exhalation valve and exhale gently into the facepiece. If a slight positive pressure can be built up in the facepiece without any indication of outward leakage of air between the facepiece and the face, it is adjusted properly. (b) Close off the breathing tube, inhale so that the facepiece starts to collapse, and hold the breath for about 10 seconds. If the facepiece stays in its partially collapsed condition and no inward leakage of air is detected, it is adjusted properly and is gastight.

(6) Make certain that the atmosphere to be entered is not so hazardous that the wearer cannot escape unharmed without the aid of the respirator.

(7) Enter the contaminated area cautiously and leave by the same route.

7.5.2.5 *Precautions To Be Taken in the Use of an Air-Line Respirator*

(1) Make certain that the air supply is respirable. Close attention should be paid to the location of the intake to the air-supply device to make certain that the entering air is not contaminated. A suitable filter should be provided to remove objectionable odors, oil and water mist, and rust particles from the air delivered to the air-supply line. A suitable reducing-type or demand-type valve and an excess-pressure relief valve should also be provided. For supplying respirable air, the use of low-pressure externally lubricated blowers is preferable to high-pressure internally lubricated compressors, since the latter may add objectionable odors to the air and may produce carbon monoxide upon overheating. Internally lubricated compressors should be equipped with an automatic shut-off which is actuated if they become overheated.

(2) Make certain that the air-line respirator is in good operating condition.

(3) Attach the proper length of air-supply hose to the source of compressed air and to the breathing tube.

(4) Adjust the pressure of the air at the inlet to the air-supply hose so that it is within the proper pressure range.

(5) Adjust the facepiece, helmet, or hood to the wearer according to the manufacturer's instructions. A full facepiece or half-mask facepiece should be adjusted so that all the excess air leaves the facepiece through the exhalation valve and none is felt leaking out under the edge of the facepiece.

(6) When the rate of flow of air into the facepiece, helmet, or hood seems to be excessive, the wearer may decrease the flow of air by means of the air-regulating valve with which most air-line respirators are equipped. However, to prevent the contaminant in the surrounding air from reaching the wearer's breathing zone, the flow of air should not be decreased below 4 cubic feet per minute for facepieces, or below 6 cubic feet per minute for helmets or hoods. Hence, the air-regulating valve should be used judiciously on an air-line respirator.

(7) Enter the contaminated area cautiously and leave by the same route.

(8) Each air-line respirator is equipped with a quick-acting detachable coupling by means of which the wearer can quickly disconnect the respirator from the air-supply line to facilitate escape in an emergency such as fire. The wearer should practice using this coupling before wearing the respirator in a contaminated atmosphere.

7.5.2.6 *Precautions To Be Taken in the Use of an Abrasive-Blasting Respirator.* The precautions to be taken in the use of an abrasive-blasting respirator are the same as those given for the air-line respirator, with the following additional precautions.

(1) Make certain that the shatterproof eyepiece and the protective cover glass (if furnished) are in place. Under no circumstances should regular window glass be used in place of the shatterproof eyepiece. Clean the inner and outer surfaces of all eyepieces.

(2) Make certain that the protective wire screen or perforated-metal eyepiece is clean and in place.

7.5.2.7 *Precautions To Be Taken in the Use of a Chemical-Cartridge Respirator*

(1) Make certain that the atmosphere to be entered is not dangerous to life.

(2) Make certain that the respirator is in good operating condition, that the gaskets are in place, and that the proper chemical cartridges are securely mounted in the respirator.

(3) Adjust the respirator to the wearer's face so that it makes a gastight fit with his face. There are two means of testing for a gastight fit: (a) Close off the exhalation valve and exhale gently into the facepiece. If a slight positive pressure can be built

up in the facepiece without any indication of outward leakage of air between the facepiece and the face, it is adjusted properly. (b) Close off the inlets to the facepiece by cardboard discs or stoppers usually furnished by the manufacturer, inhale so that the facepiece starts to collapse, and hold the breath for about 10 seconds. If the facepiece remains in its partially collapsed condition and no inward leakage of air is detected, it is adjusted properly. If the second method is used, the cardboard discs or stoppers must be removed and the cartridges assembled with the facepiece without disturbing the fit of the facepiece on the wearer's face.

(4) Enter the contaminated area cautiously.

(5) When leakage of the contaminant is noted by the wearer, he should discard the used cartridges and replace them with fresh ones.

