

Borate handling and storage

1. Introduction

Most borates produced by U.S. Borax Inc. are relatively stable materials which are normally supplied in 50 lb or 25 kg bags. These products are packed in multi-wall kraft paper bags with polyethylene liner coated barriers. To provide added protection, pallet shipments are stretch-wrapped. Packaging is designed to provide maximum protection and can be expected to give satisfactory results if reasonable care is taken during storage and handling. Provided the products are stored and handled under the conditions described below, it has been found in practice that they will remain free flowing and suitable for use for a considerable period. Borates are also available in intermediate bulk carriers (IBCs) - 2,500 or 1,100 kg superbags. The superbag is constructed from white woven 100% polypropylene with or without polyethylene liner depending on customer's preference.

With increasing demand and changes in industrial practice, it has become more economical for many users of sodium borates and boric acid to switch to bulk transfer (trucks or containers: 18-28 tons; or railcars: 100-110 tons). Before converting to a particular form of bulk shipment, it is best for the customer and the supplier to decide on the appropriate system to use. The products most likely to be required in bulk are: *Neobor*[®] borax pentahydrate, *Optibor*[®] boric acid, borax decahydrate, and *Dehybor*[®] anhydrous borax. The relevant physical properties of these products for handling and storage are summarized in [Table I](#).

Table I: Physical properties

Product	Bulk Density lb./ft ³ (kg/m ³)	Angle of Repose	Degree of Abrasiveness	Corrosivity
<i>Neobor</i> borax pentahydrate	60 (952)	35°	Non-abrasive	None Solution slightly alkaline
<i>Optibor</i> boric acid	55 (881)	33°	Non-abrasive Has lubricating properties	Very weak acid May cause rusting of steel
Borax decahydrate	48 (769)	35°	Non-abrasive	None Solution slightly alkaline
<i>Dehybor</i> anhydrous borax	67 (1074)	35°	Abrasive	None Solution slightly alkaline



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2. Handling of borates

2.1 Handling of bagged products

All bagged borate products should be handled with care. Avoid puncturing any bags while using sharp instruments. A hole in a bag not only results in spillage but may allow moist air to enter which can cause caking. The potential for contaminating the products through punctured bags is also greater.

2.2 Handling of borates in bulk

2.2.1 Flow characteristics of sodium borates and boric acid

Neobor borax pentahydrate: This product is the most stable of the three sodium borates covered by this bulletin and is ideally suited to bulk transfer. It shows little tendency to cake, except after prolonged storage, or if it becomes severely wetted by rain or other substantial water ingress.

Optibor boric acid: Boric acid transfers well in bulk.

Borax decahydrate (borax 10 mol): Of the sodium borates, borax is the material that shows the greatest tendency to cake. When designing the bulk transfer system to be installed, it is not recommended to transport the finer varieties in bulk tank lorries. Any caking may be manageable within customer's plant, but difficulties in unloading the delivery vehicle could lead to delays.

Dehybor anhydrous borax: Dehybor anhydrous borax generally handles well in terms of its flow characteristics, but attention must be given to the abrasive nature of the particles. Where large quantities and long-term continuous operation of the unloading plant are involved, preference should be given to mechanical transfer equipment rather than pneumatic systems.

2.2.2 Bulk delivery systems

Railcars

Railcars generally have a bottom gate for discharge between the tracks. However, some cars are available equipped for pneumatic discharge either with their own pneumatic systems or utilizing customer's own equipment.

Hopper cars vary in size and capacity depending on the requirements of the customer (see [Table II](#)). The average hopper car is approximately 4,450 ft³ (126 m³) and will hold 100 tons (90,718 kgs).

