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Standard Terminology Relating to Porcelain Enamel and Ceramic-Metal Systems[1]

This standard is issued under the fixed designation C286; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These definitions pertain to the terminology used in the porcelain enamel and ceramic-coated metal industries.

1.2 Words adequately defined in standard dictionaries are not included. Included are words that are peculiar to these industries.

1.3 Hyphenated words, double words, or phrases are listed alphabetically under the first word; additional important words are cross-referenced.

1.4 When a word or phrase, listed as a synonym, is not separately defined, the defined word or phrase is the accepted or preferred form.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A424 Specification for Steel, Sheet, for Porcelain Enameling
A919 Terminology Relating to Heat Treatment of Metals (Withdrawn 1999)[3]
C282 Test Method for Acid Resistance of Porcelain Enamels(Citric Acid Spot Test)
C283 Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid
C285 Test Methods for Sieve Analysis of Wet-Milled and Dry-Milled Porcelain Enamel
C313 Method of Test for Adherence of Porcelain Enamel and Ceramic Coatings to Sheet Metal (Withdrawn 1989)[3]
C314 Test Method for Flatness of Porcelain Enameled Panels (Withdrawn 1979)[3]
C346 Test Method for 45-deg Specular Gloss of Ceramic Materials
C347 Test Method for Reflectivity and Coefficient of Scatter of White Porcelain Enamels (Withdrawn 1990)[3]
C374 Test Methods for Fusion Flow of Porcelain Enamel Frits (Flow-Button Methods)
C448 Test Methods for Abrasion Resistance of Porcelain Enamels
C614 Test Method for Alkali Resistance of Porcelain Enamels
C633 Test Method for Adhesion or Cohesion Strength of Thermal Spray Coatings
C743 Test Method for Continuity of Porcelain Enamel Coatings
C756 Test Method for Cleanability of Surface Finishes

3. Terminology

abrasion resistance—the degree to which a porcelain enamel will resist attack by abrasive materials.

NOTE 1—See Test Methods C448.

acid annealing—an annealing process in which ferrous metal shapes are coated with acid before and in conjunction with the annealing.

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[1] This terminology is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.12 on Materials for Porcelain Enamel and Ceramic-Metal Systems.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

acid resistance—the degree to which a porcelain enamel will resist attack by acids.

NOTE 2—See Test Method C283 and Test Method C282.

adherence—(*1*) the degree of adhesion of a porcelain enamel or other ceramic coating to a metal substrate.

NOTE 3—See Test Method C313.

(*2*) Stress necessary to cause separation of one material from another at their interface.

NOTE 4—See Test Method C633.

aging—the storing of porcelain enamel slips or powders before use. The change occurring in slips or powders with the lapse of time.

air atomizing—air used to atomize powder and to control powder/air mix and powder cloud density.

air fluidizer—air used to impart fluid-like properties to powder via a fluid bed.

alkali resistance—*for porcelain enamels*, the degree to which a porcelain enamel will resist attack by aqueous alkaline solutions.

NOTE 5—See Test Method C614.

alligator hide—a defect characterized by an extreme roughness of the porcelain enamel surface: a severe case of orange peel.

aluminum enamel—a porcelain enamel specifically designed for application to aluminum.

annealing—see Terminology A919.

annealing acid—see **acid annealing** and **annealing**.

anti-scale compound—a preparation that is applied to burning tools to protect them from scaling in service.

back emission—the electrical breakdown of air due to excessive charge build-up in the porcelain enamel powder film during powder application. This is due to the self-limiting characteristic of electrostatic powders.

back ionization—see **back emission**.

ball mill—*in porcelain enamels*, a dense, ceramic-lined rotating cylinder in which ceramic materials are wet or dry ground, generally using pebbles or porcelain balls as grinding media.

base coat—for two coat-one fire application, the thin layer of bonding frit applied first and used to promote adherence after firing to the metal substrate.

base metal—the metal to which porcelain enamel is applied.

basis metal—see **base metal**.

basket, pickle—see **pickle basket** and **pickling**.

batch smelter—any smelter that operates as a periodic unit, being charged, fired, and discharged according to a predetermined cycle.

beading—(*1*) the application of porcelain enamel, usually of a contrasting color, to the edge or rim of porcelain enameled articles.

(*2*) Removal of excess slip from the edge of dipped ware.