(6) Knitted cotton cloth must never be used to cover the face-contacting edges of chemical-cartridge respirators, since the cloth cover is not gastight.

7.5.2.8 *Precautions To Be Taken in the Use of a Dispersoid (Dust, Mist, or Fume) Respirator*

(1) Make certain that the respirator is in good operating condition and that the proper filters are securely fastened in place.

(2) Adjust the respirator to the wearer's face so that it makes a dust-tight fit with his face. There are two means of testing for a satisfactory facepiece fit: (a) Close off the exhalation valve and exhale gently into the facepiece. If a slight positive pressure can be built up in the facepiece without any indication of outward leakage of air between the facepiece and the face, it is adjusted properly. (b) Close off the inlets to the facepiece by cardboard discs or stoppers usually furnished by the manufacturer, inhale so that the facepiece starts to collapse, and hold the breath for about 10 seconds. If the facepiece remains in its partially collapsed condition, and no inward leakage of air is detected, it is adjusted properly. If the second method is used, the cardboard discs or stoppers must be removed and the filters assembled with the facepiece without disturbing the fit of the facepiece on the wearer's face.

(3) As the total amount of solid particulate matter removed from the inspired air by the filter increases, the resistance to inhalation increases and finally reaches a value such that the wearer is conscious of increased difficulty in breathing. At this time, disposable-type filters should be discarded and replaced by fresh filters, and recleanable-type filters should be cleaned in accordance with the manufacturer's instruction. Under no circumstances should respirator filters be washed or dry cleaned.

(4) In atmospheres containing particulate matter that is irritating to the skin, or where excessive perspiration may occur, a knitted cotton cloth, furnished by the manufacturer, may be used over the edge of the facepiece to prevent contact between the rubber portion of the facepiece and the wearer's face. This must not be used on fume respirators.

(5) When the facepiece is removed, the wearer may obtain visual evidence of the dust-tightness of the facepiece fit by looking at his reflection in a mirror and noting the presence or absence of dust streaks on that portion of his face that was covered by the facepiece.

7.5.3 *Instruction in Use of Respirators*

7.5.3.1 *General Considerations.* For the safe use of any device, it is essential that the user be properly instructed in its selection, use, and maintenance. This is particularly important with respect to respirators. Competent persons should give such instruction to the supervisors of all groups who may be required to wear respirators at their work. The supervisors, in turn, should instruct their men. No person should be allowed to wear a respirator of any type until he has received such instruction. Such instruction should cover:

(1) An explanation of the need for using the respirator

(2) Its operating principle

(3) Steps to be taken to assure that it is in good operating condition

(4) Proper adjustment of the respirator to the wearer

(5) Proper use and maintenance of the respirator

The very presence of self-contained breathing apparatus, hose masks with blowers, or gas masks on the property of any organization is an indication that they are expected to be used in an emergency situation or in one that is dangerous to life. All persons who may have occasion to use these respirators, or cause them to be used, should be properly trained in their use before circumstances require that they use them to protect their lives and the property of their employer. In addition to this, efforts should be made to foresee possible emergencies and plans of action should be formulated so that when respiratory protection is needed, rescue or repair operations will proceed smoothly and safely.

Merely talking about such respirators as the self-contained breathing apparatus, the hose mask with blower, and the gas mask is not enough. The men should be given an opportunity to handle the respirator, have it fitted to them properly, test the gastightness of the facepiece fit, wear it in normal air for a period long enough for them to become familiar with it, and, finally, they should actually wear it in an irrespirable atmosphere. Such an atmosphere may be created by burning a half-ounce formaldehyde candle in a room of about 4,000 cubic foot capacity. Not only would this atmosphere be irrespirable, but it would be irritating to the eyes. This atmosphere is similar to that used by the Bureau of Mines in the training of men in the use of the self-contained breathing apparatus. After a person has worn one of these devices for a prolonged period in this formaldehyde-air mixture without any ill effect, he need only remove the facepiece or nose clip momentarily to be convinced of the efficacy of the respirator. Such training breeds confidence in the trainees that should stand them in good stead in an emergency situation.

