Zeolites are crystalline oxides of aluminum and silicon, two of the most common elements in the earth’s crust. Some zeolite crystals occur in nature. Others are synthesized in special forms to perform specific chemical tasks. The key to the demand for synthetic zeolites is their unique “cage-like” framework. This open structure gives zeolites unusual reactive properties and molecular filtering abilities that can be exploited in such different chemical processes as softening laundry washwater and refining petroleum into gasoline.

For more than 150 years, PQ Corporation has been actively involved in the development and production of sodium silicate and silica-derived products. During that time we continuously improved our reputation for quality by listening to customers and responding to what they told us. We worked to produce detergent ingredients that met customer requirements and performed in service according to customer expectations.

Now, because of increasingly sophisticated and changing market demands, there is a need for a new generation of detergents. And again PQ is listening carefully and responding positively. Our activity with detergent grade zeolite is a prime example of how we are working with customers to help reformulate their future.

PQ’s first detergent grade zeolite plant was designed and built in 1982 by an experienced group of chemists, engineers and business managers who understood the emerging concerns for environmental quality.

Today our network of facilities based on detergent grade zeolite technology extends worldwide. We lead the industry in producing high-quality zeolite products, in devising ways to make zeolite products work for customer applications, and in backing up customer efforts with high-level technical support. PQ people are working in partnership with detergent manufacturers in every segment of the industry. And VALFOR® 100 detergent grade zeolite from PQ has become a trusted ingredient whenever formulators need new dimensions of quality and performance in their products.
TABLE 1

<table>
<thead>
<tr>
<th>TYPICAL CHARACTERISTICS OF VALFOR® 100 ZEOLITE</th>
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</thead>
<tbody>
<tr>
<td>Form</td>
</tr>
<tr>
<td>Color</td>
</tr>
<tr>
<td>Calcium exchange capacity, mg CaCO₃ per gram of anhydrous zeolite</td>
</tr>
<tr>
<td>Average chemical composition, %</td>
</tr>
<tr>
<td>N₂O₃</td>
</tr>
<tr>
<td>Al₂O₃</td>
</tr>
<tr>
<td>SiO₂</td>
</tr>
<tr>
<td>H₂O</td>
</tr>
<tr>
<td>pH of 1% dispersion</td>
</tr>
<tr>
<td>Bulk density lb/ft³</td>
</tr>
<tr>
<td>g/cm³</td>
</tr>
<tr>
<td>Median particle size, μm</td>
</tr>
<tr>
<td>Nominal pore size diameter, Å</td>
</tr>
<tr>
<td>Moisture loss at 800°C, % by weight</td>
</tr>
</tbody>
</table>

* Measured in 31.1°C, 0.02 N and 10 mm calcium per anhydrous gram of zeolite
* Measured in 31.1°C, 0.02 N and 40 mm calcium per anhydrous gram of zeolite

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**VALFOR®100 TYPE A ZEOLITE**

**DETERGENT BUILDER CHARACTERISTICS**

The characteristics which are responsible for VALFOR 100 type A zeolite's strong performance as a detergent builder are its silica-to-alumina ratio and its pore structure. The three-dimensional arrangement of 4.2 micron pores featured by the crystal structure of VALFOR 100's sodium salt allows rapid exchange of water hardness ions (particularly calcium) with zeolite sodium ions, thus softening the water. The silica-to-alumina molar ratio of the crystal structure is 2:1. Because of this low ratio, the lowest of any known synthetic zeolite, the ion exchange capacity of VALFOR 100 zeolite is at the maximum. Ion exchange in zeolites takes place only at structural alumina sites, thus VALFOR 100's high alumina content leads to optimal detergent building capacity. Typical properties for VALFOR 100 detergent grade zeolite are listed in Table 1.

**ION EXCHANGE CAPACITY** — Generally, hardness ions interfere with the cleaning efficiency of detergents. VALFOR 100 zeolite is very effective at removing hardness ions from laundry wash water. Figure 1 (page 5) shows the effect of adding 0.06 percent zeolite to 40°C water containing 120 mg/l hardness with a 2:1 Ca:Mg ratio. VALFOR 100 reduces the calcium concentration to less than 2 percent of its original level in less than one minute and removes more than half the magnesium within 10 minutes—the duration of the average wash cycle. Many detergent formulators add a co-builder to their products to aid in the removal of magnesium. The most commonly used co-builders are sodium silicate and soda ash.
**CALCium Exchange Rate** - The relative activity of VALFOR 100 zeolite, STPP and sodium carbonate in removing calcium from an 80 mg/l solution is illustrated in Figure 2. The performance of STPP and VALFOR 100 are essentially equal. Within two minutes each removes 98 percent of the calcium. The final calcium concentration is less than 1 mg/l for either builder. Sodium carbonate, however, is far less effective in both the amount of calcium removed and the time of reaction.

**CALCium Ion Exchange Capacity** - As seen in Figure 3, the capacity of VALFOR 100 zeolite to remove calcium is similar to that of STPP. Increasing amounts of each builder were added to an 80 mg/l calcium solution, and the residual concentration was determined. Similar amounts of VALFOR 100 or STPP can be used to decrease 80 mg/l calcium to near zero.

**Other Ion Capacities** - VALFOR 100 is also effective in removing the iron and manganese ions that may occur in hard water. These ions, which are colored in solution, can stain fabrics if they are present at even relatively low levels.
**SURFACANT ADSORPTION** - Of the major builders, VALFOR 100 demonstrates the greatest capacity to adsorb liquid nonionic surfactant. As shown in Table 2, VALFOR 100 adsorbs approximately three times as much surfactant as sodium carbonate and five times as much as STPP. This characteristic of VALFOR 100 is important when detergents are dry-blended or agglomerated, as it enables more surfactant to be added to the formulation. At the same time, product flowability remains high and the possibility of spotting of the container resulting from surfactant migration is minimized.

