

American National Standard

ANSI B165.1-2018³

*for Power Tools –
Power-Driven Brushing Tools –
Safety Requirements for
Design, Care, and Use*



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Revision of
ANSI B165.1-
20103 |

American National Standard
for Power Tools –

**Power-Driven Brushing Tools –
Safety Requirements for
Design, Care, and Use**

Sponsor

American Brush Manufacturers Association

Approved ~~Sept~~December 30, 20138 |

American National Standards Institute, Inc.

American National Standard

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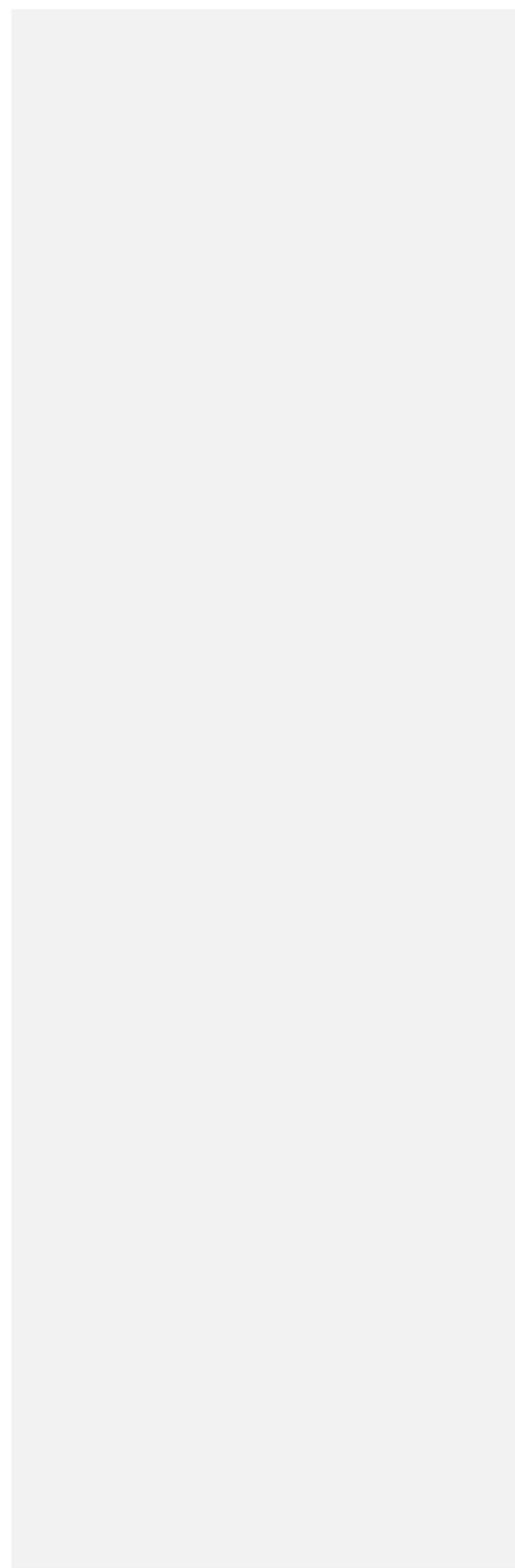
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Foreword (This foreword is not part of American National Standard ANSI B165.1-2010³.)

In an endeavor to react with sensitivity to the safety of those associated with power-driven brushes, this standard has as its primary objective the prevention of injuries to those who use them. It would do so by establishing the requirements for the design, care, and use of power-driven brushing tools, excluding those brushing tools constructed with wood, plastic, or composition hubs or cores.

Information contained in this standard is designed to assist machine operators and their supervisors in maintaining and operating all types of brushing equipment, including portable power tools.

The Safety and Standards Committee of the American Brush Manufacturers Association (ABMA) recognizes that it has an obligation to reflect, within this standard, the balanced best interests of the manufacturers and users. To assist in the interpretation of the requirements of this standard, responsibilities have been assigned to brush manufacturers, brushing machine manufacturers, and brush users. This assignment of responsibilities shows that safety must be a cooperative effort shared equally by each of these sectors.

This standard is a revision of *American National Standard for Power tools - Power-driven brushing tools - Safety requirements for design, care, and use*, ANSI B165.1-2010³. The original 1991 standard was developed after it was recognized that there was a need for a safety standard for power-driven brushes. To develop the standard, the Industrial Division of ABMA established a Safety and Standards Committee, which worked cooperatively with the Society of Manufacturing Engineers (SME).

Prior to publication of the 1991 standard, SME canvassed a large number of interested, concerned, and representative industry associations, government agencies, societies, institutions, foundations, and commissions to ensure the development of a consensus. After approval, the Standard was published by SME in 1991 with the co-sponsorship of the ABMA and the cooperative help of the American National Standards Institute (ANSI).

During the past ~~three~~ five years, the 2010 ³standard served the best interests of those most affected or influenced by its use. In accordance with the revisions of the American National Standards Institute's five-year periodic review procedure, this Standard has been reviewed, revised, and updated through the Canvass Method. The standard was reaffirmed in 2000 and revised in 2005, 2010 and 2010³.

Suggestions for improvement of the standard are welcomed. They should be sent to the American Brush Manufacturers Association, 736 Main Ave, Suite 7, Durango, CO 81301-5479.

The following organizations recognized as having an interest in the standardization of power-driven brushing tools were contacted prior to the approval of this standard. Inclusion in this list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

[Abtex Corporation](#)

Alliance of American Insurers
American Association of Industrial Management
American College of Occupational and Environmental Medicine
American Dental Association
American Federation of Labor and Congress of Industrial Organizations (AFL-CIO)
American Foundry Society
[American Industrial Hygiene Foundation](#)
American Insurance Association
American Iron and Steel Institute
American Petroleum Institute
American Society for Testing and Materials
[American Society of Safety Professionals](#)
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American Welding Society
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[Black and Decker](#)
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Canadian Vehicle Manufacturers Association
CNA Insurance
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European Brush Manufacturers Association (FEIBP)
FM Global
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~~Employees~~-United Autoworkers Union
United Brotherhood of Carpenters and Joiners of America
United Steelworkers of America
[U.S. Consumer Product Safety Commission](#)
U.S. Department of Labor - OSHA
U.S. General Services Administration
[Wausau Insurance](#)
[Weiler Corporation](#)

Explanation of Standard Format

This standard uses a two-column format to provide both specific requirements and supporting information.

The left column, designated "Standard Requirements" is confined solely to these requirements and is printed in bold type. Where supporting photographs or sketches are required, they are designated as "figures."

The right column, designated "Explanatory Information" contains only information that is intended to clarify the standard. This is not a part of the standard. Where supplementary photographs or sketches are required, they are designated as "illustrations."

The information contained in E4.3 illustration 2 is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, illustration 2 may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

Operating rules (safe practices) are not included in either column unless they are of such nature as to be vital safety requirements, equal in weight to other requirements or guides to assist in compliance with the standard.

American National Standard for Power Tools –

Power-Driven Brushing Tools – Safety Requirements for Design, Care, and Use

Standard Requirements

1 Scope

The purpose of this standard is to establish the rules and specifications for safety that apply in the design, use, and care of power-driven brushing tools. It includes specifications for shanks, adapters, flanges, collets, chucks, and safety guards and rules for the proper storage, handling, mounting, and use of brushes. It embraces configurations of brushing tools whose functional performance is accomplished by power-driven operation. Covered are brushing tools whose brushing elements are made up of ferrous wire, nonferrous wire, plastic, abrasive filaments, vegetable fibers, animal hair, or other materials, and brushes fabricated with any combination of such elements.

Brushing tools whose primary function is vehicle or train washing, carpet sweeping, dental hygiene, floor maintenance, sewer cleaning, street sweeping, and brushing tools manufactured in accordance with other applicable American National Standards are not covered.

Explanatory Information

(Not part of American National Standard ANSI B165.1-2013)

E1 Scope

It is the intent of this standard to cover power-driven brushes, of any size, any materials, any construction or any configuration except those specifically excluded under the scope. Brushes with wood or synthetic hubs and cores, which have overall appearances very similar to power brushes of this standard, have been excluded because the parameter of construction and use differ fundamentally from brushes covered in this standard. Other brushes excluded in this standard have been omitted because of significant differences in construction, dimension, service conditions or application.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI B7.1-2011, *Safety requirements for the use, care, and protection of abrasive wheels*

ANSI Z88.2, *Practices for respiratory protection*

ANSI/ISEA Z87.1-2010, *Practice for occupational and educational eye and face protection*

ANSI/UL 60745, *Safety standard for hand-held motor-operated electric tools - safety*

ANSI/UL 987, *Safety standard for stationary and fixed electric tools*

3 Definitions

3.1 General definitions

3.1.1 brush: For brevity in this standard, used interchangeably with “brushing tool,” “power-driven brushing tool,” or “power-driven brush.”

3.1.2 shall and should: The word “shall”, where used, is to be understood as mandatory, and “should” as advisory.

E2 Bibliography (informative)

ANSI/NFPA 91-2010, *Exhaust systems for air conveying of vapors, gases, mists, and noncombustible particulate solids*

ANSI/UL 154 CAN/ULC-5503-2009, *Safety standard for carbon-dioxide fire extinguishers*

OSHA Safety Code 1910.94

OSHA Title 29, Chap. 17, Part 1910.94(b)

3.1.3 revolutions per minute (rpm):
The number of complete turns that a brush makes in one minute.

E3.1.3 Revolutions per minute

Although machine spindle speeds are usually indicated in revolutions per minute (rpm), and motor name plate speeds invariably are described in terms of the number of revolutions the motor will produce in one minute, brush speeds are often classified in surface feet per minute (sfpm) or surface meters per minute (smpm). It is, therefore, essential to know the difference between how they are measured and what those measurements mean.

3.1.4 surface feet per minute (sfpm):
The distance in feet traveled by any spot on the peripheral surface of a brush in one minute.

E3.1.4 Surface feet per minute

When the diameter of a brush is indicated in inches, it is necessary to divide by 12 the result of multiplying the diameter by rpm by pi (3.1416). An example of this equation follows for a brush 12 inches in diameter turning at 1000 rpm:

$$\text{sfpm} = \frac{3.1416 \times \text{diameter in inches} \times \text{rpm}}{12}$$

or: **0.262 × diameter in inches × rpm**
for a very close approximation

$$\frac{3.1416 \times 12 \times 1000}{12} = 3141.6 \text{ sfpm}$$

This measurement is also referred to as "circumferential speed."

3.1.4a surface meters per minute (smpm): The distance in meters traveled by any spot on the peripheral surface of a brush in one minute.

E3.1.4a Surface meters per minute

When the diameter of a brush is indicated in millimeters, it is necessary to divide by 1000 the result of multiplying the diameter by rpm by pi (3.1416). An example of this equation follows for a brush 305 millimeters in diameter turning at 1000 rpm:

$$\text{smpm} = \frac{3.1416 \times \text{diameter (mm)} \times \text{rpm}}{1000}$$

or: **0.003 × diameter in millimeters × rpm**
for a very close approximation

$$\frac{3.1416 \times 305 \times 1000}{1000} = 957.6 \text{ smpm}$$

This measurement is also referred to as "circumferential speed."

3.1.5 the brush manufacturer: Any individual, partnership, corporation, or other form of enterprise that manufactures or assembles any kind of power-driven brushing tools.

3.1.6 the brush machine or power tool builder:

- Any individual, partnership, corporation, or other form of enterprise that is engaged in the development, or manufacture, or both, of any type of machine or power tool that uses power-driven brushing tools.

- One who converts, changes, or otherwise alters the original design of such machines or power tools.

3.1.7 the user: Any individual, partnership, corporation, or other form of enterprise that uses any kind of power-driven brushing tools or brush machines.

3.1.8 maximum safe free speed (MSFS or max. SFS or MAX RPM): Synonymous with maximum safe rpm (free rotation or no-load speed). The maximum speed at which the brush shall be rotated with no work applied (spinning free) to ensure safe operation. All brush manufacturers have the responsibility of determining the MSFS for their products. A recognized criterion for establishing this value for each brush is described in 8.3.

3.1.9 brush face: The surface of the brush that does the brushing as viewed from the ends of the filaments.

3.1.9.1 face width: The axial dimension at the outside diameter of a brush when it is measured in its static condition.

3.1.9.2 operating face width: The width of the face of the brush, measured at operating speed.

E3.1.9.2 Operating face width

The width of a wheel brush rotating at operational speeds frequently is different from the width or face of the same brush in a stationary condition. The face width of brush filaments in a static brush is usually wider than the same assembly of filaments at point of attachment. When rotating at operational speeds, centrifugal force orientates all filaments into a radial, more compact configuration that substantially reduces any lateral displacement. As a result, the mass of filaments are nearly the same width at the periphery as they are at the point of attachment.

3.1.10 fill or fill material: The filaments that do the brushing in a brush. Fill material can be ferrous or nonferrous wire, abrasive loaded plastic, plastic, composites, vegetable fiber, animal hair, or other materials. Sometimes the fill is a combination of two or more different fill materials, such as wire, tampico, horsehair, plastic, vegetable fiber, and pig bristle.

3.1.10.1 crimped plastic fill material: Synthetic fill material whose linear configuration is not straight or level, but is corrugated in appearance from having been passed through gears or other devices.

E3.1.10.1 Crimped plastic fill material

The configuration of crimped plastic fill materials is similar to that of crimped wire (see 3.1.13).

3.1.10.2 abrasive loaded plastic fill materials: Synthetic fill material made of plastic monofilaments that have abrasive grit homogeneously dispersed throughout.

3.1.10.3 straight or level plastic fill material: Synthetic fill material that is straight before being used in a brush or before being formed into a tuft or other configuration as part of a brush.

3.1.10.4 vegetable fiber fill material: An end product resulting from the processing of the fibrous part of the leaf or root of various types of plants and trees. Typical fibers are tampico, palmyra, bassine, and palmetto.

3.1.10.5 hair fill material: The hair of any animal except a pig, hog, or boar. Whalebone and feathers are not construed to be hair.

3.1.10.6 bristle fill material: The hair of a pig, hog, or boar.

E3.1.10.6 Bristle fill material

The term "bristle," when used in relationship to brushes, is restricted and limited to the hair of the swine exclusively and should not be used to describe any other filaments.

3.1.11 brush flexibility: The brush's capability to conform to irregular or contoured surfaces are measured by filament deflection.

E3.1.11 Brush flexibility

The quality of a brush that determines resiliency or stiffness is measured in terms of resistance to the bending of filaments. This physical characteristic of flexibility, sometimes referred to as "modulus of elasticity (stiffness)," can be varied in a number of ways. Primary ways are as follows:

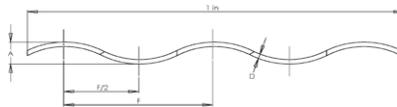
- Change modulus of elasticity of the fill materials, which varies for different materials. For example: steel, brass, hair, nylon.
- Increase or decrease the diameter of fill material. For example: 0.020 inch (0.508 mm) steel wire is stiffer than 0.005 inch (0.127 mm) steel wire of same analysis.

