











# Borates for fire retardancy in cellulosic materials

Boron compounds by themselves are effective flame retardants in lumber or plywood (Reference 8). They can be used in conjunction with other flame retardant chemicals including ammonium sulfate, diammonium phosphate or zinc chloride (Reference 9). Several theories have been proposed for the mechanism of flame retardant chemicals. The most widely accepted mechanism is referred to as the chemical theory. This theory suggests that the retardant chemicals directly alter the pyrolysis of wood, increasing the amount of char and reducing the amount of volatile, combustible vapors.

Borate-based treatments also inhibit or reduce the rate of thermal degradation in wood exposed to elevated temperatures. It is of particular concern for roof-truss lumber and plywood roof sheathing due to the typical roof temperatures induced by solar radiation (References 10 and 11). The borate-treated wood showed no significant decrease in modulus of rupture values for all temperature exposures. The phosphoric acid treatment had the most deleterious initial and thermal induced effects on modulus of rupture. Although not as severe as the effects of phosphoric acid treatment, the monoammonium phosphate treatment also had deleterious initial and thermal induced effects on modulus of rupture.

Currently, flame retardant chemicals commonly used for treating lumber and plywood include boron compounds (eg, Borax Decahydrate, *Optibor* boric acid and *Neobor* borax pentahydrate) and phosphorus compounds (eg, phosphoric acid, monoammonium phosphate, guanidylurea phosphate and diethyl-N,N-bis (2-hydroxyethyl) aminomethyl phosphate). Dicyandiamide is also used in the Dricon process for flame retardant treatment of wood products (Reference 12).

Borax-boric acid provides pH control. When used together with other chemicals, borates can neutralize some acidic commercial fire retardant chemicals and maintain a neutral pH. Phosphoric acid is not used as a sole ingredient in commercial formulations. However, it is a good fire retardant.

Monoammonium phosphate and guanidylurea phosphate are commonly used in some commercial formulations. Diethyl-N,N-bis aminomethyl phosphate, a phosphate ester, is a good flame retardant because of its neutral pH.

Generally, in commercial practice, flame retardant compositions comprise a mixture of the above-mentioned additives. Four compositions detailed in the American Wood Preservers' Association (AWPA) Specification P10 were commonly used prior to 1975. The concern over hygroscopic properties, corrosion and strength loss in the flame retardant-treated wood resulted in the change from chemical specification to performance standard by the AWPA. Under AWPA Standard C20-96, structural lumber shall be treated for fire-retardance in accordance with the requirements of the AWPA Standard C1. The flame retardant system used shall be listed in AWPA Standard PX. Subsequent to treatment, the lumber shall be air or kiln dried to a maximum moisture content of 19%. When tested in accordance with ASTM E-84 tunnel test (the 25-foot tunnel test: This test method involves the use of 20-inch by 25-foot specimen exposed horizontally to a furnace operating under forced draft conditions). The two results of this test are the flame spread index and smoke developed index.), the lumber shall have a flame spread index of 25 or less. In addition, the lumber shall show no evidence of significant progressive combustion when the test is continued for an additional 20 minute period.

Furthermore, the flame front shall not progress more than 10.5 feet beyond the centerline of the burner at any time during the test.

For both Interior Type A Low Temperature (LT) and High Temperature (HT) lumber, material shall have an equilibrium moisture content of not over 28% when tested in accordance with the ASTM D3201 procedures at 92±2% relative humidity.

However, fire retardant treated lumber which will be used in high temperature applications such as roof trusses and framing shall be tested for strength in accordance with ASTM Standard D-5664 or by











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## References

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U.S. Borax, part of Rio Tinto, is a global leader in the supply and science of borates—naturally-occurring minerals containing boron and other elements. We are 1,000 people serving 500 customers with more than 1,700 delivery locations globally. We supply 30% of the world's need for refined borates from our world-class mine in Boron, California, about 100 miles northeast of Los Angeles. We pioneer the elements of modern living, including:

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- **Solutions that make a difference:** Strategic inventory placement and long-term contracts with shippers to ensure supply reliability

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