(*3*) In dry processing enameling, a bead of porcelain enamel along the edge of ware.

beading enamel—any of the special porcelain enamels used for beading.

bisque—a coating of wet-process porcelain enamel that has been dried, but not fired.

blackboard enamel— see **chalkboard enamel**.

black edging—a black porcelain enamel applied over the ground coat and exposed in specified areas by brushing the cover coat bisque prior to firing (see also **edging**).

black speck—a defect that appears in the fired cover coat as a small dark spot.

blank—the piece cut from metal sheet that is to be used in forming the finished article.

blemish—in dry process enameling, an insignificant imperfection in the porcelain enamel surface.

blister—a defect caused by gas evolution consisting of a bubble that forms during fusion and remains when the porcelain enamel solidifies.

blow-off resistance—the degree to which a deposited layer of powder resists being blown off by a standard jet of air.

blue enamel—(*1*) in dry-process porcelain enameling, an area of enamel coating so thin that it appears blue in color.

(*2*) In wet-process enameling, a cover coat applied too thin to hide the substrate.

boiling—a defect visible in the fired porcelain enamel caused by gas evolution which results in the formation of blisters, pinholes, black specks, dimples, or spongy surface.

bolt-hole brush—a special round brush used to remove porcelain enamel bisque from in and around small openings in the ware.

bond—see **adherence**.
box furnace—a furnace in which, periodically, a load of ware is introduced; fired, and removed.

break out—in dry process enameling, a defect characterized by an area of blisters with well defined boundaries.

bright annealing—see Terminology A919.
brush—to remove bisque in a definite pattern by means of a brush.

brush, bolt-hole—see **bolt-hole brush**.
brushing—see **brush**.
bubble structure—size and spatial distribution of voids within the fired porcelain enamel.

buck—a special support for ware during the firing of porcelain enamel on heavy ware.

burning—see **firing**.
burning bars, points, or tools—equipment used to suspend or support ware during the firing operations.

burning tool mark—a defect in the porcelain enamel appearing on the surface opposite to the point of contact with the supporting burning tool.

button test—a test designed to determine relative fusibility of porcelain enamel frit or powder and so called because the completed specimens resemble buttons.

NOTE 6—See **flow button** and Test Methods C374.

cast iron enamel—a porcelain enamel specifically designed for application to cast iron.

ceramic coating—an inorganic, essentially nonmetallic coating, on metal.

ceramic colorant—see **color oxide**.
ceramic ink—an ink containing a ceramic pigment that develops its color on firing. Also known as stamping, screening, or printing ink.

ceramic-metal coating—a mixture of one or more ceramic materials in combination with a metallic phase applied to a metallic substrate which may or may not require heat treatment prior to service. This term may also be used for coatings applied to nonmetallic substrates, for example, graphite.

cermet coating—see **ceramic-metal coating**.
chalkboard enamel—a special type of mat porcelain enamel used to provide a writing surface for chalk.

chalky or chalked—the condition of a porcelain enameled surface that has lost its natural gloss and become powdery.

charge decay—loss of charge on the deposited powder due to electrical leakage.

charge decay rate—loss of charge per unit of time.

charge retention—the ability of an electrically charged layer to retain its initial charge.

charge to mass ratio—ratio of the charge on a powder expressed in coulombs to the mass of the powder expressed in kilograms.

chipping—fracturing and breaking away of fragments of a porcelain enameled surface.

cleanability—the relative ease with which soils or stains can be removed from a material.

NOTE 7—See Test Method C756.

cleaner—a solution, usually alkaline, used to remove oil, grease, drawing compounds, and loose dirt from metal as a step in preparing the surface for porcelain enameling.

clear frit—a frit that remains essentially transparent or non-opaque when processed into a porcelain enamel.

coating—see **ceramic coating** and **ceramic-metal coating**.
coefficient of scatter—the rate of increase of reflectance with thickness at infinitesimal thickness of porcelain enamel over an ideally black backing.

NOTE 8—See Test Method C347.

cold-rolled steel—a low-carbon, cold-reduced and annealed sheet steel.

color oxide—a material used to impart color to a porcelain enamel.

colored frit—a frit containing a colorant in order to produce a strong color in the porcelain enamel.

comb-rack—(*1*) a burning tool shaped like a comb used for supporting ware during firing.
(*2*) A comb-like tool for supporting ware during the metal pickling operation.

comeback—the time required for a box furnace to return to temperature after the introduction of a load of ware.

cone-screen test—a method for testing fineness of enamel with a cone-shaped sieve. (see also **screen test**)

consistency—the properties of a slip that control its draining, flowing, and spraying behavior.

continuity of coating—the degree to which a porcelain enamel or ceramic coating is free of defects, such as bare spots, boiling, blisters or copperheads, that could reduce its protective properties.