- Increase or decrease the trim length of the fill material. For example: A steel wire filament that is 0.010 inch (0.254 mm) in diameter and 1 inch (25.4 mm) long is stiffer than a similar steel wire filament that is 0.010 inch (0.254 mm) in diameter and 4 inches (101.6 mm) long.
- Increase or decrease the speed of rotation. For example: The faster a brush is rotated, the stiffer it becomes because of the influence of centrifugal force.
- Change the construction of the brush. For example: Filaments of wire twisted together as in a knotted or twisted tuft brush are stiffer than those in a crimped wire brush. In the knot or twisted tuft construction, the filaments being twisted together act as a family of filaments, while in a crimped wire brush, they act more independently of other filaments.
- Increase or decrease the number of brushing points per square unit of brush face. This changes the brush flexibility through wire packing, load division, or both; accordingly, flexibility increases as density decreases and, conversely, less capability to conform to the surface being brushed will result as density increases.
- Encapsulating, coating, or treating the brushes makes them less flexible than the brushes without encapsulation, coating, or treatment.

3.1.12 bonded brushes (also, elastomerically encapsulated brushes): Brushes that have elastomer material molded into them unitizing the fill material.

3.1.13 crimped wire: Wire that has been passed through gears or other devices to impart a corrugated appearance to the wire.

E3.1.13 Crimped wire



NOTES

- 1 The Illustration shows a single-plane crimped filament; however, dual-plane crimped filaments are more commonly used
- 2 F = Full wave length; F/2 = Half wave length; D = Filament diameter; A = Crimp amplitude

Illustration 1- Single-plane crimped filament

3.1.14 straight wire: Wire that was straight before being used in a brush or before being formed into a tuft or other configuration as part of a brush.

3.1.15 twisted tuft or knot: A group of straight wires of equal length that are passed through or around a retaining member, bent into a U-shape, then twisted together to form a single tuft. The helix angle, or angle of twist of a tuft is the angle through which a radial section of a group of wires deflects from its normal position when the wires are subjected to a predetermined twisting torque. The helix angle is a variable, contingent upon the type of wire, the diameter, and the size of the tuft.

3.1.16 shank: Male extension and driving means (usually of an end, wheel, or cup brush) capable of being gripped in a chucking device or collet of proper size.

3.1.17 arbor adapter: Device used to reduce the size of an arbor hole in a brush. Frequently, an adapter is a concentric ring with or without a shoulder.

E3.1.17 Arbor adapter

Adapter should be designed so that, when tightened, the adapter shoulder is bearing against the brush. Brushes using adapters without a shoulder are tightened to bear against the brush. When used in pairs, adapters should be of the same or proper shape to avoid cross-bending pressures and distortion of the brush; and should be of sufficient rigidity to resist distortion from mounting pressure.

Adapters can be distorted by excessive tightening, or burred by dropping; therefore, they should be checked periodically.

In some brush operations in which wheel slippage may be a problem, it may be necessary to key or otherwise securely fasten the adapters to the spindle.

3.1.18 density: The number of filament ends per given area of brush face.

3.1.19 trim length: Dimension of fill material extending from beyond the retaining member, face plate, or bridle (visible length of filament).

3.1.20 safety guard: Enclosure designed to contain any filaments, or any particles removed by brushing, that

might be thrown from the brush or by the brush while it is rotating. Guards shall be placed where necessary, except in the open area of operation to allow access to the work.

3.1.21 safety shield: Fixed or adjustable transparent visor or eye shield that is connected to the brushing machine, which provides additional safety for the operators while permitting them to visually observe the brushing being accomplished. In addition to fixed or adjustable transparent visors or eye shields that are attached to a machine, brush operators and others in the area of the brushing operation shall wear safety goggles, full face shields over safety glasses with side shields, or other forms of personal eye protection as described in ANSI/ISEA Z87.1.

3.1.22 barrier: any partition, wall, or separate brushing booth that provides protection to the operator and/or other personnel in the area.

E3.1.22 Barrier

Such protection takes the form of an enclosure that isolates the operation from the remaining work area. Barriers can be either fixed or adjustable enclosures and are usually not connected with the brushing machine.

3.1.23 arbor hole bushing: Centering device placed in an arbor hole to reduce its size. Tubular bushings are frequently used for this purpose and are used in the same way as adapters without a shoulder.

3.1.24 bridle: Brush component used to control or restrain flare on cup or end brushes.

3.2 Definitions of brush configurations

Elastomerically encapsulated brushes of the following types and classes shall be subject to the same regulations as the base brush.

3.2.1 Type I, straight cup brushes: As shown in figure 1, type I brushes are brushes with a cup configuration and straight sides that are parallel to the axis of the brush. Dimensions shall include the outside diameter, inside diameter, trim length, overall height, face width, and arbor hole diameter.

- **Class 1: Crimped wire, abrasive loaded plastic, plastic, fiber, or hair fill material:** As shown in figure 1(a), class 1 brushes with crimped wire, abrasive loaded plastic, or plastic fill material have additional dimensions such as wire or plastic diameter, crimp amplitude, and crimp wave length. Specifications include the appropriate chemical and physical attributes of the fill material. When brushes are furnished with fiber or hair fill material, the type of quality of the material shall be specified.
- **Class 2: Twisted tuft or knot fill material:** As shown in figure 1(b), class 2 brushes with a twisted tuft or knot have additional dimensions such as wire diameter and number of rows or tufts. Specifications include the appropriate chemical and physical attributes of the fill material. Helix angle or twist configuration of tufts and length of twist may be described.

3.2.2 Type II, flared cup brushes: As shown in figure 2, type II brushes are brushes with a cup configuration that have flared cups with the included angle of the cup being a variable depending upon the application. Dimensions shall include outside diameter, inside diameter, trim length, overall heights, face width, and arbor hole diameter.

- **Class 1: Crimped wire, abrasive loaded plastic, plastic fiber, or hair fill material:** As shown in figure 2(a), class 1 brushes with crimped wire, abrasive loaded plastic or plastic fill material have additional dimensions such as wire or plastic diameter, crimp amplitude, and crimp wave length. Specifications include the appropriate chemical and physical attributes of the fill material. When brushes are furnished with fiber or hair fill material, the type and quality of the material shall be specified.
- **Class 2: Twisted tuft or knot fill material:** As shown in figure 2(b), class 2 brushes with a twisted tuft or knot have additional dimensions

such as wire diameter and number of rows or tufts. Specifications include the appropriate chemical and physical attributes of the fill material. Helix angle or twist configuration of tufts and lengths of twist may be described.

3.2.3 cup brush with shank: Type I straight cup brushes, both class 1 and class 2, can be furnished with a shank as shown in figures 3(a) and 3(b). Dimensions and specifications shall be the same as in 3.2.1, except arbor hole dimensions are not applicable. Additional dimensions shall include diameter and length of shank.

Type II flared cup brushes, both class 1 and class 2, can be furnished with a shank as shown in figures 4(a) and 4(b). Dimensions and specifications shall be the same as in 3.2.2, except arbor hole dimensions are not applicable. Additional dimensions shall include diameter and length of shank.

3.2.4 Type III, wheel or radial brush: As shown in figure 5, type III brushes are circular brushes with a wheel configuration. Dimensions shall include diameter, trim length, face width, and arbor hole dimensions. Radial brushes whose length exceeds their diameter are called cylinder or wide-face brushes (see 3.2.11).

- **Class 1: Crimped wire, abrasive loaded plastic, plastic, fiber, or hair fill material:** As shown in figure 5(a) class 1 brushes with crimped wire, abrasive loaded plastic, or plastic fill material have additional dimensions such as wire or plastic diameters, crimp amplitude, and crimp wave length. Specifications include appropriate chemical and physical attributes of the fill material. When brushes are furnished with fiber or hair fill material, the type and quality of the material shall be specified.
- **Class 2: Twisted tuft or knot:** As shown in figure 5(b), class 2 brushes with a twisted tuft or knot

have additional dimensions such as wire diameter and number of rows or tufts. Specifications include the appropriate chemical and physical attributes of the fill material. Helix angle or twist configuration of tufts and length of twist may be described.

3.2.5 wheel or radial brush with shank: Type III wheel brushes, both class 1 and class 2, can be furnished with a shank as shown in figures 6(a) and 6(b). Dimensions and specifications shall be the same as 3.2.4, except that arbor hole dimensions are not applicable. Additional dimensions shall include diameter and length of shank.

3.2.6 Type IV, end brush: As shown in figure 7, type IV brushes have an end brush configuration with the fill material protruding from one end of the driving component. They generally have a permanently attached shank. The fill material is oriented so that its length is parallel to the axis of the brush. Dimensions shall include face outside diameter, trim length, shank diameter, shank length, overall length, and cup diameter.

- **Class 1: End brush with crimped wire, abrasive loaded plastic, plastic, fiber, or hair fill material.** There are three styles of class 2 end brushes (see figure 7(a)). They all have additional dimensions that include wire, abrasive loaded plastic, or plastic diameter, crimp amplitude, and crimp wave length. Specifications include appropriate chemical and physical attributes of the fill material. When brushes are furnished with fiber or hair fill material, the type and quality of the material shall be specified.

Elastomerically encapsulated brushes of this class shall be subject to the same regulations as the base brush.

- **Style A, Solid filled end brush:** Style A brushes have the cup end filled so that the brush presents a continuous face.

- **Style B, Hollow center end brush:**
Style B brushes are identical to style A brushes in every respect, except that the face has a circular void centrally located on the face of the brush. These brushes have the additional dimensions of face inside diameter.
- **Style C, Pilot end brush:** Style C brushes are identical to style A brushes in every respect, except that a pilot protrudes from the central part of the face. It has the additional dimensions of the diameter, center length, and radius of the pilot. The chemical and physical properties of pilot material shall be identified.
- **Class 2: End brush with twisted tuft or knot, hollow center:** Class 2 end brushes (see figure 7(b)) with a twisted tuft or knot have additional dimensions that include wire diameter, number of tufts, inside diameter, and face outside diameter. Specifications should include appropriate chemical and physical attributes. Helix angle or twist configuration of tufts and length of twist may be described.

3.2.7 Type V, flared end brush: As shown in figure 8, type V flared end brushes have a self-contained shank. The fill material that protrudes from the retaining cup is flared into a circular pattern, with the filaments being oriented into a radial configuration. Dimensions shall include flared diameter, face width, cup diameter, shank diameter, shank length, overall length, filament diameter, crimp amplitude, and crimp wave length. Specifications include appropriate chemical and physical attributes of wire or other fill materials.

3.2.8 Type VI, tubular end brush: As shown in figure 9, type VI tubular end brushes are constructed both with and without shank extension. The fill wire, abrasive-loaded plastic, plastic, or other fill material is oriented so that its length is parallel to the axis of the brush.

Dimensions shall include outside diameter, trim length, and overall length. The brushes can be filled with either straight or crimped fill material. The diameter of the wire, abrasive-loaded plastic, or plastic fill material shall be specified. If crimped wire, abrasive loaded plastic, or plastic is used, the dimensions of crimp wave length and crimp amplitude shall be specified. Specifications include appropriate chemical and physical attributes of the fill material. When brushes are furnished with fiber or hair fill material, the type and quality of the material shall be specified.

Elastomerically encapsulated brushes of this class shall be subject to the same regulations as the base brush.

If the tubular end brush contains a shank, the diameter and the length of the shank shall be specified.

3.2.9 Type VII, twisted-in wire brush (or tube cleaning brush): As shown in figure 10, type VII twisted-in wire brushes are made by twisting the fill material between two or more retaining stem wires. This construction places each filament in a radial position in which the total mass of fill material is helical or spiral in configuration. Specifications include type of fill, outside diameter and length of brush part, number of stem wires, stem length, and stem diameter.

Either straight or crimped fill material can be used. The size of the fill material shall be specified. If crimped material is used, the dimensions of crimp wave length and the crimp amplitude shall be specified. Specifications include appropriate chemical and physical attributes of both the fill materials and the stem wire.

If the twisted-in wire brush has a shank or extension affixed to the stem, the diameter of the shank or extensions shall be specified. If the shank is threaded, the size and length of the thread is specified.

Elastomerically encapsulated brushes of this class shall be subject to the same regulations as the base brush.

3.2.10 Type VIII, strip brush: As shown in figure 11, type VIII strip brushes are manufactured in a continuous strip form and subsequently cut to the required finish length. In addition to their straight configuration (shown in figure 11), strip brushes may also be helically wound around the outside of an arbor for use as wide-face rotary brushes (see the coil-wound strip in figures 12 and 13).

Strip brushes are commonly manufactured by roll forming a metal channel and pressing the fill material into the channel in a hairpin configuration. A retaining member runs the entire length of the strip to ensure retention of the fill material.

3.2.11 Type IX, cylinder or wide-face brushes: As shown in figure 12, type IX cylinder brushes are either directly mounted on reusable arbors by the brush manufacturer or assembled as replacement elements by the user. The mandrel on which the brushes are mounted can be manufactured by either the brush manufacturer, the brush machine builder, or the user. The specifications of the arbor shall be determined by the brush machine builder. The specifications may be modified by the brush manufacturer if the modifications do not preclude the arbor being used in the machine for which it was designed.

The dimensions for the brushes shall include outside diameter, inside diameter, face width, and trim length.

- **Class 1: Cylinder or wide-face brushes that are mounted by brush manufacturer:** Class 1 brushes are either sectional built-up face brushes or strip brushes. Many modifications of each of them are produced and many are customized for particular applications of users. Figure 12 shows several types of sectional built-up face and strip cylinder brushes.

The specifications frequently include provisions for brushes in which coolant or other liquids are

E3.2.11 (1) Class 1: Cylinder or wide-face brushes that are mounted by brush manufacturer

Aside from the two primary styles mentioned in this clause, there are many other types of class 1 cylinder or wide-face brushes. Since they are too numerous to describe in this standard, only the two most common styles have been included.

pumped through the face of the brush.

- **Style A, Sectional built-up face:**
 - **Crimped fill material:** Specifications include fill diameter, crimp amplitude, and crimp wave length and appropriate chemical and physical attributes of the fill material.
 - **Twisted tuft or knot fill material:** Specifications include wire diameter and the number of rows of tufts, helix angle (twist configuration, length of twist, and tuft concentration). Specifications include appropriate chemical and physical attributes of the fill material.
 - **Nonmetallic fill material:** Specifications shall include type of fill and size of filaments.
- **Style B, strip:** Strip brushes can be inserted in mounting clips or otherwise anchored on the permanent (reusable) arbors so that the density of the fill can range from very light to very heavy.

Dimensions shall include height and width of metal retaining device, overall height of strip, number of strips, description of the fill material, and helix (spiral) angle of the strip.

- **Straight strip brushes with wire or nonmetallic fill material:** Straight strip brushes are fastened parallel to the axis of the hub. Specifications include wire diameter,

crimp amplitude, crimp wave length, and appropriate chemical and physical properties of the wire fill material, type of material if nonmetallic, and diameter of filaments, where appropriate.

