SOLVENT STRESS ANALYSIS

Solvent stress analysis provides a quantitative means of determining stress levels in a part molded from LEXAN® resin. This test, performed as a service by the LEXAN Technical Marketing Section, is primarily used in evaluating residual molded-in stress or external stress resulting from, for example, a screw, rivet, insert, or other assembly technique.

Polarized light is commonly used to evaluate stress in a molded part. The method is fast and inexpensive, requiring only a light source and two polarizing films to perform the analysis. However, the resulting birefringence patterns are merely a qualitative indicator of stress and cannot be employed to deduce absolute values. Thus, comes the need for a more accurate, quantitative test procedure.

The combination of two solvents, methanol and ethyl acetate, is used in various proportions to "selectively" craze LEXAN resin parts at specific stress levels in a given time period. The above solvents are those used by the LEXAN Technical Marketing Section, though other mixtures have been successfully used in the analysis, including, as an example, combinations of toluene and n-propanol.

Methanol, or methyl alcohol, has a critical stress level of 3400 psi. In other words, this solvent will craze a LEXAN resin part having 3400 psi or greater molded-in or external stress after about 3 minutes time. (Environmental tensile stress crazing is observed as shiny, hair-line cracks, generally evidenced in thick sections or adjacent to cold flow areas.) Ethyl acetate, on the other hand, is extremely "corrosive" to LEXAN resin and has a critical stress value of 500 psi. In fact, 100% ethyl acetate produces whitening and crystallization of a LEXAN resin part upon contact. Thus, a maximum of 50% by volume ethyl acetate in methanol is used.

Solutions ranging from 0-50% by volume of ethyl acetate in methanol have been correlated with the stress level at which they begin to cause crazing in a LEXAN resin part after approximately 3 minutes immersion. Figure 1 graphically displays critical stress as a function of solution concentration. The determinations have been made with clear LEXAN resin bars bent to varying curvatures on

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stainless steel jigs. The induced strain and resulting stress are readily calculated. Each sample is then used to determine the solvent proportions which produce crazing. This analysis is derived from the chemical compatibility testing procedure described in Technifact T-47.

TEST PROCEDURE

1) Various solutions are prepared in accordance with Figure 1. The accuracy desired in estimating the stress level in a part dictates the number of solutions required. Often one mixture is selected as a "Go/No Go" test. The combinations used by the LEXAN Technical Marketing Section have critical stress values of 1000, 1500 or 1700 (½% strain), 2000, 2500, and 3400 psi. An intermediate solution having a critical stress level of 2000 psi may be used, for example, as a starting point.

2) Clear parts are used to facilitate the visual inspection. A part is immersed or thoroughly wetted and kept wet for a 3 minute period in a given solution. (Parts thicker than 1/8" are immersed for approximately 5 minutes.) Immersion techniques are preferred because solvent evaporation and accompanying surface whitening is avoided.

3) After 3 minutes the part is withdrawn and examined for signs of stress crazing. Slight crazing or cracking in the corners or edges of the part along with blushing in the gate area is neither unusual nor necessarily indicative of excessive stress. Crazes in the main body of the part are of greater concern since these generally propagate into cracks and functional failure.

4) If no crazing or cracking is apparent, proceed as above with another part and a more highly concentrated ethyl acetate solution. If, however, crazing does occur, a less concentrated solution should be used.

5) Iterate until the stress level is pinpointed.

GENERAL NOTES AND CONCERNS

1) Typical stress levels in properly designed, well molded parts, range from 900-1200 psi.

2) Discretion must be practiced in the detection and interpretation of the stress crazes. As previously noted, crazes in the corners and edges of a part and blushing in the gate areas are not unusual. Additionally, high stresses are not necessarily indicative of poor molding technique. It is quite possible that processing conditions are optimal and that further reduction in molding stress is impossible. Thus, high stress concentration may indicate the need to improve part or mold design.

3) A part must be discarded after having been tested. Since ethyl acetate is absorbed very quickly by polycarbonate, accurate results cannot be expected if a part is used in more than one solvent mixture. Furthermore, a tested part cannot be put back into production as a good part.

General Notes and Concerns (cont'd)

4) Care must be taken to assure that the ratio of solvents in each solution remains unchanged. Each solution should be replaced frequently, the frequency depending upon the number of parts tested in it, the ratio of part size to volume of solution, length of time solution is open to the atmosphere, etc. Preferably, solutions should be used for only one part and discarded. The process, therefore, is expensive.

5) To ensure greater accuracy, several parts should be tested at each stress level. This also assures that the results are representative of the run.

6) Parts must be allowed to cool to room temperature before being tested. For thick sections, this may require as much as 3 to 4 hours.

