MAY 2014

ADVANCED ADHESIVES REPORT

Your corrugating newsletter from Harper/Love Adhesives Corporation

Evaluating wet strength requirements

How much wet strength do you really need?

By Lou Cuccia

Today's corrugated industry deals with a mixture of wet strength levels depending on the application of the combined box. Wet strength needs range from humidity changes to top ice. A commonly used term for all levels is waterproof adhesive. What has to be determined first is what level of wet strength an application really needs. The industry can be broken down into three acceptable levels of wet strength board: Moisture Resistant Adhesive (MRA), Water Resistant Adhesive (WRA) and Water Proof Adhesive (WPA).

Moisture Resistant Adhesive (MRA)

MRA is used in lightweight applications where a minimum amount of wet strength is required for storage or shipping.

A typical MRA starch will contain approximately 0.5 to 0.75 percent liquid resin relative to the liquid volume of the adhesive. In a 300 gallon batch, you would typically add 1.5 to 2.25 gallons of resin or 15 to 22.5 pounds. Doser units are normally preset from the supplier and follow similar ratios. A MRA doser addition rate for resin is 20 to 30 ounces for a 30 gallon starch adhesive refill. There is no TAPPI test for MRA board. Generally, a one-hour soak test using a procedure similar to TAPPI method T-812 will be sufficient. If the board doesn't soak apart, the box meets the minimum requirement level for MRA.

Water Resistant Adhesive (WRA)

WRA is used in medium to heavyweight applications where small changes in humidity, certain food products or slight exposure to moisture is possible.

A typical WRA starch will contain approximately 0.75 to 1.0 percent liquid resin relative to the liquid volume of the adhesive. In a 300 gallon batch, you would typically add 2.25 to 3 gallons of resin or 22.5 to 30 pounds. A WRA doser addition rate for resin is 30 to 40 ounces for a 30 gallon adhesive starch refill.

The most widely used test method for WRA is TAPPI-812, commonly referred to as the 24-hour soak test.

Water Proof Adhesive (WPA)

WPA is used in medium to heavyweight applications where wax or a special waterproof coating is applied to the box when exposure to moisture or humidity change is imminent.

A typical WPA starch will contain approximately 1.0 percent to 1.5 percent liquid resin relative to the liquid volume of the adhesive. In a 300 gallon batch, you would typically add 3 to 4.5 gallons of resin or 30 to 45 pounds. A WPA doser addition rate for resin is 40 to 60 ounces for a 30 gallon adhesive starch refill.

The most widely used test method for WPA is TAPPI-812, 24-hour Soak Test or TAPPI-821, Dry Pin Adhesion Test with a one-hour soak prior to testing. This is referred to as a wet pin adhesion test. TAPPI is currently working on a new standard test method for wet pin adhesion test for corrugated board by selective separation and should be completed this year.

In addition to adding the recommended amounts of resin, you need to be aware of the process guidelines.

Katherine Hodges Harper

August 23, 1933 – May 3, 2014

We are saddened to relay the news of Katherine Harper's passing. Mrs. Harper was a woman of energy and accomplishment; an inspiration to her family and her business associates.

During her career, she served on, and led, many boards and committees in flexographic technical associations, often as the first woman to do so. She was the first female chairman of the Foundation of the Flexographic Technical Association International Forum and also the first female to chair an International Conference for the Technical Association of the Pulp and Paper Industry. The Business Journal recognized her as Business Woman of the Year in 1999.

Together with her life partner, Ron (1932-2012), she embraced and nurtured ideals of vision, integrity, and service. In 2007, Mr. and Mrs. Harper became the founding sponsors of the FTA Technical Education Services Team (TEST) program. They formed Harper/Love Adhesives as a joint venture with N. B. Love, of Australia, in 1978.

Guidelines for achieving wet strength testing for WRA and WPA.

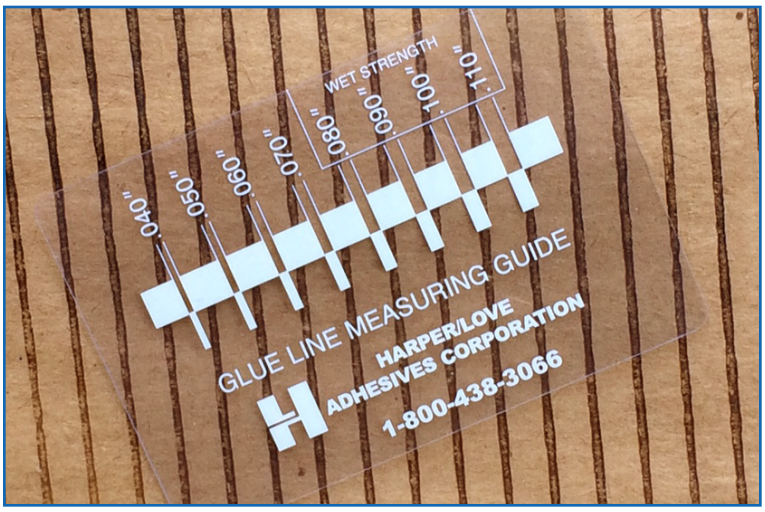
1. Prepare the WRA and WPA resins approved formulas and check the finished batches to assure they meet quality parameters.
2. Use freshly resinated adhesive.
3. Increase adhesive application rates to recommended glue line widths to achieve the corresponding water resistance levels:

Recommended glue line widths (inches)

	MRA	WRA	WPA
SF	0.080	0.090	0.110
DB	0.070	0.080	0.090

As application rate is increased, the adhesive shoulders are also increased which provides a barrier for the flute tip against water penetration.