- Helix strip brushes: Helix strip brushes can be assembled in a helically disposed arrangement with the individual strip brushes positioned in a longitudinal direction.
- Coil-wound strip brushes: Strip brushes can be wound circumferentially around the arbor with either a long lead (pitch) or a closely wound lead (pitch) to provide open or dense construction.
- **Class 2: Expendable brushes, unitized brushes, or both:** Like class 1 brushes, class 2 brushes are either sectional built-up face brushes or strip brushes. These brushes can be manufactured either by factory assembly directly onto the user's shaft or as a cartridge-type unit that is made for later assembly on the user's arbor at the time of need. Examples of these brushes are provided in figure 13.
 - **Style A, Sectional built-up face:**
 - **Crimped fill material:** Specifications include type of fill material, fill diameter, crimp amplitude, crimp wave length, and appropriate chemical and physical attributes of fill material.
 - **Twisted tuft or knot fill material:** Specifications include wire diameter and number of rows of tufts,

E3.2.11 (2) Class 2: Expendable brushes, unitized brushes, or both

Aside from the two primary styles mentioned in this clause, there are many other types of class 2 cylinder or wide-face brushes. Since they are too numerous to describe in this standard, only the two most common styles have been included.

helix angle (twist configuration), length of twist, tuft concentration, and appropriate chemical and physical attributes of wire fill material.

- **Nonmetallic fill material:** Specifications shall include type of fill and size of filaments.
- **Style B, strip:** Strip brushes can be inserted in mounting clips on the permanent (reusable) arbors or anchored to cartridges that can be mounted on the user's arbors. The mounting method allows a variation in the density of the brush from very light to very heavy. Dimensions shall include height and width of metal retaining device, overall height of strip, number of strips, description of the fill material, and helix angle of the strip, where applicable.
- **Straight strip brushes with wire fill material:** Straight strip brushes are fastened parallel to the axis off the hub. Specifications include wire diameter, crimp amplitude, crimp wave length, and appropriate chemical and physical properties of the wire fill material.
- **Straight strip brushes with nonmetallic fill material:** In addition to the specifications for straight strip brushes with wire fill material, specifications for strip brushes with nonmetallic fill material also include the type of material and the diameter of filaments, where appropriate.

- **Helix strip brushes:** Helix strip brushes can be assembled in a helically disposed arrangement with the individual strip brushes positioned in a longitudinal direction.
- **Coil-wound strip brushes:** Strip brushes can be wound circumferentially around the arbor with either a long lead (pitch) or a closely wound lead (pitch) to provide open or dense construction.

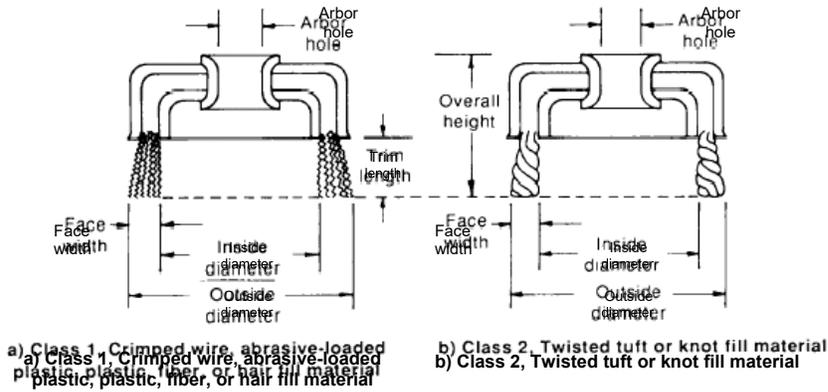


Figure 1 - Type I, Straight cup brush

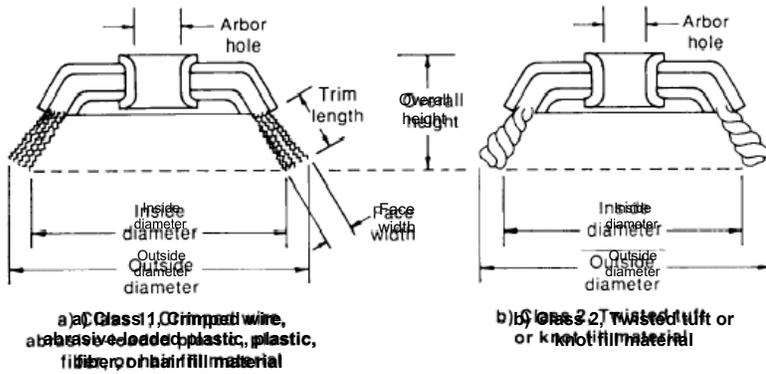


Figure 2 - Type II, Flared cup brush

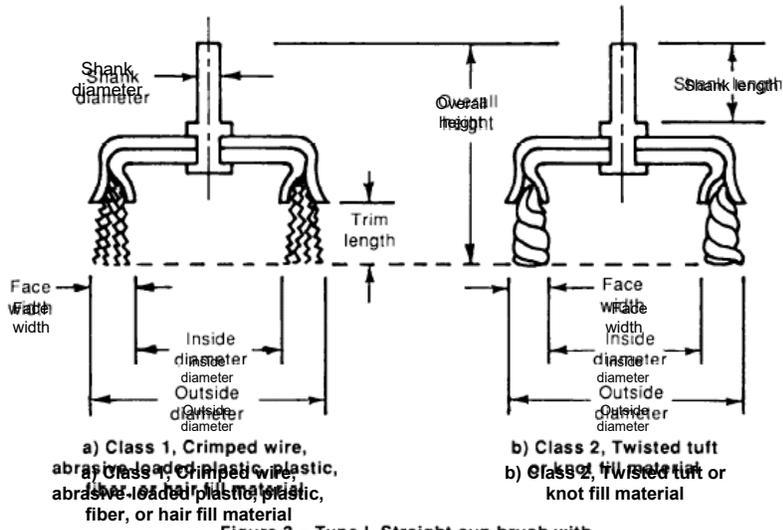


Figure 3 – Type I, Straight cup brush with shank

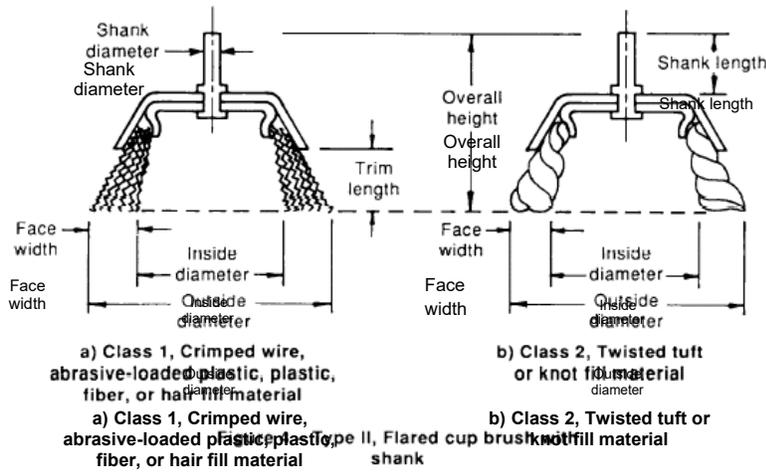


Figure 4 – Type II, Flared cup brush with shank

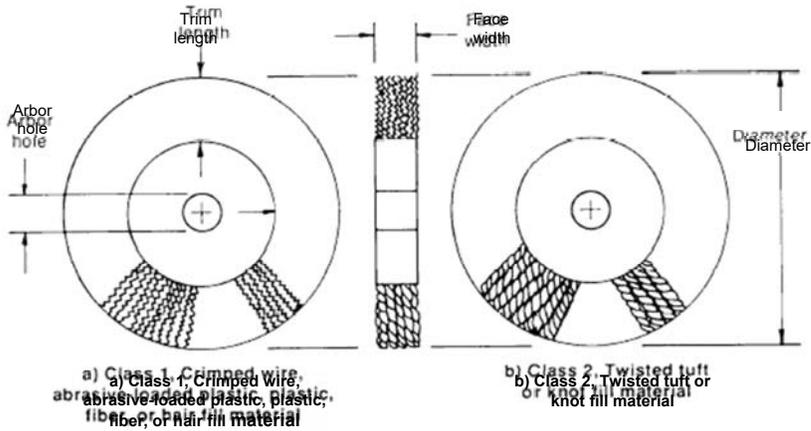


Figure 5—Type II Wheel or radial brush

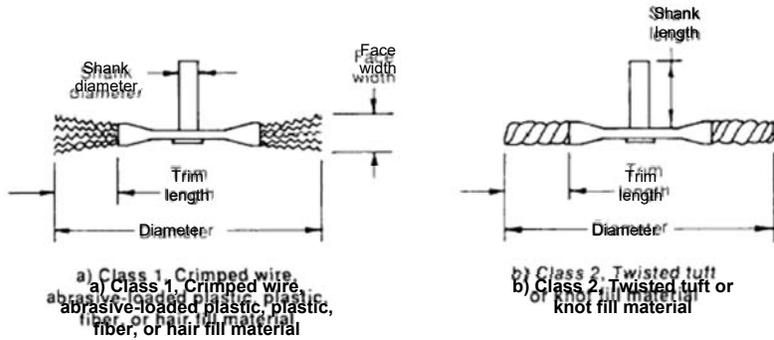


Figure 6—Type III Wheel or radial brush with shank

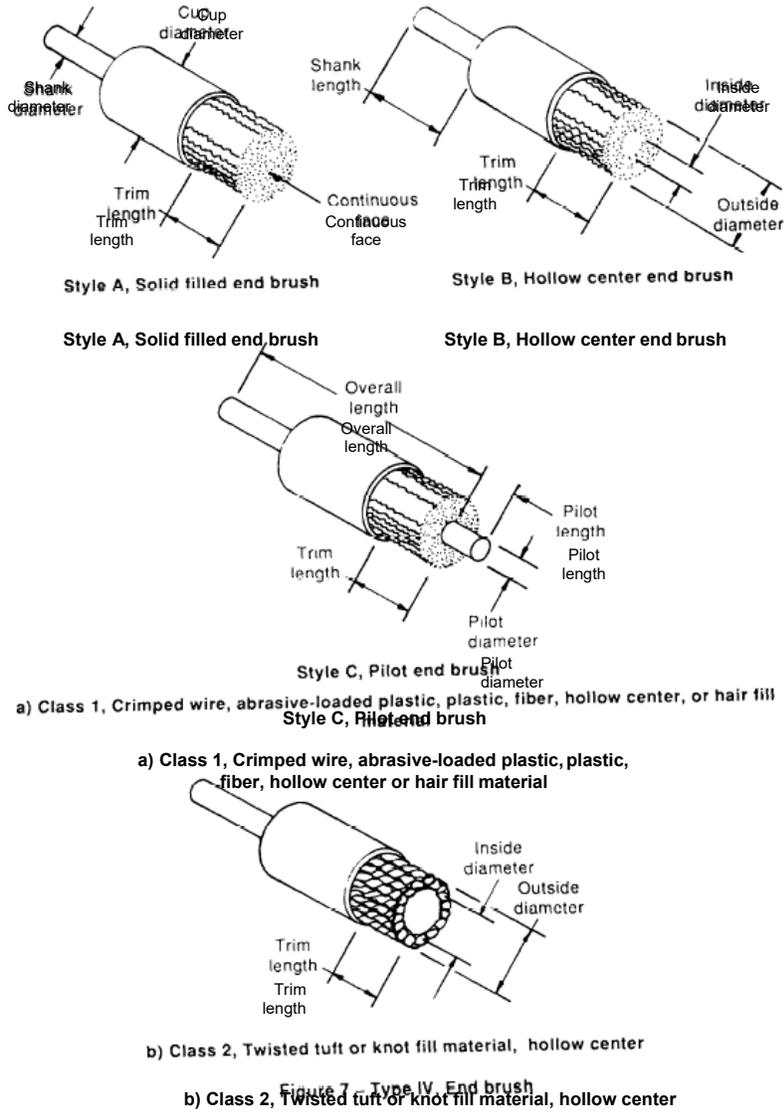
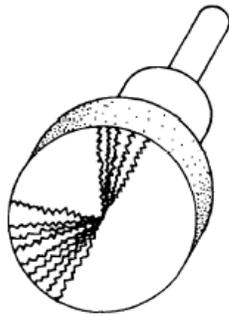
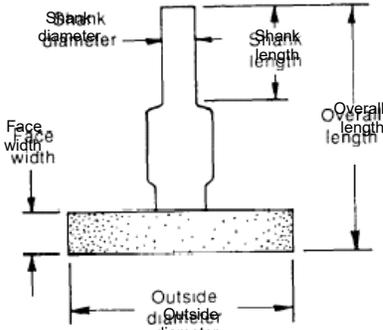


Figure 7 – Type IV, End brush

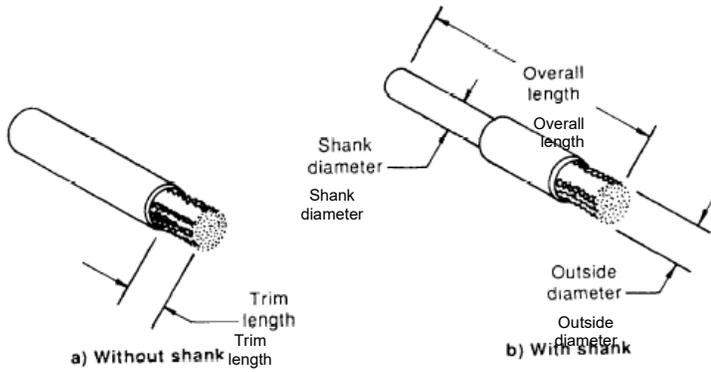


a) Bottom view
a) Bottom view



b) Side view
b) Side view

Figure 8 – Type V, Flared end brush
Figure 8 – Type V, Flared end brush



a) Without shank
a) Without shank

b) With shank
b) With shank

Figure 9 – Type VI, Tubular end brush
Figure 9 – Type VI, Tubular end brush

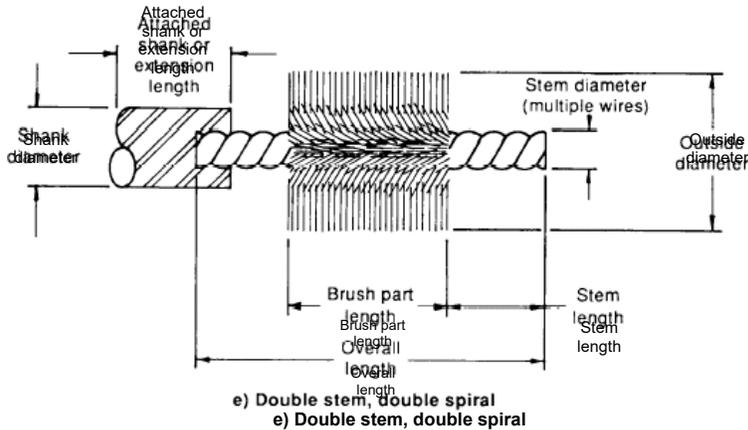
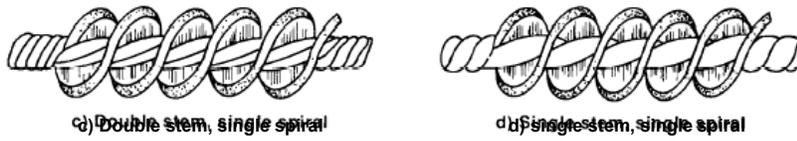
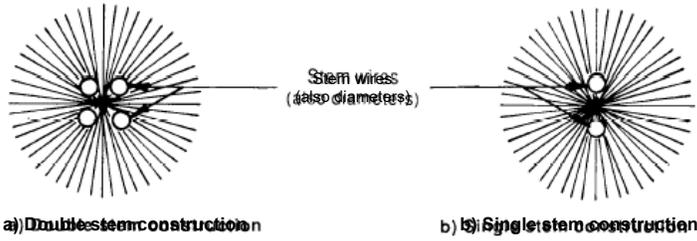