NOTE 9—See Test Method C743.

continuous cleaning (coating)—a term describing a type of porcelain enamel designed to provide the continuous removal, at normal use temperatures, of food soils accumulated on the interior surfaces of ovens.

continuous furnace—a furnace into which ware is fed continuously and through which it progresses during firing.

continuous smelter—a type of smelter into which the raw mix is fed continuously and from which the molten product is discharged continuously.

contrast ratio—the ratio of the reflectance of a coating over black backing to its reflectance over a backing of reflectance of 0.80 (80 percent).

NOTE 10—See Test Method C347.

cooling zone—that part of the continuous furnace in which the ware is allowed to cool after firing.

copper enamel—a porcelain enamel specifically designed for application to copper.

copperhead—a defect occurring in sheet metal ground coat that appears as a small freckle or pimple-like spot, reddish brown in color.

cover coat—a porcelain enamel finish applied and fused over a ground coat or direct to the metal substrate.

covering power—the degree to which a porcelain enamel coating obscures the underlying surface.

cracking—a defect in the bisque consisting of fractures or separations.

crackled—a mottled textural effect in a wet process porcelain enamel resembling a wrinkled surface.

crawling—a defect in the porcelain enamel appearing as agglomerates or irregularly shaped islands.

craze, crazing—a defect appearing as one or more fine cracks in the porcelain enamel.

crinkled—a textural effect in a porcelain enamel surface having the appearance of fine wrinkles or ridges.

crossbend test—a test in which fired or bisque porcelain enamel panels are progressively distorted by bending to determine the resistance of the coating to cracking.

cup gun—a spray gun with a fluid container as an integral part.

cupping—the pouring of slip over areas of a part during draining to produce uniform application.

curling—a defect similar to crawling.

curtains—a defect in sheet steel ground coatings characterized by a draped pattern of darkened areas that are sometimes blistered. May also appear in cover coats applied over the ground coat or direct-on.

decarburized enameling steel—a special type of steel sheet of extremely low carbon content, suitable for porcelain enamel cover coat application direct to the metal (Type I of Specification A424).

decarburized steel— see **decarburized enameling steel**.

decking—the multiple layer loading of ware for firing.

de-enameling—the removal of porcelain enamel from the base metal.

deflocculating—the thinning of the consistency of a slip by adding a suitable electrolyte.

delayed fishscaling—a fishscaling defect that occurs after the final porcelain enamel processing (see also **fishscaling**).

devitrification—a surface defect manifested by loss of gloss as a result of crystallization.

dimple—a shallow depression in the porcelain enamel, sometimes a defect.

dipping—the process of coating a metal shape by immersion in slip, removal, and draining. In dry process enameling, the method of coating by immersing the heated metal shape for a short time in powdered frit.

dipping weight—see **pick-up**.

direct fire—a method of maturing porcelain enamel wherein the products of combustion come in contact with the ware.

direct-on—see **cover coat**.

double draining—a defect evidenced by flowing of the slip on the ware, which occurs after it appears that draining has been completed.

double-face ware—ware that has a finish coat on both surfaces.

draining—the part of the dipping or flowcoating process in which the excess slip flows from suitably positioned ware.

drain line—a nonuniform thickness of coating appearing as a line or streak in dipped or flow-coated ware.

drain time—time required for porcelain enamel slip applied by dipping, slushing, or flow coating to complete movement across the surfaces of a coated part.

dredge, dredging—*in dry process enameling*, (*1*) the application of dry, powdered frit to hot ware by sifting.
(*2*) The sieve used to apply powdered porcelain enamel frit to the ware.

drying crack—a defect characterized by a fissure in the bisque.

dry milling—the grinding of porcelain enamel materials without a liquid vehicle.

dry process enameling—a porcelain enameling process in which the metal article is heated to a temperature above the maturing temperature of the coating (usually 1600 to 1750°F, (approximately 870 to 955°C)), the coating materials applied to the hot metal as a dry powder, and fired.

dry spray—a defect confined to sprayed ware manifesting itself in the fired porcelain enamel as a rough, sandy texture.