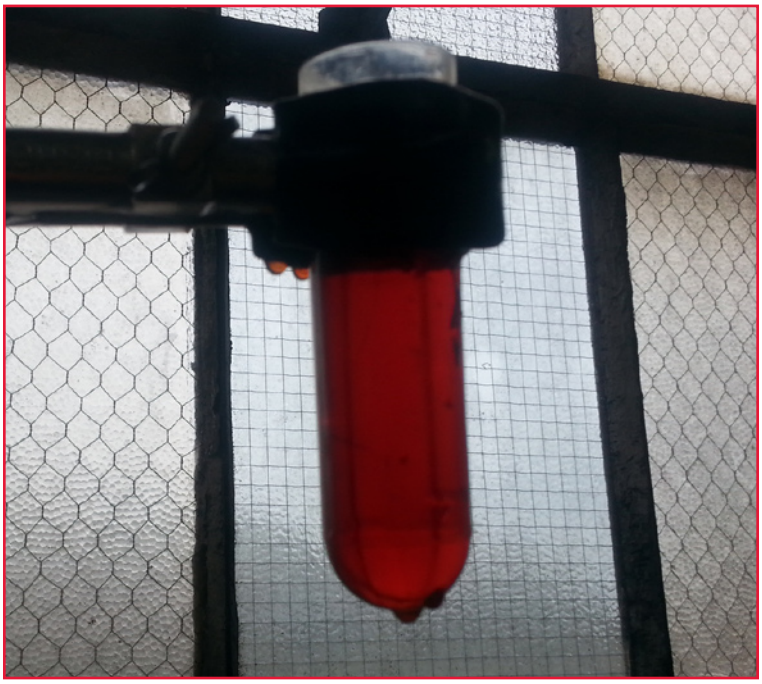
4. Use a high-solids adhesive formula (27 to 29 percent).
5. Run moist glue lines off the corrugator (green bond).
6. Use the minimum wraps/bridge content.
7. Paper liner temperatures are best around 180° F.
8. Liners should be wrapped to drive moisture to glue line.
9. Run at the highest speed possible.
10. The medium steam shower is crucial. We recommend full steam shower with limited medium wrap. Dry medium will not allow starch to penetrate into the fibers. While an overheated or over dried board may exhibit no deterioration in dry bond strength, the wet strength can be dramatically diminished. The amount of fiber tear will indicate the amount of penetration into the paper. If there is little fiber tear, you have a *surface bond* which will result in poor wet strength.



11. Allow the board to sit in stacks for a minimum of 2 to 4 hours. The longer the better as long as the stacks remain warm and moist. Samples that are not stack-cured will produce lower test numbers. Extended heat and moisture in the stack provides an excellent environment for additional water resistance development.
12. Always pull multiple samples to be tested from the stack-cured unit about 18 inches down in the stack.

Harper/Love Adhesives Contributors:

Bill Gerard, Mgr. NE Region
Lou Cuccia, Mgr. SE Region
Pete Snyder, National Sales Representative



All resins are not created equal

By Rex Woodville-Price

Today the corrugated industry uses ketone aldehyde resins, almost exclusively, to provide moisture resistance to starch based adhesives. Using a good quality resin is a critical step to ensure consistent and predictable performance on the corrugator in order to produce boxes with satisfactory wet resistance.

Ketone aldehyde resins are made by reacting acetone and formaldehyde in a temperature controlled vessel called a reactor. The reaction is very exothermic, meaning it gives off heat, lots of heat in this case. Therefore, the reactor must be cooled in order to keep the temperature in the desired range and thus help control the rate of reaction. Vacuum cooling is often employed because it quickly removes the excess heat and also strips off some of the water, further concentrating the resin.

Other chemicals are also included in the reaction; for example, caustic soda can be employed as a catalyst to make the reaction environment corrosive and promote the polymerization of the monomers. That just means that we

Additional information on wet strength board testing is available on our web site. Look for the newsletter link and scroll to August 2009 or February 2004.

Wet strength testing

By Peter Snyder

Corrugated boxes are used for a variety of packaging needs, including ones that require the boxes to withstand harsh environments. One of the more difficult environments for corrugated boxes to survive is one that exposes them to a variety of moisture levels, including hydrocooling with icewater. (This hydrocooling technique is used to chill quickly field-picked produce). The reason this can be problematic is that the bonded substrates will absorb water and the adhesive used to bond the substrates will also absorb water. This is a critical issue because all the active ingredients used in the adhesive formulation are soluble in water, even after a fiber tearing bond has been created between liner and medium. When the adhesive in a finished box gets partially or completely dissolved then the container will fail under a normal load. These vulnerable water soluble adhesive ingredients include the base starch along with caustic soda and borax. In order to create a container that will resist failure in a humid or wet environment the use of a wet strength resin is a requirement in the adhesive formulation. For wet strength corrugated board our industry has developed test methods to gauge potential performance. Experience has shown that planning for a slightly harsher environment will always pay dividends for the best wet strength board performance in the field.