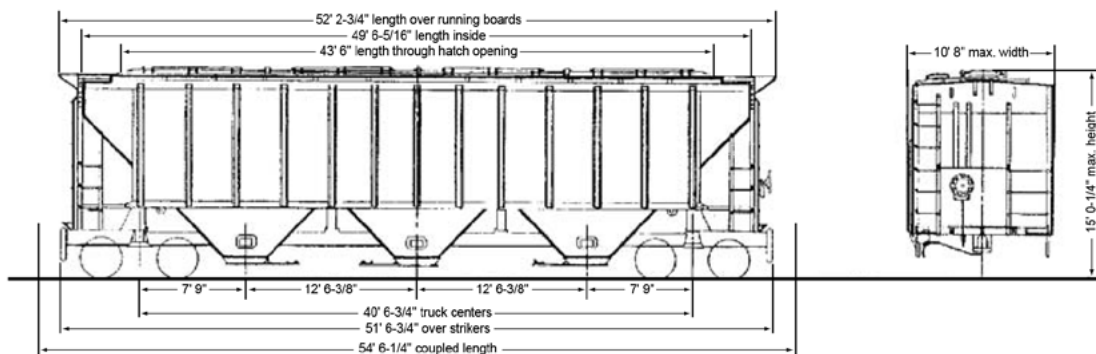
Table II: Bulk Hopper Cars Some general specifications

Capacity ft ³	Capacity tons	Number of Compartments	Outlet Specs No	Outlet Specs Size	Discharge Gate	Length	Dimensions Max Width	Max Height
3500	100	3	3	12' x 24"	Center dump, gravity pneumatic	54' 6"	10' 8"	15' 1"
4427	100	3	3	12' x 30"	Center dump, gravity pneumatic	51' 7"	10' 8"	15' 1"
4450	100	3	3	12' x 30"	Center dump, gravity only	53' 3"	10' 8"	15' 1"
4400	100	3	3	12' x 30"	Center dump, gravity only	49' 6"	10' 8"	15' 1"

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Cars are available upon request, with dual systems such that unloading can be accomplished using either gravity or pneumatic methods. All cars are equipped with center dump gates (between tracks discharge). [Figure 1](#) outlines the specifications for a 4427 ft³ (12.5 m³) covered hopper.

Figure 1



Cubic capacity: 4427 cu ft
 Each end hopper: 1574 cu ft
 Center hopper: 1279 cu ft

Roof hatches: 4 section continuous fiberglass trough hatch (43' 6" x 24")

Discharge system: Gravity
 Outlets: 3 (24" x 30")
 Height — Top of rail to discharge outlet: 11"

Hopper slope: 45°

Center of gravity — loaded car: 97:5"

Trucks: 100 tons
 Gross rail load: 263,000 lbs. Lightweight: 63,000 lbs
 Payload weight: 200,000 lbs. Bearings: Roller

Minimum horizontal curve negotiability:^o
 Coupled to AAR base car: 195 ft
 Coupled to similar car: 197 ft

Trucks

Trucks are generally equipped with their own pneumatic discharge systems operation at pressures of about 29.4 psi (2 atmospheres) and are capable of delivering into silos up to a height of 100 ft (30 m). Long horizontal runs of piping should be avoided.

Containers

These could be either special containers or containers equipped with liners, and would be emptied either by gravity or by suction using customer's own equipment.

2.2.3 Product unloading

The system best suited to individual needs will depend upon several factors including volume of product, plant arrangement, location of rail siding, space limitations, and economics. Generally, gravity unloading and mechanical system conveying to storage is more commonly used, especially with those products which tend to cake and form lumps under certain conditions of humidity and temperature such as borax decahydrate and to a lesser degree, *Neobor* borax pentahydrate.

Gravity Unloading is generally accomplished by discharging product directly from the rail hopper car to a pit mounted track hopper located between and below the track rails. The bottom slide gate opening for gravity discharge cars generally range in size from 13" x 24" (33 cm x 61.0 cm) to 24" x 30" (61 cm x 76.2 cm). It is recommended that an

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air-operated impact wrench be used for opening and closing the slide gate which can bind with the build-up of product in the slide tracks. Product can then be discharged from the track hopper, at a controlled rate, through an adjustable slide gate to a mechanical conveying system to a storage silo. The mechanical conveying system can consist of belt conveyors, screw conveyors, and centrifugal bucket elevators. Electric

or air vibrators mounted near the discharge opening of the track hopper will facilitate discharge if necessary. The track clearance between the car discharge point and top of rail is typically 11 inches (27.9 centimeters). A typical gravity unloading system utilizing mechanical conveying to storage is shown in [Figure 2](#).

