INTERPLASTIC CORPORATION
Thermoset Resins Divison

ISSUE 1

1 Tech Notes

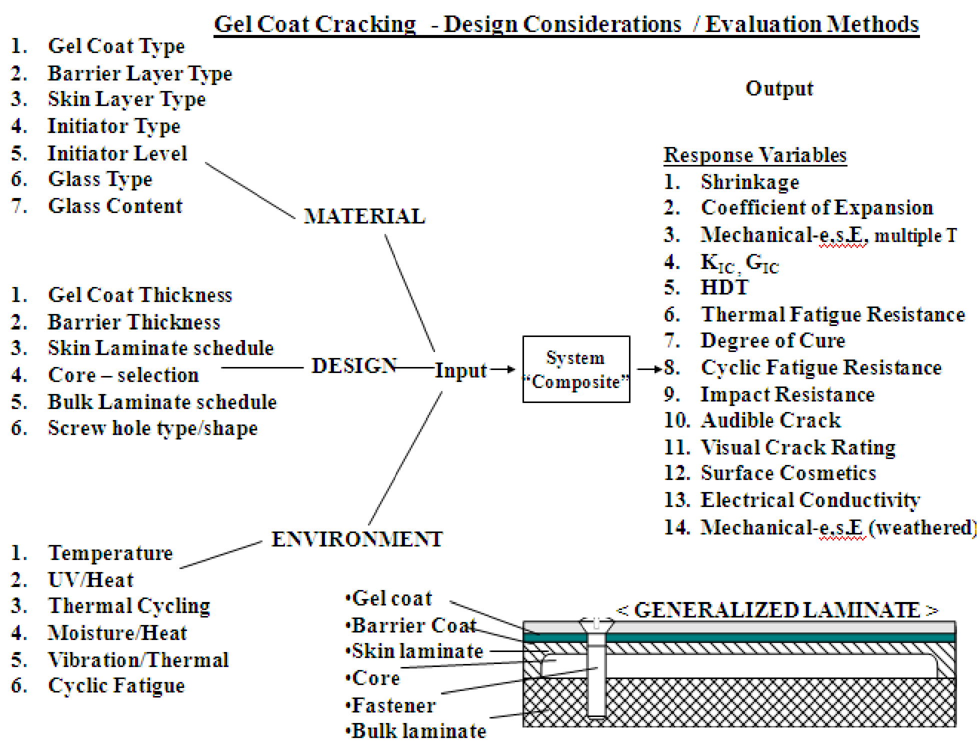
GEL COAT FLEXIBILITY

The Flex Strip Test

Gel Coat Flexibility: The Flex Strip Test

Background: Gel coat is used to improve the visual appeal of composites as well as to protect the structural laminate from damage stemming from exposure to ultraviolet radiation, mechanical abrasion or chemical attack. A crack in the gel coat compromises the aesthetics of the part and may result in faster migration of contact liquids into the laminate.

The gel coat cracks when the local stress on the part in the cracked area exceeds the maximum level of strain allowed for the gel coat. The level of strain required to produce a gel coat crack varies from one product to another. Cracking should be evaluated with consideration of the following three variables: (1) Materials, (2) Design, and (3) Environment. A crack may occur because the gel coat is simply too brittle for the application (material issue). Suboptimal laminate design, unnecessarily thick gel coat, insufficient mold preparation, rough demolding practices along with post production impacts can crack gel coats that are otherwise sufficiently tough for the intended application. The chart below lists some general variables that should be considered when determining the cause of a gel coat crack.



Standard test methods are available from ASTM (D-638, D790) and others for determining the flexural strength, tensile elongation and other mechanical properties of bulk resin or gel coat castings. The ASTM methods subject thick castings (0.25 inches) of the gel coat to controlled strain levels in a universal testing machine (ex. Instron, MTS).

Background Continued:

These tests are appropriate for laminating and casting resins, but they do not allow for testing of gel coat in the form that it will be used in during its in-service life. In addition to simple thickness differences, monomer level can have a significant impact on the mechanical properties of the cured film. A portion of formulated monomer is lost during the spray and cure cycles of any gel coat film and it is difficult to adequately account for this loss when making a bulk casting for mechanical tests. Ultimately, gel coat is applied and used as a thin film, so it is desirable to test the mechanical properties of the same thin film.

