**Ceramics**

Borates bring value to both Ceramic and Porcelain enamel glaze systems.

**Borate Benefits**

* Early glass forming during melting of oxides in glaze reducing firing temperatures
* Early maturation of glaze by reducing surface tension and viscosity of the main glass former
* Improved glaze appearance
* Improved the strength of the glaze to resist mechanical and chemical attack
* Reduction of the coefficient of expansion between substrate and glaze

However to better understand borate’s value there is a need to appreciate more fully glaze systems (ceramic and porcelain enamel).

**Ceramic Glazes**

Glazes are coatings made of frits composed of a vitreous substance that is fused to a ceramic material when fired in a kiln. Glazes have the ability to act as a colorant or decorative applique and to add strength and/or waterproofing value to a ceramic object. A frit is a ceramic composition made up of water soluble oxides that are fused with silica to form an insoluble additive as part of the total glaze package. Frits are produced separately from the main glaze system and later introduced before firing. Fritting also helps the glass formation process before the total glaze is applied to the ceramic ware, significantly lowering the glaze firing temperature. It is these frit compounds, where boric oxides are formulated that offer the benefits mentioned above. Boric oxide addition rates in the fritted glaze can be upwards of 25% by weight.

These glazes are usually composed of such raw materials as silica (main glass former), alumina (clay) and various metal oxides. These metal oxides (i.e. calcium, [sodium](http://en.wikipedia.org/wiki/Sodium), [potassium](http://en.wikipedia.org/wiki/Potassium)) act as a [flux](http://en.wikipedia.org/wiki/Ceramic_flux) to lower the melting temperature. Colorants are also important to the total glaze formulation as oxides of iron, copper, cobalt and opacifiers (which are neither transparent nor translucent). For example, tin or zirconium will modify the appearance of the glaze.

Glazes are often applied as an aqueous suspension that is composed of minerals and oxides which can be applied using a dip, pour or spray approach.

Decorative applications, also called under glaze, are applied directly to the ceramic piece that has yet to be fired, called “greenware” or has previously been fired as a ceramic and now called biscuit. The wet glaze (which is transparent) is applied to the post fired decorative cover as part of another firing in the kiln.

However, as mentioned above, while borates/boric oxides can be added to silica, boric oxide can also function as network former. It allows more fluxing oxides to be introduced without destroying the silicate lattice.

The oxides of only four elements (boron, silicon, germanium and phosphorus) are able to form glasses alone.

Applications where ceramic glazes are used include, but are not limited to floor and wall tile, tableware, china, and other ceramic substrates where a protective coating is required.

**Porcelain Enamel**

Porcelain enamel coatings are much like ceramic glazes. It is typically a material composed of a powdered glass applied in a liquid suspension but in this case to a metal substrate. These enamels can also be applied to glass and ceramic substrates. The key ingredient of porcelain enamel is a highly friable form of glass called [frit](http://en.wikipedia.org/wiki/Frit) which is common to ceramic glazes. A frit can be composed of an alkali-based borosilicate compound with a coefficient of expansion and temperature suitable for coating steel.

These are glass based inorganic coatings that can offer temperature resistant strength, chemical resistance and high luster. The main difference is that these glazes are applied to metal substrates such as steel and aluminum. Other metal substrates have included copper, stainless, and cast iron.

Generally speaking, there is a ground coat and a cover coat and in each application borates are found as part of the frit formulation. Actually there can be as many as 3 coats applied. First is the ground coat to bond to the metal substrate while the cover coat offers decorative and strength qualities. It is during the cover coat process that 2 different suspension coatings can be applied. Methods of application include dipping, electrostatic and wet spraying.

Borate requirements can be upwards of 25% by weight of the fritted glaze system for both ground and cover coats.

Finished enamels offer metal substrates

* Improved appearance due to increased luster
* Increased durability or mechanical strength (Mohs scale hardness 5 – 6)
* Protection against corrosion and possible rusting
* Reduction of the base metal’s thermal stress

General enamel applications both consumer and industrial includes chemical reactor tanks, clothes washers, cooking ware, dryers, oven exterior and interior, interior and exterior walls in construction, jewelry, signs, sinks, tubs and storage silos.

**Other Applications**

Ceramics applications outside of glazes can include consumer, industrial and advanced ceramics. Due to the broad ceramic category, other applications could include:

* Abrasives – Grinding wheels
* Refractories – kilns, crucibles, and other gas fired melting furnaces
* Structural materials – Bricks, floor and roofing tiles, and piping
* Technical ceramics (advanced ceramics) – Biomedical implants, aviation turbine blades, ceramic disk brakes, missile parts, bullet proof vests, and other high tech applications. Boride compounds (produced from boric acid and boric oxide) could be also be used in this application.
* Whitewares – tableware, cookware, wall tiles, pottery and sanitary ware

**American Borate Company Products:**

**Refined**

Borax 10 Mol, Etibor® 48 (Borax 5 Mol), Boric acid, Etibor® 68, Boric oxide

**Mineral**

Ulexite, Colemanite

**Investigate these helpful links**

Links: American Ceramic Society <http://ceramics.org/>

 Ceramic Manufacturers Association <http://www.cerma.org/>

 Porcelain Enamel Institute <http://www.porcelainenamel.com/>