



# High-Performance Nonwovens

## AQUASET™ Binders for Industrial Mat Applications

### Introduction

The AQUASET™ trade name refers to a family of thermosetting aqueous acrylic solution polymers designed to replace conventional melamine, urea and phenol formaldehyde resins in a wide array of high-performance nonwoven products. These advanced binders are based on a patented crosslinking chemistry that utilizes a polyacrylic acid solution polymer, a crosslinker and a catalyst. When an AQUASET binder is heated, its constituents react to produce polyesters with an excellent balance of properties comparable to those of conventional aminoplast resins employed in high-performance nonwoven applications. The AQUASET binders, however, also have a number of advantages over the aminoplasts. They are highly resistant to degradation in nonwoven manufacturing processes (excellent “runnability”), and they produce very low levels of foam. They are amenable to B-stage curing – AQUASET binders can be applied to a web and dried without curing; they can then be cured after the web has been fabricated. AQUASET binders can tolerate high temperatures during use of the nonwoven products. They do not impart color to a substrate and are highly stable during storage, as they do not require refrigeration.

One other critical attribute that distinguishes the AQUASET binders from conventional aminoplasts is that they do not contain formaldehyde, which has been classified as a human carcinogen by the International Agency for Research on Cancer, nor do they generate formaldehyde under normal production conditions. As a result, manufacturers using AQUASET binders instead of aminoplast resins will significantly reduce formaldehyde emissions, a benefit in terms of worker health and safety and environmental impact. The absence of formaldehyde in the AQUASET polymers also makes for nonwovens with considerably less odor.

### Key Features

- No formaldehyde\*
- B-stage cure potential
- High solids
- Ease of storage and handling
- Waterborne
- Low foaming
- Low VOC
- Excellent runnability
- Excellent strength
- Thermal stability
- Low flame response
- Minimal post-cure color contribution

### Applications

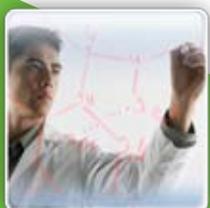
The properties offered by the AQUASET™ binders make them useful in a wide variety of nonwoven materials. They can bond many different fibers – glass, high-temperature resistant polyester, cellulose, carbon and ceramic. Possible end uses for AQUASET binders include glass fiber webs for roofing applications (shingles and built-up roofing), specialty glass mats used as facer sheets in composites, flooring, insulation applications (residential, commercial and specialty) and filtration media.

### Typical Properties

The following properties are typical but should not be considered specifications. The actual specifications for these products are available upon request.

APPEARANCE	Clear, light amber liquid
IONIC CHARGE	Nonionic
SOLIDS	>50%
pH, AS SUPPLIED	2.1 to 4.0
BROOKFIELD VISCOSITY AT 25°C (77°F)	200 to 500
DENSITY, 25°C lb/gal kg/g	10.0 1.2
WATER DILUTABILITY	Infinite
RECOMMENDED STORAGE, °C (°F)	>0 (32), >50 (122)
SHELF LIFE, months	>12

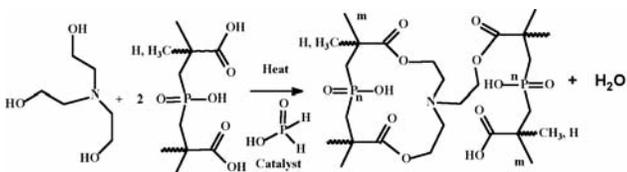
### BETTER BUILDING STARTS HERE



## Chemistry

All AQUASET™ binders consist of a waterborne polyacrylic acid solution polymer, a crosslinker and a catalyst. When exposed to temperatures in excess of 190° C (350° F), the polymeric constituents of the binders undergo a condensation reaction to form polyesters and water [Figure 1].