Figure 10 – Type VII, Twisted-in wire brush (or tube cleaning brush)

Figure 10 – Type VII, Twisted-in wire brush (or tube cleaning brush)

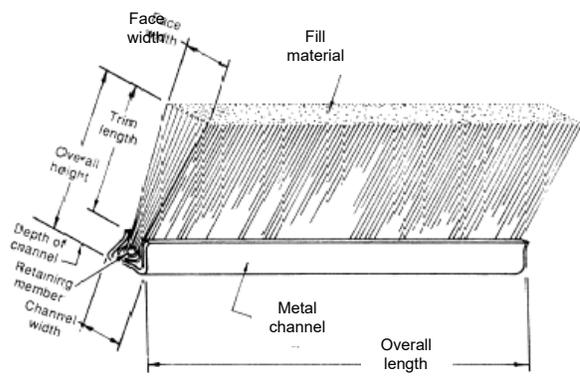


Figure 11 – Type VIII, Strip brush

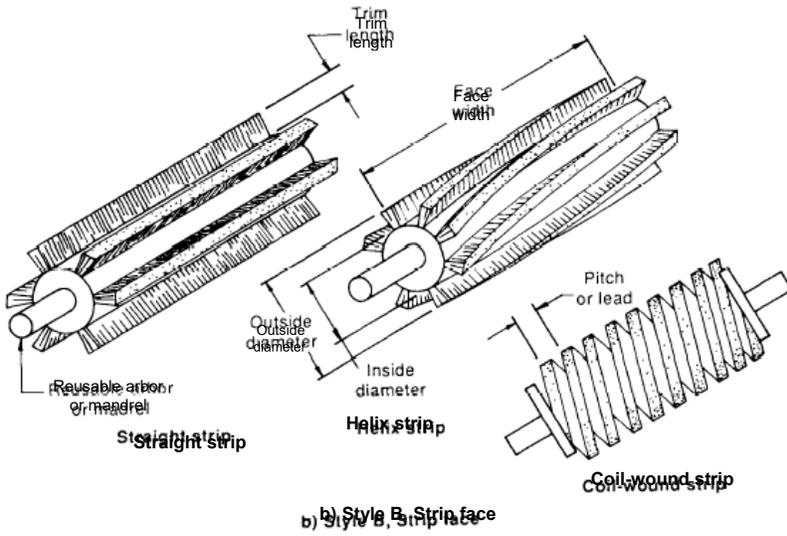
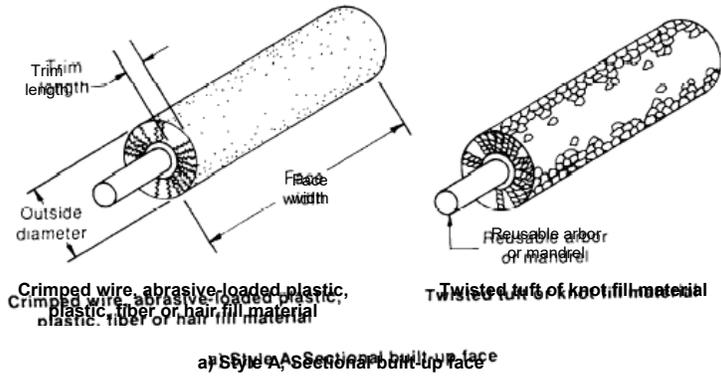


Figure 12 – Type IX, Class 1, Cylinder or wide face brushes mounted by manufacturer

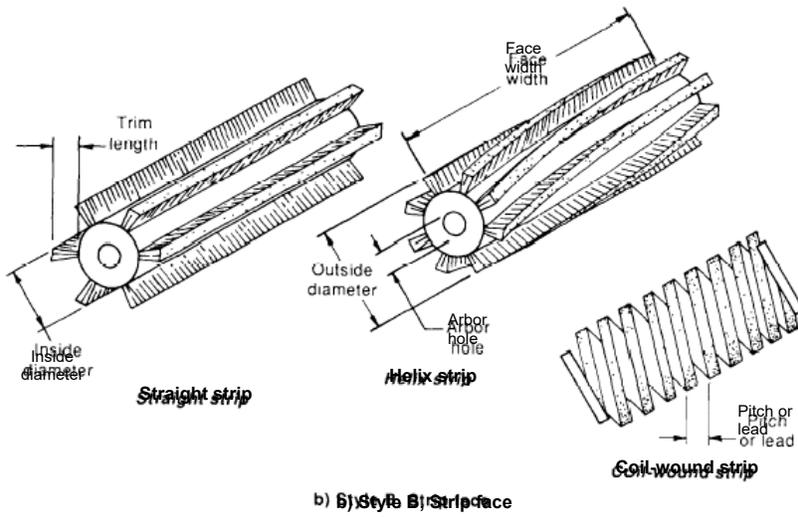
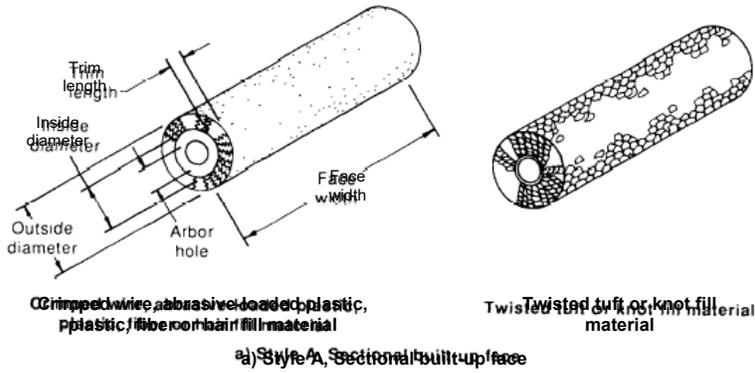


Figure 3-13 Type IX, Class 2, Disposable or untrimmed cylinder or wide-face brushes

4 Design

4.1 Manufacture of brushes

The brush manufacturer shall be responsible for the design of brushes produced and shall apply the principles of strength of materials to ensure that satisfactory materials are utilized and adequate proportions obtained to resist functional forces produced by centrifugal forces or impact.

4.2 Material

All components of the brush shall be of such design as to transmit the driving torque from the spindle to the brush periphery. They shall be constructed in such a manner as to ensure an even distribution of fill material throughout the brush so that good balance can be attained.

Adequate provision for filament retention shall be made. The fill material shall not be burned, broken, or otherwise affected by any assembly operations so as to make it unsafe.

4.3 Marking

When sufficient surface space is available, each brush shall be marked in a permanent manner to show the maximum safe free speed (MSFS or max. SFS or MAX RPM) in revolutions per minute; the brush shall also carry the words, "Wear eye protection," when sufficient space is available. If sufficient space is not available, the approved Eye Protection Icon can be substituted.

The manufacturer's name or trademark shall also be included. If only the trademark is used, it shall be of such known character that

E4.1 Manufacture of brushes

Brush manufacturers know the basic construction of their own brushes best, are knowledgeable about the nature and characteristics of their products, and are aware of the use and functions for which they were designed.

The design parameters for a brush used to defuzz a peach are obviously different from those for brushes used to descale steel. Brush manufacturers recognize the need for different strength requirements for various applications and consequently design their brushes so that the working stresses encountered in a given application will not exceed the strength of the material of the brushes.

E4.2 Material

The design of the brush and the material from which it is made should be established with operator safety in mind.

E4.3 Marking

The required type of marking will leave permanent, as well as legible, admonishments and identification on the brush.

The markings can be etched, molded in, or die stamped.

Marking or labeling the packages of smaller items (under 1 inch or 2.54 cm) is desirable and would meet the requirements of this standard.

The American Brush Manufacturers Association (ABMA) must maintain a list of

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Brush manufacturers may omit their names or trademarks on a brush sold to a distributor or another brush manufacturer whose own name or trademark will appear on the brush. In such cases (known as “private branding”), the brush manufacturer and the private brander shall mutually determine which of them is to do the marking. It shall, however, be the responsibility of the private brander to see that the brush is not transferred to the user without being permanently marked with identifying markings.

manufacturers and their marks. Each manufacturer will submit a current sample of their mark or their marks to ABMA and advise them of any future changes.

All packages containing brushes should have a summary of the safety precautions given in this standard printed either on each package or on a card or slip placed inside the package. When the card or slip is placed inside the package, the package (or label on the package) must be marked **Warning: Read and understand all warnings and operating instructions on the enclosed safety slip and those provided with your power tool before using this brush.**

All brushes delivered to end users must be accompanied with a copy of the summary of safety precautions as available from the ABMA or packaged with the product. See Illustration 2 for the recommended text for this summary.

If a copy of the summary of safety precautions is unavailable, please contact ABMA, info@abma.org, or visit the website, <http://www.abma.org>, to receive a copy.

The information contained in Illustration 2 below is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, Illustration 2 may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

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Illustration 2 – Summary of Safety Precautions (Front and BackSide-1)

AWARNING	ADVERTENCIA	AVERTISSEMENT
<p>All operators must read, study, understand and comply with all warnings and operating instructions on both sides of this safety sign and those instructions provided with your power tool before using this brush.</p>	<p>Todos los operadores deben leer, estudiar, comprender y cumplir todas las advertencias e instrucciones de funcionamiento que aparecen en ambos lados de este letrero de seguridad, así como las instrucciones que se facilitan con la herramienta eléctrica antes de usar este cepillo.</p>	<p>Tous les opérateurs doivent lire, étudier et comprendre et se conformer à tous les avertissements et d'exploitation des instructions sur les deux côtés de ce letrero de sécurité et les instructions fournies avec votre outil électrique avant d'utiliser la brosse.</p>
<p>Safety glasses and full face shields must be worn by users and others in area. Persons within 50 or more feet may be within danger zone. See ANSI/ISEA Z87.1</p>	<p>Los usuarios y otros en la zona deben utilizar lentes de seguridad y protectores faciales. Las personas dentro de 50 o más pies pueden estar dentro de la zona de peligro. Véase la norma ANSI/ISEA Z87.1</p>	<p>Les usagers et autres dans la zone doivent utiliser les lunettes de sécurité et autres dans la région. Les personnes à l'intérieur de 50 pieds ou plus peuvent être au sein de la zone de danger. Voir la norme ANSI/ISEA Z87.1</p>
<p>Observe all speed restrictions. Maximum RPM or Maximum Safe Free Speed (MSFS), See ANSI 3.1.8</p>	<p>Observe la restricción de velocidad. Máximo RPM o Máximo Libre Seguro (MSFS). Consulte ANSI 3.1.8</p>	<p>Respecter toutes les restrictions de vitesse. Maximum RPM ou Maximum Libre-Securité (MSFS). Voir ANSI 3.1.8</p>
<p>Tool guards must be in place at all times.</p>	<p>Las protecciones deben mantenerse en su lugar, en todo momento.</p>	<p>Des protections doivent être maintenues en place en tout temps.</p>
<p>Appropriate protective gloves must be worn.</p>	<p>Gaunas de protección adecuadas deben ser usadas.</p>	<p>Des gants protecteurs appropriés doivent être portés.</p>
<p>Appropriate protective clothing must be worn.</p>	<p>Ropa de protección adecuada debe ser utilizada.</p>	<p>Vêtements de protection appropriés doivent être utilisés.</p>
Over	Encima	Sur

<p>Wear respiratory protection against dust and fumes (see ANSI Z86.2).</p>	<p>Usar protección respiratoria contra el polvo y los vapores (véase ANSI Z86.2).</p>	<p>Porter une protection respiratoire contre les poussières et des fumées (voir ANSI Z86.2).</p>
<p>Comply with the Safety Standard ANSI B165.1 "Safety Requirements - Power Brushes". Inspect brushes before mounting for damage, nail or other type of deterioration. Jog to partial speed for one minute before increasing to operating speed. During this time no one is to be in front of or in line with the brush. Never exceed Maximum RPM on the Brush.</p>	<p>Cumplir con los estándares de seguridad ANSI B165.1 "Requisitos de seguridad - Cepillos de energía". Antes del montaje, inspeccione los cepillos por daños, clavos u otro tipo de deterioro. Coloque un minuto a velocidad antes de aumentar a velocidad normal de operación. Durante este tiempo, nadie debe estar en frente o en línea directa con el cepillo. Nunca exceda Max. RPM marcada en el producto.</p>	<p>Se conforme a la norma de seguridad ANSI B165.1 "Exigences de sécurité - Brosses Electriques". Avant de monter les brosses, inspectez les pour les dommages, clouilles ou autre type de détérioration. Avant de passer à la vitesse de fonctionnement, accélérez la brosse partiellement. Pendant ce temps, nul ne peut être devant ou en ligne avec la brosse. Ne jamais dépasser Max. RPM marquée sur la brosse.</p>
<p>⚠️ WARNING: This product can expose you to chemicals including Nickel, which is known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov.</p>	<p>⚠️ ADVERTENCIA: Este producto puede exponerlo a productos químicos, incluido el níquel, que es el estado de California se sabe que causa cáncer. Para más información ve a www.P65Warnings.ca.gov.</p>	<p>⚠️ ATTENTION: Ce produit peut vous exposer à des produits chimiques, y compris le nickel, qui est connu dans l'état de Californie pour causer le cancer. Pour plus d'informations, allez à www.P65Warnings.ca.gov.</p>
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AWARNING	ADVERTENCIA	AVERTISSEMENT
<p>All operators must read, study, understand and comply with all warnings and operating instructions on both sides of this safety sign and those instructions provided with your power tool before using this brush.</p>	<p>Todos los operadores deben leer, estudiar, comprender y cumplir todas las advertencias e instrucciones de funcionamiento que aparecen en ambos lados de este letrero de seguridad, así como las instrucciones que se facilitan con la herramienta eléctrica antes de usar este cepillo.</p>	<p>Tous les opérateurs doivent lire, étudier et comprendre et se conformer à tous les avertissements et d'exploitation des instructions sur les deux côtés de ce letrero de sécurité et les instructions fournies avec votre outil électrique avant d'utiliser la brosse.</p>
<p>Safety glasses and full face shields must be worn by users and others in area. Persons within 50 or more feet may be within danger zone. See ANSI/ISEA Z87.1</p>	<p>Los usuarios y otros en la zona deben utilizar lentes de seguridad y protectores faciales. Las personas dentro de 50 o más pies pueden estar dentro de la zona de peligro. Véase la norma ANSI/ISEA Z87.1</p>	<p>Les usagers et autres dans la zone doivent utiliser les lunettes de sécurité et autres dans la région. Les personnes à l'intérieur de 50 pieds ou plus peuvent être au sein de la zone de danger. Voir la norme ANSI/ISEA Z87.1</p>
<p>Observe all speed restrictions. Maximum RPM or Maximum Safe Free Speed (MSFS), See ANSI 3.1.8</p>	<p>Observe la restricción de velocidad. Máximo RPM o Máximo Libre Seguro (MSFS). Consulte ANSI 3.1.8</p>	<p>Respecter toutes les restrictions de vitesse. Maximum RPM ou Maximum Libre-Securité (MSFS). Voir ANSI 3.1.8</p>
<p>Tool guards must be in place at all times.</p>	<p>Las protecciones deben mantenerse en su lugar, en todo momento.</p>	<p>Des protections doivent être maintenues en place en tout temps.</p>
<p>Appropriate protective gloves must be worn.</p>	<p>Gaunas de protección adecuadas deben ser usadas.</p>	<p>Des gants protecteurs appropriés doivent être portés.</p>
<p>Appropriate protective clothing must be worn.</p>	<p>Ropa de protección adecuada debe ser utilizada.</p>	<p>Vêtements de protection appropriés doivent être utilisés.</p>
Over	Encima	Sur

