Durability and Performance

Atlac® Product Guide

AOC

Trusted Solutions

The Right Solutions

Our world is changing rapidly. Every day we face new challenges, and we are finding new opportunities. We must rethink, reshape and reinvent. We must find new solutions. Not just any solution, but we must find the right one. And, that's exactly what we do.

Trust AOC to create and deliver the solutions to help your business grow. We will partner with you to expand your business and your industry. With open collaboration we will make innovation truly happen.

For many years composites based on Atlac® resins have been the material of choice for manufacturing components that are used in industrial processes and chemical plants. The Atlac® resins from AOC have a track record of providing durability and continued strength in these tough environments.

Engineering companies and manufacturers of tanks, pipes and processing equipment are looking for material solutions that can continuously withstand chemicals, water and elevated temperatures. At the same time, they require cost-efficient installations that perform in line with customer expectations.

Performance that lasts

Industrial equipment and transportation piping traditionally have been constructed in steel. Yet steel is not resisting well corrosive chemicals and water, so for this purpose increasingly composite solutions are being selected. Engineers know that composite components based on Atlac® resins can better survive harsh process conditions, resulting in sustainable process safety and minimized maintenance cost. Process operators can run their processes smoothly and without interruption, because they rely on the excellent durability and reliability of parts based on Atlac® resins.

Customized shape and functionality

Composite components (including vessels, pipes and profiles) can be manufactured in unique shapes, typically through filament winding, centrifugal casting, hand lay-up or spray-up. These composite solutions bring the possibility to integrate multiple functions, and tailor the assembly for specific end uses. Atlac® resins bring great strength and toughness, and can be processed into multiple shapes with a broad variety of reinforcements.

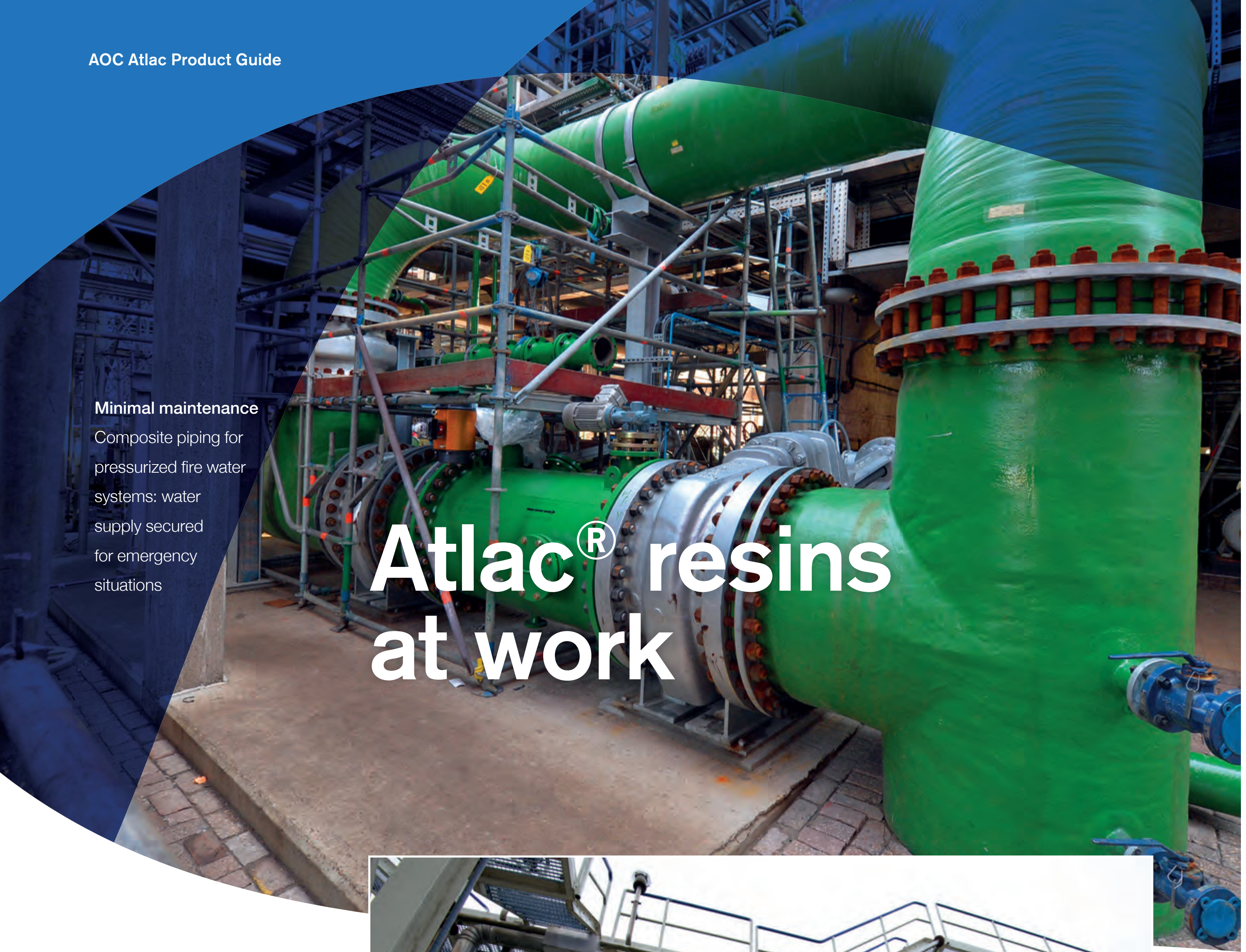
Environmentally sound

In many cases solutions based on composite materials provide a substantial reduction in carbon and/ or Eco-footprint. Composite benefits like ease of part manufacturing, low maintenance, and light weight during use or installation greatly contribute to this result. It has been demonstrated that composites can be easily recycled through co-processing in cement manufacturing, representing a sound solution at the end of a life of great performance.

Light weight capability

Unlike steel and concrete, composites feature high strength, stiffness and inherent low weight at the same time. This allows to design lighter and thinner, translating for instance into faster installation for industrial and infrastructure components.

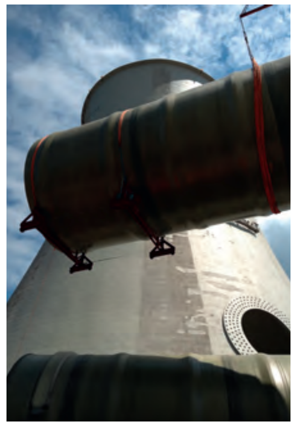
Atlac® resins at work



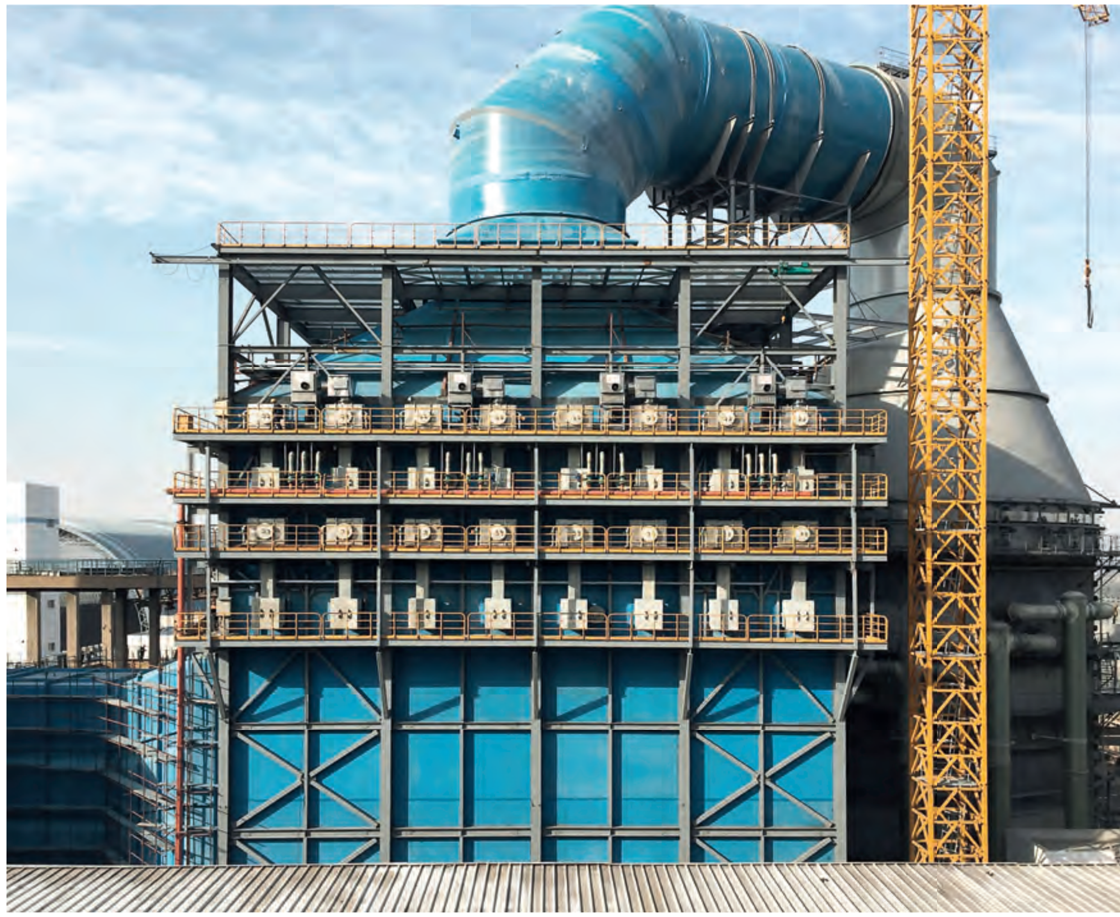
Minimal maintenance
Composite piping for pressurized fire water systems: water supply secured for emergency situations

Safe storage
Storage of many different chemicals for extended time periods

Reliable installation
Pipe protection for trenchless horizontal installation of gas transportation pipes



Continued operation
Excellent corrosion resistance at elevated temperatures in Flue Gas Desulfurization (FGD) piping/ stacked liners



Clean air
Dust emission reduction through electrostatic precipitators

Peace-of-mind
Corrosion resistance to sea water, enabling smooth desalination plant operation)

Consumer safety
Storage tanks for direct contact with food ingredients: clean to use, long lifetime

Great efficiency
Excellent chemical equipment performance and minimal process disruption

Selecting the right resin

In corrosion resistant applications it is important to select products fit for the job in question. In this guide we present the key properties and provide processing guidance for most of our high performance, chemical resistant Atlac® resins.

Atlac® F013A
Standard Bisphenol A vinyl ester resin. Provides high mechanical strength and exhibit excellent resistance to chemicals (especially alkali environments) and heat. The favorable combination of thermal resistance and elongation makes this resin suitable for applicationsexposed to intermittent temperatures.

Atlac® 430
Standard Bisphenol A vinyl ester resin. Provides resistance to a wide range of acids, alkali, and bleaches for the use in corrosive environments in the chemical processing industry. The favorable combination of thermal resistance and toughness makes this resin suitable for applications exposed to intermittent temperatures.

Atlac® 5200 FC
Epoxy Bisphenol A vinyl ester resin specifically formulated for food contact and potable water applications. Suitable for applications in a wide range of corrosive environments. This product is a FC (Food Contact) grade manufactured in line with GMP according to EU food contact law EU 10/2011 and Commission regulation EC 2023/2006.

Atlac® 4010
Flexible Bisphenol A Unsaturated Polyester resin. Flexibilised Atlac® 382, suitable for chemical linings.

Atlac® 382
Bisphenol A Unsaturated Polyester resin. Suitable for high temperature water, acid and salt solutions and medium temperature alkali solutions.

Atlac® 580
Bisphenol A urethane resin. Suitable for high temperature water, acid and salt solutions. Low peak exotherm allows the manufacture of thick laminates

Atlac® 590Z
Epoxy Novolac vinyl ester. Provides excellent thermal and chemical resistance against solvents, acids and oxidizing media like chlorine. The resin offers high retention of strength at elevated temperatures.

Atlac®w E-Nova FW 2045
Epoxy Bisphenol A Urethane vinyl ester. Provides the same excellent thermal and chemical resistance against solvents, acids, and oxidizing media as Atlac® 590Z also offers resistance against alkalis. The E-Nova technology combines the easy processing of polyester with the chemical resistance of vinyl ester. Low foam curing is possible with standard MEKP peroxides and compared to traditional vinyl ester resins it shows excellent fiber wetting.

Atlac® F086A
Epoxy Novolac vinyl ester. Provides the highest combination of thermal and chemical resistance, especially sovents, but also against acids and oxidizing media like chlorine.

Atlac® Premium 600
Atlac® Premium 600 is a medium viscous, high reactive, thixotropic vinyl ester resin dissolved in methacrylates. Atlac® Premium 600 has good resistance to hydrolysis and many chemicals. In particular, Atlac® Premium offers a high resistance to organic solvents. Reinforcements may not always be optimized for use with styrene-free resins. So when applying these resins, the suitability of the reinforcements should be confirmed.

End-use performance

Resistance to chemicals **Heat resistance** **Low maintenance**	**Exposure determines resin choice** Different solutions are available depending on heat and chemicals involved. Good chemical resistance means low maintenance and peace-of-mind on performance.
Strength **Stiffness** **Toughness**	**High mechanical strength** Selection of right resin, reinforcement and their interaction is key.
Light weight **Easy installation**	**Key benefit vs. steel** Enabling technology for light weight constructions in corrosive environments.
Design flexibility	**Optimized design** Shaping flexibility and part integration possibility are key composites benefits.
Food contact (when required)	**Food contact** Resins made in line with GMP (Good Manufacturing Practice) for good food quality and consumer safety.

Processing

Fiber wetting	**Great laminate properties** Excellent fiber wetting and resin/ fiber adhesion is key for obtaining the right laminate strength and stiffness and for achieving the right chemical resistance.
Process robustness and stability **Predictable cure** **Low peak exotherm for making thick laminates**	**Process consistency**
Pot life	**Pot life** Particularly when working with open baths, resin pot life has to enable laminate production to the desired thickness before gelation.

AOC Expertise

From our polymer scientists, manufacturing, technical service and sales experts, the AOC team will be a true partner for your business.

A world of experience

AOC's foundation began more than 60 years ago. Through the decades, AOC has been focused on creating innovation, producing quality, and developing the type of partnerships that have helped our customers grow their businesses and expand their markets. With facilities and global experts around the world, AOC is ready to work with you to find the solutions you can trust.

Previously serving the market under the names Aliancys, AOC Aliancys, and DSM Composite Resins, AOC has transformed the industry and has earned the position of the leading global supplier.

Delivering Innovation

AOC experts will help you push the limits of part performance and component manufacturing. Together we will work together to literally shape our world with products that are lighter, stronger, versatile and more competitive.

AOC takes an integral approach to new product development, using our full expertise in polymer science, manufacturing, testing and component manufacturing. Industry specialists at AOC's R&D centers around the world support customers with state-of-the-art equipment, including resin synthesis, mechanical property testing capabilities and analytical testing laboratories.

Our scientists are continuously working on new solutions to help you be more competitive today. And, they are creating the innovation to drive your success in the future.

Quality

You need consistent and reliable materials that you can trust, day after day. Your customers are counting on you. AOC produces the highest quality and most consistent products in the industry. Manufacturing expertise, proprietary equipment and automated process operation systems provide you with the consistency you can trust. AOC delivers the products you need and brings peace of mind so you can focus on your business and your customers.

Your trusted partners

The AOC team is dedicated to finding the right solutions to help drive your success. We understand your business and will work together to determine how AOC products and service can help optimize your part performance and meet your customers' requirements.
AOC experienced professionals are experts in both product performance and manufacturing processes.

Selecting the right reinforcements

Fabrication of a composite component usually begins with the making of a corrosion barrier layer. Its function is to provide corrosion resistance to the chemicals contained in the part. The corrosion barrier layer generally consists of a surface veil (saturated with resin) and two layers of chopped strand mat.

Surface veils

The purpose of a surface veil is to provide reinforcement for the resin rich inner liner of a corrosion barrier to prevent cracking and crazing. A second function is to prevent protrusion of the chopped strand mat fibers to the surface, which could allow wicking of the corrosive media into the laminate. The interior surface, which is normally 1 to 2 mm thick, contains about 90% of resin and 10% of veil material.

The primary type of surface veil used in corrosion applications is "ECR"-glass veil. However, in applications where "ECR"-glass veil is not suitable, other veil types made from "C"-glass, thermoplastic polyester or carbon fibers may be used. "ECR"-glass veil is typically recommended for most corrosion environments, synthetic veil is preferred in specific environments (e.g. containing fluoride compounds). See the AOC Chemical Resistance Guide for more details. In severe environments (like alkaline), multiple plies of veil may be recommended. Carbon veil is often used in abrasive environments or to provide a conductive liner for static electricity control.

Chopped strand mat

Chopped strand mat reinforcement consists of a felted matrix of chopped strand "E" or "ECR" glass fibers, 12.5-50 mm long and loosely held together by a styrene-soluble resin binder. "ECR" mat is made with more corrosionresistant "E" type glass fibers. Chopped strand mat is available in a variety of thicknesses (225 g/m^2, 300 g/m^2, 450 g/m^2, 600 g/m^2). Two mats (450 g/m^2) are generally used with the surfacing veil to form the corrosion barrier layer that provides additional corrosion protection.

Chopped strand mats are also used in the structural layer between layers of woven roving or as the sole reinforcement for the structural wall. The chopped mat layers in the finished laminate consist of abotut 70% resin and 30% glass.

Woven roving

Woven roving consists of continuous glass fiber rovings that are woven together to form a heavy mat, which is available in a variety of thicknesses and weights. Alternating layers of woven roving and chopped strand mat are used in the structural portion of hand lay-up laminates. The resulting laminates are generally about 40-50% glass.

Continuous roving

Continuous strand roving comes in various densities and sizing finishes for applications in filament winding and pultrusion. It results in laminates with high glass contents 50-70% for increased strength. Gun roving is used as a substitute for chopped strand mat in the corrosion barrier and the structural wall. The resulting laminates are generally about 30-40% glass.

Optimized for styrene-free

Please note that reinforcements traditionally have been optimized for the use with styrene-containing resins. Certain glass fiber sizings and binders do not work well with styrene-free resin systems. Please ask your AOC Technical Service representative for advice.

Ensuring a proper cure

Atlac® high performance resins can be cured with a wide variety of peroxides and accelerators. In order to achieve maximum part performance it is important to select the right curing system. This is dependent on the specific resin used and the end use requirements.

Vinyl ester and Polyester resin systems can be cured in many cases at ambient temperature. Gel times varying from 2 to 200 minutes can be obtained with the correct choice of the curing system. The selection depends to a large extent on the application technique and the requirements of the final application.

The chemical reaction initiated by the catalysts and accelerators creates an exothermic (heat generating) reaction that promotes optimum cure. Control of the temperature is critical to avoid delamination caused by stress and shrinkage from excessive temperatures.

Thick laminates

Fabrication of thick laminates can easily result in overheating during cure with a risk of warpage, because of thermally induced stresses and strains. Exotherm temperatures are very much resin dependant. Sometimes it is necessary to control the heat build-up in laminates, for example when flat sheets (minimum warpage) or very thick sections are laid up in one operation. The fabrication of flanges, in particular, can be critical when a combination of relatively short gel times and low exotherm (minimum shrinkage) are required. Compared with the traditional Atlac® resins, Atlac® E-Nova FW 2045 can be more easily cured fulfilling these conditions. For advice on selecting a curing system for a specific resin, please contact your AOC Technical Service representative.

Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the laminates made with Atlac® resins. Recommended postcure conditions are 3 to 6 hours at 80 to 100°C – longer times and adjusted postcure schedules being required for thicker laminates and/ or more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement (depending on resin type). Laminates must be at least 24 hours old before post-curing. Laminates up to one year old can be postcured successfully.

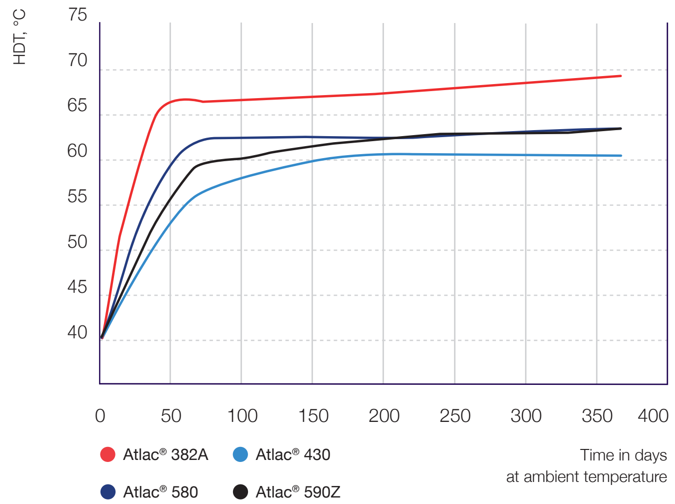
Chemical resistance of parts or laminates from Atlac® resins that have been postcured at temperatures below 80-100°C have to be tested according to the requirements of the specific application. The glass transition temperature (Tg) and heat deflection temperature (HDT) strongly depend on the temperature at which post-curing is carried out. It is important to post-cure the corrosion resistance layer inside the tank.

Curing agents and additives

The gel time can be changed by varying peroxide levels, cobalt additions or through using inhibitors. Different cure systems are available for curing Atlac® resins dependent on the cure time desired and the ambient processing temperature (see the resin-specific information in this brochure). When faster gel and cycle times are required or thin sections have to be cured, the methylethyl ketone peroxide types (MEKP) may be substituted for Acetyl acetone peroxide (AAP) or peroxide mixtures. Unsaturated polyester and vinyl ester urethane resins can be cured with standard medium activity MEKP, resulting in a wide range of gel times. The addition of standard MEKP to vinyl ester resins can result in an initial foaming (in traditional vinyl esters – Atlac® F013A, Atlac® 430, and Atlac® 590Z). In thick laminates MEKP cure systems may lead to overheating during cure and to warpage of the laminate. However, the MEKP systems are particularly effective at lower temperatures. For longer gel times, MEKP systems can easily be inhibited. Cumene hydroperoxide (CuHP) systems for vinyl esters are preferred for many applications due to the absence of foaming after the addition of peroxide. CuHP systems allow a wide choice of gel times followed by well-controlled cure. This enables relatively thick laminates to be made in one go, reducing the risk of overheating and warpage.

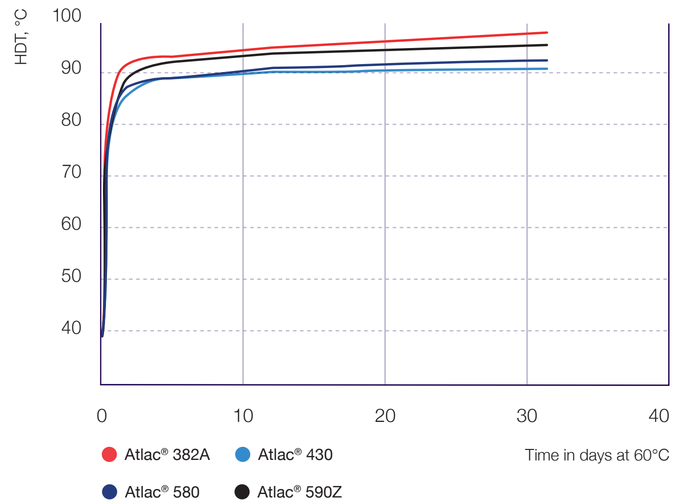
Development of HDT at Ambient Temperature

At ambient temperature high HDT levels are not reached, so postcuring is required



Post-cure will improve HDT

Note that at 60°C the HDT does not reach the maximum level possible



Optimal post-cure conditions for highest HDT values

Resin type	Post-curing conditions	HDT (°C)
Atlac® 382	24 hrs at 20°C, then 3 hrs at 100°C	120
Atlac® F013A	24 hrs at 20°C, then 5 hrs at 120°C	111
Atlac® 430	24 hrs at 20°C, 24 hrs at 80°C, then 24 hrs at 120°C	105
Atlac® 580	24 hrs at 20°C, then 3 hrs at 100°C	115
Atlac® 590Z	24 hrs at 20°C, then 24hr at 200°C	155
Atlac® E-Nova FW 2045	24 hrs at 20°C, 3 hrs at 100°C, then 3 hrs at 150°C	145
Atlac® F086A	24 hrs at 20°C, then 168 hrs at 220°C	180
Atlac® 5200 FC	24 hrs at 20°C, 24 hrs at 80°C, then 24 hrs at 120°C	105
Atlac® Premium 600	24 hrs at 20°C, 24hrs at 60°C, then 24hrs at 80°C	103

Recommended peroxides

Peroxide	Resin type	Remarks
Standard Methyl Ethyl Ketone Peroxide (MEKP)	Atlac® 382, F013A, 430, 590Z, F086A, Atlac® E-Nova FW 2045, Atlac® 5200 FC and Atlac® Premium 600	General purpose Ease of inhibition No, Slightly foaming (Atlac® 382, Atlac® E-Nova FW 2045) Foaming (Atlac® F013A, Atlac® 430, Atlac® 590Z)
Low activity Methyl ethyl Ketone Peroxide (LA-MEKP)	Atlac® 382, F013A, 430, 590Z, F086A, Atlac® E-Nova FW 2045, Atlac® 5200 FC and Atlac® Premium 600	Long geltimes High temperatures Slightly foaming (Atlac® F013A, Atlac® 430, Atlac® 590Z)
Acetyl acetone peroxide (AAP)	Atlac® 382 and 590Z	High reactivity topcoats Thin sections Low temperature
Cumene hydroperoxide (CuHP)	Atlac® F013A, 430, 590Z, F086A and A tlac® E-Nova FW 2045, Atlac® 5200 and Atlac® Premium 600	Low exotherm (Atlac® F013A/430/ 590Z) Very low exotherm, extra long geltime (Atlac® E-Nova FW 2045)
Benzoyl peroxide (BPO-50)	Atlac® 382, F0313A, 430, 590Z, F086A and Atlac® E-Nova FW 2045, Atlac® 5200 FC and Atlac® Premium 600	Amine accelerator required to cure Recommended if high temperature Postcure is required Mandatory when Cobalt cure is prohibited Low temperature High humidity

Predictable processing

Methyl ethyl ketone peroxide – Medium activity (MEKP)

This is a colorless liquid, usually supplied at a 50% concentration in a phlegmatizing solution. MEKP is the most widely used catalyst system. The levels added to the resin normally range between 1.0% and 2.5%. For curing Atlac® resins, the peroxide should be used together with cobalt salts and, when necessary with Amines and or inhibitors. MEKP is used together with promoters, usually 6% cobalt naphthenate or 6% or 10% cobalt octoate.

Methyl ethyl ketone peroxide – Low activity (LA-MEKP)

This is a colorless liquid, usually supplied at a 50% concentration in a phlegmatizing solution. It is used when long gel times are required or when the ambient temperature is high. This MEKP-peroxide is especially recommended for the cure of vinyl ester resins, because it results in reduced foaming. The foaming is observed immediately from the moment the peroxide and the accelerator have been mixed with the resin. This "gassing" is oxygen resulting from by the decomposition of the H_2O_2 present in the peroxide formulation. Low activity MEKP contains less hydrogen peroxide than the medium activity MEKP, and hence gives less oxygen. Additionally the ratio of the peroxides present in the mixture differs from medium activity MEKP.

The E-Nova resins combine the easy processing of polyester resins with the chemical resistance of vinyl esters. With this technology low foam curing is possible with standard MEKP peroxides. The main resin from this product family is Atlac® E-Nova FW 2045.

Acetyl aceton peroxide (AAP)

AAP is a clear liquid. The use of AAP is particularly suitable for curing of thin sections and high reactivity topcoats. AAP cannot be used for the curing of standard Vinyl ester resins in medium to high laminate thickness, as the gas formed during the reaction will not be able to leave before gelation. This will result in oxygen inclusions and micro porosity in the molding. Please note that post-curing is not effective with AAP.

Cumene hydroperoxide (CuHP)

CuHP is a clear liquid. The use of Cumene hydroperoxide can eliminate the foaming experienced with traditional epoxy vinyl ester resins (Atlac® 430 and 590Z) catalyzed with MEKP/ cobalt catalyzed systems. Another advantage of these systems is that the peak exotherm is reduced resulting in less shrinkage, and less warpage. In cool weather, a small amount of Dimethylaniline may be used to accelerate cure. Care must be taken to ensure that a thorough cure is obtained, particularly at ambient temperatures. A postcure is recommended to ensure a thorough cure.

Benzoyl peroxide (BPO)

Dibenzoyl peroxide is commercially available in powder, emulsion and paste forms. In combination with Amine accelerators it shows a very fast cure, which is hardly influenced by humidity and fillers. Even at low temperatures a relatively good cure will be obtained. BPO/ Amine systems may cause higher exotherm temperatures, and are more difficult to fully postcure. However, in applications were hypochlorite or peroxides are present, BPO/ Amine curing is compulsory. In these cases Cobalt or other metals may decompose the stored material with a detrimental effect on the chemical resistance performance.

Safety notice

Accelerators and promoters should never be mixed directly with a peroxide catalyst (such as MEKP). Mixing would cause a violent reaction, and a fire or explosion could result.

Accelerators and Promoters

Promoters and accelerators are used to speed up and enhance the cure.

Cobalt accelerator

Cobalt solutions are blue or purple liquids and are available on the market with different percentages of active cobalt that can be used with MEKP and CuHP curing systems. Dilution in styrene will prevent formation of small particles of cobalt and will facilitate uniform mixing. Other cobalt accelerators can be used. Furthermore, when stored for long periods in unsatisfactory conditions, they lose their reactivity.

Amines

Dimethylaniline (DMA) is a yellow Amine liquid with a strong odor. DMA can be used for ambient cure with BPO. The addition of DMA is not required with MEKP and CuHP systems. However, small amounts of DMA may be used in conjunction with cobalt to improve Barcol development and/ or shorten the cure time. With ambient temperature BPO systems, the addition of DMA is required.

Dimethyl-para-toluidine (DMPT) is a yellow Amine liquid with a strong odor. DMPT can be used in BPO/ Amine curing systems in those applications where a very short gel time is required.

Inhibitors

Inhibitors are used to lengthen the gel time of vinyl ester and polyester resins to give a controllable cure. The most widely available inhibitor is a 10% solution of Tertiary butyl catechol (TBC). Inhibitors should be used with care as additions above 0.25% (of a 10% solution) can lead to undercure, low Barcol, or reduced corrosion resistance. Recommended inhibitor levels vary from type to type and from resin to resin. Besides TBC some other inhibitors used include hydroquinone (HQ), and toluhydroquinone (THQ). Tertiary butyl catechol is not effective with cumene hydroperoxyde systems.

UV stabilizers

Atlac® resins typically resist very well outdoor weathering conditions. If an ultraviolet absorber is required for further improvement of UV protection, either an additional level of 0.2% throughout the laminating resin or 0.2% to 0.5% in the topcoat is effective.

Electrically conductive materials

The creation or improvement of the electrical conductivity of a composite is generally achieved by the introduction of carbon into the laminate.

This can be achieved by incorporating a carbon based veil, or by incorporating carbon (or graphite) in powder form into the resin before lamination. It is recommended to verify for each part design the level of conductivity obtained. Once the level of conductivity required has been obtained, the pipe or equipment must be satisfactorily earthed. Information regarding conductivity requirements can be found in ISO 14692.

Abrasion resistant additives

Abrasion resistance in corrosion resistant composite material is generally required for equipment handling slurries or solids in suspension, which would generally erode or abrade standard corrosion resistant materials. Typical additives that may be included within internal and/ or external barriers, or throughout the total thickness of a laminate, are usually based upon various forms of aluminium oxide or Silicon carbide (SiC). Secondary fillers or additives are generally required to achieve a satisfactory material dispersion and resin viscosity. The characteristics of abrasion vary immensely from one application to another.

Flame or fire retardant additives

Aluminium trihydrate will improve the fire resistance of both halogenated and non-halogenated resins. In the case of alumina trihydrate, the high level of filler required may have negative effects on corrosion resistance, mechanical properties and general handling properties of the resin.

Fabrication of tanks and pipes

Components used in industrial applications with anti-corrosion properties can be produced according to different production techniques. The tanks and vessels are often made through a combination of filament (helical) winding, hand lay-up or Resin Transfer Moulding. In this section these production techniques are discussed in detail.

Filament winding

In the filament winding process, a number of continuous glass fiber rovings, woven glass tapes or unidirectional glass fabrics are impregnated with a matrix resin. These wetted fibers are applied onto the outside of a rotating mandrel in a pre-determined pattern and under controlled tension.The filament winding technique can roughly be divided into two principle types, being Continuous filament winding and Helical winding.

With continuous filament winding (also called tangential winding), the glass fibers are wound in a closed pattern or an overlap onto the outside of a (continuously advancing) mandrel, adding chopped fibers, resin and optionally additives and fillers. The winding angle and the amount of materials applied at each rotation determine the wall thickness and the wall construction.

With helical winding, repeated passes of wetted fibers around a rotating mandrel in a specific helical pattern, result in a multiple layered wall construction of continuous fibers (either woven or as a unidirectional roving). The angles can vary in theory in theory up to 90° and can be adapted to specific strength requirements of the product.

Centrifugal casting

In the centrifugal casting process, glass fibers and/ or mats are placed or applied at the inside of a hollow mandrel (steel tube). As the steel tube rotates at high speed, resin is injected wetting out the reinforcement and optionally fillers and additives. These materials are compressed against the wall due to the centrifugal forces, thus forming a dense pipe wall. The main difference compared to filament winding is that a higher filler content can be achieved.

Hand lay-up/ Spray-up

Hand lay-up, also called contact molding, is a production technique suitable for low volume production of composite components. The fibers are manually placed onto a mould surface and impregnated with resin, usually by using a hand roller. More layers are added and after

curing, the composite part can be removed from the mould. The process is very flexible as it can produce very small parts, as well as very large parts with a wide range of potential shapes and performance profiles. The cycle time per part is rather long, and hence this production technique is used mainly for small series or for large complex shapes. For larger series the spray-up technique is more favorable.

Resin Transfer Moulding

Resin injection, also called resin transfer moulding (RTM), produces strong fiber reinforced parts with two smooth surfaces. Several layers of dry continuous strand mat, woven roving or cloth are placed in a closable mould. A liquid resin is then injected into the mould, which is subsequently cured. As an option, a pre-form can be used as a core material, enhancing the economics and efficiency of this production technique. The advantages of RTM are the possibility to manufacture complex, high performance structures with a good surface finish, design flexibility, the possibility to integrate more components into one part and to produce parts without styrene emission.

Dual Laminates

Dual-Laminates have been used in chemical plants such as towers, scrubbers, process vessels and tanks for over thirty years in highly corrosive applications, where chemicals such as chlorine and chlor-alkali products, strong acids, strong bases, organic compounds and other corrosive media are present.Dual laminates consist of a thermoplastic inner liner protected by a fiberglass composite outer layer, thus combining the advantages of thermoplastic corrosion resistance with the high mechanical properties of composites. Thermoplastic liner materials include most grades used for manufacturing thermoplastic pipe and equipment, such as polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polypropylene (PP), the fluoropolymer family and others. PVC and CPVC are usually bonded directly to the composite laminate using a bonding resin (like Palatal A 410-01 and/ or blends with Atlac® E-Nova FW 2045. For details please contact your AOC Technical Service representative. Other thermoplastic liners are typically manufactured with an embedded fabric or fiberglass backing. This fabric backing can provide a mechanical bond with the fiber glass structural composite but requires compatibility of the base materials.

Liner essentials

The inner corrosion resistant liner consists mainly of resin, reinforced with a corrosion veil or veils, sometimes backed by a chopped strand fiberglass mat. The veil(s) may be either a corrosion grade fiber glass (ECR- or C-glass), or an organic veil such as polyester ECTFE or graphite. An organic veil would be used in environments known to attack glass, such as sodium hydroxide, hydrofluoric acid, etc. After curing, the liner thickness can vary between 0.25 to 5 mm at 10% to 50% reinforcement for C/ ECR-glass. The fiber glass chopped strand E-glass mat that backs up the veil, generally contains up to 30% reinforcement.

The recommendations given above are general guidelines; the final corrosion resistant liner may vary depending upon the corrosive properties of the fluid contained. The performance of the liner is highly dependent on the quality and compatibility of both the resin and the reinforcing material, and liner designs are not interchangeable. Each new combination of materials has to be examined carefully. To avoid confusion, the corrosion liner and the corrosion allowance should be specified. Some specifications include the corrosion liner in calculating required overall pipe wall thickness, but generally specifications require the liner be treated as a sacrificial corrosion allowance, and not to be used in any of the pipe structural calculations for pressure and vacuum handling capability.

Design and product quality

After the installation of equipment and piping in a chemical factory, the process should run safely and without interruption. This means that both the performance of the individual components and the entire assembly must be predictable and in line with initial process design.

Mechanical property evolution

The mechanical properties of composite components depend on the production technique, part design (e.g. laminate thickness, fiber orientation) and compatibility of the starting materials (glass, sizing and resin). After manufacturing these part properties can change through ageing. Ageing is a characteristic of any plastic material, and is influenced by environmental conditions (temperature, weather, exposure to UV light), exposure to a chemical medium, and by stresses applied to the part. Typically, material ageing reduces the original mechanical properties.

The ageing differs for each composite composition. For that reason long term testing according to ASTM D 2992 (regression) is required to better understand the mechanical property evolution of pressurized tanks and pipe systems made in composite materials. Property retention can be positively influenced by the correct selection of the resin, as the behavior of a resin in a particular environment is strongly related to the resin backbone.

Through our Chemical Resistance information service, AOC offers customers insights on the behavior of resins and composites systems over time, building on years of chemical resistance testing on our resins combined with the experience gained in many projects around the world.

Joints

For combining pipes, joints and fittings into composite assemblies, different jointing techniques can be used. Each technique has its own specific benefits and limitations, and can be designed either to endorse full end thrust loads or with limited or no axial load ability These joining techniques include:

- Adhesive bonded joints
- (Integral) mechanical (rubber sealed) joints; either tensile resistant or non-tensile resistant
- Laminated joints
- Threaded joints
- Flanged joints
- Third party mechanical joints

Making a reliable joint in composite materials requires – as with any other material – a certain level of skill, knowledge and good workmanship. Fabricating a joint in composites should be no more difficult than with traditional materials.

Note that for composite piping the number of joints is significantly lower than for steel piping. Because of their inherent weight, steel pipes can only be installed in relatively short lengths in order to avoid bending and permanent deformation. Chances for leakage of composite joints are significantly lower, also due to the inherent corrosion of the steel pipes.

