L&L Products

L-F610: Reformable Epoxy Adhesive Film

Commercial presentation - April 2015

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A Novel Epoxy Adhesive Film

Reformable Epoxy Adhesive Film

- New polymeric epoxy based thermoplastic with adhesive capabilities.
- Amorphous materials
- Exhibits excellent adhesion to a variety of substrates while retaining the handling and processing ease of a thermoplastic.
- Good candidate when typical thermoplastic adhesive films require superior adhesion strength and stiffness.
- **L-F610 replaces messy and time consuming liquid epoxy materials.**
- **Can be used to wet fabrics.**

Key Features & Benefits

of L-F610 Reformable Epoxy Adhesive Film

- **High strength, rigidity and toughness:** strain-to-failure up to 40%
- Better adhesion than traditional thermoplastic adhesive systems:
  dissimilar substrate structural bonding applications ranging from treated Polyethylene to SMC, PA, natural fibers, carbon fiber, epoxy, glass…
- **Short cycle times** needed for bonding
- Dry-to-the-touch and transparent
  Usable for applications where a good cosmetic finish is required
- Shelf life: 2 years if stored away from UV exposure
- Unlike most epoxy adhesive films, it can be stored at room temperature
  No refrigeration is needed
- Flexible, clear and low odor
- Fully thermoplastic
- Recyclable
- Repairable / formable
- Bonding - Debonding capability
  Allowing parts and components to be modified in existing structures

Typical Properties

		L-F610
Physical Properties	Color	Clear
	Thickness	127 μm / 0.005 in (other thickness can be explored)
	Weight	151.34 g / m2 / 0.031 lbs / ft²
	Standard Width	1.542 m / 60 in
	Tg (Amorphous)	80°C / 176°F
	O2TR, BU (60% RH; 23 °C)	0.8 BU
	CO2TR, BU (60% RH; 23 °C)	3.9 BU
	Yield Stress	8400 psi / 58 MPa
	Break Stress	6900 psi/ 47.6 MPa
	Break Elongation	40%
	Flex Modulus	387,000 psi / 2.67 GPa
	Notched Izod	13 J / m / 0.2 ft-lb / in
	Creep	Testing in progess
Optical Properties	Clarity (ASTM D 1003)	99%
	Haze (ASTM D 1003)	2.7%
	Light Transmittance (ASTM D 1003)	93%
	Yellowness Index (ASTM D 925)	2.1%

Structural Adhesion Properties

- L-F610 develops adhesion with heat and pressure:
  - Typical bonding temperature range 150° C / 300° F - 176° C / 350° F
  - Lower temperatures better suited for cellulosic products
  - Processing Temperatures should not exceed 230° C / 445° F
  - Typical time : less than 1 to 15 minutes
- There is no gel time since this epoxy is a thermoplastic. It solidifies below Tg (80° C / 176° F). The quicker the material cools down, the quicker it solidifies. Handling time can vary from seconds to minutes depending on the application.

LAP SHEAR OF ADHESIVE FILM				
Substrate	Surface Treatment	Test Temperature	LS Strength	Failure
Galvanized Steel (G/10)	Degreased	23°C	15 MPa	95% CF
Aluminum	Sand Paper	23°C	13 MPa	95% CF
Aluminum	Chemical Deoxidation	23°C	19 MPa	95% CF
Aluminum	Chemical Deoxidation	-55°C	16.5 MPa	95% CF
Aluminum	Chemical Deoxidation	80°C	14.4 MPa	95% CF
Aluminum*	Sand Paper	23°C	11 MPa	95% CF
Epoxy and Glass Fiber	Cleaned with Alcohol	Room Temperature	13 MPa	100% CF

Bond line 0.25 mm

*Humidity aging : 336h at 70° C and 70% RH

Additional adhesion testing on going. Experience shows excellent results with treated Polyethylene, SMC, PA, wood and natural fibers, carbon fiber, epoxy and glass.