<p>Wear respiratory protection against dust and fumes (see ANSI Z86.2).</p>	<p>Usar protección respiratoria contra el polvo y los vapores (véase ANSI Z86.2).</p>	<p>Porter une protection respiratoire contre les poussières et des fumées (voir ANSI Z86.2).</p>
<p>Comply with the Safety Standard ANSI B165.1 "Safety Requirements - Power Brushes". Inspect brushes before mounting for damage, nail or other type of deterioration. Jog to partial speed for one minute before increasing to operating speed. During this time no one is to be in front of or in line with the brush. Never exceed Maximum RPM on the Brush.</p>	<p>Cumplir con los estándares de seguridad ANSI B165.1 "Requisitos de seguridad - Cepillos de energía". Antes del montaje, inspeccione los cepillos por daños, clavos u otro tipo de deterioro. Coloque un minuto a velocidad antes de aumentar a velocidad normal de operación. Durante este tiempo, nadie debe estar en frente o en línea directa con el cepillo. Nunca exceda Max. RPM marcada en el producto.</p>	<p>Se conforme a la norma de seguridad ANSI B165.1 "Exigences de sécurité - Brosses Electriques". Avant de monter les brosses, inspectez les pour les dommages, clouilles ou autre type de détérioration. Avant de passer à la vitesse de fonctionnement, accélérez la brosse partiellement. Pendant ce temps, nul ne peut être devant ou en ligne avec la brosse. Ne jamais dépasser Max. RPM marquée sur la brosse.</p>
<p>⚠️ WARNING: This product can expose you to chemicals including Nickel, which is known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov.</p>	<p>⚠️ ADVERTENCIA: Este producto puede exponerlo a productos químicos, incluido el níquel, que es el estado de California se sabe que causa cáncer. Para más información ve a www.P65Warnings.ca.gov.</p>	<p>⚠️ ATTENTION: Ce produit peut vous exposer à des produits chimiques, y compris le nickel, qui est connu dans l'état de Californie pour causer le cancer. Pour plus d'informations, allez à www.P65Warnings.ca.gov.</p>
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<p>⚠️ WARNING All operators must read, study, understand and comply with all warnings and operating instructions on both sides of this safety sign and those instructions provided with your power tool before using this brush.</p> <p>👤 Safety glasses and full face shields must be worn by users and others in area. Persons within 50 or more feet may be within danger zone. See ANSI/ISEA Z87.1</p> <p>🚫 Observe all speed restrictions. Maximum RPM or Maximum Safe Free Speed (MSFS). See ANSI 3.1.8</p> <p>🛡️ Tool guards must be in place at all times.</p> <p>🧤 Appropriate protective gloves must be worn.</p> <p>👕 Appropriate protective clothing must be worn.</p>	<p>⚠️ ADVERTENCIA Todas las operaciones deben leer, estudiar, comprender y cumplir todas las advertencias e instrucciones de funcionamiento que aparecen en ambos lados de este hoja de seguridad, así como las instrucciones que se facilitan con la herramienta eléctrica antes de usar este cepillo.</p> <p>👤 Los usuarios y otros en la zona deben utilizar lentes de seguridad y protección facial. Las personas dentro de 50 o más pies pueden estar dentro de la zona de peligro. Véase la norma ANSI/ISEA Z87.1</p> <p>🚫 Observe las restricciones de velocidad Máxima RPM o Máxima Velocidad Libre Segura (MSFS). Consulte ANSI 3.1.8</p> <p>🛡️ Las protecciones deben mantenerse en su lugar, en todo momento.</p> <p>🧤 Guantes de protección adecuada deben ser usados.</p> <p>👕 Ropa de protección adecuada debe ser utilizada.</p>	<p>⚠️ AVERTISSEMENT Tous les opérateurs doivent lire, étudier et comprendre et se conformer à tous les avertissements et d'exploitation des instructions sur les deux côtés de ce signal de sécurité et les instructions fournies avec votre brosse.</p> <p>👤 Les utilisateurs et autres dans la région. Les personnes à l'intérieur de 50 pieds ou plus peuvent être au sein de la zone de danger. Voir la norme ANSI/ISEA Z87.1</p> <p>🚫 Respecter toutes les restrictions de vitesse. Maximum RPM ou Maximum Coffre-fer Gratuit Vitesse (MSFS). Voir ANSI 3.1.8</p> <p>🛡️ Des protections doivent être maintenues en place en tout temps.</p> <p>🧤 Des gants protecteurs appropriés doivent être portés.</p> <p>👕 Vêtements de protection appropriés doivent être utilisés.</p>	<p>🧑‍🚒 Wear respiratory protection against dust and fumes (see ANSI Z88.2).</p> <p>⚠️ Comply with the Safety Standard ANSI B165.1 "Safety Requirements - Power Brushing". Inspect brushes before mounting for damage, rust or other type of deterioration. Jog to partial speed for one minute before increasing to operating speed. During this time no one is to be in front of or in line with the brush. Never exceed Maximum RPM on the brush.</p> <p>🇺🇸 WARNING: This product can expose you to chemicals including Lead, which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information, see www.P65Warnings.ca.gov.</p>	<p>🧑‍🚒 User respiratory protection against dust and fumes (see ANSI Z88.2).</p> <p>⚠️ Cumplir con los estándares de seguridad ANSI B165.1 "Requisitos de seguridad - Cepillos de energía". Antes del montaje, inspeccionar los cepillos por daños, oxidación u otro tipo de deterioro. Correr por un minuto a velocidad parcial antes de aumentar a la velocidad normal de operación. Durante este tiempo, nadie debe estar en frente directa con el cepillo en el espacio.</p> <p>🇺🇸 ADVERTENCIA: Este producto puede exponerlo a químicos, incluido el plomo, que el estado de California considera que causa cáncer y defectos de nacimiento u otros daños reproductivos. Para obtener más información, vea el www.P65Warnings.ca.gov.</p>	<p>🧑‍🚒 Porter une protection respiratoire contre les poussières et des fumées (voir ANSI Z88.2).</p> <p>⚠️ Se conformer à la norme de sécurité ANSI B165.1 "Exigences de sécurité - Brosses Électriques". Avant de monter les brosses, inspecter les dommages, l'oxydation ou autre type de détérioration. Avant de passer à la vitesse de fonctionnement, accélérer la brosse parfaitement. Pendant ce temps, nul ne peut être devant ou en ligne avec la brosse. Ne jamais dépasser Max. RPM marqué sur la brosse.</p> <p>🇺🇸 ATTENTION: Ce produit peut vous exposer à des produits chimiques, y compris le plomb, qui est connu dans l'état de Californie pour causer le cancer et des malformations congénitales ou d'autres problèmes de reproduction. Plus d'informations, allez à www.P65Warnings.ca.gov.</p>
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Illustration 2 – Summary of Safety Precautions (Front and Back)

The information contained in Illustration 2 above is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, Illustration 2 may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

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4.4 Balance

Brushes that are out of balance set up vibrations that can result in marred work surfaces or machine damage, and can also cause stress that could result in brush failure. A brush that vibrates in service shall not be used (see 4.1).

4.5 Adapters

If arbor adapters are used in a brush to reduce it to the correct arbor hole size, they shall seat properly in the brush to maintain alignment and balance.

5 General machine conditions

5.1 Machine design and maintenance

It shall be the brush machine builder's responsibility to indicate the maximum rpm of the machine and the size of the brush to be used on the machine based on the requirements for guarding the machine as described in ANSI B7.1, ANSI/UL 60745, or ANSI/UL 987, as applicable.

It shall be the user's responsibility to maintain the machines in safe operating condition.

5.2 Safety Guards

When accommodating brushes, machines and power tools shall be equipped with safety guards as required by 7.7.

5.3 Power

Brushing machines and other power tools on which brushes are used shall be supplied with sufficient power to maintain the rated spindle speed under operating load.

E4.4 Balance

Unlike many other rotating tools, it would be difficult for the user to bring back into true balance.

E5.1 Machine design and maintenance

It is important that the maintenance of the machine be such that the equipment remains in the same condition as originally furnished. If the brush machine builder has provided special operating instructions or placed warning signs on the machine, these, as well as the general operating rules, should be followed to ensure a safe brushing operation.

E5.3 Power

Deterioration of operating conditions caused by insufficient power causes many problems. For example, reduction in brush speed, even while holding normal brush pressures, will cause a substantial decrease in cutting rate and efficiency. If pressure is increased to compensate for low brush speed, excessive heat and wear will be encountered, resulting in decreased cutting rate and efficiency.

Reduced speed means reduced centrifugal force and a consequent reduction in the stiffness of the brush fill material. This loss of stiffness permits normal brush pressures to overflex the filament and induce premature fatigue. Over-stressed filaments that undergo fatigue will break off, creating a hazard. Adequate power will avoid this hazard.

5.4 Exhaust provision

It shall be the user's responsibility to provide adequate ventilation and swarf removal in dry brushing operations. If the user determines that stationary brushing machines used for dry brushing are creating an unsafe amount of dust or other contaminants, then the user shall make provision for connection to an exhaust system.

The exhaust system shall conform to the requirements in ANSI Z88.2 (see 7.9).

E5.4 Exhaust provision

The adequacy of the ventilation should be determined by following the minimum exhaust provisions shown in E7.9 and E7.9a. If connection of an exhaust system is not possible, then personal respirators for operators and others in the area should be provided.

5.5 Diameter of spindle

Tables 1 and 1a show the minimum diameters of spindles that shall be used for brushes of various sizes. They apply to power tools and machines in which power brushes are not mounted between bearings. Spindles shall be sufficiently heavy and of adequate diameter to perform safely as designed. In some situations, the use of heavier spindles than those listed in Tables 1 and 1a as the minimal diameters is desirable.

E5.5 Diameter of spindle

Spindles are also referred to as "shafts" or "arbors" depending upon the nomenclature used by the various brush machine builders. Their usual machine design generally conforms to the minimum shaft diameters shown in Tables 1 and 1a. It is not uncommon for the user to unwittingly circumvent Tables 1 and 1a by requests for brushes larger in diameter than were originally intended for the machine. Since such a change in the outside diameter would also likely require a larger shaft hole and arbor, this is a dangerous practice that is to be avoided.

Table 1 – Minimum spindle (shaft) diameter for brushes of various sizes (in)

Maximum outside diameter of wheel brush (in)	Maximum face width (in)	Minimum outside diameter of spindle (shaft) (in)
2	3/4	1/4
3	3/4	1/4
3 (Heavy duty)	1	3/8
4	1	3/8
6	1-1/4	1/2
8	1-1/4	5/8
10	2	3/4
12	3	1
14	3	1-1/4
15	3	2
16	3	2

NOTE – These diameters are based upon the wheel brush being mounted next to the supported end of the bearing, rather than the unsupported end, in order to minimize overhang.

Table 1a – Minimum spindle (shaft) diameter for brushes of various sizes (mm)

Maximum outside diameter of wheel brush (mm)	Maximum face width (mm)	Minimum outside diameter of spindle (shaft) (mm)
50	20	6
75	20	6
75 (Heavy duty)	25	10
100	25	10
150	32	13
200	32	16
250	50	19
300	75	25
350	75	32
380	75	32
400	75	50

NOTE – These diameters are based upon the wheel brush being mounted next to the supported end of the bearing, rather than the unsupported end, in order to minimize overhang.

5.6 Work rests

On single- or double-end pedestal machines used for brushing, work rests shall be used, where applicable, to support the work. They shall be of rigid construction and be designed to be adjustable to compensate for brush wear.

Work rests shall be kept adjusted close to the brush with a maximum opening of 1/8 inch (3.175 mm) to prevent the work from being jammed between the brush and the work rest, as such jamming may cause failure of the brush or injury to the operator. The work rest shall be securely clamped after each adjustment. The adjustment shall be made with the power source off, with the machine in zero mechanical state, and with no possibility of the brush rotating.

5.7 Limiting brush diameter

Nonportable brushing machines shall be provided with a means of limiting the diameter of the brush to be mounted.

On variable-speed machines, the speed-shifting device shall be connected with an adjustable guard or other diameter-limiting device to prevent the mounting of a brush that might run at higher than the recommended surface speed or rated rpm.

5.8 Direction of machine spindle thread

If brushes are secured by means of a spindle nut, the direction of the thread in relation to the direction of the rotation shall cause the nut to tighten as the spindle revolves.

E5.6 Work rests

Measurement of the 1/8-inch (3.175-mm) clearance can be accomplished from the nominal face condition while the brush is stationary. Jogging of the brush will establish whether further adjustment is necessary to help compensate for a normal expansion.

E5.7 Limiting brush diameter

The safety guard can be used to limit the diameter of the brush on single-spindle or multiple-spindle machines. On variable-speed machines, a positive mechanical or manual regulation check should be maintained to avoid overspeeding another or full-sized brush after a worn brush has been removed.

In general, brush driving equipment that is stationary (fixed position) should use brushes with an outside diameter of 6 inches (152.4 mm) or larger. Portable tools and hand-held power tools are designated size specific (i.e., 4-1/2-inch angle grinder). The user should always match the appropriate size brush with the specified size called out on the tool. The user should also use a brush with a higher Maximum Safe Free Speed (MSFS) rating than the **MAX** rpm specified on the tool.

E5.8 Direction of machine spindle thread

In many types of equipment, such as double-end pedestal or bench grinders on which brushes are used, a right-hand thread is found on one end and a left-hand thread on the opposite end. If such machines are disassembled for maintenance or repair, it is essential that they be reassembled correctly in relation to the direction of threads.

The following rule will assist in determining the proper relationship: "To remove the nut, it must be turned in the direction in which the spindle revolves when the brush is in operation."

5.9 Length of machine spindle thread

E5.9 Length of machine spindle thread

If brushes are mounted by means of a spindle nut and flanges, two conditions shall be maintained:

These two conditions are necessary to avoid the geometry of the threads from inadvertently preventing proper axial compressions and anchoring of brush rolls, especially when made up of sections.

- Spindles shall be of sufficient length to allow a full nut mounting;
- The threaded portion shall be sufficient so that the threading will extend well inside the flange but not more than halfway within the arbor hole of the brush.

5.10 Spindle, drive arbor, and arbor hole size

E5.10 Spindle, drive arbor, and arbor hole size

The size of the arbor hole of the brush shall be such that the brush will slip-fit on the drive spindle or drive arbor and shall remain within this fit class under all operating temperatures.

It is important that the diameter of the spindle be no larger than the nominal size (usually +0.000 inch, -0.002 inch or +0.000 mm, -0.051 mm) and that the hole in the brush be kept suitably oversized to ensure a free fit under all operating conditions. This clearance is needed for expansion of the spindle caused by the heat of the operation.