**SURFACE ADSORPTION** – Since zeolites are tiny, insoluble particles that end up being suspended in cleaning solutions, they provide an added dimension of detergency not offered by soluble builders, namely, surface adsorption. VALFOR 100’s highly adsorptive surface area traps dispersed particles, low solubility salts, and soluble matter so these unwanted soils cannot redeposit themselves on laundry during the cleaning process.

**PARTICLE SIZE** – VALFOR 100 zeolite has a median particle size in the 3-5 μm range. These extremely fine particles readily pass through fabric pores and do not build up on either fabrics or washing machine parts.

**PACKAGING** – VALFOR 100 zeolite is available in bulk, in 1000-pound sacks, or in 50-pound multiwall bags.

**SAFETY** – VALFOR 100 detergent grade zeolite is completely inorganic, nontoxic and non-combustible. It is mildly alkaline and warrants care in handling to prevent discomfort to the skin and eyes. In handling areas where dust could present a health hazard, the use of a NIOSH-approved mask is recommended. The material safety data sheet for VALFOR 100 detergent grade zeolite is available from our customer service department.
**Production Performance**

Interlocked with a PQ sodium silicate plant from which it draws its main feedstock, our Kansas City, Kansas zeolite production facility employs many unique processing advantages that lead to efficient, reliable manufacturing. Innovative planning has gone into every PQ detergent zeolite facility, from our first in Kansas City, to those in Augusta, Georgia and Jeffersonville, Indiana, and others around the world.

**New Dimensions in Process and Performance**

**PQ** is one of the world’s largest producers of detergent grade zeolite, supplying all major detergent manufacturers. Our leadership position is the result of added ingredients: partnerships, product quality and a commitment to continuous improvement.

Our objective is to provide zeolite products that perform to your expectations—meeting your quality, quantity and delivery requirements.

To make that objective a reality, PQ is taking the lead in systems designed to improve manufacturing efficiency. Statistical process control systems, in place throughout our manufacturing facilities, continually monitor production processes during operations. And PQ’s skilled, professional workforce employs advanced production techniques to reduce operating variables and improve reliability.

The result, for you, is detergent grade zeolite products from PQ that consistently meet your specific standards, order after order.

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**Manufacture of Valfor® 100 Zeolite**

- **Alumina**
- **Reactor**
- **Crystallizer**
- **Filter**
- **Dryer**
- **Silica**
- **Zeolite**
- **Water**
REFORMULATING FOR THE FUTURE

Zeolites have become a desirable alternative to the phosphate compounds that have been used as water-softening builders in laundry detergents since the late 1930's. Phosphate tends to promote excessive growth of aquatic plant life which can damage ecosystems. Concern about environmental damage has led to widespread banning of detergent phosphates. Detergent makers have responded by reformulating their products with sodium type A zeolite. Its performance as an alternate builder in detergents is unrivaled.

NEW DIMENSIONS IN HEALTH AND SAFETY CONCERNS

A driving force behind zeolite's emergence has been safety to human health and to the environment. Extensive studies have demonstrated that type A zeolite is non-toxic when encountered via oral, dermal, ocular or respiratory routes. It is also environmentally benign as was shown in tests conducted by major detergent producers.

VALFOR 100 zeolite is completely inorganic. In effluents, its alkalinity dissipates on dilution. The soluble silica (SiO₂) component either remains in the dissolved state and joins the dissolved silica found in most natural waters, or it precipitates as calcium or magnesium silicate to join the insoluble silicates of mineral origin which make up the major portions of the earth's crust.

In order to manufacture VALFOR 100 zeolite, silica, an oxide of silicon which comes from mined sand, is combined with alumina, an oxide of aluminum which comes from the ore bauxite. (See chart on page 8, Manufacture of Zeolite NaA.) After the resulting crystalline aluminosilicate performs its function as a detergent builder, it re-enters the environment. Because it is a metastable material, the zeolite then decomposes back into natural materials such as silica and alumina. Since silicon, aluminum, and oxygen are among the most prevalent elements throughout the earth's crust, the elemental balance of the environment is maintained. (See chart, Zeolite A's Environmental Cycle.)

NEW DIMENSIONS IN CONTINUOUS QUALITY IMPROVEMENT

**PQ** is a world-class producer of sodium silicate and silicate derivatives such as VALFOR 100 type A zeolite. This assures you of total quality management—from advanced research and development—through efficient manufacturing and process control—to prompt service and detailed attention to your product requirements. Our commitment to quality is evident throughout the entire PQ organization. Continuous Quality Improvement allows us to improve our products and processes as we address important areas of customer satisfaction such as reliability, sales support and technical assistance.

**PQ CUSTOMER SERVICE AND TECHNICAL SUPPORT**

Whatever level of service and support you may require, PQ customer service representatives are available to help. Drawing on personal experience or the expertise of their technical support teammates, our customer service representatives are prepared for any situation—from initial product selection—through translating customer specifications into production lineups—to meeting your critical scheduling requirements. At PQ, our customer service team is ready to help you find the right solution to your formulation problem.

**LET US TAKE YOU TO NEW DIMENSIONS OF SUCCESS**

The experience and energy of PQ are ready for your challenge. Contact us about any application where detergent grade zeolites might be beneficial in the formulation of your end-product.

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