A less severe training atmosphere that can be built up in any room without damage to its contents, or to other people in the same building, may be prepared by vaporizing isoamyl acetate to the amount of 173 cubic centimeters per 1,000 cubic foot capacity of the room. The liquid isoamyl acetate is vaporized from a cloth wick placed in front of a fan in the room. This produces a concentration of about 1,000 parts of isoamyl acetate per million parts of air (0.1 percent) by volume. If the odor of isoamyl acetate is detected by a person wearing an emergency-type respirator, he would be able to detect the odor of phosgene or chlorine if he entered a 2-percent concentration of either of these gases while wearing the device. Isoamyl acetate vapor in this concentration is used by the Bureau of Mines as a preliminary means of testing the gastightness of gas-mask facepieces before actually wearing them in highly toxic concentrations of gases.

7.5.4 *Maintaining, Cleaning, Disinfecting, and Storing Respirators*

7.5.4.1 *General Considerations.* It is especially important that respirators be properly maintained and stored. The life of the wearer may be dependent on their proper functioning and ready availability. Adequate attention to cleaning and disinfecting is also required because the respiratory inlet coverings are worn on the face. Whenever possible, a centralized maintenance, cleaning, and storage station should be established to care for equipment of this type. It should be equipped adequately and manned by trained personnel.

7.5.4.2 *Procedures Applicable to All Respirators*

7.5.4.2.1 Inspection. All respirators should be inspected at regular intervals to make sure that they are ready for use. For respirators that are used and maintained daily, inspection becomes a rather automatic function; however, it is often neglected for respirators that are stored throughout a plant for use in emergency situations. These devices should be checked as regularly as fire extinguishers; as a matter of fact, it is good practice to integrate these inspection and maintenance programs.

All rubber parts such as facepieces, mouthpieces, exhalation valves, breathing tubes, and headbands should be inspected carefully for signs of deterioration such as hardening, checking, or tackiness. During the inspection, time should be given to "working" the rubber between the fingers with a stretching and massaging action. This will reveal defects in rubber parts and prolong the life of non-defective parts.

A check should be made to see that all gaskets are present and that they are held in place tightly.

Metal parts should be checked for signs of corrosion, and plastic and glass parts for breakage.

7.5.4.2.2 Maintenance. When it is necessary to replace worn or deteriorated parts, only those made specifically for the device should be used and the repair work should be accomplished by experienced personnel. Makeshift repairs for respiratory protective equipment cannot be tolerated. After equipment that is used frequently is cleaned and disinfected, it should be repaired routinely; emergency equipment should be repaired immediately after inspection reveals the need for repairs.

Repairs to intricate parts should not be attempted unless adequate facilities and trained personnel are available. For most users, it is preferable that parts of this type be replaced as a unit or returned to the manufacturer for repair.

7.5.4.2.3 Cleaning and Disinfecting. Respiratory protective equipment should be cleaned and disinfected after each use. However, because of the wide variety of materials used in these devices, the manufacturer should be consulted for the cleaning and disinfecting method best suited to his products.

In general, facepieces and mouthpieces for respiratory protective devices are made from rubber or rubber-like compounds. Usually, these can be cleaned with detergent and lukewarm water by hand-brushing or agitation in a washing machine. Formaldehyde, modified phenolics, hypochlorite, or quaternary ammonium compounds in the proper strength can be used to disinfect the parts. Normally all detergent is rinsed from the protective device before disinfecting; however, there are several combination cleaning and disinfecting materials available in both liquid and powder form which contain a detergent and quaternary ammonium salts and this permits combining the washing and disinfecting operations. After cleaning and disinfecting, the parts should be rinsed in clean water and dried quickly for most disinfectants. It may not be desirable to rinse parts treated with quaternary ammonium compounds since their disinfectant properties will continue indefinitely and may not produce a skin irritation. After reassembly, the device should be placed in a clean and dust-tight container.

Hot water, steam, solvents, and ultraviolet light should be avoided in the cleaning and disinfecting of rubber parts because all have deteriorating effects. If paint or other difficult-to-remove substances are encountered, it is preferable that they be removed by mild caustic cleaners rather than by solvents.

7.5.4.2.4 Storage. All types of respirators should be stored in clean and dry compartments under conditions of moderate temperature. Most devices of this type are received in re-usable cartons or cases and should be kept in these containers during the period of storage. Exposure to heat, sunlight, extreme cold, and excessive moisture is harmful to respiratory protective devices if the exposure continues over extended periods.