The brush spindle or drive arbor shall not be made larger than the nominal dimension size. The arbor hole of the brush shall be made oversize from the nominal dimension by the brush manufacturer by an amount necessary to ensure a free fit but not a loose fit. When the arbor hole is changed by the manufacturer or user, the recommended tolerances for the arbor hole shall be as follows in tables 2 and 2a below:

Table 2 – Recommended tolerances for arbor hole size (in)

Arbor Hole Size (in)	Minimum Tolerance (in)	Maximum Tolerance (in)
Under 5/8	+0.001	+0.005
5/8 – 2	+0.001	+0.006
2 – 6	+0.002	+0.007
6 – 12	+0.003	+0.012

Table 2a – Recommended tolerances for arbor hole size (mm)

Arbor Hole Size (mm)	Minimum Tolerance (mm)	Maximum Tolerance (mm)
Under 15.9	+0.025	+0.127
15.9 – 50.8	+0.025	+0.152
50.8 – 152.4	+0.051	+0.178
152.4 – 304.8	+0.076	+0.305

The minimum arbor hole to be used for each class of brush shall be the smallest size offered for sale by the individual brush manufacturer. The minimum size offered shall be compatible with the service conditions for which the brush is intended. Where the user reduces the arbor hole by use of a bushing, or otherwise, the minimum arbor size, the maximum brush face length, and the maximum overhang length shall be in accordance with the recommendations of the brush manufacturer.

The user shall ensure that the size and shape of the arbor hole of the brush will not cause the hole to catch the threads during mounting, which would cause the brush to be eccentric or would prevent proper axial compression and tightening.

5.11 Threaded arbor hole brushes

Machines on which threaded hole brushes are mounted shall be designed with spindles that are threaded so as to allow the brush to be screwed firmly and flat against the back flange, with a minimum engaged thread length of 1X diameter for steel and 2X diameter for aluminum components. See tables 3 and 3a below for minimum threaded arbor hole diameters that shall be used for brushes of various sizes. Tables 3 and 3a list the recommended minimum threaded arbor diameter sizes with a minimum shaft yield strength of 50,000 PSI for various brushes diameters. Multiple factors including RPM, dynamic loads, along with brush and equipment configuration, must always be considered when mating a brush to a power tool or any custom-designed equipment to drive power brushes.

E5.11 Threaded arbor hole brushes

If the flange that is in contact with the threaded portion of the brush is not flat or is recessed, it would be possible, by tightening the brush on the arbor, to distort the brush or even pull the threaded bushing out of the brush.

If the spindle stops quickly when power is shut off, the energy stored in the spinning brush may cause it to unscrew from the arbor and “spin off” the machine.

To help prevent “spinning off,” the thread on the machine arbor should be maintained in good condition and the brush should be held in contact with the work piece until the brush has stopped rotating.

When applicable, a spindle end nut should be used to preclude “spinning off.”

For any nonrecommended arbor size, it is critical to consult your brush and equipment designer or manufacturer prior to brush application.

The back of the flange shall be flat, securely fastened, and square to the spindle axis. The fixed back flange shall be of sufficient diameter to ensure proper support to the brush. The direction of the thread shall be such that, in order to be removed, the brush must be turned in the direction of rotation.

If threaded hole brushes have blind holes, the length of the spindle shall be in relationship to the depth of the hole such that the end of the spindle will not touch the bottom of the brush hole.

Table 3 – Minimum threaded arbor hole (major diameter) for brushes of various sizes (in)

Maximum outside diameter of wheel brush (in)	Minimum threaded arbor hole (major diameter) (in)
Up to and including 4	3/8
Greater than 4 and up to and including 5	1/2
Greater than 5 and up to and including 8	5/8
Greater than 8	Do not use a threaded hole

Table 3a – Minimum threaded arbor hole (major diameter) for brushes of various sizes (mm)

Maximum outside diameter of wheel brush (mm)	Minimum threaded arbor hole (major diameter) (mm)
Up to and including 100	M10
Greater than 100 and up to and including 125	M12
Greater than 125 and up to and including 175	M14
Greater than 175	Do not use a threaded hole

5.12 Solid shanks for brushes to be used with collets and chucks

These requirements do not apply to shanks on twisted-in wire brushes.

The shank shall be of a uniform cylindrical shape, to be used with circular collets and self-centering chucks. Shanks of other geometric shapes that may or may not include special locking features are not within scope of this standard. It is the responsibility of the tool manufacturer and brush manufacturer for providing a safe product design.

Shank diameters shall be of nominal size, expressed in decimal form with a tolerance not exceeding +0.000 inch -0.005 inch or +0.000 mm -0.127 mm.

The geometric configuration of shank-type brushes or shank-type arbors shall include generous fillets where the diameters of the parts increase and where stress concentration is likely to occur.

Where extension of a brush shank or arbor shank is needed to obtain additional reach, a special tool extension shall be used. This tool or brush holder shall be of such dimension and geometrical shape as to withstand the brushing pressure used, and avoid deflection that causes vibrations that can become dangerous. The brushes shall be test-run under guarded or shielded conditions for 30 seconds after each mounting or remounting to ensure that they are properly gripped in the chuck or collet.

Shank brushes used with an extension shall only be rotated when contained within the cavity or interior to be abraded. The power shall be turned off and the rotation of the brush stopped before the brush is extracted from the part.

Construction details of user-made or user-selected extension holders shall meet the foregoing requirements.

Brushes used with shanks (types I through VI) are hazardous when chucked with the axis of the brush not parallel to, and concentric with, the axis of the chuck; or not tightened in the chuck tightly enough to drive it under load; or when used at speeds higher than those recommended by the brush manufacturer; or when the shank has not been inserted to the maximum depth with the minimum overhang.

E5.12 Solid shanks for brushes to be used with collets and chucks

The method of manufacture of twisted-in wire brushes precludes holding shank diameters to the same tolerances as those for shanks made by turning, forming, cold-heading, or machining techniques.

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6 Mounting of brushes

6.1 Inspection

Immediately before mounting, all brushes shall be closely inspected in accordance with 7.2 and 7.4 to make sure they are suitable for use.

6.2 Arbor size

Brushes shall fit freely on the spindle and remain free under all brushing conditions. If, however, the spindle is worn or undersized, the brush shall not be mounted, since off-center mounting will cause the brush to be out of balance. If the spindle is oversized, the brush shall not be forced on, since damage to the brush and the machine is almost unavoidable. A sufficient clearance between the arbor hole of the brush and the machine spindle (or adapters) shall be maintained to avoid problems in mounting or removal caused by spindle expansion from temperature change.

To accomplish this, the machine spindle and the brush arbor hole shall be made in accordance with the requirements of 5.10.

6.3 Surface condition

All contact surfaces of brushes, flanges, and adapters shall be flat and free of foreign matter that could result in uneven pressure. Flanges, adapters, and brushes shall be checked periodically to see that they are not distorted or burred so as to cause improper functioning.

6.4 Bushing

When a bushing is used in the arbor hole of the brush, it shall center the brush and ensure that the brush, rather than the bushing, will be gripped by the machine spindle shoulder or machine flange. The driving of the brush shall be accomplished positively through the back or center of the brush rather than through the bushing to ensure proper anchoring and driving of the brush. A bushing should never be used that will violate 5.5, table 1 or 5.5, table 1a.

E6.2 Arbor size

Arbors that become undersize from wear, and brush adapters that become oversize from wear, can cause the machine to become unbalanced. The user should maintain both the arbor and the brush adapter diameters to preclude this problem.

E6.3 Surface condition

Excessive tightening can cause serious distortion of the flanges. They should be inspected prior to each mounting to ascertain that they are still flat and suitable for proper seating in the brush.

E6.4 Bushing

If the bushing is wider than the brush in which it is used, it will interfere with proper tightening of the flanges against the brush. The power required to drive a brush is transferred through the flanges. If this power is partially or completely transferred through the bushing, failure of the brush could occur.

6.5 Multiple-section brushes mounted on a common arbor

When more than one brush is mounted on a common arbor, they shall have equal arbor hole diameters. They shall be of a type manufactured for multiple mounting and so designated by the brush manufacturer.

6.6 End nut

The spindle end nut shall be tightened only enough to drive the brush and prevent slippage, and shall be used only if the direction of the threads (right hand or left hand) is such that the nut tends to tighten when rotated and under load.

Spindle end nuts with locking devices such as set screws shall be used under heavy duty conditions or where brush rotation reversal or stopping by brake action is practiced.

6.7 Mounting of shank-type brushes

All shank-type brushes of types I through V, and type VI brushes with and without shank, shall be firmly tightened in a chuck or collet so that no slippage can occur. The shank shall be inserted into the chuck or collet as far as possible on the uniform diameter of the shank with minimum possible overhang of the brush.

6.8 Twisted-in wire brush

Twisted-in wire brushes, type VII, used under power, shall be securely held in a collet, chuck, or similar holding device. The operator shall secure the unit to be brushed and position all guards before starting the brush. The equipment in and the arrangement of the workplace shall ensure rotation of the brush on the true centerline to avoid deflection that may instantly multiply to destructive bending.

6.9 Strip and cylinder brushes

Types VIII and IX brushes shall be affixed firmly to the arbor so that no axial or rotational movement is possible between

E6.5 Multiple-section brushes mounted on a common arbor

In some applications of wide-face brushes that consist of sections in a stacked array mounted on a common arbor, slippage of the whole unit of brushes or of sections within the group of brushes may be a problem. In these cases, it may be necessary to key or otherwise securely fasten each of the individual brushes to the arbor.

E6.6 End nut

If multiple screw flanges are used, they must be tightened uniformly to prevent springing of the flanges and to ensure even distribution of mounting pressure over the entire surface of the flanges.

E6.7 Mounting of shank-type brushes

Since the overhang of a shank-type brush is a factor in determining the maximum allowable operating speed, care should be taken to ensure that the overhang conforms to the limitations that have been established for the brush.

E6.8 Twisted-in wire brushes

The shank of a twisted-in wire brush, because of its basic construction, is not inherently as strong as the shank on most other brushes. Therefore, it is even more important that the overhang not be excessive, and that other conditions of use avoid the load application and speed of rotation that will cause the shank to deflect, and therefore bend, instantly resulting in total destruction of the brush and creating an unsafe condition for the operator.

E6.9 Strip and cylinder brushes

Arbors that accommodate cylinder brushes usually are fitted with two keyways at 180° from each other. If one key is omitted, an

the brush and the arbor. Keys and keyways that fit shall be used so that no radial movement is possible.

6.10 Flanges

Flanges shall be used when integral face plates are not provided or to ensure safe mounting on the driving shaft or arbor.

Flanges shall be used with brushes where bushings are installed to prevent the axial separation of the brush and the bushing while the brush is in service. The outside diameter of the flanges shall be larger than the bushing and shall actually grip the brush retaining member.

Each pair of flanges shall be of the same size and geometry so that tightening or compressing of the brushes on the arbor will not cause distortion of the retaining members.

Flanges shall be of such size and shape so as not to destructively contact the fill material and cause stress concentration that swiftly leads to long filament breakage.

In multiple-section wide-face brushes, flanges shall contact only the solid brush retaining member that is capable of withstanding the required anchoring compression without distortion. The flanges shall not be of a size or geometry that will contact central web areas or equivalent areas that will bend or distort.

Flanges with either two keys or two keyways, 180° apart, shall be used under heavy duty conditions or with type IX wide-face brushes.

Threaded flanges shall have the correct thread so as to tighten when rotated and under load.

7 Use of brushes

7.1 General

The general rules of this clause shall be equally applicable to all types of classes of brush.

imbalanced condition is created because of loss of weight. If only one key is used, the cylinder brush should be rebalanced before use to compensate for the asymmetrical weight distribution.

E6.10 Flanges

The major stresses produced in an operating brush tend to combine and become greatest at the true retaining member of the brush structure. It is therefore important that stresses due to mounting and driving do not unnecessarily concentrate on the same part of the brush.

Flanges should be identical in diameter and radial bearing surface to avoid cross-bending pressures and stresses in the brush.

Flanges should be large enough in diameter to approximately equal the size of the face plate of a brush, or the size that a face plate would be, if used, so that the brush retaining members (the wire anchoring means) are safely enclosed between the face plates. Such ample flanges ensure positive driving of the brush.

7.2 Inspection

Before mounting, all brushes shall be closely inspected to make sure that they have not been damaged from handling, shipping, storage, or other causes.

If the brushes are wire filled, the wire in the brushes shall be inspected to ensure that no rust or degradation has occurred.

Any rust, discoloration, or other evidence of chemical or physical change in the surface finish of the wire can cause premature failure of the brush by fatigue (see 9.2 and 9.3).

All surfaces of the brush that mount onto the tool should be free of foreign matter and not have burrs. Brushes shall be checked periodically to see that they are not distorted or burred so as to cause improper functioning.

7.3 User's responsibilities

Persons qualified by experience shall be assigned to the mounting, care, and inspection of brushes and brush machinery.

The user shall be responsible for the proper handling, storage, and inspection of brushes after receipt and shall maintain them and the equipment on which they are mounted in a safe operating condition at all times.

It shall be the responsibility of the user to fully inform all operating personnel about all of the hazards relating to use of the brush and to instruct them in all aspects of safety in operation of the brush, including but not limited to, correct speeds, proper guarding, protective clothing, and especially, eye protection. All operation and safety instructions shall be followed, as well as common safety practices that will reduce the likelihood or severity of physical injury.

E7.2 Inspection

The first inspection should be made on the original shipping container. If there is visible evidence of damage to the container, special attention should be given to an immediate inspection of the brushes.

It is important that all brushes be inspected carefully before mounting.

E7.3 User's responsibilities

On new and future products developed by the brush manufacturer and the brush machine builder, the standard recommended practices may apply. However, the user should review and understand provided information, operating manuals, safety data sheets, and recommended practices to ensure safe operation.

7.4 Brush speed

Before mounting a brush, it shall be determined that the machine speed does not exceed the maximum safe free speed (MSFS or max. SFS or MAX RPM) for the brush, as established by the brush manufacturer.

Under no circumstances shall a brush be mounted on a machine whose rpm exceeds the maximum safe free speed (MSFS or max. SFS or MAX RPM) recommended for the brush.

7.5 Protective clothing and equipment

Appropriate protective clothing and equipment required for any brushing operation will vary with the size, nature, and location of the work. The user shall specify the special protective clothing and equipment required for all personnel in the area of each brushing operation.

Use of protective eye equipment shall be required for all brush operators and others in the area of the brushing operation, and face equipment shall also be required where there is a reasonable possibility of injury that can be prevented by such equipment. In such cases, users shall make conveniently available a type of protector recommended for the work to be performed, and personnel shall use such protection. No unprotected personnel shall be purposely subjected to a hazardous environmental condition, and the user shall supply adequate eye protection equipment to all personnel working or coming into the hazardous area.

Brush operators and others in the area of the brushing operation shall wear safety goggles, full face shields over safety glasses with side shields, or other forms of personal eye protection designed, constructed, and tested in accordance with ANSI/ISEA Z87.1.

7.6 Additional enclosure (or barrier)

Because the nature of many brushing operations requires personnel, other than the operator, to be in proximity to the brushing area, these personnel shall be protected by an enclosure that isolates the operation from the remaining work area, or

E7.4 Brush speed

Based on the structural strength of the brush, a maximum safe free speed is established. This speed should not be exceeded. Faster speeds may be expected to exceed the ability of the brush to withstand the stresses that are developed by the rotational forces and tangential forces combined.

E7.5 Protective clothing and equipment

In normal power brushing operations, the material being removed (such as burrs, scale, dirt, weld slag, or other residue) will fly off the brush with considerable force along with the brush filaments, which break off due to fatigue.