Qualification and design of composite pipes

Composites systems can be diverse, because of the combinations of raw materials, their compatibility, and the use of different production techniques. Consequently, composite part design requires to determine the design parameters of each variant, both initially after production and in the context of the entire service life of the composite system. Many Engineering companies have built the expertise to design in composites, and can mimic mechanical and thermal behavior for complicated part configurations. AOC has been highly supportive in providing technical advice and material property evolution data, so the performance of systems and assemblies can be maximized.

The ISO 14692 standard deals with this subject in combination with qualification of components, system design, installation and quality assurance. The original scope of this document refers to offshore applications, but the standard is actively being used as the basis for onshore applications. The main principle for this document is the link between the properties of the specific composite component and the safety in the installed pipe system.

The qualification involves a test program that involves full-scale hydrostatic performance tests, establishing a long-term design basis. This is not only for pipes, but also for the system as a whole including joints and fittings. Verification of the long-term performance of pipes, fittings and joints is done by means of:

A. Regression analysis according to ASTM D 2992-B at the maximum design temperature on the pipes.
B. Medium term testing on joints and fittings. For this test, two representative samples have to be tested for 1,000 hrs. at maximum temperature and at a test pressure exceeding the pressure level at 1,000 hrs. resulting from the regression analysis performed on pipes. In practice this will be ± 2.5-5 times the nominal pressure rating. This figure differs from each manufacturer, depending on the type of product, manufacturing procedures, etc.

The manufacturer can carry out qualification testing provided it is witnessed and certified by a recognized independent authority. Alternatively, testing and certification may be carried out by an independent testing organization. This should be confirmed by submitting a certificate stating the test results.

Product information

Atlac® 382

Chemical/ Physical nature

Atlac® 382 is a propoxylated bisphenol A maleate unsaturated polyester resin, dissolved in styrene.

Performance

Atlac® 382 is suitable for high temperature water, acid and salt solutions and medium temperature alkali solutions.

Major applications

Atlac® 382 can be used in all fabrication methods, but is especially adapted to meet the requirements of filament winding, centrifugal casting, hand lay-up and spray-up applications. Atlac® 382 may also be used to formulate glassflake coatings and mortars.

Approvals

Cured non-reinforced Atlac® 382 conforms to type 1310 according to DIN 16946/2 and is classified group 5 in the former DIN 18820/1 and group 6 according to EN 13121/2.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	sl. hazy	-	TM 2265
Viscosity, 23°C	560-660	mPa.s	TM 2013
Density, 23°C	1030	kg/m^3	TM 2160
Solid content	49-51	%	TM 2033
Gel time from 25-35°C	4-10	min	TM 2625
Cure time from 25°C to peak	12-30	min	TM 2625
Peak temperature	170-200	°C	TM 2625

Curing system used
3.0% Cobalt accelerator (1%)
1.0% DMA (10%)
1.5% Medium active MEKP

Test methods
Test methods (TM referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Density, 20°C	1,120	kg/m^3	-
Hardness	40	Barcol	TM 2604
Tensile strength	62	MPa	ISO 527-2
Elongation at break	2.1	%	ISO 527-2
Tensile modulus	3.4	GPa	ISO 527-2
Flexural strength	113	MPa	ISO 178
Flexural modulus	3.4	GPa	ISO 178
Impact resistance - unnotched sp.	9	kJ/m^2	ISO 179
Heat Deflection Temperature (HDT)	120	°C	ISO 75-A
Glass transition temperature (Tg)	137	°C	DIN 53445

Curing system used
0.8% Cobalt accelerator (6%)
0.5% DMA (10%)
1.5% Medium active MEKP

Postcure
24 hrs at 20°C followed by 3 hrs at 100°C

Typical properties reinforced laminate

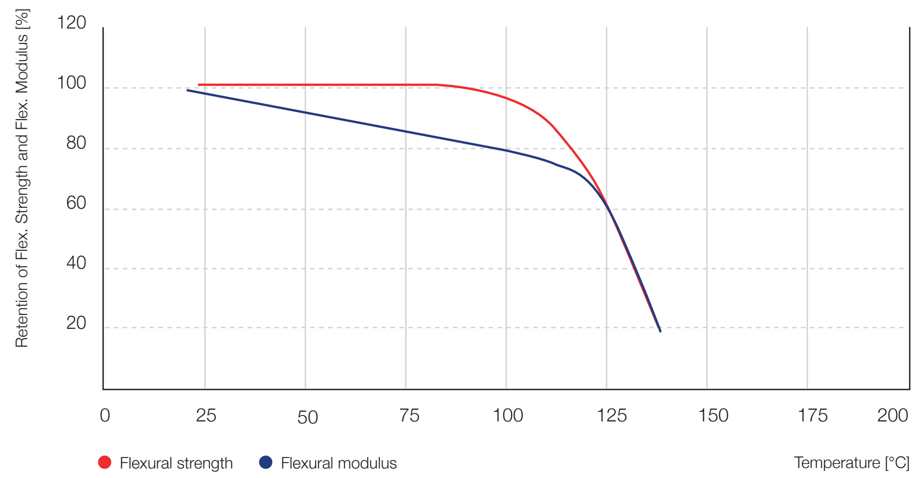
Curing system		Laminate build up		
Cobalt accelerator (6%)		450 g/m^2 CSM	450 g/m^2 CSM	
DMA (10%)		450 g/m^2 CSM	800 g/m^2 WR	
1.5% Medium active MEKP		450 g/m^2 CSM	450 g/m^2 CSM	
Postcure 24 hrs at 20°C followed by 3 hrs at 100°C		450 g/m^2 CSM	800 g/m^2 WR 450 g/m^2 CSM 800 g/m^2 WR	
Properties/ Unit				**Test methods**
Glass content	%	30	44	ASTM D 2584
Tensile strength	MPa	85	164	ISO-527-2
Modulus of elasticity in tension	GPa	7.5	10.7	ISO-527-2
Flexural strength	MPa	139	260	ISO-527-2
Modulus of elasticity in bending	GPa	6.6	8.8	ISO-178
Density	kg/m^3	1,330		-
Impact resistance - unnotched sp.	kJ/m^2	80		ISO-179
Linear expansion	C^{-1}	31 x 10^{-6}		-
Thermal conductivity	W/m.K	0.22		-

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-140°C were measured according to ISO-178. The laminates were based on 4 layers of 450 g/m^2 chopped strand mat with a fiber content of 30-35% w/w. Standard (post)curing systems have been used.

High Temperature Properties

Atlac® 382 (4 layers CSM 450 g/m², fiber content 30%, fully postcured)

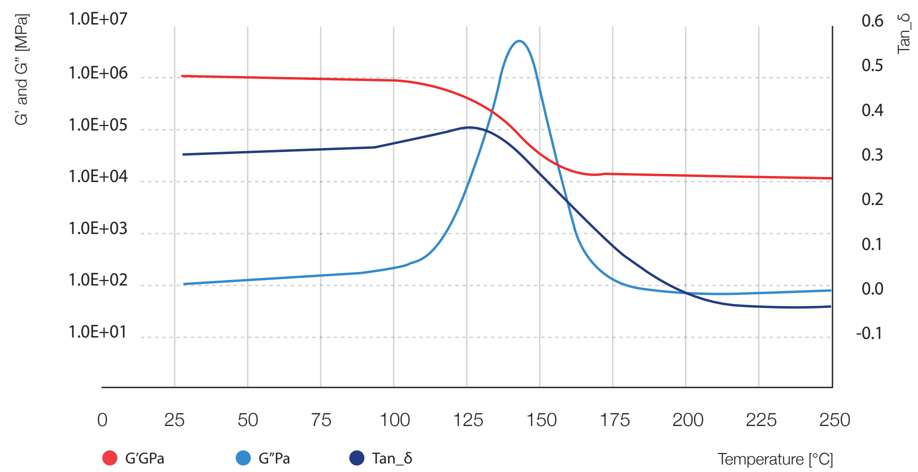


Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard (post)curing systems have been used.

Dynamic Mechanical Analysis

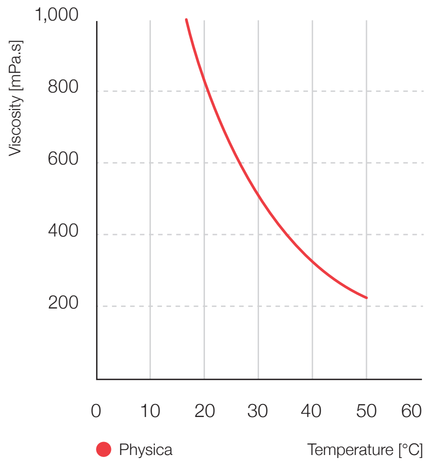
Atlac® 382 (reinforced product curing system)



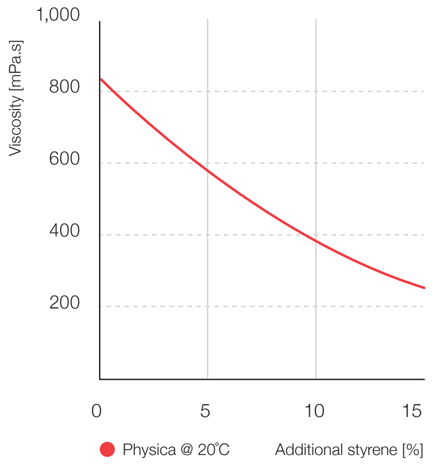
Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

Viscosity versus Temperature
Atlac® 382



Viscosity versus Additional Styrene
Atlac® 382



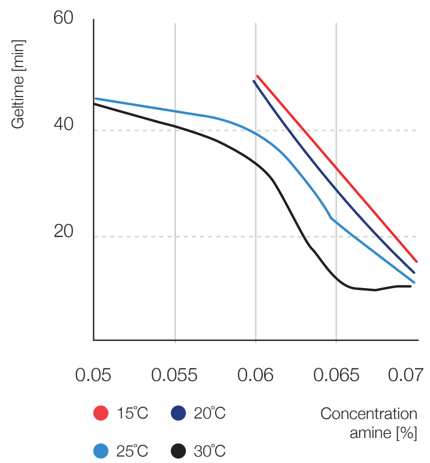
Atlac® 382: typical geltimes, using standard MEKP/ Cobalt

Used curing agents: Standard (Medium active) Methyl ethyl ketone peroxide (MEKP), Cobalt accelerator 6% (Cobalt-6) and Dimethylaniline (DMA).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	0.5% Cobalt-6 0.07% DMA 1.5% MEKP	0.5% Cobalt-6 0.06% DMA 1.5% MEKP	0.5% Cobalt-6 0.05% DMA 1.5% MEKP
20°C	0.5% Cobalt-6 0.07% DMA 1.5% MEKP	0.5% Cobalt-6 0.065% DMA 1.5% MEKP	0.5% Cobalt-6 0.060% DMA 1.5% MEKP
25°C	0.5% Cobalt-6 0.07% DMA 1.5% MEKP	0.5% Cobalt-6 0.065% DMA 1.5% MEKP	0.5% Cobalt-6 0.06% DMA 1.5% MEKP
30°C	0.5% Cobalt-6 0.07% DMA 1.5% MEKP	0.5% Cobalt-6 0.065% DMA 1.5% MEKP	0.5% Cobalt-6 0.06% DMA 1.5% MEKP

Reactivity of Atlac® 382
vs DMA concentrations at different temperatures

Constant accelerator concentration: Cobalt-6 = 0.5% and **constant peroxide concentration:** St. MEKP = 1.5%)



Atlac® 382: typical geltimes, using BPO/ amine

Used curing agents: Dibenzoyl peroxide (BPO-50) and Dimethylaniline (DMA).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	0.4% DMA 4.0% BPO-50	0.3% DMA 3.0% BPO-50	0.2% DMA 2.0% BPO-50
15°C	0.35% DMA 3.5% BPO-50	0.25% DMA 2.5% BPO-50	0.15% DMA 1.5% BPO-50
20°C	0.3% DMA 3.0% BPO-50	0.2% DMA 2.0% BPO-50	0.175% DMA 1.0% BPO-50

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

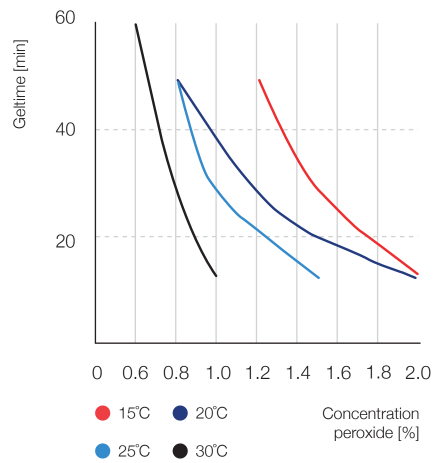
Atlac® 382A: typical geltimes, using standard MEKP/ Cobalt

Used curing agents: Standard (Medium active) Methyl ethyl ketone peroxide (MEKP), Cobalt accelerator 6% (Cobalt-6).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	1.0% Cobalt-6 2.0% MEKP	1.0% Cobalt-6 1.5% MEKP	1.0% Cobalt-6 1.2% MEKP
20°C	1.0% Cobalt-6 2.0% MEKP	1.0% Cobalt-6 1.2% MEKP	1.0% Cobalt-6 0.8% MEKP
25°C	1.0% Cobalt-6 1.5% MEKP	1.0% Cobalt-6 1.0% MEKP	1.0% Cobalt-6 0.8% MEKP
30°C	1.0% Cobalt-6 1% MEKP	1.0% Cobalt-6 0.8% MEKP	1.0% Cobalt-6 0.7% MEKP

Reactivity of Atlac® 382A
vs Standard MEKP concentrations at different temperatures

Constant accelerator concentration: Cobalt-6 = 1%



Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the Atlac® high performance resins. Recommended postcure conditions are 3 to 6 hours at 90 to 100°C – longer times and adjusted postcure schedules being required for thicker laminates and/ or more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Topcoat

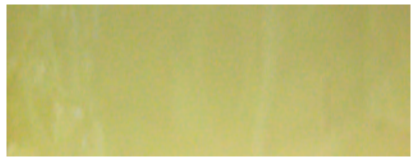
Topcoats applied, as final layer in linings for the outside surface must contain paraffin wax to obtain full cure (preventing air inhibition). The resin requires about, 0.1-0.2% addition of wax. The wax should have a melting point of 54-57°C and is best added into the resin as 10% solution in styrene. Topcoats must be cured quickly for the wax to be effective. Use a MEKP or AAP cure system to obtain a gel time of 15 minutes or less. Properly cured topcoats will not become tacky when rubbed with acetone.

Inhibitor systems

Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.25% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

Thixotropy

Atlac® 382 can be made thixotropic by using the standard (polyester) fumed silica types: Aerosil R 200 or Cab-O-Sil M5 (0.5%-2%). They should be blended into the resin using a high-shear stirrer (Cowless type). To improve a maximum thixotropic effect, it is recommended to use a wetting agent (e.g. 0.2% w/w Tween 20 – ICI). Thixotropic agents should not be used in laminates intended for service with hypochlorite solutions or fluorine. In his case, sagging can only be reduced to a minimum by very short gel times (20-25 min).



Liquid resin

Cured resin, Standard MEKP/ cobalt curing system

Cured resin, BPO/ Amine curing system

Resin Type	Grade	Remark
Atlac® 382	Atlac® 382 Atlac® 382A Atlac® 382 flakes/ powder	Standard Amine promoted Solid version to be dissolved by users Exceptional shelf life

Product information

Atlac® F013A

Chemical/ Physical nature

Atlac® F013A is a vinyl ester based on bisphenol A epoxide, dissolved in styrene.

Performance

Atlac® F013A provides resistance to a wide range of acids, alkali, and bleaches for the use in corrosive environments in the chemical processing industry. The favorable combination of thermal resistance and elongation makes this resin suitable for applications exposed to intermittent temperatures.

Major applications

Atlac® F013A can be used in all fabrication methods, but is especially adapted to meet the requirements of filament winding, centrifugal casting, hand lay-up and spray-up applications.

Approvals

Cured non-reinforced Atlac® F013A conforms to type 1310 according to DIN 16946/2 and is classified group 5 in the former DIN 18820/1. According to EN 13121/2 Atlac® F013A is classified group 7a.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	Hazy	-	TM 2265
Viscosity, 23°C	340-440	mPa.s	TM 2013
Density, 23°C	1100	kg/m³	TM 2160
Solid content	52-56	%	TM 2033
Gel time from 25-35°C	19-24	min	TM 2625
Cure time from 25°C to peak	34-40	min	TM 2625
Peak temperature	130-155	°C	TM 2625

Curing system used
1.5% Cobalt accelerator (1%) + 0.5% DMA (10%)
2.0% Low active MEKP

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Density, 20°C	1,040	kg/m³	-
Hardness	43	Barcol	TM 2604
Tensile strength	88	MPa	ISO 527-2
Elongation at break	6.6	%	ISO 527-2
Tensile modulus	3.2	GPa	ISO 527-2
Flexural strength	150	MPa	ISO 178
Flexural modulus	3.7	GPa	ISO 178
Heat Deflection Temperature (HDT)	111	°C	ISO 75-A
Glass transition temperature (Tg)	126	°C	DIN 53445

Curing system used
0.6% Cobalt accelerator (1%)
1.25% Low active MEKP
0.1% DMA

Postcure
24 hrs at 20°C followed by 5 hrs at 120°C

Typical properties reinforced laminate

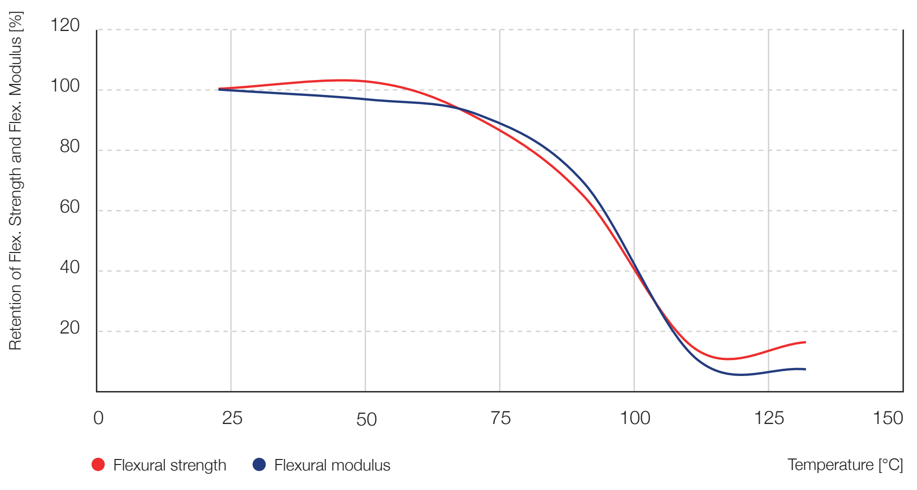
Curing system		Laminate build up		
0.6% Cobalt accelerator 1%		450 g/m2 CSM		
1.25% Low active MEKP		450 g/m2 CSM		
0.1% DMA		450 g/m² CSM		
Postcure 24 hrs at 20°C followed by 3 hrs at 100°C and 3 hrs at 150°C		450 g/m² CSM		
Properties/ Unit				**Test methods**
Glass content	%	35.3		ASTM D 2584
Tensile strength	MPa	155		ISO-527-2
Modulus of elasticity in tension	GPa	9.3		ISO-527-2
Flexural strength	MPa	---		ISO-527-2
Modulus of elasticity in bending	GPa	---		ISO-178

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-110°C were measured according to ISO-178. The laminates were based on 4 layers of 450 g/m² chopped strand mat with a fiber content of 30-35% w/w. Standard cure systems have been used and all specimen have been fully post-cured 24 hrs at 80 °C.