dry weight—the weight per unit area of the bisque.

dust coat—a relatively thin, sprayed coating of slip.

dusting—(*1*) In dry-process enameling, see *dredging*.
(*2*) A spraying defect characterized by a piling up of almost dry slip in confined areas.
(*3*) The removal of extraneous material from the bisque before firing.
(*4*) See **dry spray**.

edging—(*1*) the process of removing bisque from the edge of a piece of ware to expose the underlying porcelain enamel.
(*2*) The spraying of special slip onto the edge of the ware.

edging brush—a stiff-bristled brush with metal guide, used to remove bisque from edges of ware before the firing operation.

eggshell or eggshelling—the texture of a fired ceramic coating similar in appearance to the surface of an eggshell. In porcelain enamel, usually a defect.

ejector air—air used to convey powder from pump to the part being coated.

electrophoretic deposition—the process of depositing material on a workpiece from a porcelain enamel slip suspension due to the movement of particles under the influence of an impressed direct current voltage.

electrostatic powder porcelain enamel— a mixture comprised of frit and additives ground and/or blended together to form a powder suitable for dry electrostatic application.

electrostatic retention—the tenacity with which a charged, electrostatically deposited powder porcelain coating adheres to the work piece before it is fired.

enamel—see **porcelain enamel**.

enamel, aluminum—see **aluminum enamel**.

enamel, beading—see **beading enamel**.

enamel, blackboard— see **chalkboard enamel**.
enamel, cast iron— see **cast iron enamel**.
enamel, chalkboard— see **chalkboard enamel**.
enamel, copper—see **copper enamel**.
enamel, jewelers'— see **jewelers' enamel**.
enamel, reclaim—see **reclaim**.
enamel scrapings—see **scrapings**.
enameling iron—a very low-carbon, low-metalloid, cold-rolled sheet steel, produced specifically for use as a base metal for porcelain enamel.

etched—an altered surface texture resulting from chemical attack.

fall-off—tendency of an electrostatically deposited powder to fall off the work piece during normal processing.

filter—see **plugging compound**.
film strength—the relative resistance of the bisque to mechanical damage.

fineness of enamel—a measurement of the degree to which a frit has been milled in wet or dry form, usually expressed in grams residue retained on a certain mesh screen from a 50-cm^3 or a 100-g sample.

fire marks—a defect characterized by tiny indentations similar in appearance to shallow pinholes.

firing—the controlled heat treatment of ceramic ware in a kiln or furnace to develop the desired final properties.

firing range—the time-temperature interval in which a porcelain enamel or ceramic coating is satisfactorily matured.

firing temperature—the degree of sensible heat attained by the ware during the maturing of the coating.

firing time—the period during which the ware remains in the firing zone of the furnace to mature the coating.

firing zone—that portion of the furnace, usually a continuous furnace, through which the ware passes and that remains at or near the firing temperature of the coating.

first point of no break—the amount (weight-mass) of porcelain enamel slip retained when it stops sliding off an enameled pick-up panel and is observed to drain smoothly from the panel without showing a wavey pattern on the wet surface (known also as "yield point").

fishscaling—a defect appearing as small half-moon shaped fractures somewhat resembling the scales of a fish.

fishscaling, delayed— see **delayed fishscaling**.
flaw—in dry process enameling, a defect of the ware that is cause for rejection.

flocculating—the thickening of the consistency of a slip by adding a suitable electrolyte.

flow-button—the pellet of frit used in the Fusion Flow Test.

NOTE 11—See Test Methods C374.

flow coating—the process of coating a metal shape by causing the slip to flow over its surface and allowing it to drain.

flux—a substance that promotes fusion in a given ceramic mixture.

fork—a piece of metal equipment used during the firing operation for placing ware in, and removing it from a box furnace.

frit, clear—see **clear frit**.
frit, colored—see **colored frit**.
frit, porcelain enamel—the small friable particles produced by quenching a molten glassy material (see also **clear frit** and **colored frit**).

fritting—the rapid chilling of the molten glassy material to produce frit.

furnace, box—see **box furnace**.
furnace, continuous— see **continuous furnace**.
fusion flow—the relative flow of various glasses or frits in the molten state.

NOTE 12—See Test Methods C374.

fusion test, button— see **button test**.
fuzzy texture—a defect characterized by a myriad of minute bubbles, broken bubbles, and dimples in the porcelain enamel surface.