The potential of serious injury exists for both the brush operator and others in the work area (possibly 50 feet (15.2 meters) or more from the brush). Before rotating the brush, the operator and others in the area are required to wear protective eye equipment and face equipment, such as safety goggles or full face shields, worn over safety glasses with side shields, along with protective clothing capable of resisting a force of 23 Newtons with a penetration of 0.5 inch (1.3 centimeters).

E7.6 Additional enclosure (or barrier)

Any wall, partitions, or booths serving as an enclosure or barrier for a brushing operation should be identified as such.

It is the user's responsibility to identify the additional enclosure or barrier.

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equivalent (see 3.1.20). (See also 7.5 for the required protective clothing and equipment for such personnel.)

All personnel who have occasion to come into the enclosed brushing area (even if not in close proximity to the brushing operation) shall wear suitable eye protection as well as protective clothing and equipment described in 7.5.

7.7 Guarding of brushes

Because rotating brushes can be hazardous, the operator, as well as other workers in proximity to the brushing station, shall be protected by safety guards meeting the requirements of the applicable brush machine (power tool) standard (see 5.1).

Rotating brushes shall be used only on machines provided with safety guards; however, safety guards are not required for brushes used for recessed work, brushes used for internal work, and brushes used on hand-held power tools, i.e., drills and grinders, unless recommended by the power tool manufacturer in the instruction manual provided with the tool.

7.7.1 Safety guards on pedestal grinders, bench and floor stands

Machines known as bench or pedestal grinders shall comply with ANSI B7.1, ANSI/UL 987, or both.

7.7.2 Safety guards on automated equipment

The safety guards on automated brushing equipment shall be designed to admit the work to be brushed, but not the hands or other parts of the operator's body. It may be constructed so as to be adjustable for brushes of different sizes, but, once adjusted, it shall be affixed in that position.

E7.7 Guarding of brushes

Exceptions to the use of safety guards are based on the impossibility of using smaller brushes with conventional guards in place. In these cases, the work often forms a guard. Eye and face protection is particularly important when using smaller brushes.

E7.7.1 Safety guards on pedestal grinders, bench and floor stands

Maximum guard openings are based on the fact that the line of flight of particles from the part being brushed, swarf, and the residue from the brush will be tangential in the direction of rotation of the brush. The maximum exposure angle should not be exceeded.

E7.7.2 Safety guards on automated equipment

Frequently, in automated brushing equipment fitted with large cylinder brushes, the machine is made in such a manner as to totally enclose the brush. This type of guarding restrains bursting brushes, swarf produced by brushing, and brush filaments that have broken off, and also prevents access to the brush while it is rotating.

7.7.3 Interlocking safety guards

When the brushing machine is not covered by an end-use product safety standard (see 5.1), interlocking safety guards shall be considered if fixed safety guards are not practical.

E7.7.3 Interlocking safety guards

When end-product safety standards for brushing machines are available, such as those mentioned in 5.1, compliance with their guarding requirements provides sufficient protection to the users of brushes.

An interlocking safety guard is not fixed, and may be operated or removed as the operation requires. However, due to an electrical or mechanical interlocking connection with the operating mechanism, the operation of the machine is prevented until the guard is returned to an operating position and the operator can no longer reach the point of danger.

After mounting a brush, care should be taken to see that the electrical or mechanical mechanisms actuated by an open safety guard are operational. This should be ascertained before starting the brush.

7.7.4 Safety guards for exposed brush protrusions

Brushes with exposed collars, couplings, cams, clutches, flywheels, shaft ends, or other protrusions shall have such protrusions guarded with a brush safety guard or the equivalent.

7.7.5 User's responsibility

It shall be the user's responsibility to maintain the safety guards, safety shields, and barriers in good condition. The user shall also make provision for the safety and protection of the personnel in the operating area (see 7.3, 7.5, and 7.6).

7.8 Starting the brush

Before starting the machine on which a brush is mounted, all required personal eye protection and personal protective equipment, safety guards, barriers, or enclosures shall be in place. The machine shall be jogged to ensure that it is in readiness for use and that the brush is fastened securely and is concentric with the axis of rotation.

E7.8 Starting the brush

This provides for the safety of the operator and others, should there have been damage to the brush, foreign matter accumulated in the brush, or malfunction of the machine from any cause.

After the machine has been turned on, the brush shall be run at operating speed for at least one minute before applying work to dislodge loose particles. During this time, no one shall stand in front of or in line with the brush.

7.9 Exhaust provision

On dry brushing operations, where brushes are mounted on floor stands, pedestals, benches, or special purpose machines, the user shall determine the need for connection to an exhaust system.

If it is determined that there is such a need, then provision shall be made for connection to an exhaust system that conforms to the minimum exhaust provisions recommended by OSHA Safety Code 1910.94 (see E7.9 and E7.9a). The exhaust system shall be in operation before the brushing is started (see 5.4).

E7.9 Exhaust provision

In accordance with OSHA Safety Code 1910.94 under section 2, Table G5, the recommended minimum exhaust volume that should be used is as follows:

Wheel Diameter (in)	Minimum Width (in)	Exhaust Volume (ft ³ /min)
To 9	2	300
9 to 16	3	500
16 to 19	4	610

To determine the need for an exhaust system, see OSHA Title 29, Chap. 17, Part 1910.94 (b) Table G, or ANSI/NFPA 91.

E7.9a Exhaust provision

In accordance with OSHA Safety Code 1910.94 under section 2, Table G5, the recommended minimum exhaust volume that should be used is as follows:

Wheel Diameter (mm)	Minimum Width (mm)	Exhaust Volume (m ³ /min)
To 229	50.8	8.5
229 to 406	76.2	14.2
406 to 483	101.6	17.3

To determine the need for an exhaust system, see OSHA Title 29, Chap. 17, Part 1910.94 (b) Table G, or ANSI/NFPA 91.

8 Speeds

8.1 Safe free speeds

Safe free speed is any speed below the maximum safe free speed (**MSFS or max. SFS or MAX RPM**). The maximum safe free speed (**MSFS or max. SFS or MAX RPM**) for each brush shall be established by the brush manufacturer (see 3.1.8).

8.2 Maximum speeds

It shall be the user's responsibility not to exceed the maximum safe free speed (MSFS or max. SFS or MAX RPM) established by the manufacturer.

It shall be recognized that the maximum safe free speed (MSFS or max. SFS or MAX RPM) is not necessarily the most efficient brushing speed. Better results are frequently obtained at speeds lower than maximum safe free speeds.

8.3 Speed test (brush manufacturer's responsibility)

The speed test described in this subclause is based on the fact that centrifugal forces caused by excessive speeds can permit the working stresses to which the brush is subjected to exceed the strength of its materials. The purpose of the test is to ensure the existence of a factor of safety to minimize this risk. Representative brushes shall be speed-tested in accordance with Table 4. These brushes shall be speed-tested for a period of 30 seconds at the test speed, determined by multiplying the maximum safe free speed of the brushes by the minimum test factor as shown in the table. However, the ultimate destruction speed shall be greater than the minimum test speed. If any representative brushes burst during the test at speeds shown in Table 4, the entire lot shall be rejected.

This speed test is not designed to determine the mechanical properties of the brush, which should already have been determined by the brush manufacturer (see 4.1 and E4.1).

In some cases, the shape, size, construction, or conditions of use of the brush make the speed test inapplicable or misleading. Examples of brushes that need not be speed-tested include twisted-in wire brushes and strip brushes.

The brush manufacturer shall, upon demand, furnish certification showing that representative brushes have been speed-

E8.2 Maximum speeds

The maximum safe free speed as determined by the manufacturer is dependent upon the brush shape and strength. The strength of a brush may be defined as the ability of the brush to withstand rotational stress under no-load conditions.

E8.3 Speed test (brush manufacturer's responsibility)

The test speed subjects a brush to significantly greater forces than does the maximum safe free speed. This test establishes an adequate factor of safety, provided the brushes are used in accordance with safe practices outlined in this standard, and have not been altered, damaged, or abused.

The speed test does not justify operation of the brush at higher than the maximum safe free speed established by the brush manufacturer. The maximum safe free speed should never be exceeded, because the additional test strength covers other normal brushing stresses encountered in use.

No simple formula can possibly accommodate all of the various types and proportions of brushes, and, at the same time, provide a uniform factor of safety for each. Because of the considerations of safety, such a formula would penalize the better constructions to accommodate the weaker designs.

Table 4 - Test factors for speed test of brushes

Class of Brush	Minimum test factor >
Type I. Straight cup brush	
Class 1. Crimped	1.2
Class 2. Twisted tuft or knot	1.2
Type II. Flared cup brush	
Class 1. Crimped	1.2
Class 2. Twisted tuft or knot	1.2
Type I. Straight cup brush with shank	
Class 1. Crimped	1.2
Class 2. Twisted tuft or knot	1.2
Type II. Flared cup brush with shank	
Class 1. Crimped	1.2
Class 2. Twisted tuft or knot	1.2
Type III. Wheel or radial brush	
Diameter	
Class 1. Crimped	
2 to 6 in - 101.6 to 152.4 mm	1.2
6 to 9 in - 152.4 to 228.6 mm	1.3
9 in and over - 228.6 mm and over	1.5
Class 2. Twisted tuft or knot	
2 to 6 in - 101.6 to 152.4 mm	1.2
6 to 9 in - 152.4 to 228.6 mm	1.3
9 in and over- 228.6 mm and over	1.5
Type III. Wheel or radial brush With shank	
Class 1. Crimped	1.2
Class 2. Twisted tuft or knot	1.2
Type IV. End brush	
Class 1. Crimped	1.2
Style A. Solid fill	
Style B. Hollow enter	1.2
Style C. Pilot end	1.2
Class 2. Twisted tuft or knot	
Hollow center	1.2
Type v. Flared end brush	1.2
Type VI. Tubular end brush	
With shank	1.2
Without shank	1.2
Type VII. Twisted-in wire brush	No Speed Test
Type VIII. Strip brush	No Speed Test
Type IX. Cylinder brush	
Class 1. Mounted by manufacturer Style A.	No Speed Test
Crimped, or twisted tuft or knot	
Style B. Straight, helix, or coil-wound strip	
Class 2. Expendable or unitized Style A.	No Speed Test
Crimped, or twisted tuft or knot	
Style B. Straight, helix, or coil-wound strip	No Speed Test
¹ $\frac{1}{2}$ Maximum safe free speed (MSFS or max. SFS or MAX RPM) shall be multiplied by this test factor to establish the minimum speed at which brushes are to be tested by the brush manufacturer.	

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8.4 Brush machine and power tool builder's responsibility

All brushes classified for use under table 4 of this standard shall be used on machines and power tools designed and equipped in accordance with all of the requirements for guards and other general machine conditions described in clauses 5 and 9.

8.5 User's responsibility

All brushes shall be used in conformance with instructions given in clauses 4 to 9.

8.5.1 Speed check of machines and power tools

The speed of the spindle on brush machines or power tools shall be checked frequently with suitable instruments, by competent personnel employed by the user, to make sure that the speed is correct for the type and size of brushes used.

8.5.2 Speed adjustment control

If the speed of the machine spindle is adjustable, the speed adjustment shall be under the supervision and control of competent and authorized personnel only.

Such personnel shall use care in determining that the speed at any present moment conforms to and does not exceed the peripheral speeds (in surface feet/meters per minute), the rated MSFS, (MSFS or max. SFS or MAX RPM) as established for a new brush, or both (see tables 5 and 5a).

E8.4 Brush machine and power tool builder's responsibility

The references to other applicable clauses and regulations are important. All designers of brush machinery should be familiar with them. Their proper application has a direct relationship to the safe use of brushes.

E8.5 User's responsibility

The references to other applicable clauses and regulations are important. All users of brushes should be familiar with them. Their proper application has a direct relationship to the safe use of brushes.

E8.5.1 Speed check of machines and power tools

It is of special importance that the portable air grinders be checked to be sure that proper air pressure is maintained and that the machine governor mechanism is clean, in good operating condition, and functioning properly. This reference to air tools is not intended to downplay the necessity for a regular check of the speed on all types of brushing machines. Various types of speed-testing equipment are available, including tachometers, revolution counters, speed indicators, and stroboscopic mechanisms. A record of such speed checks should be maintained by the user.

E8.5.2 Speed adjustment control

Certain machines are designed with adjustable speeds to permit maintenance of efficient surface speeds by increasing the speed of the brush spindle to compensate for the reduction of the brush diameter.

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Table 5 – Conversion table for brush speeds

Surface speed in feet per minute									
Brush diameter (inches)									
r/min*	2	3	4	6	8	10	12	15	16
200	105	157	209	314	419	524	629	785	838
400	209	314	419	628	838	1 047	1 257	1 571	1 676
600	314	471	628	942	1 257	1 571	1 885	2 356	2 513
800	419	628	838	1 257	1 676	2 094	2 513	3 142	3 351
1 000	524	785	1 047	1 571	2 094	2 618	3 142	3 927	4 189
1 200	628	942	1 257	1 885	2 513	3 142	3 770	4 712	5 027
1 400	633	1 100	1 466	2 199	2 932	3 665	4 398	5 498	5 864
1 600	838	1 257	1 676	2 513	3 351	4 189	5 027	6 283	6 702
1 800	942	1 414	1 885	2 827	3 770	4 712	5 655	7 069	7 540
2 000	1 047	1 571	2 094	3 142	4 189	5 236	6 283	7 858	8 378
2 200	1 152	1 728	2 304	3 456	4 608	5 760	6 912	8 639	9 215
2 400	1 257	1 885	2 513	3 770	5 027	6 283	7 540	9 425	10 053
2 600	1 361	2 042	2 723	4 084	5 445	6 807	8 168	10 210	10 891
2 800	1 466	2 199	2 932	4 398	5 864	7 330	8 796	10 996	11 729
3 000	1 571	2 356	3 142	4 712	6 283	7 854	9 425	11 781	12 566
3 200	1 676	2 513	3 351	5 027	6 702	8 378	10 053	12 566	13 404
3 400	1 780	2 670	3 560	5 341	7 121	8 901	10 681	13 352	14 242
3 600	1 885	2 827	3 770	5 657	7 540	9 425	11 310	14 137	15 080
3 800	1 990	2 985	3 979	5 969	7 959	9 948	11 938	14 923	15 917
4 000	2 094	3 142	4 189	6 283	8 378	10 472	12 566	15 708	16 755
4 400	2 304	3 456	4 608	6 912	9 215	11 519	13 823	17 279	18 431
4 800	2 513	3 770	5 027	7 540	10 053	12 566	15 080	18 050	20 106
5 200	2 723	4 084	5 445	8 168	10 891	13 674	16 336	20 420	21 782
5 600	2 932	4 398	5 864	8 796	11 729	14 661	17 593	21 991	23 457
6 000	3 142	4 712	6 283	9 425	12 566	15 708	18 850	23 562	25 133
6 500	3 403	5 105	6 807	10 210	13 614	17 017	20 420	25 525	27 227
7 000	3 665	5 498	7 330	10 996	14 661	18 326	21 991	27 499	29 322
7 500	3 927	5 890	7 854	11 781	15 708	19 635	23 562	29 452	31 416
8 000	4 189	6 283	8 378	12 566	16 755	20 944	25 133	31 416	-
8 500	4 451	6 676	8 901	13 352	17 802	22 253	26 704	-	-
9 000	4 712	7 069	9 425	14 137	18 850	23 562	28 274	-	-
9 500	4 974	7 461	9 948	14 923	19 897	24 871	29 845	-	-
10 000	5 236	7 854	10 472	15 708	20 944	26 180	31 416	-	-
11 000	5 756	8 639	11 519	17 279	23 038	28 798	-	-	-
12 000	6 283	9 425	12 566	18 850	25 133	31 413	-	-	-
13 000	6 807	10 210	13 614	20 420	27 227	-	-	-	-
14 000	7 330	10 996	14 661	21 991	29 322	-	-	-	-
15 000	7 854	11 781	15 708	23 562	31 416	-	-	-	-
16 000	8 377	12 566	16 755	25 133	-	-	-	-	-
17 000	8 901	13 352	17 802	26 704	-	-	-	-	-
18 000	9 425	14 137	18 850	28 274	-	-	-	-	-
19 000	9 948	14 923	19 897	29 845	-	-	-	-	-
20 000	10 472	15 708	20 945	31 416	-	-	-	-	-
22 000	11 519	17 279	23 038	-	-	-	-	-	-
24 000	12 566	18 850	25 133	-	-	-	-	-	-
26 000	13 614	20 420	27 227	-	-	-	-	-	-
28 000	14 661	21 991	29 322	-	-	-	-	-	-
30 000	15 708	23 562	31 416	-	-	-	-	-	-

*Revolutions per minute for various diameters of brushes to give surface speed in feet per minute as indicated.