High Temperature Properties

Atlac® F013A (4 layers CSM 450 g/m²)

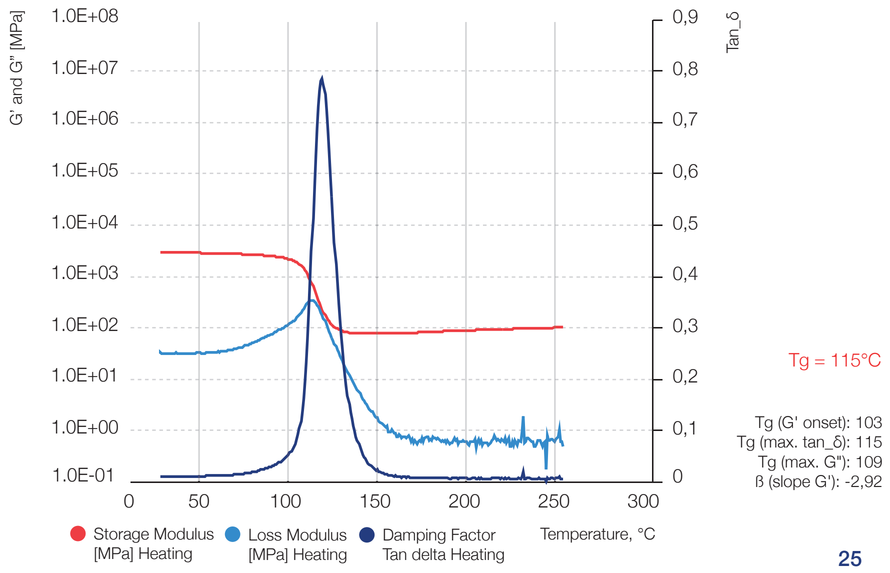


Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard curing systems have been used and post-cured 24 hrs at 80°C.

Dynamic Mechanical Analysis

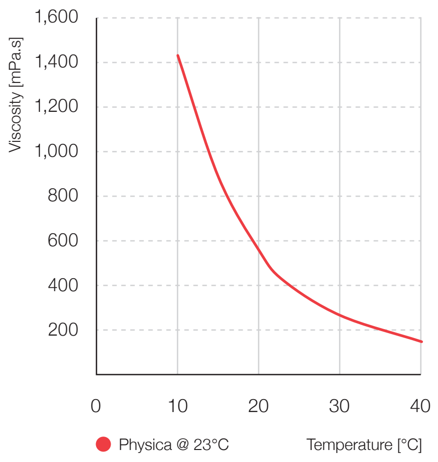
Atlac F013A (reinforced product)



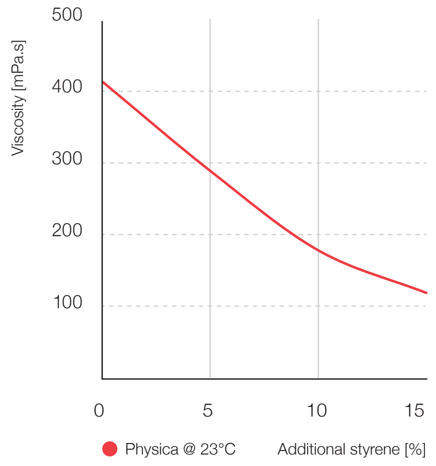
Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

Viscosity versus Temperature
Atlac® F013A



Viscosity versus Additional Styrene
Atlac® F013A



Atlac® F013A: typical geltimes, using Low activity MEKP/ cobalt

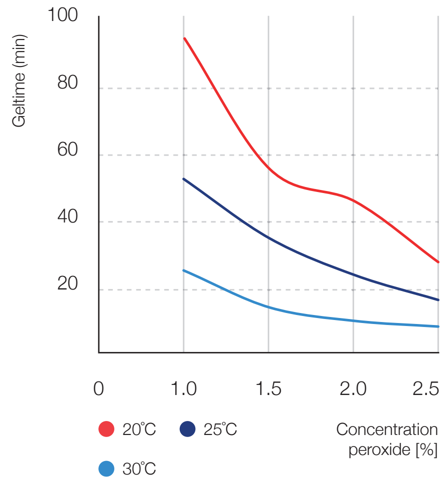
Used curing agents: Low activity Methyl ethyl ketone peroxide (LA-MEKP), Cobalt accelerator 1% (Cobalt-1) and Tertiair butyl catechol (TBC), Dimethylaniline (DMA)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	3.0% Cobalt-1 3.0% LA-MEKP 0.6% DMA	3.0% Cobalt-1 3.0% LA-MEKP 0.3% DMA	3.0% Cobalt-1 3.0% LA-MEKP 0.1% DMA
20°C	2.5% Cobalt-1 3.0% LA-MEKP	2.0% Cobalt-1 2.5% LA-MEKP	2.0% Cobalt-1 2.0% LA-MEKP
25°C	2.0% Cobalt-1 2.5% LA-MEKP	1.5% Cobalt-1 1.5% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP
30°C	1.5% Cobalt-1 1.5% LA-MEKP	1.0% Cobalt-1 1.5% LA-MEKP	1.5% Cobalt-1 1.5% LA-MEKP 0.015% TBC

Reactivity of Atlac® F013A

vs Low activity MEKP concentrations at different temperatures

Constant accelerator concentration:
2% Cobalt solution, 1% MEKP Butanox LPT



Atlac® F013A: typical geltimes, using BPO/ amine

Used curing agents: Dibenzoyl peroxide (BPO-50), Dimethylaniline (DMA)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	0.8% DMA 4.0% BPO-50	0.4% DMA 4.0% BPO-50	0.3% DMA 3.0% BPO-50
15°C	0.4% DMA 4.0% BPO-50	0.35% DMA 3.5% BPO-50	0.25% DMA 2.5% BPO-50
20°C	0.4% DMA 4.0% BPO-50	0.25% DMA 2.5% BPO-50	0.2% DMA 2.0% BPO-50

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

Atlac® F013A: Typical geltimes, using Cumene hydroperoxide

Used curing agents: Cumene hydroperoxide (CuHP), Cobalt accelerator 1% (Cobalt-1), Dimethylaniline (DMA) and Tertiair butyl catechol (TBC)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	NA	3.0% Cobalt-1 3.0% CuHP 1.0% DMA	3.0% Cobalt-1 3.0% CuHP 0.6% DMA
20°C	3.0% Cobalt-1 3.0% CuHP 1.5% DMA	3.0% Cobalt-1 3.0% CuHP 0.3% DMA	3.0% Cobalt-1 3.0% CuHP 0.1% DMA
25°C	3.0% Cobalt-1 4.0% CuHP 0.25% DMA	2.5% Cobalt-1 4.0% CuHP	1.0% Cobalt-1 2.0% CuHP
30°C	1.0% Cobalt-1 2.5% CuHP	1.0% Cobalt-1 1.0% CuHP 0.015% TBC	1.0% Cobalt-1 1.0% CuHP 0.03% TBC

Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the Atlac® high performance resins. Recommended postcure conditions are 3 to 6 hours at 90-100°C – longer times and adjusted postcure schedules being required for thicker laminates and/ or more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Topcoat

Topcoats applied, as final layer in linings for the outside surface must contain paraffin wax to obtain full cure (preventing air inhibition). The resin requires about, 0.1-0.2% addition of wax. The wax should have a melting point of 54-57°C and is best added into the resin as 10% solution in styrene. Topcoats must be cured quickly for the wax to be effective. Use a MEKP cure system to obtain a gel time of 15 minutes or less. Properly cured topcoats will not become tacky when rubbed with acetone.

Inhibitor systems

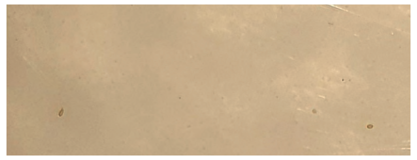
Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.1% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

Thixotropy

Atlac® F013A can be made thixotropic by using the hydrofobe fumed silica types: Wacker HDK 20, Cab-O-Sil TS 720 and Aerosil R202 (1%-2%). They should be blended into the resin using a high-shear stirrer (Cowless type). To improve a maximum thixotropic effect, it is recommended to use a wetting agent (e.g. Byk R605 – Byk Chemie). Thixotropic agents should not be used in laminates intended for service with hypochlorite solutions or fluorine. In this case, sagging can only be reduced to a minimum by very short gel times (20-25 min).

Liquid resin

Cured resin, Standard MEKP/ cobalt curing system



Cured resin, BPO/ Amine curing system

Resin Type	Grade	Remark
Atlac® F013	Atlac® F013A Atlac® F013B Atlac® F013C Atlac® F013H Atlac® F013T	Standard Products optimized for specific customer processes and requirements. Please consult your AOC Technical Service representative for details.

Product information

Atlac® 430

Chemical/ Physical nature

Atlac® 430 is a vinyl ester based on bisphenol A epoxide, dissolved in styrene.

Performance

Atlac® 430 provides resistance to a wide range of acids, alkali, and bleaches for the use in corrosive environments in the chemical processing industry. The favorable combination of thermal resistance and elongation makes this resin suitable for applications exposed to intermittent temperatures.

Major applications

Atlac® 430 can be used in all fabrication methods, but is especially adapted to meet the requirements of filament winding, centrifugal casting, hand lay-up and spray-up applications.

Approvals

Cured non-reinforced Atlac® 430 conforms to type 1310 according to DIN 16946/2 and is classified group 5 in the former DIN 18820/1. According to EN 13121/2 Atlac® 430 is classified group 7A.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	clear	-	TM 2265
Viscosity, 23°C	440-500	mPa.s	TM 2013
Density, 23°C	1,060	kg/m³	TM 2160
Solid content	59-62	%	TM 2033
Gel time from 25-35°C	10-15	min	TM 2625
Cure time from 25°C to peak	19-25	min	TM 2625
Peak temperature	140-160	°C	TM 2625

Curing system used
1.0% Cobalt accelerator (1%)
2.0% Low active MEKP

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Density, 20°C	1,145	kg/m³	-
Hardness	40	Barcol	TM 2604
Tensile strength	95	MPa	ISO 527-2
Elongation at break	6.1	%	ISO 527-2
Tensile modulus	3.6	GPa	ISO 527-2
Flexural strength	150	MPa	ISO 178
Flexural modulus	3.4	GPa	ISO 178
Impact resistance - unnotched sp.	28	kJ/m²	ISO 179
Heat Deflection Temperature (HDT)	105	°C	ISO 75-A
Glass transition temperature (Tg)	130	°C	DIN 53445

Curing system used
0.5% Cobalt accelerator (1%)
1.0% Low active MEKP

Postcure
24 hrs at 20°C followed by 24 hrs at 80°C
HDT and Tg postcure: 24 hrs 120°C

Typical properties reinforced laminate

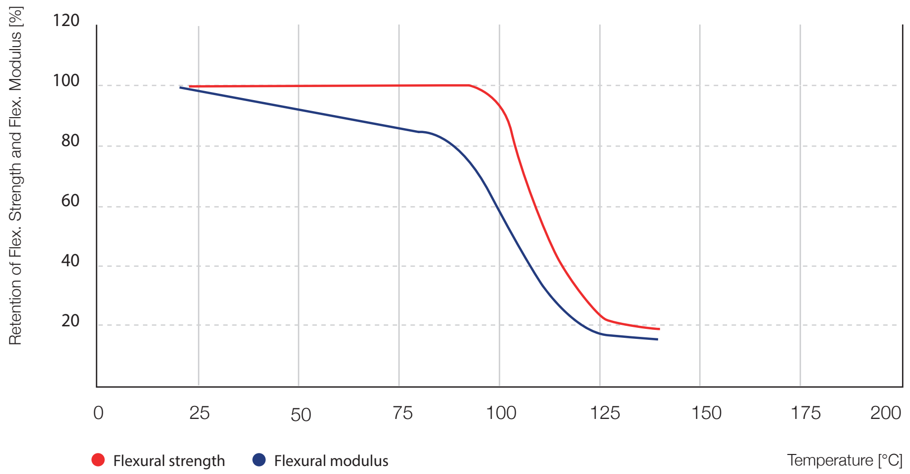
Curing system		Laminate build up		
0.5% Cobalt accelerator (1%)		450 g/m² CSM	450 g/m² CSM	
1.0% Low active MEKP		450 g/m² CSM	800 g/m² WR	
Postcure 24 hrs at 20°C followed by 24 hrs at 80°C		450 g/m² CSM 450 g/m² CSM	450 g/m² CSM 800 g/m² WR 450 g/m² CSM 800 g/m² WR	
Properties/ Unit				**Test methods**
Glass content	%	38.6	39	ASTM D 2584
Tensile strength	MPa	138	146	ISO-527-2
Modulus of elasticity in tension	GPa	10	10.4	ISO-527-2
Flexural strength	MPa	210	216	ISO-527-2
Modulus of elasticity in bending	GPa	10	8.4	ISO-178
Density	kg/m³	1,400		-
Impact resistance - unnotched sp.	kJ/m²			ISO-179
Linear expansion	C^{-1}	30×10^{-6}		-
Thermal conductivity	W/m.K	0.20		-

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-140°C were measured according to ISO-178. The laminates were based on 4 layers of 450 g/m² chopped strand mat with a fiber content of 30-35% w/w. Standard cure systems have been used and all specimen have been fully post-cured 24 hrs at 80°C.

High Temperature Properties

Atlac® 430 (4 layers CSM 450 g/m²)

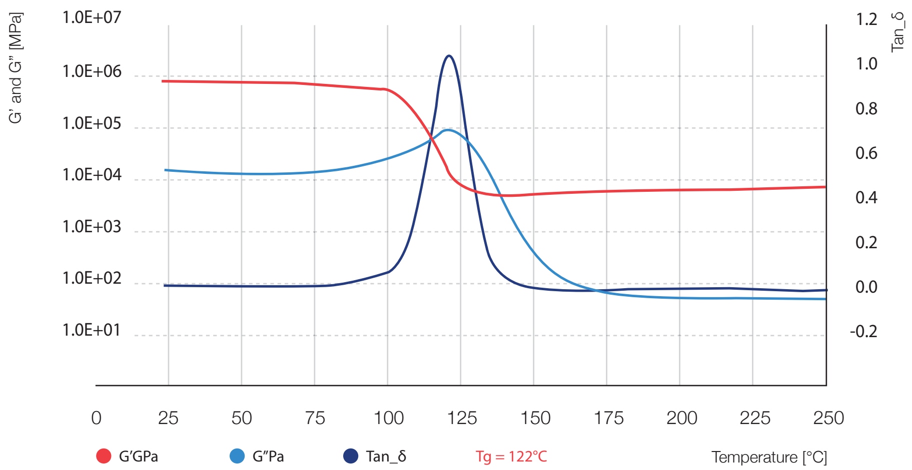


Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard curing systems have been used, and all specimens have been post-cured 24 hrs at 80°C.

Dynamic Mechanical Analysis

Atlac® 430 (reinforced product)

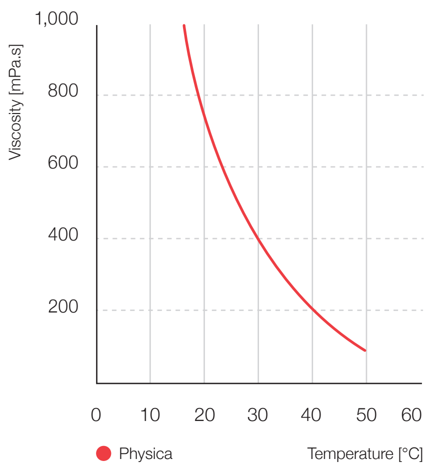


Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

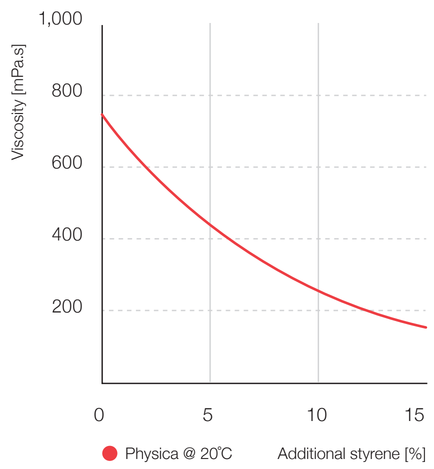
Viscosity versus Temperature

Atlac® 430



Viscosity versus Additional Styrene

Atlac® 430



Atlac® 430: typical geltimes, using Low activity MEKP/ cobalt

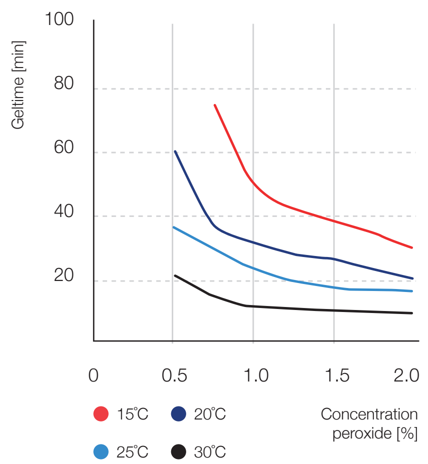
Used curing agents: Low activity Methyl ethyl ketone peroxide (LA-MEKP), Cobalt accelerator (1%) (Cobalt-1) and Tertiair butyl catechol (TBC)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	2.0% Cobalt-1	1.0% Cobalt-1 2.0% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP
20°C	1.0% Cobalt-1 2.0% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 1.0% LA-MEKP
25°C	1.0% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 0.75% LA-MEKP
30°C	0.5% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 0.5% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP 0.04% TBC

Reactivity of Atlac® 430

vs Cumene Hydroperoxide concentrations at different temperatures

Constant accelerator concentration:
Cobalt-1 = 1%



Atlac® 430: typical geltimes, using BPO/ amine

Used curing agents: Dibenzoyl peroxide (BPO-50), Dimethylaniline (DMA) and Dimethyl-para-toluidine (DMPT)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	0.35% DMA + 0.05% DMPT 4.0% BPO-50	0.25% DMA + 0.05% DMPT 3.0% BPO-50	0.15% DMA + 0.05% DMPT 2.0% BPO-50
15°C	0.4% DMA 4.0% BPO-50	0.3% DMA 3.0% BPO-50	0.2% DMA 2.0% BPO-50
20°C	0.3% DMA 2.0% BPO-50	0.3% DMA 1.0% BPO-50	0.175% DMA 1.0% BPO-50

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

Atlac® 430: Typical geltimes, using Cumene hydroperoxide/ Cobalt

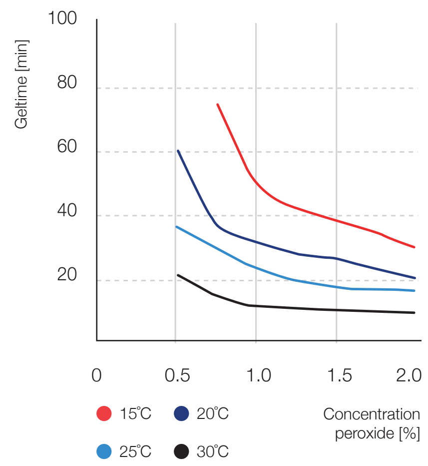
Used curing agents: Cumene hydroperoxide (CuHP), Cobalt accelerator 1% (Cobalt-1) and Tertiair butyl catechol (TBC)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	2.0% Cobalt-1 2.0% CuHP	1.0% Cobalt-1 2.0% CuHP	1.0% Cobalt-1 1.0% CuHP
20°C	1.0% Cobalt-1 2.0% CuHP	1.0% Cobalt-1 1.0% CuHP	0.8% Cobalt-1 1.0% CuHP
25°C	1.0% Cobalt-1 1.0% CuHP	0.7% Cobalt-1 1.0% CuHP	0.5% Cobalt-1 1.0% CuHP
30°C	0.5% Cobalt-1 1.0% CuHP	0.5% Cobalt-1 0.7% CuHP	1.0% Cobalt-1 1.0% CuHP 0.075% TBC

Reactivity of Atlac® 430

vs Cumene Hydroperoxide concentrations at different temperatures

Constant accelerator concentration:
Cobalt-1 = 1%



Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the Atlac® high performance resins. Recommended postcure conditions are 3 to 6 hours at 90-100°C – longer times and adjusted postcure schedules being required for thicker laminates and/ or more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Topcoat

Topcoats applied, as final layer in linings for the outside surface must contain paraffin wax to obtain full cure (preventing air inhibition). The resin requires about, 0.1-0.2% addition of wax. The wax should have a melting point of 54-57°C and is best added into the resin as 10% solution in styrene. Topcoats must be cured quickly for the wax to be effective. Use a MEKP cure system to obtain a gel time of 15 minutes or less. Properly cured topcoats will not become tacky when rubbed with acetone.