Figure 2: Gravity unloading system

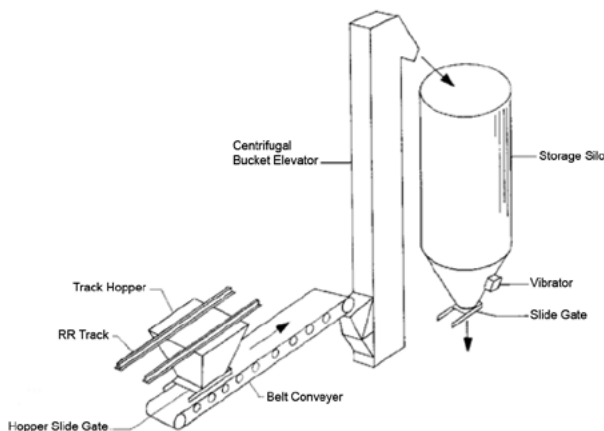
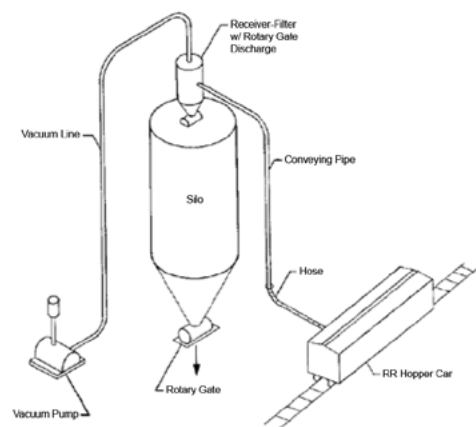


Figure 3: Vacuum unloading system



Pneumatic unloading is done by vacuum or combination vacuum-pressure techniques. *Neobor* borax pentahydrate and *Optibor* boric acid are non-abrasive and can be easily conveyed by this procedure directly from the car to the silo. A flexible hose with quick coupler is usually attached to a side port on the car with the other end attached to the permanent piping which runs parallel to the silo. This method of unloading has the advantage that the product is not exposed to the elements and, since it is a closed system, contamination, from outside sources is eliminated.

It is strongly recommended that the borax decahydrate be gravity discharged through a double finger crusher and into a holding bin before being pneumatically conveyed to the silo.

Borax decahydrate contains a higher percentage of water than either *Neobor* borax pentahydrate or *Optibor* boric acid and is more prone to caking. While mechanical unloading for U.S. Borax is strongly recommended, pneumatic unloading is possible but becomes more difficult. If this approach is deemed necessary, extra precautions must be observed to insure a smooth flow of product through the lines.

Because of temperature-humidity fluctuations during shipment, lumps invariably will form which, in most cases, are soft and friable. These lumps, nevertheless, can clog pneumatic lines resulting in a complete shutdown of the equipment. For this reason, it is important that a lump breaker be used which also minimizes heat buildup such that a temperature, never exceeding 95°F (35°C), is maintained. High temperatures will result in some release of the water of crystallization of borax causing caking and severe sticking to the equipment. [Figure 3](#) shows a typical vacuum unloading system to storage.

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2.2.4 Transfer of borates

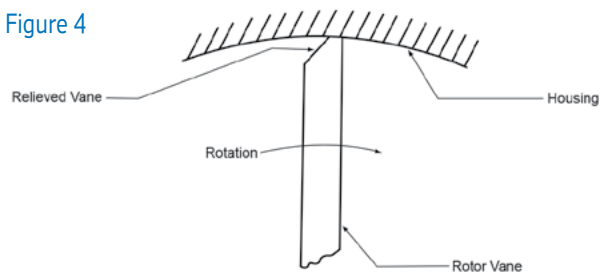
Generally with truck delivery, the product is delivered into silos by the truck's own pneumatic system, while with railcar and container deliver, a customer's own equipment would be used, which could be conveyor and bucket elevator or pneumatic. Discharge from silos is normally by gravity to some form of mechanical conveying system. Where screw conveyors are used, they should be fitted with self-lubricated sleeve bearings.

Pneumatic conveying systems have the advantage of being dust free but mechanical systems should incorporate sealed transfer chutes and/or dust extraction. *Neobor* borax pentahydrate, *Optibor* boric acid and borax decahydrate can be air conveyed by pneumatic pipe systems or air slides. *Dehybor* anhydrous borax because of its abrasive nature, will require the use of ceramic or hard faced liners at specific points where abrasive wear is expected, such as elbows, transition pieces, and impingement surfaces in cyclones, receivers, and diverters.