Product form

L-F610 format

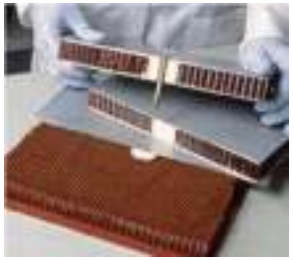
- Comes in a roll format:
  - **Thickness**: 5 mil/127 µm
  - **Width**: 60 inches/1.542 m
  - **Length**: 250 yard/ 228 meters long
- Can be custom made in a 2.5 mill and thicker under specific conditions
- Material is dry to the touch (non-tacky)
- Lead time can vary (talk to our Sales Representatives)
- Material should be stored below 32° C / 89° F, away from all sources of heat and sunlight.

Shelf Life

- 2 years if stored away from UV exposure
- Can be shipped and stored in multiple type of climates if storage at recommended temperatures

Made in the U.S.A

Films rolls



Markets

L-F610 is used and evaluated within multiple markets today:

Sporting goods
- Looking for a clean and rapid manufacturing solution.

Industrial Composites/Armor
- Looking at automated laminates manufacturing.

Aerospace
- Looking at easier panel maintenance and increased panel assembly speed.

Office furniture applications
- Looking at bonding substrates with a higher strength than thermoplastics.

Automotive
- Looking for a solution that is easy to store and that is an easy to use epoxy for reinforcement and trim applications.

Customer Feedback

"We can eliminate liquid epoxies and use this dry film for faster and cleaner manufacturing."
- Snow sport industry

"Stampable composites are now possible, allowing the entire manufacturing process to be fully automated."
- Armor industry

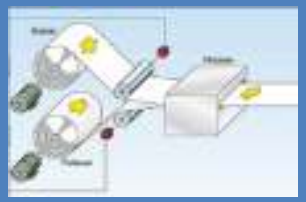
"This film can bond difficult surfaces together. This allows us to develop multiple new laminate combinations with just one unique product."
- Furniture industry

Future Developments

L-F610

Dry Epoxy UD Tape

Dry Epoxy Pre-Preg



In line lamination

Hybrid Epoxy Fabrics

Stitching Yarn

Commingled fabric

Co-woven fabric

Hot melt gun

Pellet fed hot melt gun

These are development products, therefore, their status is evolving.

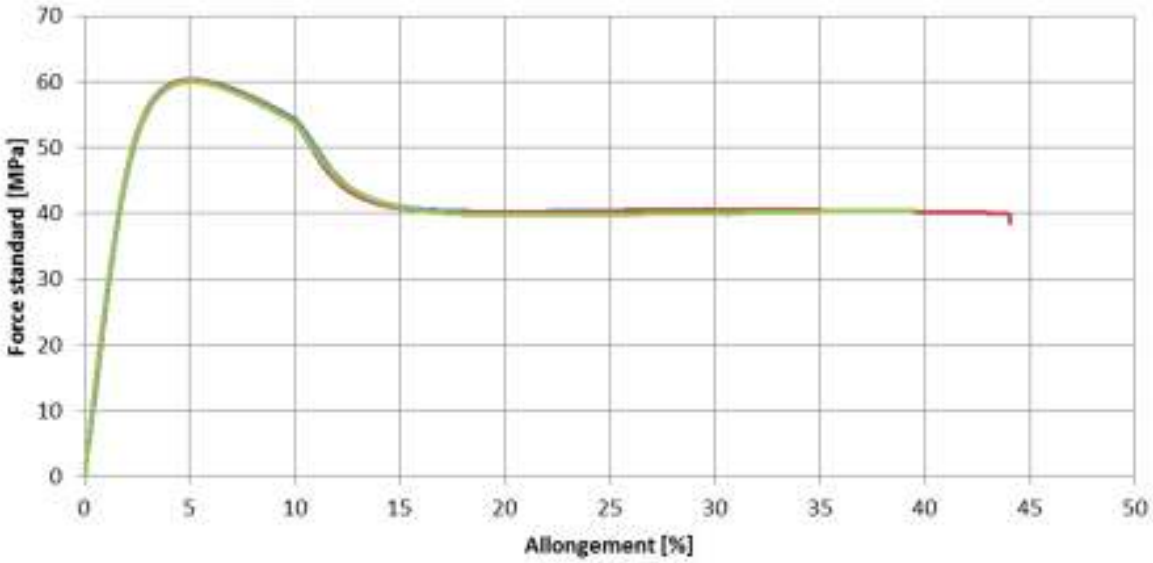
Ask you Sales Representative about their progress.