In some cases, it is necessary to locate respiratory protective devices at convenient stations throughout the work area for ready availability in the event of an emergency. Special care must be taken to insure adequate storage under these conditions. In some instances, it is necessary to construct special compartments to protect the equipment from the process materials as well as from the elements.

Additional emergency-type respiratory protective devices should be stored just outside the immediate danger area so that men can retreat to them and don them for judicious re-entry into the contaminated area to carry out rescue or repair operations.

No respirator can be adequately stored outside its carrying case or carton in a tool box or clothing locker.

7.5.4.3 *Special Procedures for Maintaining Cleaning, Disinfecting, and Storing Respirators*

7.5.4.3.1 Self-Contained Breathing Apparatus. In compressed oxygen recirculating apparatus, make sure the carbon dioxide removing chemical is replaced after use and that the oxygen cylinder is refilled to rated capacity in order to insure full service life. The cylinder pressure should be checked periodically and brought to rated pressure if necessary. The tightness of the high pressure and low pressure sides of the apparatus should be checked periodically following the manufacturer's instructions. In self-generating apparatus, periodic tightness tests as outlined by the manufacturer should be followed.

7.5.4.3.2 Hose Masks. Check the blower periodically for proper operation. Check hose for wear and tear after each use and steam clean when necessary. Keeping hose capped when not in use will prevent entrance of dust or other contaminants.

7.5.4.3.3 Air-Line Respirators. The facepiece should be serviced after each use just as for all other respiratory protective equipment. The flow-control valves should be inspected after each use and cleaned and repaired if necessary. Chemical cartridges in the continuous-flow control-valve assemblies should be changed when necessary. Air-line hose should be checked for wear and tear after each use and be steam cleaned when necessary.

The air-supply system should be inspected routinely to insure continued proper functioning. Air compressors, air-cylinder manifold systems, pressure reducers, pressure-release valves, air-line filters, air-line instrumentation, and permanent piping and outlet fittings must be kept in good repair to assure satisfactory condition of the air reaching the breathing zone of the wearer.

7.5.4.3.4 Gas masks. Check the facepiece to be sure that (1) the eyepieces are not broken and that they are held firmly in place; (2) the rubber portion of the facepiece is flexible and free from cracks; (3) the head harness is flexible and that the straps and buckles are in good condition; (4) the exhalation valve is in place, works freely, and has no dirt on its contact surfaces; (5) the breathing tube is flexible and free from cuts and that it is securely fastened to the canister neck or to the outlet of the timer; (6) the canister is of the proper type, is free from dents and rust spots, and is securely attached to the canister harness. If a timer is used, check to be sure that the gaskets are in place and are making proper contact, and that the timer is reset when a new canister is attached. Universal gas-mask canisters should be replaced after one year from date of breaking seal if not exhausted before this time. Canisters should be stored in a cool, clean, dry location and the stock rotated so that no canister remains in storage for more than four years before it is used.

7.5.4.3.5 Self-Rescuers. Frequent inspection is the most important phase of the maintenance program with this type of equipment because the equipment is seldom used but must always be ready. The type which offers protection against carbon monoxide utilizes hopcalite in the chemical fill and must be protected from moisture to remain effective. Follow the manufacturer's recommendations for checking the moisture seal at regular and frequent intervals.

7.5.4.3.6 Dispersoid and Chemical-Cartridge Respirators. Mechanical filters of the "throw-away" type should be discarded when the breathing resistance becomes bothersome to the wearer. In most plants with centralized maintenance stations, the filters are destroyed and discarded at the time the respirator is serviced.

Some respirators employ re-cleanable filters, in which case the filters are cleaned when the respirator is being serviced.

Chemical cartridges should be changed when the wearer detects the odor or irritating effect of the contaminant. In plants with centralized maintenance stations, cartridges are sometimes discarded after a given period of use (based on group experience), but in most cases the wearer is responsible for discarding and replacing cartridges in his respirator.

Particular care should be exercised in the storage of chemical cartridges because they usually deteriorate if exposed to excess moisture and to gaseous air contaminants. Cartridges should not be stored in the area where it is necessary for the workmen to use chemical-cartridge respirators.

Appendix for Section 6

(This Appendix is not a part of American Standard Safety Code for Head, Eye, and Respiratory Protection, Z2.1-1959, but is included to facilitate its use.)