The same precautions noted for the pneumatic unloading of borax dehydrate would apply if air slide unloading is to be considered. It is also important that dry and cooled air be used and care be taken to maintain air conveying temperatures below 95°F (35°C). The use of air conveying, for locations that are frequently humid with high ambient air temperatures, is not recommended.

Some airlock units have been known to cause borax decahydrate and *Neobor* borax pentahydrate buildup in the rotor's casing. This problem can be minimized with the installation of relieved vanes in the housing. Consultation with an engineering firm should be made to establish the best type suitable for your particular system. One arrangement is shown in [Figure 4](#) where the vanes are relieved by machining off the vanes' trailing edges thus allowing the rotor to keep the product buildup scraped off.

Figure 4



On a small scale, where the unloading equipment is used for short periods only, pneumatic transfer systems can be used, although bends in the pipework should be minimized and where installed, should be constructed of hard-faced or ceramic material. Alternatively, rubberized canvas bends may be suitable. The recommended conveying systems for borate products are summarized in [Table III](#).

Ideally, unloading and transfer equipment should be sheltered from direct rainfall. Caking, as opposed to mild consolidation, usually only occurs if the material becomes wet as a result of massive ingress of water.

Table III: Conveying of borate compounds

Product	Conveying System
<i>Neobor</i> borax pentahydrate	Air or mechanical methods satisfactory; tendency to build up diminished because of lower water content
<i>Optibor</i> boric acid	Flows very well; easy to handle using air or mechanical means
Borax decahydrate	Air acceptable but mechanical conveying recommended. Will build up at points of impact in air systems
<i>Dehybor</i> anhydrous borax	Air acceptable but mechanical (anhydrous borax) conveying recommended because of product's abrasiveness. If air used face hardened or ceramic coated elbows necessary

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Depending on the design of transfer equipment, dusty conditions can occur and dust extraction should be installed to comply with local environmental regulations. Most of the dust from pneumatic conveying systems can be collected in a cyclone, and removed for possible recycle. The excess dust-laden air can then be sent to a bag house where the final separation of air and product is made. If a gravity discharge and a mechanical conveying system is used for transporting material to storage, it is generally only necessary to install a baghouse dust collector to control the dust emissions. Most equipment manufacturers offer dust equipment as part of their package.

3. Storage of borates

3.1 Storage of bagged products

Borates should be stored in a dry warehouse, preferably on wooden pallets. Bags must not rest directly on a concrete or earthen floor. Product compaction may be minimized by keeping the number of layers on a pallet to a minimum and by not stacking pallets on top of one another for extended periods of time. Powdered products are much more susceptible to compaction than granular products.

Lumps caused by compaction are generally friable and should not be confused with hard caking which results from changes in water content. Caked material is chemically unchanged and suitable for most industrial applications. If necessary, changes in water content can be determined in a laboratory.

Always store product using the "first in/first out" principle. The oldest material should always be used first. If prolonged storage is necessary, caking tendencies may be reduced by rolling individual bags on a clean, dry surface.

3.1.1 Effect of prolonged storage

When stored under normal conditions of temperature (<85°F or 29°C) and humidity (<45% relative humidity), the products are unlikely to degrade or lose their effectiveness. Prolonged storage can, however, lead to changes in moisture content which can show itself in various ways. The following concerns special precautions of storing borate products:

Borax decahydrate

When exposed to temperature greater than 85°F (29°C), borax will lose water of crystallization which can cause caking and weight loss. During the summer months, borax must be kept in a cool dry area. Under very hot dry conditions, borax is likely to lose water of crystallization. Nevertheless, after allowing for the changes in moisture content, borax will continue to be suitable for use in most industrial applications.

Dehbor anhydrous borax, borax glass, and boric oxide

These anhydrous products are all hygroscopic. They will pick up water and cake if exposed to the atmosphere. Care should be taken to keep bags intact and material as dry as possible.