Appendix

- Tensile properties
- Value proposition

Tensile Properties (XP-TE01-15)

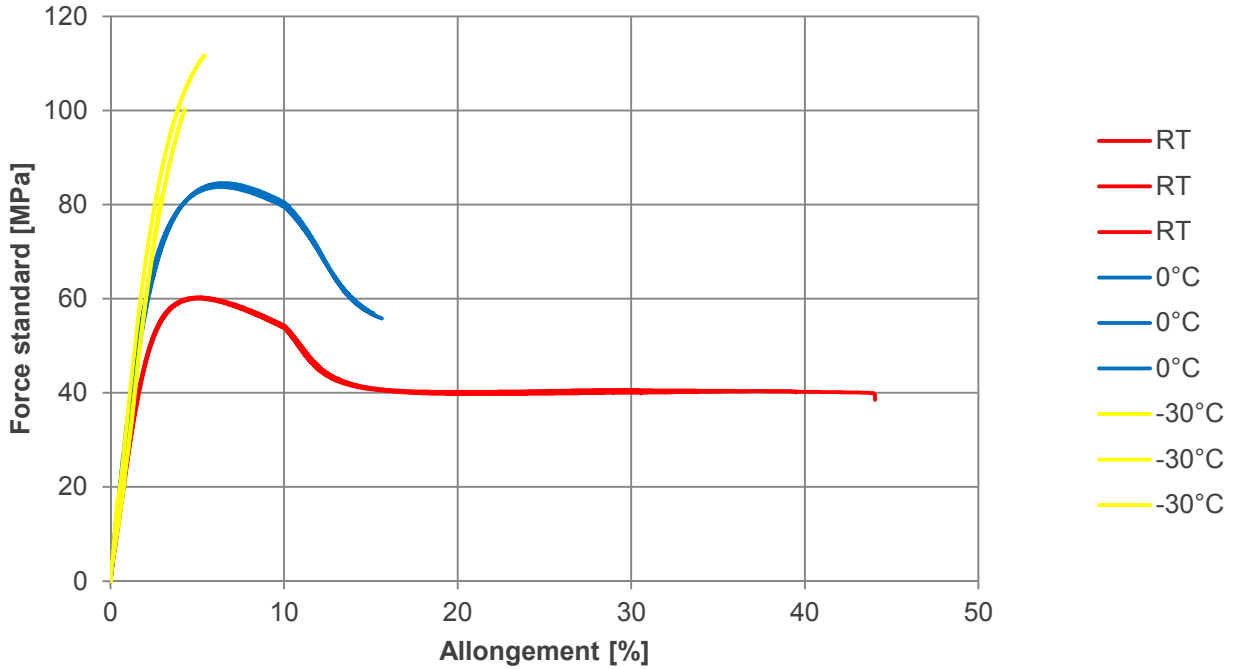
Toughness is similar to that of a typical thermoplastic:



Young Modulus	3000 MPa
Elongation @ yield	5 %
Tensile strength @ yield	60 MPa
Elongation @ break	40%
Tensile strength @ break	40MPa

Tensile Properties – Temperature Effect

XP-TE01-15	23°C	0°C	-30°C
Young Modulus	3000 MPa	2300MPa	3800MPa
Tensile strength @ yield	60 MPa	84MPa	98MPa
Elongation @ break	40%	18%	4%



L-F610 Film Value Proposition

Thermoplastic Properties

•Rapid bonding (1/2 min vs. 1 hour)

- Flexible processing:
  - Injection Molding
  - Extrusion
  - Film Casting
  - Blow Molding
  - Recyclable
  - Repairable
- Storage: No climate controlled room needed
- Flexible and dry to touch
- Shelf life: Greater than 2 years
- Clarity and Low Color
- Low Processing Temperatures

Epoxy Properties

- Adhesion to a variety of substrates and fibers
- Strength, Rigidity and Toughness
- Accepts high filler loading (Glass/ Carbon/ Aramid fibers)
- Particularly well suited for blending natural fibers