

# PHYSICAL PROPERTIES/ HANDLING CHARACTERISTICS OF MAS RESINS AND HARDENERS

## Low Viscosity Resin

## FLAG - Medium Viscosity Resin

	RESIN	SLOW	MEDIUM	FAST	FLAG	SLOW	MEDIUM	FAST
Color (Gardner)	1	3	2	2	1	3	2	2
Viscosity @ 77°F, cp unmixed,	850-1000	200	225	250	3000-3400	200	225	250
Specific Gravity @ 77°F/ 25°C	1.08-1.13	1	1	1	1.09-1.15	1	1	1
Flash Point (closed cup) °F	>200	234	242	250	>200	234	242	250
% Reactive Solids	100	100	100	100	100	100	100	100
<b>HANDLING PROPERTIES:</b>								
Mix Ratio: 2:1 Resin to Hardener	2 parts	1 part	1 part	1 part	2 parts	1 part	1 part	1 part
Mixed Viscosity w/ MAS Low					Mixed w/ FLAG Resin @ 77°F			
Viscosity Resin @ 77°F / 25°C		550-700 cps	550-700	550-700		1600 - 1825	1600 - 1825	1600 - 1825
Pot Life, mins. (150g mix @ 77°F/ 25°C)		27	12	7		22	12	7
Thin Film Set Time, hrs. @ 77°F/ 25°C		5	3	2		4	3	2
Peak Exotherm, °F (30g mix @ 77°F/ 25°C)		250	340	370		260	350	380
Peak Exotherm Time, mins.		29	15	10		25	13	9
<b>FULL CURE TIME (DAYS):</b>								
		7	5	2 TO 5		5	4	3
<b>PERFORMANCE:</b>								
T <sub>g</sub> (Glass Transition Temp) °F		131	132	136		140	140	141
Barcol Hardness (Model GYZI-935)		83	82	82		83	82	82
Bond Strength, psi (steel to steel)		1850	1925	2000		1850	1925	2000
Flexural Strength, psi		14600	15235	15870		14600	15235	15870
Flexural Modulus, psi		535000	445000	355000		535000	445000	355000
Tensile Strength, psi		6688*	7350*	6700*		6665*	7350*	6700*
Tensile Modulus, psi		315,000 +/-	315,000 +/-	315,000 +/-		315,000 +/-	315,000 +/-	315,000 +/-
Elongation, %		9	8	8		8	7	7
Compressive Strength, psi		14000				14000		
Compressive Modulus, psi		384000				384000		
* Physical properties are empirical and are subject to change based on formula updates. For recent independent lab test results, please contact us								

## Understanding All Those Numbers!

### A Users Guide to Understanding Epoxy Resin Testing for Physical Properties

Resins intended for the boat building and composites industry often carry with them a whole battery of figures which describe the resins handling characteristics and cured physical properties. We, as boat builders, place our work and job strategy on the former and the Naval architects, yacht designers and engineers use the latter in designing key structural components.

**Resin handling characteristics help us understand the flow and feel of a resin system.** For instance we may describe a resin as a liquid of a certain **viscosity**. This measure is described most commonly in centipoise. The instrument used to measure viscosity is a viscometer (we use a Brookfield Viscometer a standard in

the industry). Viscosity is very temperature dependent. Lower temperatures usually result in a viscosity increase. Higher viscosity figures represent a liquids resistance to flow. What this all boils down to is the resin we love to laminate with at 65°F may be a real bear at 45°F.

Another handling characteristic of importance is the **pot life and thin film set time** of a resin system. **These two properties help us plan our work pace.** The pot life is almost always shorter than the thin film set time as the pot builds heat and inspires a faster rate of curing. The thin film may stay flowable for many hours while a pot life may be described in minutes. Since we offer 3 "speeds" to cure our resins most builders will find

one hardener fits most of their requirements while the others represent "special" applications (beauty is in the eye of the beholder).

**Resin handling characteristics vary.** We have very narrow specifications for resin and hardener viscosity (though it is a range), color, and various chemical values. What this means is that the average builder should notice no variation between a one-gallon of resin and the next even if they were produced in separate batches.

Cured physical properties are also closely measured both by our in house testing facilities and out-sourced certified testing labs (such as Structural Composites). We have tested thousands of coupons (dog bones) over the years. **There is considerable variation in the data due to many outside influences too numerous to mention. The figures found in our catalog and other literature, represent the statistical mean (our most accurate averages) of all known data.**

We have over the years determined that the average maximum strain figure of 8%-10% is our target (this means the resin when cured can stretch 8-10% before breaking). We have on occasion had test figures as high as 12% and as low as 2.5%. Usually the reason for variation in tensile strain and stress results are due to air bubbles in the test coupon resulting in concentration of stress and an early failure mode (this is why we like to get bubbles out of parts).

Modulus (a calculated figure based on both stress and strain  $y = mx + b$ , where  $y$  is = to stress, and  $x$  is = to strain) on the other hand shows little variation due to air bubbles. Modulus is more variable when the sample is aged and temperature cycled. In our opinion, we are less concerned about the results we get from a 2 week old coupon versus a 2-year-old coupon, which has been subject to both high and low seasonal temperature exposure. These coupons represent the masts we sail, and the boats we enjoy after they have been built.

Many polymers become brittle with age. If the epoxy grows brittle the boat becomes less durable and more prone to cracking (just like us). Here at MAS we take this very seriously. We have an excellent track record in both the new construction and repair of fine boats. We can assure all builders that this very important parameter has been formulated for and consciously

engineered for a long lasting boat.

Thermal properties of a resin system help us determine the stability of the boat through out the normal operating temperature spectrum. We normally discuss the thermal stability of an epoxy resin as Tg (t-sub-g). If the Tg of a resin system is too low the boat will tend to fail in highly loaded areas on hot days (not good). We have seen failures like this in the field (fortunately none in MAS). Higher Tg's are usually considered an advantage as long as the formula retains its durability.

**All MAS formulas are optimized for the greatest possible Tg in conjunction with durability.** We have at MAS a new technique for measuring the durability of a laminate. In fact, we are to credit with the design of the test fixturing, and development of the testing protocol. There are currently only two such fixtures in the world, we own one and one of our customer owns the other one.

It is our opinion that the measurement of **Tg** is the most effective means of quantifying a resin systems upper temperature limits. The *older* technique of **HDT** (heat deflection temperature) is a testing procedure by which coupons are subjected to a temperature controlled oil bath while under a specified load. When the coupon yields to a certain degree the Heat Deflection Temperature is noted. Tg is measured on an analytical instrument known as a Differential Scanning Calorimeter (DSC). Data is collected through out a temperature range and the inflection "deflection" points are determined by the use of interpretative software. DSC results generate a minimum of waste and are repeatable and quantifiable. HDT results are affected by the same group of problems, which plagues all coupon production as mentioned above.

All builders, amateur and professional alike, should feel both comfortable and reassured that we have been looking out for your interests for over 10 years and thousands of data points.