A1. Visible-Light Transmission and Haze Test[3]

A1.1 Specimen. The test specimens shall be 2 inches in diameter, minimum. They may be cut from the plastic sheets or molded pieces or they may be prepared from a plastic material in the customary manner peculiar to the physical properties of the plastic to be tested (by compression molding, injection molding, laminating, casting, etc). The surfaces of the test specimens shall be substantially flat and parallel. The thickness of the test specimen shall be as furnished or, for comparative purposes, shall be 0.125 ± 0.005 inch.

A1.2 Apparatus. The apparatus shall consist of a haze meter, detailed drawings of which are obtainable from Organic Plastics Section, National Bureau of Standards, Washington 25, D.C. The light source shall consist of a concentrated filament lamp mounted in front of a reflector. It shall be placed within a cylindrical shield the inside of which is blackened. The base of the cylindrical shield opposite the reflector shall be closed and equipped with a 1-inch circular aperture. A circular blackened disk containing a similar aperture shall be mounted directly in front of a photoelectric cell 18 inches from the first aperture. The photoelectric cell shall be the Weston Photronic cell, Types I or III, with Viscor filter. The cell shall be connected at an ammeter with a 100-microampere range and an internal resistance not exceeding 50 ohms. If a dark room is not available, the light source unit and the photoelectric cell unit may be mounted in a suitable box finished on the inside in dull black to reduce reflection to a minimum. The box lid, also finished in dull black on the inside, shall fit tightly to prevent any external light from reaching the photoelectric cell. The lid shall be closed when making measurements unless the measurements are made in a dark room. A suitable storage battery or voltage stabilizer shall be used to operate the lamp. The intensity of the lamp shall be adjustable by means of a rheostat.

[3] This test is technically the same as Method No. 3021 of Federal Specification L-P-406.

A1.3 Procedure

A1.3.1 Care shall be taken to remove dust and grease from the specimens prior to measurement. At least three measurements of the light transmission and haze shall be made and averaged for each test specimen.

A1.3.2 ***Light Transmission Determination.*** The light is adjusted in intensity so that a current of 100 microamperes is obtained from the photoelectric cell. The specimen is then placed in front of the aperture (A) at the photocell. Of the light incident on the sample, a fraction is transmitted undeviated, and a fraction is scattered by the surfaces and the interior of the sample. The photoelectric cell receives the undeviated fraction of the light and that part of the scattered light which is not deflected at angles greater than about 90 degrees. The total light transmission of the plastic as defined is the fraction of the original light received by the photoelectric cell which continues to reach the sensitive element when the plastic is placed over the aperture (A) at the photoelectric cell. When the initial reading is 100, a reading of the microammeter taken with the specimen at position (A) gives the percentage total light transmission directly, and a reading obtained with the specimen at position (B) gives the percentage parallel light transmission directly.

A1.3.3 ***Haze Determination.*** The specimen is then placed at the aperture (B) 18 inches distant from aperture (A) and just in front of the cylindrical shield covering the light source, and the microammeter is read again. The photoelectric cell still receives the undeviated fraction of the total light but collects only that small portion of the scattered light which is confined to the small solid angles subtended by aperture (A) at points in opening (B). The difference between the photoelectric current with the sample at (A) and at (B) is a measure of the light scattered, assuming that a linear relation exists between the photoelectric current and the total light incident upon the sensitive element of the cell. The current is practically proportional to the total incident light for no external resistance; the deviation is only slight for the 50-ohm resistance in the microammeter as specified. Percentage of haze is calculated by dividing the difference between the readings of the microammeter in positions (A) and (B), respectively, by the reading in position (A) and multiplying by 100.

A1.4 Report. The report shall include the data specified under Section I, paragraph 8 of Specification L-P-406 and the following:

(1) Average percentage of total diffuse light transmission

(2) Average percentage of parallel light transmission

(3) Average percentage of haze

A1.5 Definition

A1.5.1 ***Haze.*** Haze is defined as that fraction of the total transmitted light from a normally incident beam which is not transmitted in a straight line. If T be the total light transmitted, T_r the parallel light transmission, i.e., the amount transmitted in a straight line, and T_d the diffuse light transmission, i.e., the amount transmitted in all directions but rectilinearly, then

$$\text{Haze} = \frac{T_d}{T} = \frac{T - T_r}{T}$$

Measurements of haze shall be equivalent to those which would be obtained by the CIE[4] Standard Observer and CIE[4] Standard Illuminant A.