FIGURE 1. AQUASET Chemical Reaction



The strength provided by the crosslinker results in a web that can tolerate heat and other stresses. The fact that substrates with applied AQUASET binders can be dried prior to cure makes AQUASET binders appropriate for B-stage curing processes. In these cases, webs with dried but uncured binder are supplied to a fabricator. The fabricator then creates a finished product with a high-temperature process, such as molding, that cures the binder. The advantage for the fabricator is that a web with uncured binder is less rigid and easier to process. AQUASET binders are low in VOCs, have no formaldehyde\* and are less prone to pre-cure during shipment and storage than the alternative, aminoplast resins.

## Performance Properties

AQUASET resins are comparable to the conventional melamine, urea and phenol formaldehyde resins they are designed to replace in key performance areas; they offer the same kind of strength, durability and flame resistance. The strength properties of the AQUASET resins were confirmed during their development and commercialization in evaluations conducted with both glass fibers used for roofing mats and fiberglass filter paper. In testing conducted with other fibers – polyester, for example – AQUASET resins also demonstrated the excellent resistance to high temperatures needed for roofing substrates and the very good solvent resistance required by specialty applications. This section reports results from laboratory trials documenting AQUASET resin capabilities in the areas of tensile strength, resistance to high temperature and solvent resistance.

## Tensile Strength

The relative tensile strength provided by the AQUASET™ binders, a conventional urea formaldehyde (UF) resin and a conventional self-crosslinking acrylic emulsion was established on fiberglass wet chop fibers typically used in roofing mat, insulation and specialty applications. The specific physical properties measured in these evaluations included dry tensile strength (toughness), hot wet strength (degree of cure or reactivity) and hot dry tensile strength (asphalt application) [Table 1]. Elmendorf tear strength trials were also conducted to help verify that the performance of the AQUASET resins and urea formaldehyde resins is comparable. (One note of caution: the values for dry tensile strength and Elmendorf tear strength balance in this literature should not be treated as absolutes. Both properties can vary significantly, depending on certain aspects of the system: fiber type and length, white water, and temperature, among others).

The glass fiber hand sheets used in these tests were prepared with 1-inch fibers and white water containing Magnifloc™ 1885A flocculant, Rhodameen™ VP-552 surfactant and ammonium hydroxide. The final weight of the sheets was 1.8 pounds per 100 square feet, with a binder content of approximately 22 percent. The hand sheets were dried and cured at 200° C (392° F) for three minutes to achieve complete cure, as indicated by the high hot wet/dry tensile strength ratio. Dry and hot wet tensile strengths were measured on 1-inch-wide samples with an Intellect Tensile Tester (Thwing Albert) set at a separation rate of two inches per minute and a gap of two inches. Hot wet tensile strength was determined on samples that had been soaked at 85° C (185° F) for 10 minutes. Hot Dry tensile strength was determined on an Instron™ Tensile Strength Tester, equipped with an environmental chamber, one minute after reaching the desired temperature (150° C, 302° F).

The results demonstrated that the AQUASET resins are comparable to urea formaldehyde resins in typical tensile properties required for applications in the roofing industry and a prerequisite for fiberglass insulation: home, commercial and specialty. Of course, the ultimate performance of any fiberglass web for insulation depends not only on the tensile strength supplied by the binder, but also on complete removal of the dilution water.



TABLE 1. Strength Properties

BINDER	DRY TENSILE (lb/in)	HOT WET TENSILE (lb/in)	HOT DRY TENSILE (lb/in)	ELMENDORF TEAR (lb/in)
Urea Formaldehyde	32.9	27.5	29.8	278
Conventional Acrylic	33.1	24.4	5.3	333
AQUASET™ 100	34.9	30.2	30.1	300

TABLE 2. Percent Elongation at Elevated Temperatures

SAMPLE	5 NEWTONS	FORCE 8 NEWTONS	12 NEWTONS
AQUASET	7	13	22
Conventional Acrylic	12	24	39
Acrylic/Melamine Formaldehyde (10%)	8	17	37
Acrylic/Urea Formaldehyde Resin (10%)	9	21	44