Optibor boric acid

Boric acid is less sensitive but may, under extreme conditions, lose some water of hydration. If boric acid picks up moisture it will show a tendency to cake. This pick up of moisture is generally only a physical phenomenon, and provided this product has not been in direct contact with water, causing hard caking, it should still have a near normal assay. Loose boric acid is very slippery and spillage may create hazardous footing and poor traction for warehouse vehicles. Avoid puncturing any bags and sweep or vacuum spills immediately, followed by flushing the surface with water.

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Ammonium pentaborate

Ammonium pentaborate is relatively stable but care should be taken to avoid prolonged storage. This material does exhibit a tendency to cake.

Sodium metaborate 4 mol

If exposed to air, sodium metaborate 4 mol crystals will react with carbon dioxide, forming sodium carbonate and borax.

Sodium metaborate 8 mol

At low humidity, sodium metaborate 8 mol tends to lose some water of crystallization forming sodium metaborate 4 mol. The crystals will also react with carbon dioxide if exposed to air, forming sodium carbonate and borax.

3.1.2 Storage life of borates

The storage life is that period of time during which a product remains in usable condition. The storage life of borates depend on many factors. As long as the products are stored in properly sealed original containers, the storage life (shelf life) is theoretically indefinite since borates will not break down or decompose. Store under proper conditions, eg, keeping the container off the floor, away from external heat (temperature < 85°F or 29°C) and humid atmosphere (<45% relative humidity). All borates have a natural tendency to cake under prolonged storage. Prolonged storage periods are not recommended, although in many cases the products will remain free flowing for up to a year. These guidelines apply to granular products and it is desirable to consider shorter storage periods for powdered products.

Powders are more sensitive to the changes outlined and will often show a fairly early tendency to form loose agglomerates. Generally speaking these agglomerates disintegrate under hand pressure and this compaction should not be mistaken for hard caking.

3.2 Storage of borates in bulk

Although most borates can be stored in silos, some borates, such as *Dehybor* anhydrous borax can cake if storage is prolonged, due to the hygroscopic nature of the material. It should be noted, silo storage of powdered borax decahydrate, powdered *Neobor* borax pentahydrate and powdered boric acid is not recommended. This would be especially true for borax powder which can readily lose water of crystallization under some conditions of temperature and relative humidity. The product can then rehydrate to cause severe caking.

Either concrete or mild steel (not recommended for *Optibor* boric acid due to potential corrosion problem) silos may be used. For silos of less than 500 tons capacity, steel construction is possibly the cheaper option. If concrete is preferred it may still be more economical to make the conical section in steel. There are advantages to installing two or more smaller silos rather than one large silo since:

- Each silo can be emptied at regular intervals
- Stock control is more accurate
- Repairs can be carried out while maintaining a storage capability

3.2.1 Coating of silos

Silos should be vented for proper discharge and to avoid severe dusting and moisture condensation within the silo. Mild steel silos used to contain borax do not need an interior coating since borax is mildly alkaline and will protect the metal. Boric acid is mildly acidic and a protective interior coating is recommended. This is especially true where iron contamination is to be avoided. Silo located outdoors should have a waterproof seal coating applied to concrete exterior surfaces to prevent infusion of moisture which can promote caking.

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3.2.2 Dust control in silos

A dust extraction unit is normally fitted into the top of each silo to filter dust from the air displaced during filling and to keep the silo under slight suction when being filled. The size of the unit depends on the method of filling, size of batch etc., but for a mechanical conveying system, a unit with a fan capacity of 8-12 times the volumetric filling rate should be suitable. However, the size of unit for a pneumatic system will depend on the volume of air used for conveying. To prevent a vacuum developing in the silo, a separate air vent should always be incorporated.

3.2.3 Particle segregation in silos

Particle size segregation may be a problem in silo storage. Design features should be included in silo construction to minimize this tendency toward segregation. Discharge over a cone, multiple loading points, and other methods may be used. The discharge from the silo should be controlled by a valve or feeder connected to the silo outlet. To allow for maintenance, a slide gate should be incorporated above this valve or feeder.

3.2.4 Discharge from silos

Cone bottoms of storage silos should have a minimum 55° slope to effect proper discharge. The use of electric or pneumatic vibrators is recommended to promote discharge flow, however, it is important that vibration be used during actual periods of discharge only, otherwise product packing and caking will result in the cone bottom. The storage properties of borates are listed in [Table IV](#).