Inhibitor systems

Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.1% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

Thixotropy

Atlac® 430 can be made thixotropic by using the hydrofobe fumed silica types: Wacker HDK 20, Cab-O-Sil TS 720 and Aerosil R202 (1%-2%). They should be blended into the resin using a high-shear stirrer (Cowless type). To improve a maximum thixotropic effect, it is recommended to use a wetting agent (e.g. Byk R605 – Byk Chemie). Thixotropic agents should not be used in laminates intended for service with hypochlorite solutions or fluorine. In this case, sagging can only be reduced to a minimum by very short gel times (20-25 min).

Liquid resin

Cured resin, Standard MEKP/ cobalt curing system

Cured resin, BPO/ Amine curing system

Product information

Atlac® 580

Chemical/ Physical nature

Atlac® 580 is a bisphenol A based vinyl ester urethane resin, dissolved in styrene.

Performance

Atlac® 580 is suitable for high temperature water, acid and salt solutions. Low peak exotherm allows the manufacture of thick laminates.

Major applications

Atlac® 580 can be used in all fabrication methods, but is especially adapted to meet the requirements of filament winding, centrifugal casting, hand lay-up and spray-up applications.

Approvals

Cured non-reinforced Atlac® 580 conforms to type 1310 according to DIN 16946/2 and is classified group 5 in former DIN 18820/1 and group 8 according EN 13121/2.

Atlac® 580 passed testing at TÜV for use in flue gas cleaning plants.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	hazy	-	TM 2265
Viscosity, 23°C	400-500	mPa.s	TM 2013
Density, 23°C	1,074	kg/m³	TM 2160
Solid content	52-54	%	TM 2033
Gel time from 25-35°C	25-35	min	TM 2625
Cure time from 25°C to peak	40-45	min	TM 2625
Peak temperature	105-135	°C	TM 2625

Curing system used
2.5% Cobalt accelerator (1%)
1.0% DMA (10%)
1.0% Medium active MEKP

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Density, 20°C	1,110	kg/m³	-
Hardness	40	Barcol	TM 2604
Tensile strength	83	MPa	ISO 527-2
Elongation at break	4.2	%	ISO 527-2
Tensile modulus	3.5	GPa	ISO 527-2
Flexural strength	153	MPa	ISO 178
Flexural modulus	3.6	GPa	ISO 178
Impact resistance - unnotched sp.	15	kJ/m²	ISO 179
Heat Deflection Temperature (HDT)	115	°C	ISO 75-A
Glass transition temperature (Tg)	132	°C	DIN 53445

Curing system used
0.5% Cobalt octoate (6%) solution
0.5% n,n-Dimethylaniline (10%) in TXIB
1.5% Medium active MEKP

Postcure
24 hrs at 20°C followed by 3 hrs at 100°C

Typical properties reinforced laminate

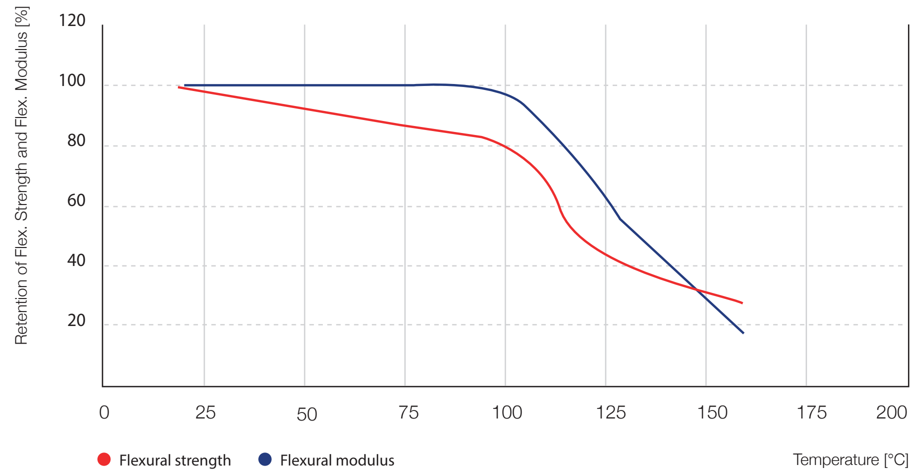
Curing system		Laminate build up		
0.5% Cobalt accelerator (6%)		450 g/m² CSM	450 g/m² CSM	
0.5% DMA (10%)		450 g/m² CSM	800 g/m² WR	
1.5% Medium active MEKP		450 g/m² CSM	450 g/m² CSM	
Postcure 24 hrs at 20°C followed by 3 hrs at 100°C		450 g/m² CSM	800 g/m² WR 450 g/m² CSM 800 g/m² WR	
Properties/ Unit				**Test methods**
Glass content	%	30	44	ASTM D 2584
Tensile strength	MPa	105	162	ISO-527-2
Modulus of elasticity in tension	GPa	7.4	11.9	ISO-527-2
Flexural strength	MPa	160	281	ISO-527-2
Modulus of elasticity in bending	GPa	6.8	10.0	ISO-178
Density	kg/m³	1,320		-
Impact resistance - unnotched sp.	kJ/m²	115		ISO-179
Linear expansion	C^{-1}	30 x 10^{-6}		-
Thermal conductivity	W/m.K	0.21		-

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-160°C were measured according to ISO-178. The laminates were based on 4 layers of 450 g/m² chopped strand mat with a fiber content of 30-35% w/w. Standard (post) cure systems have been used.

High Temperature Properties

Atlac® 580 (4 layers CSM 450 g/m²)

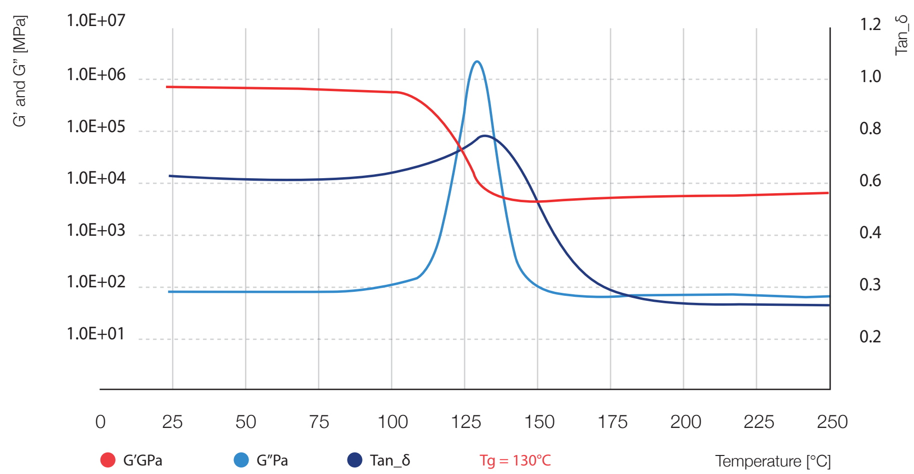


Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard (post)curing systems have been used.

Dynamic Mechanical Analysis

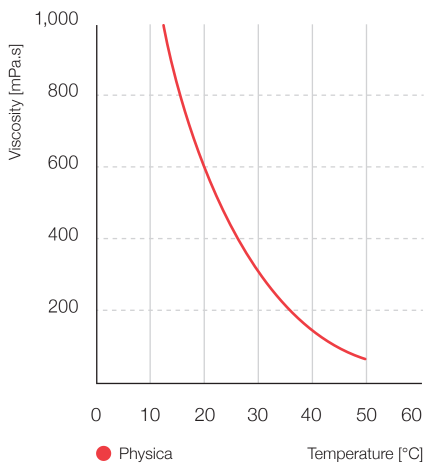
Atlac® 580 (reinforced product)



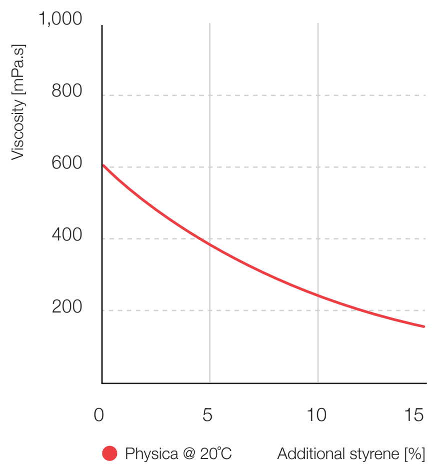
Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

Viscosity versus Temperature
Atlac® 580



Viscosity versus Additional Styrene
Atlac® 580



Atlac® 580: typical geltimes, using standard MEKP/ Cobalt

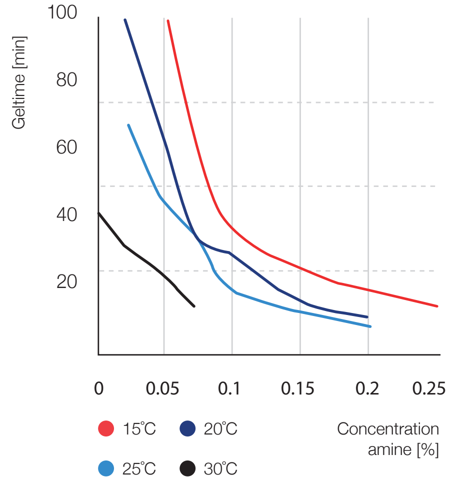
Used curing agents: Standard (Medium active) Methyl ethyl ketone peroxide (MEKP), Cobalt accelerator 6% (Cobalt-6) and Dimethylaniline (DMA)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	0.5% Cobalt-6 0.17% DMA 1.5% MEKP	0.5% Cobalt-6 0.10% DMA 1.5% MEKP	0.5% Cobalt-6 0.12% DMA 1.0% MEKP
20°C	0.3% Cobalt-6 0.14% DMA 1.5% MEKP	0.3% Cobalt-6 0.08% DMA 1.5% MEKP	0.3% Cobalt-6 0.05% DMA 1.5% MEKP
25°C	0.3% Cobalt-6 0.10% DMA 1.5% MEKP	0.3% Cobalt-6 0.05% DMA 1.5% MEKP	0.3% Cobalt-6 0.04% DMA 1.5% MEKP
30°C	0.2% Cobalt-6 0.07% DMA 1.5% MEKP	0.2% Cobalt-6 0.02% DMA 1.5% MEKP	0.2% Cobalt-6 0.01% DMA 1.5% MEKP

Reactivity of Atlac® 580

vs DMA concentrations at different temperatures

Constant accelerator concentration: Cobalt-6 = 0.3% and **constant peroxide concentration:** MEKP = 2.0%)



Atlac® 580: typical geltimes, using BPO/ amine

Used curing agents: Dibenzoyl peroxide (BPO-50), Dimethylaniline (DMA) and Dimethyl-para-toluidine (DMPT)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	0.4% DMA + 0.1% DMPT 4.0% BPO-50	0.4% DMA 4.0% BPO-50	0.35% DMA 3.50% BPO-50
15°C	0.3% DMA + 0.1% DMPT 4.0% BPO-50	0.4% DMA 4.0% BPO-50	0.3% DMA 3.0% BPO-50
20°C	0.35% DMA + 0.05% DMPT 4.0% BPO-50	0.3% DMA 3.0% BPO-50	0.25% DMA 2.25% BPO-50

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

Atlac® 580: Typical geltimes, using Low activity MEKP/ Cobalt

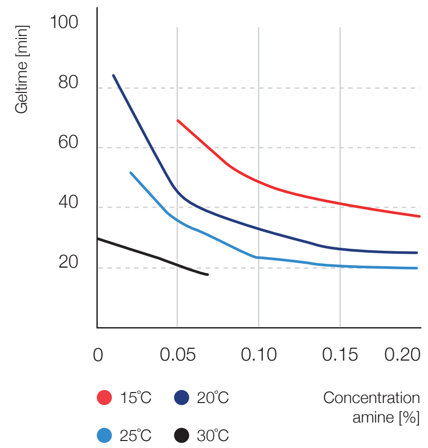
Used curing agents: Low activity Methyl ethyl ketone peroxide (LA-MEKP), Cobalt accelerator 6 % (Cobalt-6) and Dimethylaniline (DMA)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	0.5% Cobalt-6 0.2% DMA 3.0% LA-MEKP	0.5% Cobalt-6 0.15% DMA 2.0% LA-MEKP	0.5% Cobalt-6 0.1% DMA 1.5% LA-MEKP
20°C	0.3% Cobalt-6 0.15% DMA 3.0% LA-MEKP	0.3% Cobalt-6 0.08% DMA 2.5% LA-MEKP	0.3% Cobalt-6A 0.04% DMA 2.0% LA-MEKP
25°C	0.3% Cobalt-6 0.15% DMA 3.0% LA-MEKP	0.3% Cobalt-6 0.06% DMA 2.0% LA-MEKP	0.3% Cobalt-6A 0.02% DMA 2.0% LA-MEKP
30°C	0.3% Cobalt-6 0.05% DMA 2.0% LA-MEKP	0.3% Cobalt-6 2.0% LA-MEKP	0.3% Cobalt-6A 1.25% LA-MEKP

Reactivity of Atlac® 580

vs DMA concentrations at different temperatures

Constant accelerator concentration: Cobalt-6 = 0.3% and **constant peroxide concentration:** LA-MEKP = 2.0%)



Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the Atlac® high performance resins. Recommended postcure conditions are 3 to 6 hours at 90 to 100°C – longer times and adjusted postcure schedules being required for thicker laminates and/ or more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Topcoat

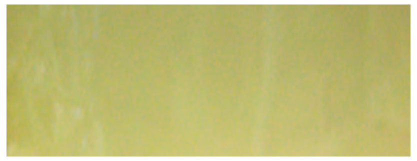
Topcoats applied, as final layer in linings for the outside surface must contain paraffin wax to obtain full cure (preventing air inhibition). The resin requires about, 0.1-0.2% addition of wax. The wax should have a melting point of 54-57°C and is best added into the resin as 10% solution in styrene. Topcoats must be cured quickly for the wax to be effective. Use a MEKP cure system to obtain a gel time of 15 minutes or less. Properly cured topcoats will not become tacky when rubbed with acetone.

Inhibitor systems

Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.25% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

Thixotropy

Atlac® 580 can be made thixotropic by using the standard (polyester) fumed silica types: Aerosil R 200 or Cab-O-Sil M5 (0.5%-2%). They should be blended into the resin using a high-shear stirrer (Cowless type). To improve a maximum thixotropic effect, it is recommended to use a wetting agent (e.g. 0.2% w/w Tween 20 – ICI). Thixotropic agents should not be used in laminates intended for service with hypochlorite solutions or fluorine. In this case, sagging can only be reduced to a minimum by very short gel times (20-25 min).



Liquid resin

Cured resin, Standard MEKP/ cobalt curing system

Cured resin, BPO/ Amine curing system

Resin Type	Grade	Remark
Atlac® 580	Atlac® 580 Atlac® 580 AC 300 Atlac® 580 ACT	Standard Amine and cobalt pre-accelerated, injection/ vacuum infusion Amine and cobalt pre-accelerated and thixotropic

Product information

Atlac 590Z

Chemical/Physical nature

Atlac® 590Z is a novolac based vinyl ester, dissolved in styrene.

Performance

Atlac® 590Z provides excellent thermal and chemical resistance against solvents, acids and oxidizing media like chlorine. The resin offers high retention of strength at elevated temperatures.

Major applications

Atlac® 590Z can be used in all fabrication methods, but is especially adapted to meet the requirements of filament winding, centrifugal casting, hand lay-up and spray-up applications. Atlac® 590Z may also be used to formulate glassflake coatings and mortars.

Approvals

Cured non-reinforced Atlac® 590Z conforms to type 1310 according to DIN 16946/2 and is classified group 5 in the former DIN 18820/1 and group 8 according EN 13121/2.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	clear	-	TM 2265
Viscosity, 23°C	450-550	mPa.s	TM 2013
Density, 23°C	1,090	kg/m³	TM 2160
Solid content	65-71	%	TM 2033
Gel time from 25-35°C	14-20	min	TM 2625
Cure time from 25°C to peak	20-30	min	TM 2625
Peak temperature	140-180	°C	TM 2625

Curing system used
1.0% Cobalt accelerator (1%)
1.0% Medium active MEKP

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Hardness	50	Barcol	TM 2604
Tensile strength	89	MPa	ISO 527-2
Elongation at break	3.7	%	ISO 527-2
Tensile modulus	3.6	GPa	ISO 527-2
Flexural strength	147	MPa	ISO 178
Flexural modulus	3.7	GPa	ISO 178
Impact resistance - unnotched sp.	13	kJ/m²	ISO 179
Heat Deflection Temperature (HDT)	155	°C	ISO 75-A
Glass transition temperature (Tg)	165	°C	DIN 53445

Curing system used
0.5% Cobalt accelerator (6%)
1.0% Medium active MEKP

Postcure
24 hrs at 20°C followed by 2 hrs at 155°C.
HDT samples were postcured for 24 hrs at 200°C

Typical properties reinforced laminate

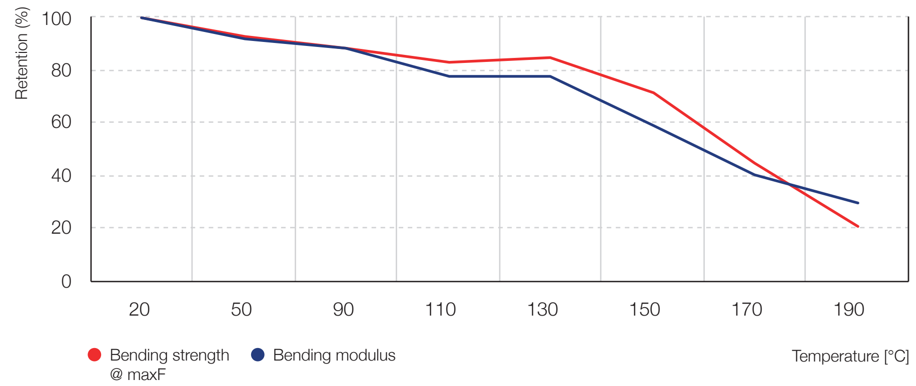
Curing system		Laminate build up	
0.5% Cobalt accelerator (1%)		450 g/m² CSM	
1.0% Medium active MEKP		450 g/m² CSM	
Postcure 24 hrs at 20°C followed by 3 hrs at 100°C and 3 hrs at 150°C		450 g/m² CSM	
		450 g/m² CSM	
Properties / Unit			**Test methods**
Glass content	%	34.4	ASTM D 2584
Tensile strength	MPa	108	ISO-527-2
Tensile modulus	GPa	9.2	ISO-527-2
Flexural strength	MPa	---	ISO-527-2
Flexural modulus	GPa	---	ISO-178

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-180°C were measured according to ISO-178. The aminates were based on 4 layers of 450 g/m² chopped strand mat with a fiber content of 30-35% w/w. Standard cure systems have been used and all specimen have been fully post-cured 5 hrs at 155°C and 48 hrs at 200°C.