NOTE – "Centrifugal force," the force that tends to rupture a given brush when overspeeding, increases as the square of the velocity of that wheel brush. For example, the centrifugal force in a brush running at 5 500 surface feet per minute is 49% greater than in the same brush running at 4 500 surface feet per minute, although the speed is actually only 22% greater.

Table 5a – Conversion table for brush speeds

Surface speed in M per minute									
Brush diameter (millimeters)									
r/min*	51	76	102	152	203	254	305	381	406
200	32	78	64	96	128	160	192	239	255
400	64	96	128	192	255	319	383	479	511
600	96	144	192	287	383	479	585	718	766
800	128	192	255	383	511	638	766	958	1 021
1 000	160	239	319	479	638	798	958	1 197	1 277
1 200	192	287	383	575	766	958	1 149	1 436	1 532
1 400	223	335	447	670	894	1 117	1 341	1 676	1 787
1 600	255	383	511	766	1 021	1 277	1 532	1 915	2 043
1 800	287	431	575	862	1 149	1 436	1 724	2 155	2 298
2 000	319	479	638	958	1 277	1 596	1 915	2 394	2 553
2 200	351	527	702	1 053	1 404	1 756	2 107	2 633	2 809
2 400	383	575	766	1 149	1 532	1 915	2 298	2 873	3 064
2 600	415	622	830	1 245	1 660	2 075	2 490	3 112	3 320
2 800	447	670	894	1 341	1 787	2 234	2 681	3 351	3 585
3 000	479	718	958	1 436	1 915	2 394	2 873	3 591	3 830
3 200	511	766	1 021	1 532	2 043	2 553	3 064	3 830	4 086
3 400	543	814	1 085	1 628	2 170	2 713	3 256	4 070	4 341
3 600	575	862	1 149	1 724	2 298	2 873	3 447	4 309	4 596
3 800	606	910	1 213	1 819	2 426	3 032	3 639	4 548	4 852
4 000	638	958	1 277	1 915	2 553	3 192	3 830	4 788	5 107
4 400	702	1 053	1 404	2 107	2 809	3 511	4 213	5 267	5 618
4 800	766	1 149	1 532	2 298	3 064	3 830	4 596	5 745	6 128
5 200	830	1 245	1 660	2 490	3 320	4 149	4 979	6 224	6 639
5 600	894	1 341	1 787	2 681	3 575	4 469	5 362	6 703	7 150
6 000	958	1 436	1 915	2 873	3 830	4 788	5 745	7 182	7 660
6 500	1 037	1 556	2 075	3 112	4 149	5 187	6 224	7 780	8 299
7 000	1 117	1 676	2 234	3 351	4 469	5 586	6 703	8 379	8 937
7 500	1 197	1 795	2 394	3 591	4 788	5 985	7 182	8 977	9 576
8 000	1 277	1 915	2 553	3 830	5 107	6 384	7 660	9 576	-
8 500	1 357	2 035	2 713	4 070	5 426	6 783	8 139	-	-
9 000	1 436	2 155	2 873	4 309	5 745	7 182	8 618	-	-
9 500	1 516	2 274	3 032	4 548	6 065	7 581	9 097	-	-
10 000	1 596	2 394	3 192	4 788	6 384	7 980	9 576	-	-
11 000	1 756	2 633	3 511	5 267	7 022	8 778	-	-	-
12 000	1 915	2 873	3 830	5 745	7 660	9 576	-	-	-
13 000	2 075	3 112	4 149	6 224	8 299	-	-	-	-
14 000	2 234	3 351	4 469	6 703	8 937	-	-	-	-
15 000	2 394	3 591	4 788	7 182	9 576	-	-	-	-
16 000	2 553	3 830	5 107	7 660	-	-	-	-	-
17 000	2 713	4 070	5 426	8 139	-	-	-	-	-
18 000	2 873	4 309	5 745	8 618	-	-	-	-	-
19 000	3 032	4 548	6 065	9 097	-	-	-	-	-
20 000	3 192	4 788	6 384	9 576	-	-	-	-	-
22 000	3 511	5 267	7 022	-	-	-	-	-	-
24 000	3 830	5 745	7 660	-	-	-	-	-	-
26 000	4 149	6 224	8 299	-	-	-	-	-	-
28 000	4 469	6 703	8 937	-	-	-	-	-	-
30 000	4 788	7 182	9 576	-	-	-	-	-	-

*Revolutions per minute for various diameters of brushes to give surface speed in meters per minute as indicated.
 NOTE – “Centrifugal force,” the force that tends to rupture a given brush when overspeeding, increases as the square of the velocity of that wheel brush. For example, the centrifugal force in a brush running at 5 500 surface meters per minute is 49% greater than in the same brush running at 4 500 surface meters per minute, although the speed is actually only 22% greater.

8.6 Requirements for special speeds

On effectively guarded, fully protected machines, brushes used on special applications at speeds higher than those recommended by the brush manufacturer shall be used only in accordance with 8.6.1 through 8.6.3, as applicable.

If the brush manufacturer allows a special speed, the special speed shall replace the safe free speed for that brush. In this case, the brush manufacturer shall determine the special maximum safe free speed.

8.6.1 The brush manufacturer's responsibility

It shall be the manufacturer's responsibility to speed-test brushes required for special speeds and to identify them as being able to operate safely at special speeds.

If it is impractical to mark the brush, then the box or package in which it is wrapped shall contain the required markings, either on the outside of the package or printed on an insert placed inside of the package.

The brush manufacturer shall make certain that the brushes are of adequate strength, have been speed-tested in accordance with table 4, and bear the brush manufacturer's approval of the higher speed.

8.6.2 The brush machine builder's responsibility

The brush machine builder shall make certain at the time of manufacture that the machine has been designed and guarded in such a manner as to protect the operator from injury.

It shall be the brush machine builder's responsibility to design and construct those machine components that are concerned with the safe operation of the brushing machine at the speed and for the type of operation for which the machine is intended.

Particular attention shall be given to the design of the safety guards and the mounting spindle of the brush.

E8.6 Requirements for special speeds

When brushes are used at speeds in excess of standard speeds, extra precautions should be observed to ensure safe operation of the brush.

E8.6.1 The brush manufacturer's responsibility

The brush manufacturer should do the testing necessary to establish an adequate factor of speed. The brush should be marked to indicate that it has been approved for high speed under specific conditions of use.

E8.6.2 The brush machine builder's responsibility

The machine builder should be sure that the components of the machine, such as the spindle, bearings, guards, flanges, and horsepower, are adequate for the brushing operation.

The brush machine builder and brush manufacturer should cooperate to make sure that a brush of adequate strength can be manufactured for the operation; design and composition limitations might preclude making a brush for operation at special speeds.

The brush machine builder should decide upon the fitness of the machine for the proposed operation. If it becomes necessary or desirable to convert, change, or alter the machine from the design or purpose for which it was originally

If an existing machine is to be adapted for use at a special speed, the brush machine builder shall check all component parts of the brushing machine and, if necessary, modify or adjust all component parts prior to operation at the special speed.

When the operation is beyond the conditions for which the guards were designed, the brush machine builder shall ensure by test or calculation that the guards are capable of withstanding the special speeds, and, if necessary, replace, modify, or adjust the guards prior to operating at the special speed.

When the operating conditions are determined as exceeding the capacity of the machine and guards, the brush machine builder shall ensure by test or calculation the specifications for adequate replacement of the mechanical mechanisms and apparatus.

8.6.3 The user's responsibility

Before operating the machine at a special speed, the machine user shall make certain that the machine is operated with approved safety guards as defined in 7.7, and that the machine is maintained in a satisfactory condition, as defined in clause 5.

After receipt of the brushes, it shall be the user's responsibility to provide safe handling, storage, and inspection for the brushes designed for special needs in accordance with clause 4 and to maintain his/her brushing equipment in a safe operating condition at all times. Rules of safe operation of this equipment submitted by the brush machine builder shall be observed as well as those rules specified in other clauses of this standard. A user shall not operate a brush designed for special needs faster than the special maximum safe free speed (MSFS or max. SFS or MAX RPM) established by the brush manufacturer.

When an existing machine is altered by the user to operate at special speeds, the user shall assume all of the responsibility of a machine builder as outlined in this standard.

made by the builder, the components involved with the use of the brush should be designed in accordance with the appropriate clauses of this standard.

E8.6.3 The user's responsibility

The user should establish that all guards on the machine are adequate for the higher speed and should also maintain the machine in good condition for continuing safety.

The special speed as determined by the manufacturer is dependent on the size, geometry, and material of the brush. In this instance, strength is defined as the ability of the brush to withstand rotational stress.

The user shall fully inform all operating personnel that only brushes identified for operation at special speeds shall be used, and that, at no time, shall the special maximum safe free speed be exceeded.

9 Handling, storage, and inspection

9.1 Handling

All power-driven brushing tools can be damaged by improper handling. The following rules shall always be observed:

- 1) **Handle brushes carefully so that the fill material is not disoriented or bent, potentially causing an imbalanced condition to exist.**
- 2) **Do not rest any brush on its face, or place any object on the face of the brush that might tend to distort the face or become imbedded in the face.**
- 3) **Do not roll cylinder brushes (barrel fashion) or wheel brushes (hoop fashion).**
- 4) **When handling cylinder brushes with a sling, do not use a sling that is narrow enough to become impressed into the face of the brush.**
- 5) **Do not open packaged brushes until they are to be used or unless they need to be inspected. After inspection, repackage them in a manner that will ensure the same amount of protection as the original package.**
- 6) **During handling, keep all brushes boxed or covered so that foreign matter cannot accumulate and become lodged in the face of the brush.**
- 7) **Place brushes carefully on shelves or in boxes, bins, or other compartments so that brushes do not rest in any way that could cause a distorted condition.**

E9.1 Handling

Poor handling of brushes can contribute to unsafe conditions in a number of ways. Brushes damaged as in 9.1(1), (2), (4), and (7) that have filaments permanently deformed prior to use must be expected to adversely affect brush life, fill stiffness, surface finish, and safety itself, since stress concentrations at bends will occur and higher stresses will result when non-radially disposed wires lengthen upon contact with the work surface. This condition can also create imbalance in a brush that could result in extensive damage to the machine and the operator. Brushes that are out of balance and that cannot be balanced by adding or removing weight should be removed from the machine (see 4.2).

Poor handling creates safety hazards in another way, as shown in 9.1(2), (3), (5), and (6). In each instance, there is a possibility of foreign objects being lodged in the face of the brush. These imbedded objects can be thrown from the brush at great velocities when the brush attains operating speed.

9.2 Storage

Suitable racks, bins, drawers, or boxes shall be provided by the user to store the various types of brushes used. Storage recommendations of the brush manufacturer shall be followed. Brushes shall not be stored where they will be subjected to:

- Exposure to high humidity, heat, water, UV or other liquids that might induce deterioration or dimensional changes to the filaments or other brush components. (This deterioration includes rusting of ferrous metals and rotting, checking, or warping of wood and degrading of plastics.)
- Exposure to acids or fumes from acids that might induce deterioration to the filaments or other brush components.
- Any temperature low enough to cause condensation on the brushes when they are moved from storage to an area of higher temperature or humidity or both, or low enough to cause embrittlement or other deterioration of the filaments or other brush components.
- Storage that causes bent or distorted brush components.
- Damaged brush filaments from sliding the brushes across abrasive or rough surface.
- Exposure to the accumulation of foreign matter that may become attached to or lodged in any of the brush components.

E9.2 Storage

Any type of storage that permits the formation of rust on the filament wires or any corrosion to the filament surfaces, or that permits such mechanisms as hydrogen embrittlement to occur, can cause premature failure of the material. The failure is caused by corrosion fatigue. When corrosion occurs, there is a general roughening and etching effect that influences the fatigue strength of the material. Pitting caused by corrosion can result in a reduced cross section, thus increasing the magnitude of the stress unit. Even when only a few spots on the material are involved, the results are harmful, since the first crack will almost always occur prematurely in the corroded area, and, once started, will propagate through the unaffected area.

When corrosion is occurring during in-service use due to the repeated stressing that occurs naturally in a brush during use, the deleterious effect of corrosion fatigue is even greater. Special care should be exercised to avoid this condition because filaments that have been fatigued by corrosion present a hazard since they break off in use in long lengths and fly from the brush at dangerous velocities.

If rust is visible, corrosion has already become extensive enough to reduce the fatigue life of the brush.

If it is unavoidable that wire brushes will be stored in an environment that may contribute to corrosion, some protective steps can be taken. The brushes can be wrapped in protective paper before being placed in the storage area. This practice, or some equivalent, can preclude much difficulty assignable to corrosion resulting from storage conditions that are less than desirable.

Some users who have less than adequate storage facilities compensate for the lack by better planning of deliveries. They schedule deliveries so that brushes do not remain long in poor storage conditions.

Brushes can also be damaged by sliding them over an abrasive surface. This abrades the fill material and consequently creates a new fatigue hazard. Such fatigue failures frequently start from even superficial-appearing surface scratches, markings, and discontinuities that

develop into fatigue cracks. As the material flexes in use, these cracks, even though initially microscopic in size, propagate and material breaks off. This flying material poses a safety hazard for the brush operator and those in the area.

9.3 Inspection

Immediately after being unpacked or uncrated, all brushes shall be closely inspected to make sure that they have not been damaged from handling, shipping, or other causes. If examination discloses damage, the brushes shall not be used.

A typical defect that might be encountered on wire brushes is rust (oxidation), discoloration in the surface finish caused by exposure to environmental conditions.

E9.3 Inspection

The first inspection should be made on the box, crate, or container in which the brushes were shipped. If there is any evidence of damage to the container, special care should be used in the inspection of brushes.

Other examples of damage caused by poor handling or packaging are bent or dented shafts or arbors and disarranged working faces that preclude safe balance and concentric operation. Other typical defects may include any or all defects as a result of incorrect handling (see 9.1) and storage (see 9.2).

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