A2. Water Absorption Test[5] (For Weight and Dimensional Changes)

A2.1 Specimens

A2.1.1 ***Molding Compounds.*** Test specimens for molding compounds shall be disks 2 inches in diameter by 0.125 ± 0.007 inch thick.

A2.1.2 ***Sheets.*** Test specimens of laminated compounds and specimens cut from material shall be 1 by 3 inches by the thickness of the sheet.

A2.1.3 ***Rods.*** The test specimen for rods shall be 1 inch in length for rods 1 inch in diameter or under and ½ inch in length for larger diameter rods. The diameter of the specimen shall be the diameter of the finished rod.

A2.1.4 ***Tubes.*** The test specimen for tubes less than 3 inches in inside diameter shall be the full section of the tube and 1 inch in length. For tubes 3 inches or more in inside diameter, a rectangular specimen shall be cut 3 inches in length in the circumferential direction of the tube and 1 inch in width lengthwise of the tube.

A2.1.5 ***Finish.*** The test specimens for sheets, rods, and tubes shall be machined, sawed, or sheared from the sample so as to have smooth edges free from cracks. The cut edges shall be made smooth by finishing with No. 000 or finer sandpaper or emery cloth. Sawing, machining, and finishing operations shall be slow enough so that the material is not heated appreciably.

A2.2 Apparatus

(1) Circulating air oven maintained at 122 ± 4 F (50 ± 2 C)

(2) A desiccator

(3) Analytical balance

(4) Micrometer, gage, or caliper capable of measuring accurately to 0.001 inch

A2.3 Procedure

A2.3.1 Three specimens of the sample to be tested shall be conditioned in an oven at 122 ± 4 F (50 ± 2 C) for 24 hours. After conditioning, the specimens shall be cooled in a desiccator and weighed. Dimensions of the specimens shall be measured with a micrometer gage to 0.001 inch. The specimens shall then be completely immersed in distilled water maintained at a temperature of 77 ± 4 F (25 ± 2 C). At least 50 milliliters of distilled water shall be employed for immersing each specimen. At the end of 24 hours immersion, each specimen shall be removed, the surface moisture quickly absorbed by a dry cloth, and the specimen reweighed. If the specimen is $\frac{1}{16}$ inch or less in thickness, it shall be put in a weighing bottle immediately after removing the surface moisture and shall be weighed in the bottle. The dimensions shall then be remeasured.

A2.3.2 When materials are known or suspected to contain any appreciable amount of water-soluble ingredients, the specimens after immersion, weighing, and measuring shall be reconditioned for the same time and temperature as used in the original drying period. They shall then be cooled in a desiccator and immediately reweighed. If the reconditioned dry weight is lower than the conditioned dry weight found after the original drying before immersion, the difference shall be considered as water-soluble matter lost during the immersion test. For such materials, the water absorption value shall be taken as the sum of the increase in weight on immersion and of the weight of the water-soluble matter.

A2.4 Report. The report shall include the data specified under Section 1, paragraph 8 of Specification L-P-406 and the following:

(1) The percentage increase in weight during im-

[4] International Commission on Illumination.

[5] This test is technically the same as Method No. 7031 of Federal Specification L-P-406.

mersion calculated to nearest 0.01 percent as follows:

Increase in weight, percent =

$$\frac{\text{wet weight} - \text{conditioned weight}}{\text{conditioned weight}} \times 100$$

(2) The percentage of soluble matter lost during immersion, if determined, calculated to nearest 0.01 percent as follows:

Soluble matter lost, percent =

$$\frac{\text{conditioned weight} - \text{reconditioned weight}}{\text{conditioned weight}} \times 100$$

When the weight on reconditioning the specimen after immersion in water exceeds the conditioned weight prior to immersion, report "no loss of soluble matter."

(3) The percentage of water absorbed in 24 hours, which is the sum of the values in items (1) and (2).

(4) The percentage change in each dimension during immersion.

(5) Observations regarding any change in physical condition of the specimen.

A3. Selection of Shade Numbers for Welding Filters

The following is a guide for the selection of the proper shade numbers of filter lenses or windows used in welding. These recommendations may be varied to suit the individual's needs.