High temperature properties

Atlac® 590Z (4 layers CSM 450 g/m²)

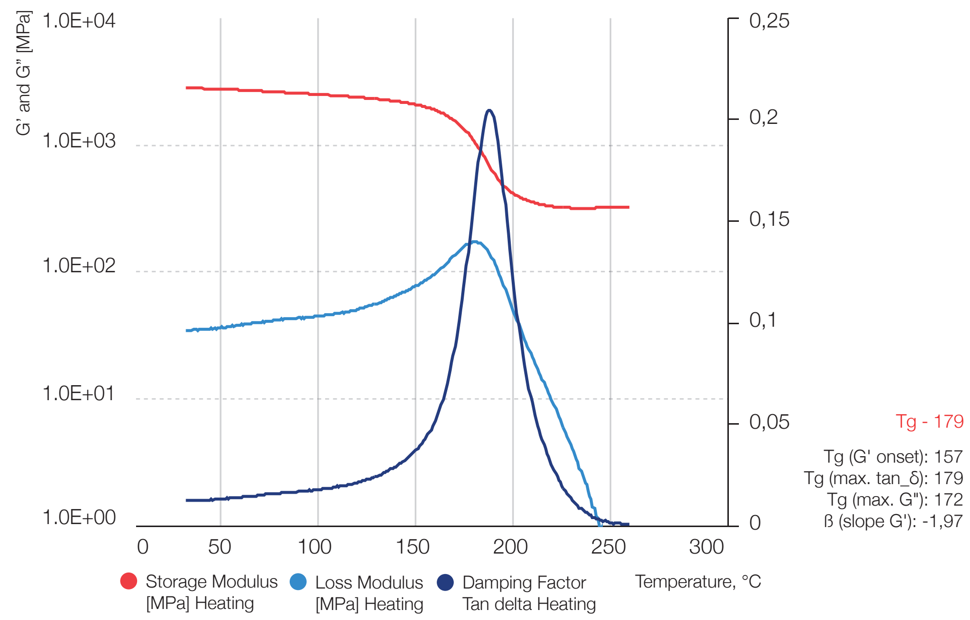


Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard curing systems have been used, with subsequent post-cure of 3hrs at 100°C, 3 hrs at 150°C, and 48 hrs at 200 °C.

Dynamic Mechanical Analysis

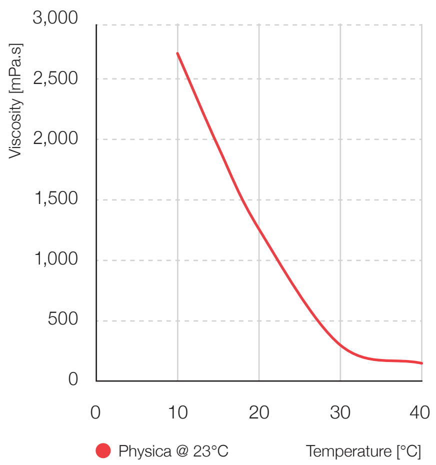
Atlac® 590Z (reinforced product)



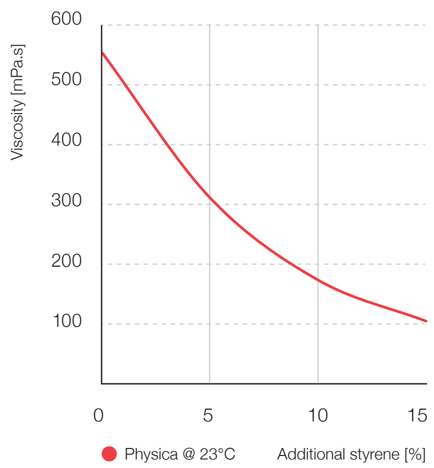
Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

Viscosity versus Temperature
Atlac® 590Z



Viscosity versus Additional Styrene
Atlac® 590Z



Atlac® 590Z: typical geltimes, using standard MEKP/ Cobalt

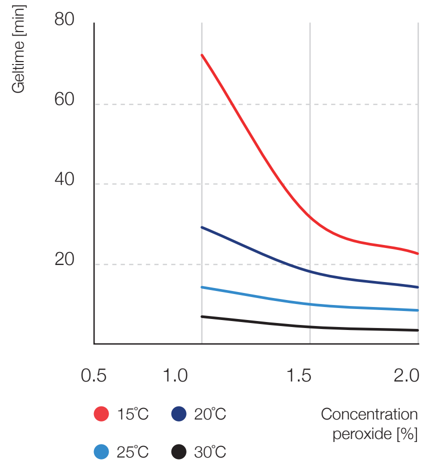
Used curing agents: Standard (Medium active) Methyl ethyl ketone peroxide (MEKP), Cobalt accelerator 6% (Cobalt-6) and Dimethylaniline (DMA) and Tertiair butyl catechol (TBC)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	2.0% Cobalt-1 2.0% MEKP 0.05% DMA	1.5% Cobalt-1 1.5% MEKP	1.0% Cobalt-1 1.0% MEKP
20°C	1.5% Cobalt-1 1.5% MEKP	1.0% Cobalt-1 1.0% MEKP	1.0% Cobalt-1 1.0% MEKP 0.03% TBC
25°C	1.0% Cobalt-1 1.0% MEKP	1.0% Cobalt-1 1.0% MEKP 0.005% TBC	1.0% Cobalt-1 1.0% MEKP 0.015% TBC
30°C	1.0% Cobalt-1 1.0% MEKP 0.01% TBC	1.0% CP-12 1.0% MEKP 0.02% TBC	1.0% Cobalt-1 1.0% MEKP 0.03% TBC

Reactivity of Atlac® 590Z

vs standard MEKP concentrations
at different temperatures

Constant accelerator concentration:
1.0% Cobalt accelerator (1%), 1% MEKP



Atlac® 590Z: typical geltimes, using BPO/ amine

Used curing agents: Benzoyl peroxide (BPO-50), Dimethylaniline (DMA), Tertiair butyl catechol (TBC)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	0.3% DMA 2.0% BPO-50	0.2% DMA 1.5% BPO-50	0.1% DMA 1.5% BPO-50
15°C	0.2% DMA 2.0% BPO-50	0.15% DMA 1.5% BPO-50	0.1% DMA 1.0% BPO-50
20°C	0.15% DMA 1.5% BPO-50	0.15% DMA 1.5% BPO-50 0.02% TBC	0.15% DMA 1.5% BPO-50 0.03% TBC

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

Atlac 590Z: Typical geltimes, using Cumene hydroperoxide/ Cobalt

Used curing agents: Cumene hydroperoxide (CuHP), Cobalt accelerator (1%) (Cobalt-1), Dimethylaniline (DMA) and Tertiair butyl catechol (TBC).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	2.0% Cobalt-1 2.0% CuHP 0.15% DMA	1.5% Cobalt-1 1.5% CuHP	1.0% Cobalt-1 1.0% CuHP
20°C	1.5% Cobalt-1 1.5% CuHP	1.0% Cobalt-1 1.0% CuHP	1.0% Cobalt-1 1.0% CuHP 0.02% TBC
25°C	1.0% Cobalt-1 1.0% CuHP	1.0% Cobalt-1 1.0% CuHP 0.02% TBC	1.0% Cobalt-1 1.0% CuHP 0.04% TBC
30°C	1.0% Cobalt-1 1.0% CuHP 0.015% TBC	1.0% Cobalt-1 1.0% CuHP 0.05% TBC	1.0% Cobalt-1 1.0% CuHP 0.08% TBC

Post-curing

Postcuring is necessary to obtain the optimum heat and chemical resistance of the Atlac® high performance resins. Recommended postcure conditions are 3 to 6 hours at 90 to 100°C – longer times and adjusted postcure schedules being required for thicker laminates and/ or more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Topcoat

Topcoats applied, as final layer in linings for the outside surface must contain paraffin wax to obtain full cure (preventing air inhibition). The resin requires about, 0.1-0.2% addition of wax. The wax should have a melting point of 54-57°C and is best added into the resin as 10% solution in styrene. Topcoats must be cured quickly for the wax to be effective. Use a MEKP or AAP cure system to obtain a gel time of 15 minutes or less. Properly cured topcoats will not become tacky when rubbed with acetone.

Inhibitor systems

Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.25% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

Thixotropy

Atlac® 590Z can be made thixotropic by using the hydrofobe fumed silica types: Wacker HDK 20, Cab-O-Sil TS 720 and Aerosil R202 (1.0%-2.0%). They should be blended into the resin using a high-shear stirrer (Cowless type). To improve a maximum thixotropic effect, it is recommended to use a wetting agent (e.g. Byk R605 – Byk Chemie). Thixotropic agents should not be used in laminates intended for service with hypochlorite solutions or fluorine. In this case, sagging can only be reduced to a minimum by very short gel times (20-25 min).

Liquid resin

Cured resin, Standard MEKP/ cobalt curing system

Cured resin, BPO/ Amine curing system

Resin Type	Grade	Remark
Atlac® 590Z	Atlac® 590Z	Standard

Product information

Atlac F086A

Chemical/Physical nature

Atlac® F086A is a novolac based vinyl es-ter, dissolved in styrene.

Performance

Atlac® F086A providesthe highest combina-tion of thermal and chemical resistance, especially sovents, but also against acids and oxidizing media like chlorine.

Major applications

Atlac® F086A can be used in all fabrication methods, but is especially adapted to meet the requirements of filament winding, centrifugal casting, hand lay-up and spray-up applications.

Approvals

Cured non-reinforced Atlac® F086A conforms to type 1310 according to DIN 16946/2 and is classified group 8 in the former DIN 18820/1. According to EN 13121/2 Atlac® 430 is classified group 8.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	Hazy	-	TM 2265
Viscosity, 23°C	375-450	mPa.s	TM 2013
Density, 23°C	1,080	kg/m³	TM 2160
Solid content	61-67	%	TM 2033
Gel time from 25-35°C	24-35	min	TM 2625
Cure time from 25°C to peak	28-40	min	TM 2625
Peak temperature	150-190	°C	TM 2625

Curing system used
2.0% Cobalt accelerator (1%)
2.0% Low active MEKP
1.0% DMA (10%)

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Hardness	45	Barcol	TM 2604
Tensile strength	83	MPa	ISO 527-2
Elongation at break	2.8	%	ISO 527-2
Tensile modulus	3.8	GPa	ISO 527-2
Flexural strength	155	MPa	ISO 178
Flexural modulus	4.2	GPa	ISO 178
Impact resistance - unnotched sp.	13	kJ/m²	ISO 179
Heat Deflection Temperature (HDT)	180	°C	ISO 75-A
Glass transition temperature (Tg)	190	°C	DIN 53445

Curing system used
Cobalt accelerator (1%)
Low active MEKP

Postcure
24 hrs at 20°C followed by 6 hrs at 100°C.
HDT and Tg post-cure: 168 hrs 220°C

Typical properties reinforced laminate

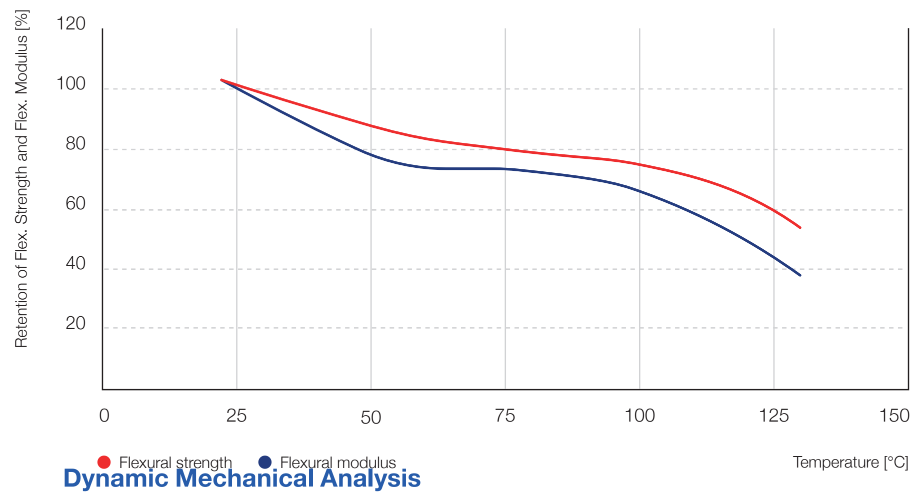
Curing system		Laminate build up	
0.5% Cobalt octoate (1%) solution		450 g/m² CSM	
1.8% Medium active MEKP		450 g/m² CSM	
Postcure 24 hrs at 20°C followed by 3 hrs at 100°C and 3 hrs at 150°C			
		450 g/m² CSM	
		450 g/m² CSM	
Properties / Unit			**Test methods**
Glass content	%	35.1	ASTM D 2584
Tensile strength	MPa	121	ISO-527-2
Modulus of elasticity in tension	GPa	9.7	ISO-527-2
Flexural strength	MPa	---	ISO-527-2
Modulus of elasticity in bending	GPa	---	ISO-178

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-180°C were measured according to ISO-178. The aminates were based on 4 layers of 450 g/m² chopped strand mat with a fiber content of 30-35% w/w. Standard cure systems have been used and all specimen have been post-cured for 5 hrs at 155°C, 48 hrs at 200°C.

High temperature properties

Atlac® F086A (4 layers CSM 450 g/m², fiber content 30%, fully postcured)

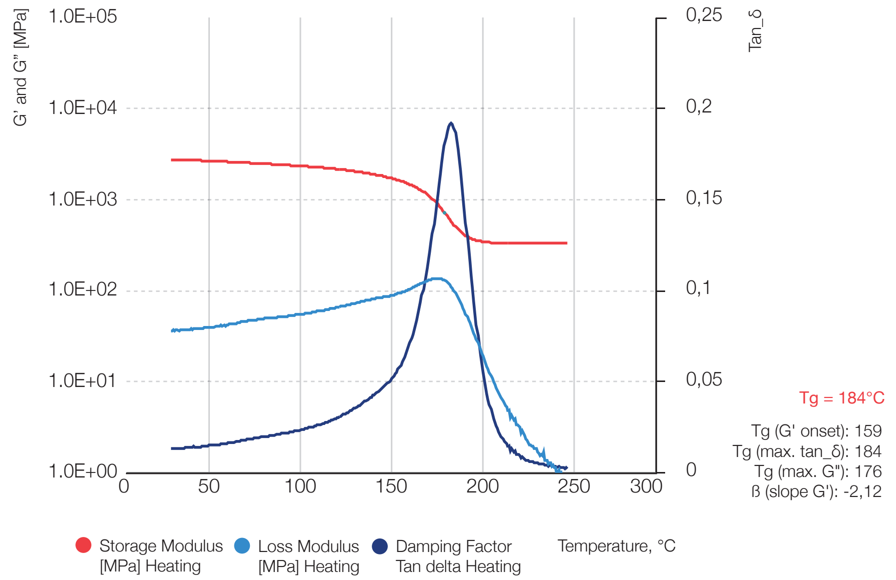


Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard curing systems have been used, and a post-cure of 3 hrs at 100°C, 3 hrs at 155°C, 48 hrs at 200°C.

Dynamic Mechanical Analysis

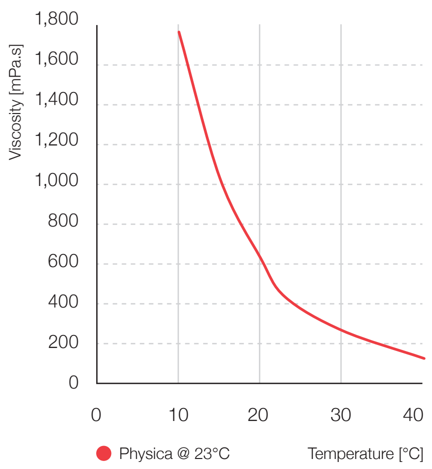
Atlac® F086A (reinforced product)



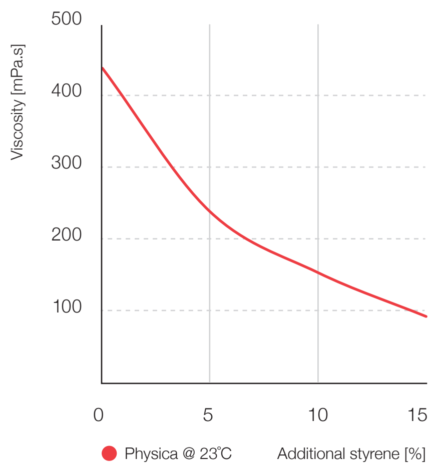
Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

Viscosity versus Temperature
Atlac® F086A



Viscosity versus Additional Styrene
Atlac® F086A



Atlac® F086A: typical geltimes, using Standard MEKP/Cobalt

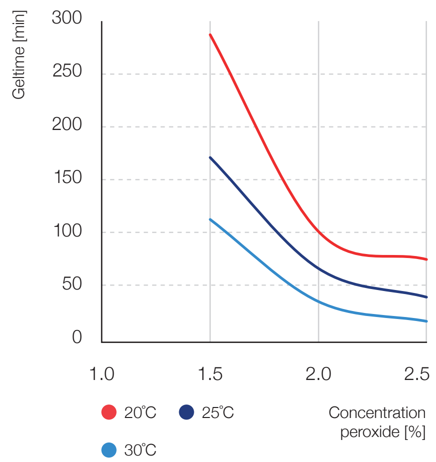
Used curing agents: Standard (Medium active) Methyl ethyl ketone peroxide (MEKP), Cobalt accelerator 1% (Cobalt-1), Tertiair butyl catechol (TBC), Dimethylaniline (DMA).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	2.5% Cobalt-1 2.5% MEKP 0.3% DMA	2.5% Cobalt-1 2.5% MEKP 0.15% DMA	2.5% Cobalt-1 2.5% MEKP 0.1% DMA
20°C	2.5% Cobalt-1 2.5% MEKP 0,.2% DMA	2.5% Cobalt-1 2.5% MEKP 0.1% DMA	2.5% Cobalt-1 2.5% MEKP 0.05% DMA
25°C	2.5% Cobalt-1 2.5% MEKP 0.1% DMA	2.0% Cobalt-1 2.5% MEKP 0.05% DMA	2.0% Cobalt-1 2.5% MEKP
30°C	2.0% Cobalt-1 2.5% MEKP	2.0% Cobalt-1 2.0% MEKP	2.0% Cobalt-1 2.0% MEKP 0.01% TBC

Reactivity of Atlac® F086A

vs standard MEKP concentrations at different temperatures

Constant accelerator concentration:
2% Cobalt Accelerator (1%), 1% MEKP



Atlac® F086A: typical geltimes, using BPO/ amine

Used curing agents: Dibenzoyl peroxide (BPO-50) and Dimethylaniline (DMA)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	NA	1.0% DMA 4.0% BPO-50	0.6% DMA 4.0% BPO-50
15°C	1.0% DMA 5.0% BPO-50	0.4% DMA 4.0% BPO-50	0.5% DMA 5.0% BPO-50
20°C	0.8% DMA 4.0% BPO-50	0.6% DMA 3.0% BPO-50	0.5% DMA 3.0% BPO-50

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

Atlac® F086A: Typical geltimes, using Cumene hydroperoxide/ Cobalt

Used curing agents: Cumene hydroperoxide (CuHP), Cobalt solution 1% (Cobalt-1), Dimethylaniline (DMA) and Tertiair butyl catechol (TBC).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	NA	NA	3.0% Cobalt-1 3.0% CuHP 0.3% DMA
20°C	NA	2.5% Cobalt-1 3.0% CuHP 0.4% DMA	2.0% Cobalt-1 2.0% CuHP 0.5% DMA
25°C	3.0% Cobalt-1 3.0% CuHP 0.3% DMA	2.0% Cobalt-1 2.0% CuHP 0.2% DMA	1.5% Cobalt-1 1.5% CuHP 0.5% DMA
30°C	2.0% Cobalt-1 3.0% CuHP	1.0% Cobalt-1 2.0% CuHP 0.2% DMA	1.0% Cobalt-1 1.5% CuHP 0.01% TBC

Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the Atlac® high performance resins. Recommended postcure conditions are 3 to 6 hours at 90-100°C – longer times and adjusted postcure schedules being required for thicker laminates and/ or more complex shapes. Lower temperatures are ineff ective; higher temperatures can lead to embrittlement.