The Flex Strip Test was developed as a way to quickly and quantitatively test the flexibility of gel coat films. The gel coat is sprayed, allowed to cure, cut and then post-cured to produce ¼ inch wide strips of gel coat film for testing.

Test Procedure: CRSTP-348

References: Project#: 7599; Report: Flex Strip Test Method Development

Process:

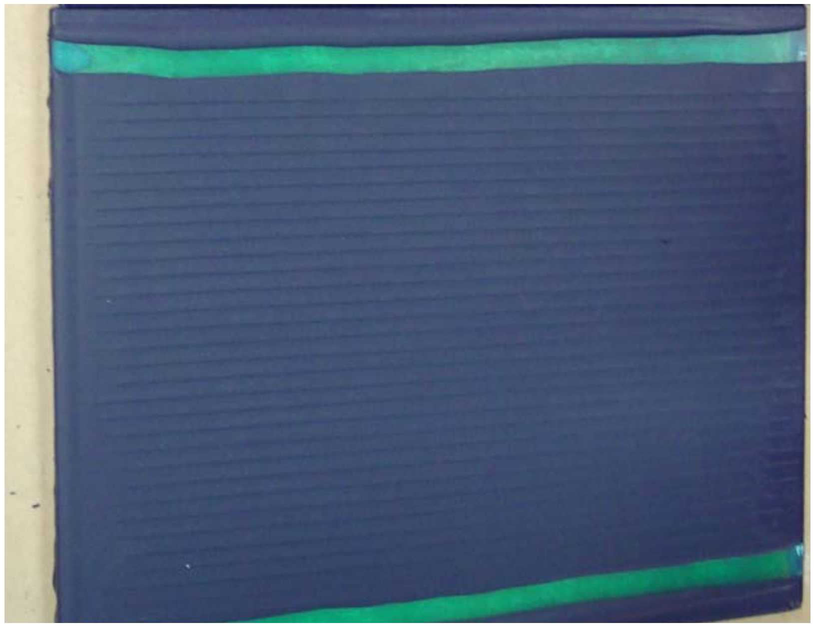
Apply a mold release agent to a glass plate then spray the glass plate with 30-35 mils or more of gel coat. Use a drawdown bar with a 25 mil gap to drawdown the gel coat into a film of consistent thickness. Allow the film to cure at room temperature (75°F +/- 3°F) until it is film cured. This cure time can be difficult to time properly particularly in low VOC and MACT compliant gel coats.

If the gel coat is too wet or tacky when the strips are cut they will adhere to the template and be destroyed. If the gel coat is too well cured when the strips are cut they may be difficult to cut and be prone to prerelease along the edges of each strip. This part of the test requires a bit of trial-and-error in order to achieve the best results. The film cure time of most gel coats ranges from 30-90 minutes and depends heavily on MEKP level, glass temperature and air movement.

Once the gel coat film is properly cured, place a sheet of parchment paper over the film. Parchment paper works best; waxed paper has a tendency to stick to the gel coat. On top of that, place a paper template that has printed lines spaced ¼ inch apart and secure it to the parchment paper using masking tape. Use a rolling cutter or sharp knife to cut along each line to produce a sheet of 20-25, ¼ inch gel coat strips. Gently remove the template and parchment paper leaving the strips still stuck to the glass plate.

In order to fully cure the strips, post-cure them in an oven at 200°F for 3 hours. After that time carefully remove the strips, still attached to the glass plate, from the oven and allow them to cool for 16-24 hours before testing them. It is important to allow the gel coat to have an equilibration period between the post-cure cycle and the test. The internal stress that develops during the rapidly accelerated cure should be allowed to partially relax before testing mechanical properties.

Process Continued:



Approximately 25 flex strips, still attached to the glass plate.

After the cool-down period remove the strips from the glass plate. Inspect each strip to determine its quality. If the strip is warped or curved the strip prereleased during the post-cure cycle and it no longer exhibits a geometry that will provide reliable results using this test.