The silo volume and strength calculations should be based on the bulk densities given in [Table I](#). As with all solids handling, an allowance should also be made for dynamic stresses when discharging and possible impact loads due to the collapse of any bridge that may form in the material.

3.2.5 Silo design

Consideration should also be given as to whether mass flow or core flow is required and the silo designed accordingly. Mass flow conditions exist in a silo or hopper if all the product is in motion (ie where every part of the material in the silo moves in unison from entry to exit) when discharging. With core flow, product flows down a channel (or core) extending upwards from the outlet which is surrounded by stationary product. As the level in the channel drops, product slides from the top of the surrounding stationary mass into the channel.

The majority of silos in use for storage of bulk borates and boric acid are of the core flow design, although mass flow silos have the advantage of uniform flow, minimum segregation and first in first out discharge. Core flow silos are generally less expensive to construct than mass flow. However, they have the disadvantage that higher segregation can occur and they do not give first in first out discharge.

Table IV: Storage properties of borate compounds

Product	Recommended Storage
<i>Neobor</i> borax pentahydrate	Use a 55°-60° cone with vibrators and provide cleanouts.
<i>Optibor</i> boric acid	Use 55°-70° cone with vibrators and cleanouts. Protective interior coating advised.
Borax decahydrate	Cone bottom steel bin (55°-60° cone). Use electric vibrators on cone and provide cleanouts; or a silo with the side sloping inwards (ie diameter at top less than at bottom) and a flat bottom. The product being fed to a central outlet by a screw conveyor rotating around the bottom. Product may cake.
<i>Dehybor</i> anhydrous borax	Cone bottom 55°-60°, impact points should be face hardened to minimize effect of abrasion. Product generally flows well. Slow hydration with caking may occur in humid areas.

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Mass flow silos

A silo designed for mass flow will have a large height to diameter ratio and a cone angle of at least 65°-70°, to the horizontal. To ensure a correct mass flow design, the flow properties of the material to be stored need to be known. Typical values for *Optibor* boric acid and *Neobor* borax pentahydrate are available but these should be checked when designing the silo.

It is essential that there are no ledges no protrusions on the inside walls of the silo and all horizontal welds must be ground flat.

Any shut-off gate should be fully open and any feeder or conveyor should take product from the full outlet area so that discharge is not obstructed. Allowance must be made for the very high horizontal dynamic pressure at the hip or transition level between the cylindrical and hopper sections of the silo. This pressure could be at least five times higher than that calculated by the conventional Rankine and Janssen theories based on the depth of the material.

Core flow silos

As with mass flow silos, the cone section should have its internal surface free of ledges with all the horizontal welds being flat. The diameter of the silo should be as small as practicable. Experience has shown that a cone angle of 60° to the horizontal will generally provide free flow when discharging but under no circumstances should the cone angle be less than 60°.

Mass flow conditions could occur within a core flow silo if the material itself forms a cone. This could then give the high horizontal pressure anywhere within the cylindrical section.

4. Health and safety

Borax decahydrate, *Optibor* boric acid, and other inorganic borates are in safe use in a variety of industrial applications, in which no cases of intoxication have been reported. These borates have a low acute toxicity in mammals and are not absorbed through intact skin. Although no special precautions are required in handling these products, the normal practices of industrial hygiene should be followed, for example, to avoid inhalation of dust.

First aid

In case of eye or skin contact, wash away with plenty of water.

Spillage

Remove with broom or shovel, and wash away remaining traces with water.

Fire

Borax decahydrate, *Optibor* boric acid, and other inorganic borates are non-flammable and non-explosive. Any fire extinguisher may be used on nearby fires.



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About U.S. Borax

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:

- **Minerals that make a difference:** Consistent product quality secured by ISO 9000:2001 registration of its integrated quality management systems
- **People who make a difference:** Experts in borate chemistry, technical support, and customer service
- **Solutions that make a difference:** Strategic inventory placement and long-term contracts with shippers to ensure supply reliability

About 20 Mule Team® products

20 Mule Team borates are produced from naturally occurring minerals and have an excellent reputation for safety when used as directed. Borates are essential nutrients for plants and key ingredients in fiberglass, glass, ceramics, detergents, fertilizers, wood preservatives, flame retardants, and personal care products.