Corrugated board can be tested for resistance to failure upon exposure to moisture with several different methods. The two most common tests used in the United States are:

1. TAPPI Test T-812: The 24 Hour Soak Test.

Some variations in this test have been established to allow for shorter soak periods of 20 minutes, 1 hour or 6 hours for the needs of certain box customers.

The results of this test are *pass* or *fail*. If the liner on either side of the approximately 6 X 10 piece of corrugated board does not stay adhered to the medium after soaking in room temperature water for the time allotted the result is a *fail*. If the board continues to cling together after the 20 minute, 1 hour, 6 hour or 24 hour soak then the result would be a *pass*.

2. Wet Pin Adhesion Test. This is an adaptation of TAPPI Test T-821: Dry Pin Adhesion Test.

To perform a wet pin adhesion test many plants use TAPPI T-821 whereby the test specimens are soaked for one hour in room temperature water prior to testing with the traditional pin jigs.

Dry pin adhesion numbers will vary with many factors including board basis weight, adhesive application level and manufacturing conditions. The dry pin number reported is usually in pounds/lineal foot of glue line. This test can be selective to test SF and DB separately or be set up to be non-selective whereby the weaker side will break to end the test.

- Selective pin adhesion tests are recommended.
- An acceptable dry pin number is often in the 45 to 60 lbs/linear ft range.
- An acceptable wet pin number will depend on the end use of the board. In many cases the best wet pins for non waxed board will be 5 to 10 percent of the dry pin number. An example would be achieving dry pins of 50 lbs/linear ft for a certain box sample and then achieving wet pins in the 2.5 to 5 lbs/linear ft range.

take many smaller molecules and join them to make long chains called polymers.

Formaldehyde scavenging agents such as urea are used to ensure that no free formaldehyde is present in the final product. After the resin comes out of the reactor it must be distilled, to remove water and concentrate it, increasing its effectiveness.

Our unique understanding of the wet strength requirements of box plants equips us to tailor our manufacturing process to yield resins that give superb performance on the corrugator and in the box. Varying several factors in the manufacturing process such as the ratio of formaldehyde to acetone, the temperature of the reaction, and the speed at which the reaction is allowed to progress, will yield different grades of resin, with different physical and chemical properties. We manipulate these process variables to give our resins certain boutique qualities such as purity and a dependable rate of reactivity. With such a resin, a smaller amount is needed to give the same level of performance as compared to a lesser product.

We conduct extensive quality assurance tests on our resins to ensure consistent and predictable performance. QC tests such as the resin gelatinization test, predict its rate of reactivity. How fast a resin gels is an indicator of how aggressively it will react once it is added to the batch. Reactivity of the finished product is what we experience as resin shock in the adhesive. We design our resins so that they will not cause resin shock, yet will crosslink expediently once the adhesive gelatinizes.

Ketone aldehyde resin behaves somewhat like a liquid plastic. Its function in the adhesive is to cross link with the starch molecules and make them resistant to redissolving in a humid environment. This is a thermosetting process, which begins after the starch based adhesive gelatinizes in the machine. The resin requires only about 125° F (52° C) to set it off, while most adhesive gels above 140° F. The reaction is irreversible; once it dips below 125° F it will not reinitiate even if the temperature is once again raised above the threshold temp. As long as the requisite temperature is maintained, the cross linking will continue for several hours, becoming increasingly insoluble and thus more moisture resistant. This process continues in the stacks and is aptly referred to as stack cure.

Leaders in the science of making good adhesives better™

Harper/Love Adhesives Corporation
11101 Westlake Drive
P.O. Box 410408
Charlotte, NC 28241-0408
800-438-3066 • www.harperlove.com
e-mail: salestech@harperlove.com

In this issue:

- **Evaluating wet strength needs**
- **All resins are not equal**
- **Wet strength testing**

Aquaseal™ W-150 wet-strength resin

Aquaseal W-150 is our workhorse liquid thermosetting resin. It features zero free formaldehyde and offers excellent pot life and low batch shock properties. Excellent water-resistant glue line protection. Promotes superior board quality, and efficient production.

Uses:

- Wet-strength corrugated board production
- Improve overall board quality for finishing

Operational benefits:

- Exceeds TAPPI 24-hour soak tests
- Convenient liquid form
- Safe and easy to use
- Compatible with automatic starch kitchens
- Distinctive red color provides visual assurance of use
- No resin shock to the adhesive
- Zero free formaldehyde: complies with OSHA regulations

Use 15 to 30 pounds per 300-gallon batch. Available in 55-gallon drums, 275-gallon totes.