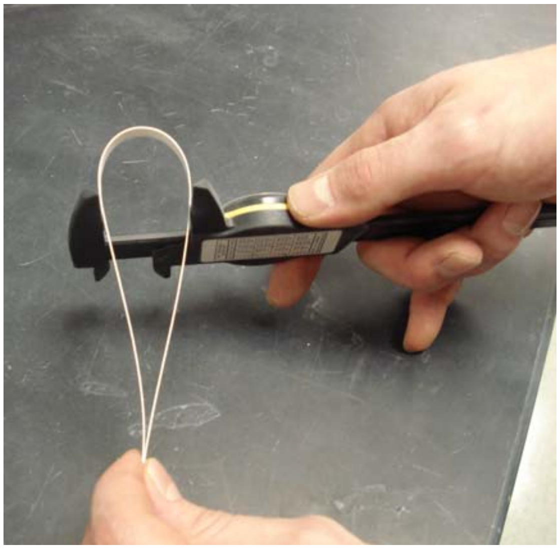
For testing, obtain a micrometer and a caliper.

Micrometer

Caliper

Process Continued: Determine and record the thickness of each strip using the micrometer (thickness should be around 0.0150 inches or 15 mils). The measurement should be done on the center of the strip where it will be bent for testing.

Bend the first strip into a teardrop shape with the mold side (glossy side) facing out. Pull the strip through the jaws of the caliper. Reduce the gap between the jaws and pull the strip through again. Repeat this procedure until the strip breaks and record the final reading from the caliper. Continue to test until all strips have been broken.



Record the thickness and fail diameter of each strip in a spreadsheet for calculation. Use the equation below to calculate the percent elongation for each strip. Calculate the mean elongation of the 15-25 strips and calculate the standard deviation. If the standard deviation is less than 10% of the mean value, the test can be considered valid. If the standard deviation is more than 10% of the mean the variability is too high and the results should be discarded.

$$\%\,\text{elongation} = \varepsilon = \frac{(\text{thickness})}{(\text{fail diameter}) - (\text{thickness})} \times 100$$

$$\text{mean elongation} = \bar{\varepsilon} = \frac{\varepsilon_1 + \varepsilon_2 \ldots \varepsilon_n}{(\text{number of strips tested})} \times 100$$

$$\text{standard deviation} = \sigma = \sqrt{\frac{(\varepsilon_1 - \bar{\varepsilon})^2 + (\varepsilon_2 - \bar{\varepsilon})^2 \ldots (\varepsilon_n - \bar{\varepsilon})^2}{\text{number of strips tested}}}$$

$$\%\,\text{standard deviation} = \frac{\sigma}{\bar{\varepsilon}} \times 100$$

Example:

	Post-cure 3hrs @ 200F		
	All readings are in inches		
	73F when tested		
	Panel ID:		
	Thickness	Fail Diameter	Max % Elongation
1	0.0165	0.76	2.22
2	0.0150	0.84	1.82
3	0.0150	0.78	1.96
4	0.0145	0.76	1.95
5	0.0150	0.76	2.01
6	0.0145	0.82	1.80
7	0.0145	0.88	1.68
8	0.0150	0.90	1.69
9	0.0150	0.86	1.78
11	0.0145	0.74	2.00
12	0.0140	0.78	1.83
13	0.0140	0.72	1.98
14	0.0140	0.74	1.93
15	0.0150	0.78	1.96
		Average	**1.90**
		Std. Dev.	**0.14**
		% S. Dev	**7.61**

Example

$$\text{\% elongation of strip 1} = \varepsilon_1 = \frac{(0.0165)}{(0.76)-(0.0165)} \times 100 = 2.22\%$$

$$\text{mean elongation} = \bar{\varepsilon} = \frac{2.22 + 1.82 \quad + 1.96 ... 1.96}{15} \times 100 = 1.90$$

$$\text{standard deviation } = \sigma = \sqrt{\frac{(2.22-1.90)^2 + (1.82-1.90)^2 ... (1.96-1.90)^2}{15}} = 0.144$$

$$\text{\% standard deviation} = \frac{0.14}{1.90} \times 100 = 7.6\%$$