Welding Operation	Suggested Shade Number
Shielded metal-arc welding	
1/16-, 3/32-, 1/8-, 5/32-inch electrodes	10
Inert-gas metal-arc welding (nonferrous)	
1/16-, 3/32-, 1/8-, 5/32-inch electrodes	11
Inert-gas metal arc welding (ferrous)	
1/16-, 3/32-, 1/8-, 5/32-inch electrodes	12
Shielded metal-arc welding	
3/16-, 7/32-, 1/4-inch electrodes	12
5/16-, 3/8-inch electrodes	14
Atomic hydrogen welding	10-14
Carbon-arc welding	14
Soldering	2
Torch brazing	3 or 4
Light cutting, up to 1 inch	3 or 4
Medium cutting, 1 inch to 6 inches	4 or 5
Heavy cutting, over 6 inches	5 or 6
Gas welding (light), up to 1/8 inch	4 or 5
Gas welding (medium), 1/8 inch to 1/2 inch	5 or 6
Gas welding (heavy), over 1/2 inch	6 or 8

NOTE: In gas welding or oxygen cutting, where the torch produces a high yellow light, it is desirable to use a filter or lens that absorbs the yellow or sodium line in the visible light of the operation.

A4. Maintenance and Disinfection of Eye Protectors

A4.1 Maintenance

A4.1.1 It is essential that the lenses of eye protectors be kept clean. Continuous vision through dirty lenses can cause eye strain, which could possibly result in substandard production by the operator. Daily cleaning of the eye protector with soap and hot water is recommended.

A4.1.2 Replace pitted lenses. Pitted lenses, like dirty lenses, can be a source of reduced vision. They should be replaced periodically. Deep scratches or excessive pitting of lenses are apt to weaken the lenses and cause them to break more readily.

A4.1.3 Replace headbands. Slack, worn-out, sweat-soaked, or twisted headbands do not hold the eye protector in proper position. Visual inspection can determine when the elasticity is reduced to a point beyond proper function.

A4.1.4 Keep goggles in case when not in use. Spectacles, in particular, should be given the same care as one's own glasses, since the frame, nose pads, and temples can be damaged by rough usage.

A4.2 Disinfection. Personal protective equipment which has been previously used shall be disinfected before being issued to another employee. Even when each employee is assigned protective equipment for extended periods, it is recommended that this equipment be cleaned and disinfected regularly. Several methods for disinfecting eye-protective equipment are acceptable. The most effective method is to disassemble the goggles or spectacles and thoroughly clean all parts with soap and hot water. Carefully rinse all traces of soap and replace defective parts with new ones. Swab thoroughly or completely immerse all parts for 10 minutes in a solution of germicidal deodorant fungicide. Remove parts from solution and suspend in a clean place for air drying at room temperature or with heated air. Do not rinse after removing parts from solution because this will remove the germicidal residue which retains its effectiveness indefinitely.

The dry parts or items should be placed in clean, dust-proof containers, such as a box, bag, or plastic envelope to protect them until re-issue.

A5. Fitting of Goggles and Spectacles

A5.1 Cup Goggles. The first step in fitting cup goggles is to adjust the nose bridge. Both the ball- and link-chain bridges of goggles are adjustable to

accommodate the individual wearer. Both types of bridges usually have some means for shortening or lengthening. In either case, to shorten or lengthen the bridge, the instructions of the manufacturer should be followed. Chain not needed after adjustment should be cut off. The chain should be insulated to protect the nose of the wearer.

The proper procedure for adjusting headbands is to keep the band loose enough to slip two fingers under it, palm side down, without stretching. Headbands should be worn low and flat and approximately at the base of the skull in order to hold goggles in a comfortable position. Most cup goggles are thinner and slanted away at the lower nasal sides, which makes for comfort as well as easy identification in getting them right side up.

A5.2 Spectacles. The first step in fitting spectacles is to determine the proper eye and bridge sizes. This is done best by using fitting samples and placing the sample spectacles on the nose to arrive at the proper size. The adjustable rocker pads should fit flush against the sides of the nose without allowing the metal bridge of the spectacle to rest on the nose bridge of the wearer. The small metal arms, to which the pearloid pads are attached, can be readily adjusted by round nose pliers which are especially designed for this purpose. To fit the temples comfortably over the ears, hold the spectacle firmly in one hand and shape the bow of the temple gradually by drawing it slowly between thumb and forefinger of other hand. Temples should be angled down from frame to ear so that lenses will be perpendicular to the line of vision.

Prescription safety spectacles should be fitted only by qualified optical personnel.

American Standards

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