Topcoat

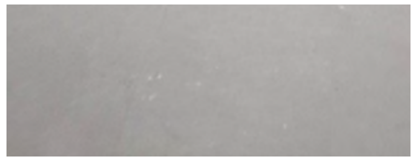
Topcoats applied, as final layer in linings for the outside surface must contain paraffin wax to obtain full cure (preventing air inhibition). The resin requires about, 0.1-0.2% addition of wax. The wax should have a melting point of 54-57°C and is best added into the resin as 10% solution in styrene. Topcoats must be cured quickly for the wax to be effective. Use a MEKP or AAP cure system to obtain a gel time of 15 minutes or less. Properly cured topcoats will not become tacky when rubbed with acetone.

Inhibitor systems

Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.25% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

Thixotropy

Atlac® F086A can be made thixotropic by using the hydrofobe fumed silica types: Wacker HDK 20, Cab-O-Sil TS 720 and Aerosil R202 (1.0%-2.0%). They should be blended into the resin using a high-shear stirrer (Cowless type). To improve a maximum thixotropic effect, it is recommended to use a wetting agent (e.g. Byk R605 – Byk Chemie). Thixotropic agents should not be used in laminates intended for service with hypochlorite solutions or fluorine. In this case, sagging can only be reduced to a minimum by very short gel times (20-25 min).



Liquid resin

Cured resin, Standard MEKP/ cobalt curing system

Cured resin, BPO/ Amine curing system

Product information

Atlac® E-Nova FW 2045

Chemical/Physical nature

Atlac® E-Nova FW 2045 is a modified epoxy bisphenol A vinyl ester urethane resin, dissolved in styrene.

Performance

Atlac® E-Nova FW 2045 provides the same excellent thermal and chemical resistance against solvents, acids and oxidizing media as an epoxy novolac vinyl ester, but offers in addition also resistance against alkaline. The E-Nova technology combines the easy processing of polyester with the chemical resistance of vinyl ester. Low foam curing is possible with standard MEKP peroxides and compared to traditional vinyl ester resins it shows excellent fiber wetting. Atlac® E-Nova FW 2045 can be easily made thixotropic.

Major applications

Atlac® E-Nova FW 2045 can be used in all fabrication methods, but is especially adapted to meet the requirements of filament winding, centrifugal casting, hand lay-up and spray-up applications.

Approvals

Cured non-reinforced Atlac® E-Nova FW 2045 conforms to type 1310 according to DIN 16946/2 and is classified group 5 in former DIN 18820/1 and group 7B according EN 13121/2. Atlac® E-Nova FW 2045 received from the DIBt (Deutsches Institute für Bautechnik) a general approval for parts to store chemicals.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	clear	-	TM 2265
Viscosity, 23°C	350-450	mPa.s	TM 2013
Density, 23°C	1,070	kg/m³	TM 2160
Solid content	58-61	%	TM 2033
Gel time from 25-35°C	13-21	min	TM 2625
Cure time from 25°C to peak	21-32	min	TM 2625
Peak temperature	155-180	°C	TM 2625

Curing system used
3.0% Cobalt accelerator (1%)
2.0% Medium active MEKP

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Density, 20°C	1,160	kg/m³	-
Hardness	45	Barcol	TM 2604
Tensile strength	90	MPa	ISO 527-2
Elongation at break	4	%	ISO 527-2
Tensile modulus	3.5	GPa	ISO 527-2
Flexural strength	140	MPa	ISO 178
Flexural modulus	3.7	GPa	ISO 178
Impact resistance - unnotched sp.	25	kJ/m²	ISO 179
Heat Deflection Temperature (HDT)	145	°C	ISO 75-A
Glass transition temperature (Tg)	160	°C	DIN 53445

Curing system used
1.8% Cobalt accelerator (1%)
0.2% DMA(10%)
1.5% Medium active MEKP

Postcure
24 hrs at 20°C followed by 3 hrs at 100°C and 3hrs at 150°C

Typical properties reinforced laminate

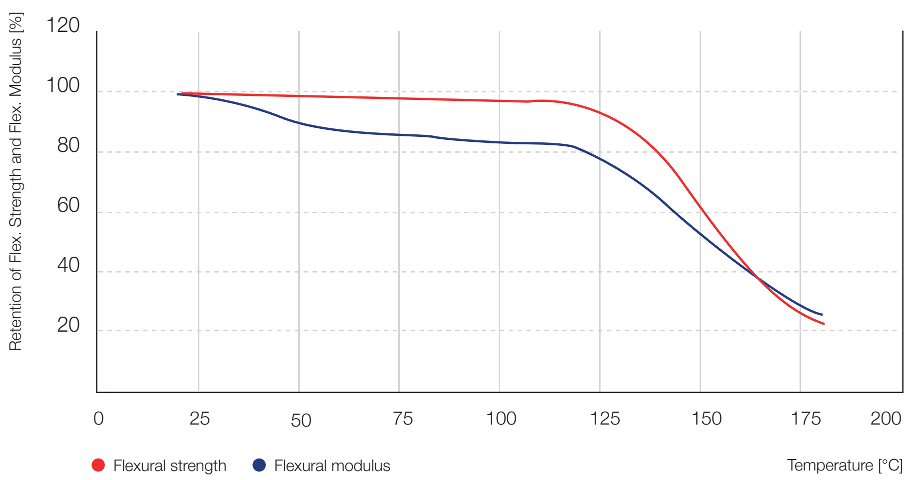
Curing system		Laminate build up		
0.3% Cobalt accelerator (1%)		450 g/m² CSM	450 g/m² CSM	
1.0% Medium active MEKP		450 g/m² CSM	800 g/m² WR	
Postcure 24 hrs at 20°C followed by 3 hrs at 100°C and 3 hrs at 150°C		450 g/m² CSM 450 g/m² CSM	450 g/m² CSM 800 g/m² WR 450 g/m² CSM 800 g/m² WR	
Properties/ Unit				**Test methods**
Glass content	%	30	38	ASTM D 2584
Tensile strength	MPa	120	129	ISO-527-2
Modulus of elasticity in tension	GPa	8.3	8.6	ISO-527-2
Flexural strength	MPa	210	228	ISO-527-2
Modulus of elasticity in bending	GPa	8.7	7.9	ISO-178
Density	kg/m³			-
Impact resistance - unnotched sp.	kJ/m²			ISO-179
Linear expansion	C⁻¹	30 x 10⁻⁶		-
Thermal conductivity	W/m.K	0.20		-

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-180°C were measured according to ISO-178.
The laminates were based on 4 layers of 450 g/m² chopped strand mat with a fiber content of 30-35% w/w. Standard cure systems have been used and all specimen have been fully postcured.

High Temperature Properties

Atlac® E-Nova FW 2045 (4 layers CSM 450 g/m², fiber content 30%, fully postcured)

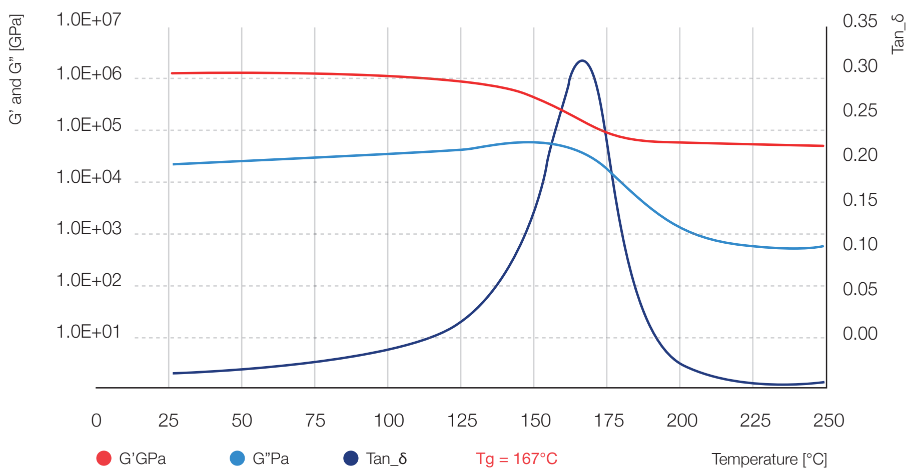


Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard (post)curing systems have been used.

Dynamic Mechanical Analysis

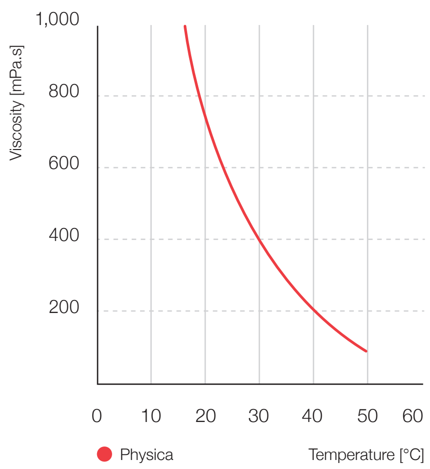
Atlac® E-Nova FW 2045 (reinforced product curing system)



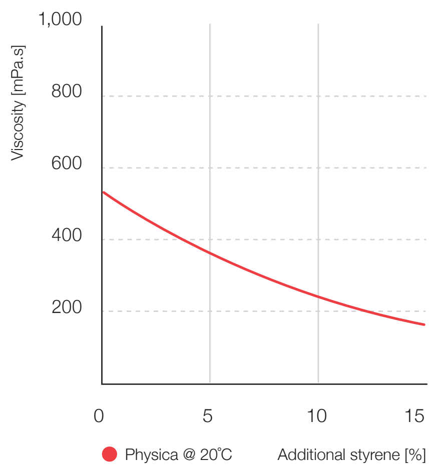
Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

Viscosity versus Temperature
Atlac® E-Nova FW 2045



Viscosity versus Additional Styrene
Atlac® E-Nova FW 2045



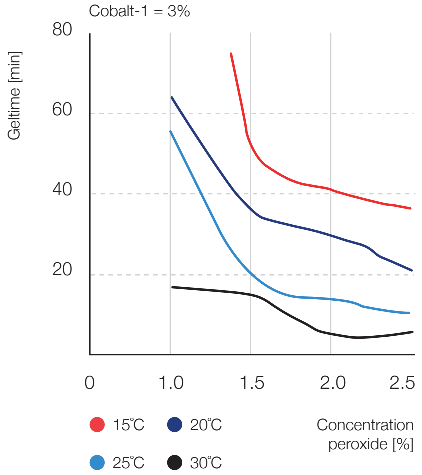
Atlac® E-Nova FW 2045: typical geltimes, using standard MEKP/ Cobalt

Used curing agents: Standard (medium active) Methyl ethyl ketone peroxide (MEKP), Cobalt accelerator 1% (Cobalt-1), Tertiair butyl cathechol (TBC).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C			1.0% Cobalt-1
20°C	1.0% Cobalt-1 2.0% MEKP	1.0% Cobalt-1 1.0% MEKP	0.5% Cobalt-1 1.0% MEKP
25°C	1.0% Cobalt-1 1.0% MEKP	0.5% Cobalt-1 1.0% MEKP	0.5% Cobalt-1 0.75% MEKP
30°C	0.5% Cobalt-1 1.0% MEKP	0.5% Cobalt-1 0.5% MEKP	1.0% Cobalt-1 1.0% MEKP 0.04% TBC

Reactivity of Atlac® E-Nova FW 2045
vs Standard MEKP concentrations at different temperatures

Constant accelerator concentration:
Cobalt-1 = 3%



Atlac® E-Nova FW 2045: typical geltimes, using BPO/ amine

Used curing agents: Dibenzoyl peroxide (BPO-50) and Dimethylaniline (DMA).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	0.35% DMA + 0.05% DMPT 4.0% BPO-50	0.25% DMA + 0.05% DMPT 3.0% BPO-50	0.15% DMA + 0.05% DMPT 2.0% BPO-50
15°C	0.4% DMA 4.0% BPO-50	0.3% DMA 3.0% BPO-50	0.2% DMA 2.0% BPO-50
20°C	0.3% DMA 2.0% BPO-50	0.3% DMA 1.0% BPO-50	0.175% DMA 1.0% BPO-50

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

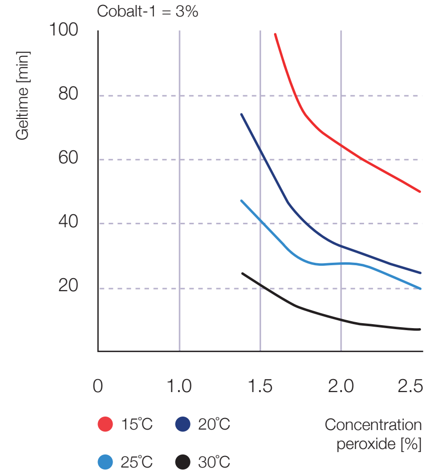
Atlac® E-Nova FW 2045: Typical geltimes, using Low activity MEKP/ Cobalt

Used curing agents: Low activity Methyl ethyl ketone peroxide (LA-MEKP), Cobalt accelerator 1% (Cobalt-1), Dimethylaniline (DMA)

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	3.0% Cobalt-1 0.05% DMA 3.0% LA-MEKP	3.0% Cobalt-1 3.0% LA-MEKP	2.5% Cobalt-1 2.5% LA-MEKP
20°C	3.0% Cobalt-1 0.05% DMA 3.0% LA-MEKP	3.0% Cobalt-1 2.0% LA-MEKP	3.0% Cobalt-1 1.25% LA-MEKP
25°C	3.0% Cobalt-1 2.5% LA-MEKP	3.0% Cobalt-1 1.5% LA-MEKP	3.0% Cobalt-1 1.0% LA-MEKP
30°C	3.0% Cobalt-1 1.5% LA-MEKP	3.0% Cobalt-1 1.0% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP

Reactivity of Atlac® E-Nova FW 2045
vs Low Activity MEKP concentrations at different temperatures

Constant accelerator concentration:
Cobalt-1 = 3%



Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the Atlac® high performance resins. Recommended postcure conditions are 3 to 6 hours at 90 to 100°C – longer times and adjusted postcure schedules being required for thicker laminates more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Topcoat

Topcoats applied, as final layer in linings for the outside surface must contain paraffin wax to obtain full cure (preventing air inhibition). The resin requires about, 0.1-0.2% addition of wax. The wax should have a melting point of 54-57°C and is best added into the resin as 10% solution in styrene. Topcoats must be cured quickly for the wax to be effective. Use a MEKP cure system to obtain a gel time of 15 minutes or less. Properly cured topcoats will not become tacky when rubbed with acetone.

Inhibitor systems

Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.25% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

Thixotropy

Atlac® E-Nova resins can be made easily thixotropic by using the standard (polyester) fumed silica types: Aerosil R 200 or Cab-O-Sil M5 (0.5%-2%). They should be blended into the resin using a high-shear stirrer (Cowless type). To improve a maximum thixotropic effect, it is recommended to use a wetting agent (e.g. 0.2% w/w Tween 20 – ICI). Thixotropic agents should not be used in laminates intended for service with hypochlorite solutions or fluorine. In this case, sagging can only be reduced to a minimum by very short gel times (20-25 min).

Liquid resin

Cured resin, Standard MEKP/ cobalt curing system

Cured resin, BPO/ Amine curing system

Resin Type	Grade	Remark
Atlac® E-Nova FW 2045	Atlac® E-Nova FW 2045 Atlac® E-Nova FW 2245	Standard Pre-accelerated

Atlac® 5200 FC

Chemical/ Physical nature

Atlac® 5200 FC is a vinyl ester based on bisphenol A epoxide, dissolved in styrene. This resin is specifically formulated for food contact and potable water applications and manufactured in line with Good Manufacturing Practice (GMP).

Performance

Atlac® 5200 FC provides resistance to a wide range of acids, alkali, and bleaches for the use in corrosive environments in the food processing industry and for potable water process installations. The favorable combination of thermal resistance and elongation makes this resin suitable for applications exposed to intermittent temperatures.

Major applications

Atlac® 5200 FC can be used for the manufacturing op pipes, tanks and assemblies in contact with food stuff and drinking water.

Approvals

Cured non-reinforced Atlac® 5200 FC conforms to type 1310 according to DIN 16946/2 and is classified group 5 in the former DIN 18820/1. According to EN 13121/2 Atlac® 5200 FC is classified group 7A. Atlac® 5200 FC is produced according to EU 10/2011 and 2023/2004 regulations in line with Good Manufacturing Practice (GMP).