TABLE 3. Solvent Resistance

SAMPLE	IPA, MACHINE (lb/in)	IPA, CROSS-MACHINE (lb/in)
AQUASET, 150°C (302°F)	2.7	0.9
AQUASET, 200°C (392°F)	5.4	2.0
ACRYLIC, ANIONIC, 150°C (302°F)	2.7	0.7
ACRYLIC, NONIONIC, 150°C (302°F)	3.5	0.8

N.B.: The results generated in our testing represent preliminary assessment of the acrylic thermoset chemistry. Optimization of AQUASET chemistry will result in products even more beneficial to our customers and the environment.

### Resistance to High Temperature

Some industrial applications require resistance to high temperature during a conversion process, such as application of modified bitumen for polyester-based built-up roofing (BUR). Binder systems for this application use acrylic or styrene butadiene resins (SBR) that are frequently modified with substantial amounts of melamine formaldehyde resin to minimize high-temperature elongation. This type of modification adds to the cost of the binder and results in the problem of formaldehyde emissions. AQUASET resins do not require this treatment because they react at higher temperatures than acrylic or styrene butadiene emulsion resins and so possess better inherent resistance to high-temperature elongation.

The AQUASET advantage is illustrated by an application test in which elongation of bonded webs at a temperature of 180° C (356° F) was measured at three loads (5, 8 and 12 Newtons) [Table 2]. The samples were prepared by saturating needle-punched spun polyester fiber with a laboratory padder to achieve 20 percent binder add-on. After the samples had been prepared, they were dried for three minutes at a temperature of 150° C (302° F) if the binder was the conventional acrylic and 200° C (392° F) if it was a thermoset resin.

### Solvent Resistance

Testing also confirmed the significantly exceptional solvent resistance provided by the AQUASET binders, a feature that enables them to be used in applications where firm hand and solvent resistance are of primary importance [Table 3]. In our trials, completely cured acrylic thermosets exhibited 100 percent more solvent tensile strength than conventional acrylic emulsion

polymers. These figures were obtained by exposing thermally prebonded lightweight polyester (0.5 ounces per square yard) to isopropanol; similar results have been achieved in other trials employing fiberglass webs exposed to methanol or acetone. In the trials, conducted in our laboratories, samples having a binder content of approximately 20 percent were soaked in isopropanol for three minutes, then tensile tested.

### Flame Response

Flame response is a critical feature for nonwoven binders, particularly those in which the finished product is expected to be fire-retardant or fire-resistant; obviously, insulation is a prime example of such applications. Testing conducted with standard industry analytical methods has conclusively established the low flame response of the AQUASET™ binders. In both horizontal (ASTM F-776) and vertical (NFPA-701) flame tests, the AQUASET binders were equivalent to urea formaldehyde resin.

N.B.: The best test of a product's flammability is its behavior in an actual fire situation. In such cases, it is not the response of the individual components but rather of the product as a whole that matters. Ideally, the item should neither ignite nor contribute to the process of combustion. Manufacturers must evaluate the fire safety performance of their products with test methods mandated by their industries. They should also ascertain the extent of legal liability in situations involving the ignition or combustion properties of their products.

### Environmental Impact

AQUASET binders have a significant advantage over their aminoplast counterparts in terms of both VOC and formaldehyde emissions. Testing also has demonstrated that the AQUASET binders are not harmful to aquatic species: they are officially considered "practically nontoxic" under the regulatory statutes currently in force in both Europe and the United States. So long

as appropriate waste treatment procedures are employed, the AQUASET binders can be used safely near groundwater sources.

### Product Stewardship

Dow has a fundamental concern for all who make, distribute and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy, by which we assess the safety, health and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products – from the initial concept and research, to manufacture, use, sale, disposal and recycle of each product.

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## Construction Chemicals

\*AQUASET binders are made without formaldehyde or formaldehyde-generating materials and do not release formaldehyde under normal operating conditions.

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