7) Identical parts from the same molding run may differ in molded-in stresses by 100 psi or more. This is because the structure of polymers contributes to a slight variance in a material's modulus from one part to the next.

8) Solvent stress analysis is solely a quantitative measure of residual stress in a molded part and does not provide information on other material characteristics, such as polymer degradation.

9) Ethyl acetate and methanol are both volatile solvents which necessitates that the test be conducted in a well ventilated area.

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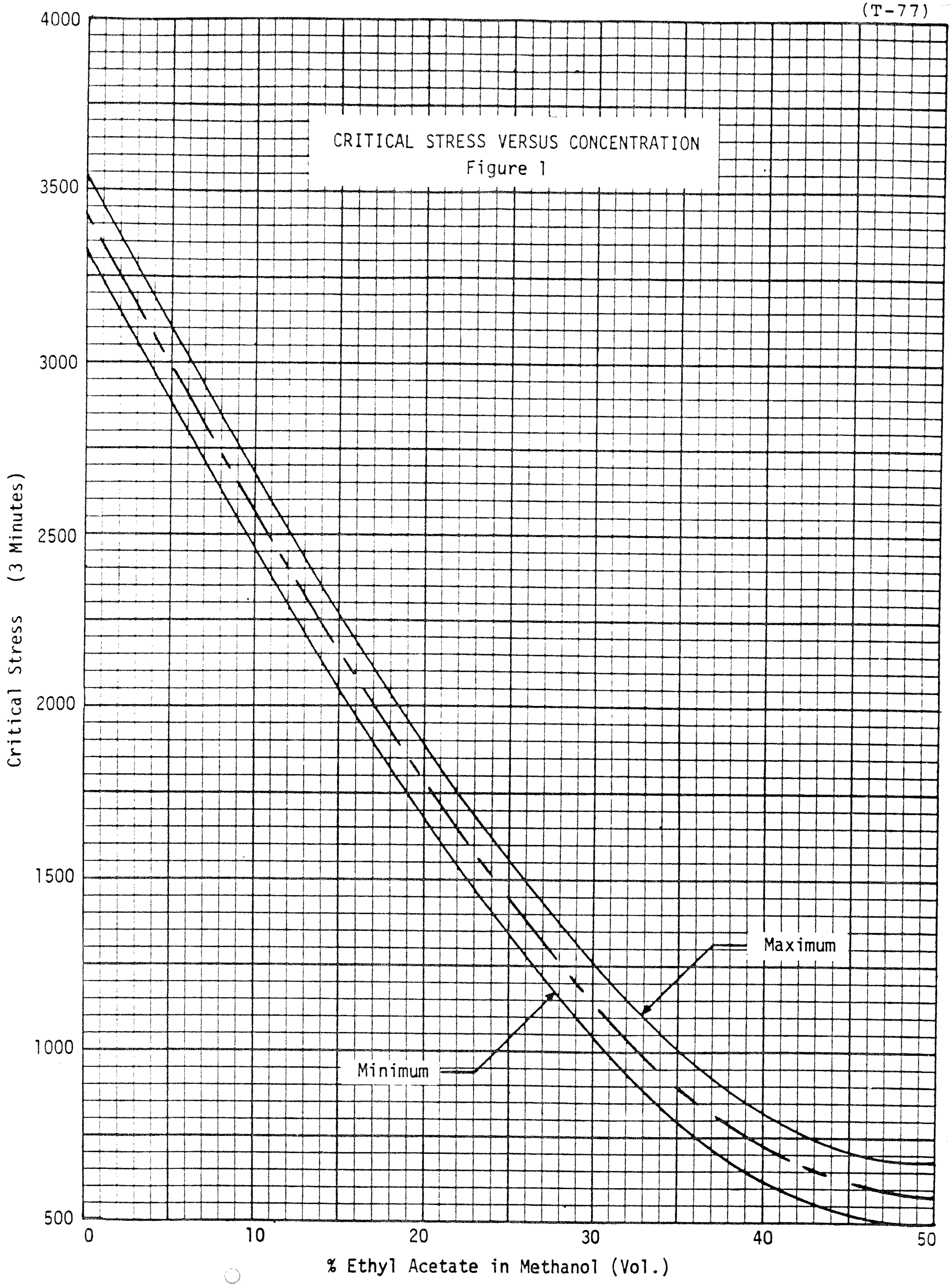
NOTE: Technifacts may be filed under the Technical Reports tab in your LEXAMPLE binder.


CRITICAL STRESS VERSUS CONCENTRATION
Figure 1
Critical Stress (3 Minutes)
4000
3500
3000
2500
2000
1500
1000
500
0
10
20
30
40
50
Maximum
Minimum
% Ethyl Acetate in Methanol (Vol.)