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	clear	-	TM 2265
Viscosity, 23°C	440-500	mPa.s	TM 2013
Density, 23°C	1,060	kg/m³	TM 2160
Solid content	59-62	%	TM 2033
Gel time from 25-35°C	10-15	min	TM 2625
Cure time from 25°C to peak	17-24	min	TM 2625
Peak temperature	140-160	°C	TM 2625

Curing system used
Cobalt accelerator (1%)
2.0% Low active MEKP

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Density, 20°C	1,145	kg/m³	-
Hardness	40	Barcol	TM 2604
Tensile strength	95	MPa	ISO 527-2
Elongation at break	6.1	%	ISO 527-2
Tensile modulus	3.6	GPa	ISO 527-2
Flexural strength	150	MPa	ISO 178
Flexural modulus	3.4	GPa	ISO 178
Impact resistance - unnotched sp.	28	kJ/m²	ISO 179
Heat Deflection Temperature (HDT)	105	°C	ISO 75-A
Glass transition temperature (Tg)	130	°C	DIN 53445

Curing system used
0.5% Cobalt accelerator (1%)
1.0% Low active MEKP

Postcure
24 hrs at 20°C followed by 24 hrs at 80°C
HDT and Tg postcure: 24 hrs 120°C

Typical properties reinforced laminate

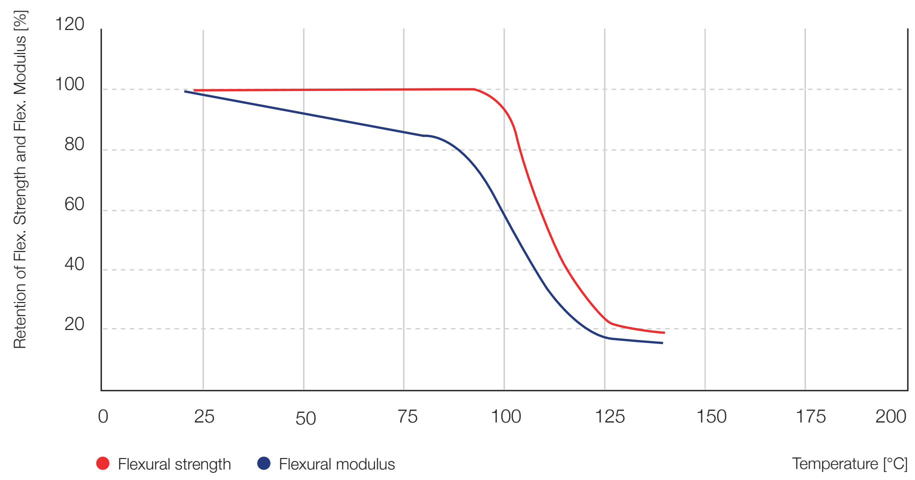
Curing system		Laminate build up		
0.5% Cobalt accelerator (1%)		450 g/m² CSM	450 g/m² CSM	
1.0% Low active MEKP		450 g/m² CSM	800 g/m² WR	
Postcure 24 hrs at 20°C followed by 24 hrs at 80°C		450 g/m² CSM 450 g/m² CSM	450 g/m² CSM 800 g/m² WR 450 g/m² CSM 800 g/m² WR	
Properties/ Unit				**Test methods**
Glass content	%	38.6	39	ASTM D 2584
Tensile strength	MPa	138	146	ISO-527-2
Modulus of elasticity in tension	GPa	10	10.4	ISO-527-2
Flexural strength	MPa	210	216	ISO-527-2
Modulus of elasticity in bending	GPa	10	8.4	ISO-178
Density	kg/m³	1,400		-
Impact resistance - unnotched sp.	kJ/m²			ISO-179
Linear expansion	C⁻¹	30 x 10-6		-
Thermal conductivity	W/m.K	0.20		-

High Temperature Properties

The flexural moduli and strengths of the resin over a temperature range of 20-180 were measured according to ISO-178.
The laminates were based on 4 layers of 450 g/m² chopped strand mat with a fiber content of 30-35% w/w. Standard cure systems have been used and all specimen have been fully postcured.

High Temperature Properties

Atlac® 5200 FC (4 layers CSM 450 g/m², fiber content 30%, fully postcured)



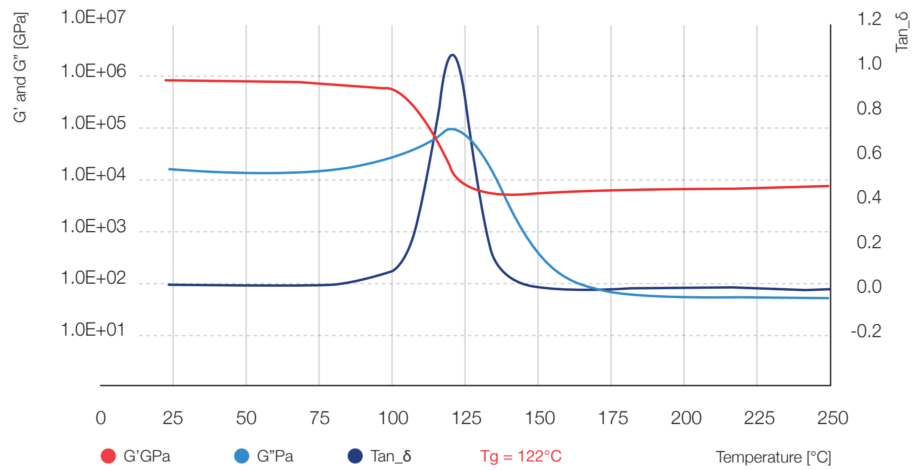
Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state.

Standard (post)curing systems have been used.

Dynamic Mechanical Analysis

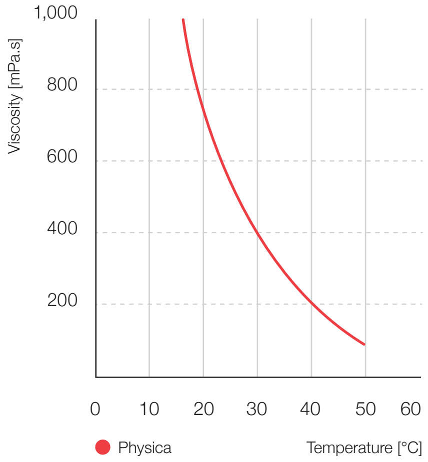
Atlac® 5200 FC (reinforced product curing system)



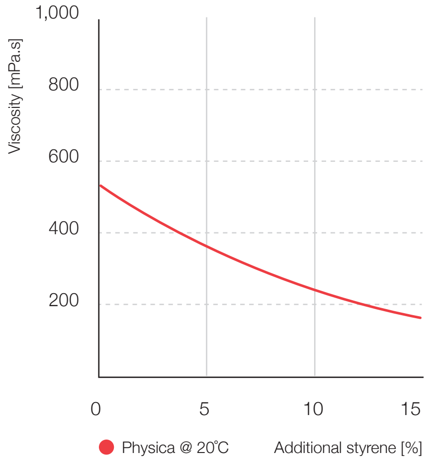
Viscosity

The viscosity of the Atlac® resin can be influenced by temperature and/ or the styrene content. Additional styrene, up to approx. 5% can be used without affecting the chemical resistance and mechanical properties.

Viscosity versus Temperature
Atlac® 5200 FC



Viscosity versus Additional Styrene
Atlac® 5200 FC



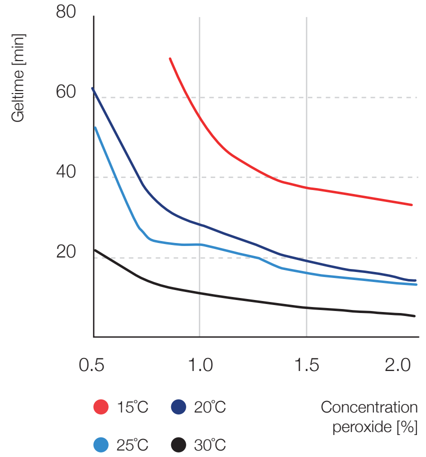
Atlac 5200 FC: typical geltimes, using low activity MEKP/ Cobalt

Used curing agents: Low activity Methyl ethyl ketone peroxide (LA-MEKP), Cobalt accelerator (1%) (Cobalt-1) and tertiair butyl catechol (TBC).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	2.0% Cobalt-1 2.0% LA-MEKP	1.0% Cobalt-1 2.0% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP
20°C	1.0% Cobalt-1 2.0% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 1.0% LA-MEKP
25°C	1.0% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 0.75% LA-MEKP
30°C	0.5% Cobalt-1 1.0% LA-MEKP	0.5% Cobalt-1 0.5% LA-MEKP	1.0% Cobalt-1 1.0% LA-MEKP 0.04% TBC

Reactivity of Atlac® 5200 FC
vs Low Activity MEKP concentrations at different temperatures

Constant accelerator concentration:
Cobalt-1 = 1%



Atlac 5200 FC: typical geltimes, using BPO/ amine

Used curing agents: Dibenzoyl peroxide (BPO-50), Dimethylaniline (DMA) and Dimethyl-para-toluidine (DMPT).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
10°C	0.35% DMA + 0.05% DMPT 4.0% BPO-50	0.25% DMA + 0.05% DMPT 3.0% BPO-50	0.15% DMA + 0.05% DMPT 2.0% BPO-50
15°C	0.4% DMA 4.0% BPO-50	0.3% DMA 3.0% BPO-50	0.2% DMA 2.0% BPO-50
20°C	0.3% DMA 2.0% BPO-50	0.3% DMA 1.0% BPO-50	0.175% DMA 1.0% BPO-50

For curing at low temperatures (outdoor jointing or repairing, lining, etc.) and or high humidity BPO/ Amine curing is recommended. This curing system is mandatory in applications were hypochlorite or peroxides are present.

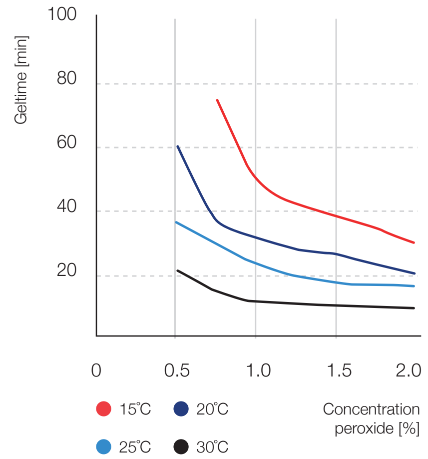
Atlac® 5200 FC: Typical geltimes, using Cumene hydroperoxide/ Cobalt

Used curing agents: Cumene hydroperoxide (CuHP), Cobalt accelerator 1% and Dimethylaniline (DMA) and Tertiair butyl catechol (TBC).

Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	2.0% Cobalt-1 2.0% CuHP	1.0% Cobalt-1 2.0% CuHP	1.0% Cobalt-1 1.0% CuHP
20°C	1.0% Cobalt-1 2.0% CuHP	1.0% Cobalt-1 1.0% CuHP	0.8% Cobalt-1 1.0% CuHP
25°C	1.0% Cobalt-1 1.0% CuHP	0.7% Cobalt-1 1.0% CuHP	0.5% Cobalt-1 1.0% CuHP
30°C	0.5% Cobalt-1 1.0% CuHP	0.5% Cobalt-1 0.7% CuHP	1.0% Cobalt-1 1.0% CuHP 0.075% TBC

Reactivity of Atlac® 5200 FC
vs Low Activity MEKP concentrations at different temperatures

Constant accelerator concentration:
Cobalt-1 = 1%



Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance, and to comply with food contact regulations. Recommended postcure conditions are 3 to 6 hours at 80°C – longer times and adjusted postcure schedules may be required for thicker laminates and/ or more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Cleaning

After the production of the part, it is important to clean it with steam before use. This is to avoid the potential migration of resin/ glass ingredients into the food or water contained in the part.

Inhibitor systems

Geltime may also be controlled by the use of inhibitors. For food contact applications 1,4-dihydroxybenzene (standard Hydroquinone) is recommended, because of its listing as authorized polymer production aid in EU commission regulation 10/2011 (Plastic materials and articles intended to come into contact with food). The amount of 1,4-dihydroxybenzene is regulated with a specific migration limit (SML) of 0.6 mg/kg, to be measured on the finished article.

When using other types of inhibitors, resolution AP (92)2 needs to be verified(Control of aids to polymerization for plastic materials and articles intended to come into contact with foodstuffs). Evaluation of the SML or threshold limits needs to be determined case by case. Please contact your AOC Technical Service representative for advice.

Thixotropy

It is not recommended to make this resin thixotropic, as many additives are not approved for food contact and drinking water applications. Please contact your AOC Technical Service representative for additional advice.

Liquid resin

Cured resin, Standard MEKP/ cobalt curing system

Cured resin, BPO/ Amine curing system

Product information

Atlac® Premium 600

Chemical/ Physical nature

Atlac® Premium 600 is a thixotropic modified epoxy bisphenol A vinyl ester resin, dissolved in methacrylates.

Performance

Atlac® Premium 600 provides excellent chemical resistance against solvents, acids and oxidizing media. In particular, Atlac Premium offers a high resistance to organic solvents. Atlac Premium 600 is styrene free and can therefore be applied without emission and close-to-zero smell.

Major applications

Atlac® Premium 600 can be used in all fabrication methods, but is specially adapted to meet the requirements of hand lay-up and spray-up applications.

Typical properties liquid resin

Properties	Range	Unit	TM
Appearance	hazy	-	TM 2265
Viscosity, 23°C, 20s-1	1250-1550	mPa.s	TM 2313
Density, 23°C	1100	kg/m3	TM 2160
Gel time	14-20	min	TM 2259
Peak time	21-33	min	TM 2259
Peak temperature	110-175	°C	TM 2259

Curing system used
1.0% Cobalt accelerator (1%)
0.8% Di(4-tert-butylcyclohexyl) peroxydicarbonate
1.0% tert-Butyl peroxy benzoate

Test methods
Test methods (TM) referred to in the tables are available on request.

Typical properties cured resin - non reinforced

Properties	Value	Unit	TM
Hardness	40	Barcol	TM 2604
Tensile strength	66	MPa	ISO 527-2
Elongation at break	2-5	%	ISO 527-2
Tensile modulus	3.3	GPa	ISO 527-2
Flexural strength	120	MPa	ISO 178
Flexural modulus	3.4	GPa	ISO 178
Heat Deflection Temperature (HDT)	103	°C	ISO 75-A

Curing system used
1.0% Cobalt accelerator (1%)
0.8% Di(4-tert-butylcyclohexyl) peroxydicarbonate
1.0% tert-Butyl peroxy benzoate

Postcure
24 hrs at 60°C followed by 24 hrs at 80°C

Typical properties reinforced laminate

Curing system	Laminate build up	
1.5% Cobalt accelerator (1%)	450 g/m² CSM	450 g/m² CSM
2.0% LA-MEKP	450 g/m² CSM	800 g/m² WR
Postcure 24 hrs at 60°C, followed by 24 hrs at 80°C	450 g/m² CSM 450 g/m² CSM	450 g/m² CSM 800 g/m² WR 450 g/m² CSM 800 g/m² WR

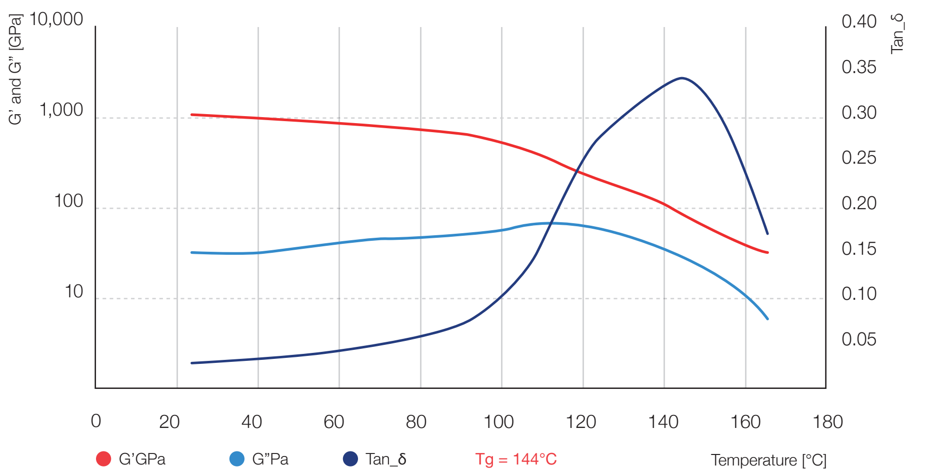
Properties/ Unit				Test methods
Glass content	%	38	54	ASTM D 2584
Tensile strength	MPa	117	256	ISO-527-2
Modulus of elasticity in tension	GPa	8.1	13.8	ISO-527-2
Flexural strength	MPa	206	323	ISO-527-2
Modulus of elasticity in bending	GPa	8.7	17.4	ISO-178
Density	kg/m³	1,443	1,610	-

Dynamical Mechanical Analysis (DMA)

In torsion mode the DMA measures the storage modulus (G') and loss modulus (G") of the resin (frequency is 6.22 rad/sec). Based on the moduli the tan delta (tan_δ) can be calculated. The peak in the tan_δ curve corresponds to the glass transition temperature (Tg), indicating the change from glassy to the rubbery state. Standard (post)curing systems have been used.

Dynamic Mechanical Analysis

Atlac® Premium 600

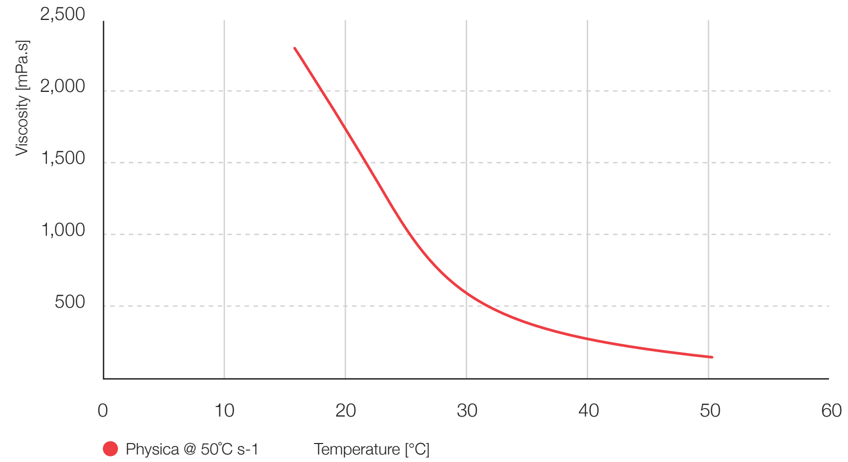


Viscosity versus Temperature

The viscosity of the Atlac® Premium 600 resin can be influenced by temperature. We do not recommend to modify the viscosity by the addition of additional monomers.

Viscosity versus Temperature

Atlac® Premium 600



Atlac Premium 600: Typical geltimes, using Low activity MEKP/ Cobalt

Used curing agents: Low activity Methyl ethyl ketone (LA-MEKP), Cobalt 1%, Dimethylaniline (DMA) 10%.

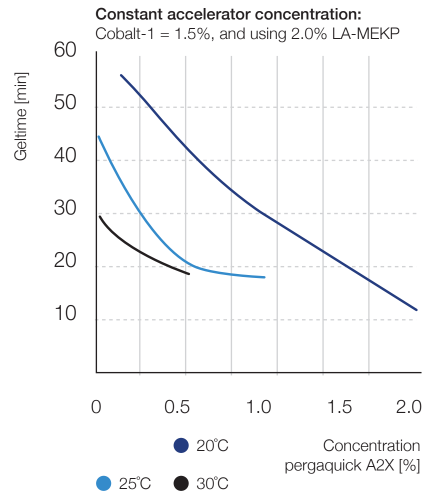
Temperature	10-20 minutes	20-40 minutes	40-60 minutes
15°C	Not recommended	Not recommended	Not recommended
20°C	1.5% Cobalt-1 2.0% LA-MEKP 1.5% DMA-10	1.5% Cobalt-1 2.0% LA-MEKP 1.5% DMA-10	1.5% Cobalt-1 2.0% LA-MEKP 1.5% DMA-10
25°C	1.5% Cobalt-1 2.0% LA-MEKP 0.8% DMA-10	1.5% Cobalt-1 2.0% LA-MEKP 0.3% DMA-10	1.5% Cobalt-1 2.0% LA-MEKP
30°C	1.5% Cobalt-1 2.0% LA-MEKP 0.5% DMA-10	1.5% Cobalt-1 2.0% LA-MEKP 0.1% DMA-10	1.5% Cobalt-1 1.0% LA-MEKP

If you would like to cure the laminate with BPO,

please contact your AOC Technical Service Representative for advice.

Reactivity of Atlac® Premium 600

vs. DMA-10 concentrations at different temperatures



Post-curing

Post-curing is necessary to obtain the optimum heat and chemical resistance of the Atlac high performance resins. Recommended postcure conditions are 3 to 6 hours at 80 to 100°C – longer times and adjusted postcure schedules being required for thicker laminates and for more complex shapes. Lower temperatures are ineffective; higher temperatures can lead to embrittlement.

Inhibitor systems

Control of geltime may also be achieved by the use of inhibitors; the most widely available is a 10% solution of Tertiary butyl catechol (TBC). Additions above 0.25% can lead to undercure. Use at workshop temperature below 15°C is not recommended. TBC is not effective with cumene hydroperoxide systems.

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