

Low Durometer, User-Friendly Polyurethane Elastomers



Crosslink Technology Inc.

Jamie Dinsmore
Crosslink Technology Inc.
6680 Finch Ave., West,
Toronto, Ontario, Canada
M9W 6C2
1-800-563-3769
fax:416-674-7563

INTRODUCTION:

Low durometer urethane elastomers find many industrial uses including roll covers, grommets, bushings and vibration isolators. To achieve elastomers in the lower hardness range (from 40 Shore A to 10 Shore A), the addition of significant amounts of plasticizer to a mid-range hardness system by the processor has traditionally been required. The high plasticizer levels may then require the use of reinforcing fillers and subsequently the incorporation of catalysts may also be necessary in order to speed up the cure to prevent settling of the fillers. As well as these processing difficulties, hardness drift as a result of plasticizer migration is also frequently experienced.

The low durometer systems presented in the following paper eliminate the need for adding plasticizers, catalysts or fillers. In fact, these systems are easily processed at moderate to low temperatures and with proper mold temperatures can be de-molded in five to ten minutes which can increase throughput significantly.

OBJECTIVE:

The advantages of polyurethanes lie in their unique combination of cured properties and vast processing ranges. The low durometer urethanes in particular offer properties that are virtually un-attainable by any other elastomer system. However, the extra processing steps required to obtain hardnesses at the extremely low end of the durometer scale (ie: less than 40 Shore A) can render traditional systems cumbersome to work with as well as cost prohibitive. The object of our research therefore, was to develop low durometer urethane systems that eliminate the extraneous processing requirements of standard low hardness systems.

In order to achieve the objective of this study there were five criteria that required improvements over the traditional or standard low durometer systems. The first improvement necessary was to reduce the number of raw material components. With fewer raw materials to handle, there is less chance of ratio errors, mixing errors and in general, less chance of process error. Fewer errors results in lower scrap rates which will improve efficiencies.

As well as reducing the number of components, it is also necessary to reduce the number of processing steps required. As with reducing the number of components, reducing the steps minimizes potential processing errors. Although reducing the number of raw materials and reducing the required steps are very closely related, it was felt that reducing the steps was an important enough criteria that it was worth emphasizing in this study. Reducing the processing steps can also result in substantially lower processing costs through greater output rates and lower scrap rates.

The third parameter, that was considered important to improve upon, was the relatively high processing temperatures. Significant reductions in processing temperatures can result in direct cost savings. As well, low temperature processing offers a safer environment to the workers handling these materials.

In order to truly speed up production rates and mold turn over rates, mold residence times must be minimized. Direct cost savings can be achieved through these increased rates as well as through the reduced number of molds required.

The final parameter that was considered in this study was that of post-cure times and temperatures. Substantial reductions in both the times and temperatures required for post cure offer cost savings in the form of increased output rates and energy savings. The improved safety of lower oven temperatures is also an important consideration.

EVALUATION:

As a comparative tool, a traditional or Standard low durometer system was chosen (approximately 30 Shore A). This 'standard system' consisted of a TDI(Toluene-diisocyanate)/polyester glycol pre-polymer (NCO approximately 4%) containing 45 parts per hundred (based on pre-polymer) of a phthalate plasticizer, 60 parts per hundred of a silica filler and a multi functional glycol/catalyst blend as a chain extender. The systems developed by Crosslink Technology Inc. are based on MDI(Diphenyl methane diisocyanate) with various polyglycol blends. All evaluations and comparisons of the Standard system and the Crosslink Systems focus mainly on the five parameters listed in the previous section.

Raw Material Components:

The low hardness systems developed by Crosslink have been designed with only two raw material components; a resin component (Part A) and an isocyanate component (Part B). The properties of these systems are listed in table 1.

table.1: Crosslink System Properties.

SYSTEM	CLC 1A-010	CLC 1A-020	CLC 1A-030	CLC 1A-040
VISCOSITY PARTA @ R.T. (cps)	400-600	500-700	800-1,000	1,200-1,400
VISCOSITY PARTB @ R.T. (cps)	2,000-2,500	2,000-2,500	2,000-2,500	2,000-2,500
MIXED VISCOSITY @ R.T. (cps)	800-1,000	900-1,100	1,500-1,700	1,700-2,000
MIX RATIO @ 95% THEORY	100:18.5	100:29	100:35	100:45
COLOUR	CLEAR	CLEAR	CLEAR	CLEAR
SPECIFIC GRAVITY	1.05	1.06	1.06	1.08

The properties of the Standard system have been listed in table 2., below.

table.2: Standard System properties.

PRE-POLYMER VISCOSITY @ R.T. (cps)	SOLID
CURATIVE BLEND VISCOSITY @ R.T. (cps)	SOLID
PLASTICIZER LEVEL (pph)	45
FILLER LEVEL (pph)	60
MIX RATIO*	100:2.1
COLOUR	OPAQUE/AMBER
SPECIFIC GRAVITY	1.44

*100 parts of pre-polymer blend to 2.1 parts of the curative/catalyst blend

As can be seen in table 1., both part A and part B have room temperature viscosities which are relatively low which makes these systems easy to handle at normal ambient conditions. Another important feature of the Crosslink Systems are their relatively high mix ratios. These higher mix ratios will significantly reduce the potential for metering errors that are common with the very small mix ratios associated with most traditional low hardness formulations.

Processing Steps:

The processing steps for the Standard System have been outlined in a flow diagram (fig.1.) on the next page and following that, fig.2. represents a flow diagram of the processing steps required for the Crosslink Systems. Just by virtue of the number of components we can reason that the number of processing steps of the Standard System will be larger. However, there are ancillary steps that must be performed with the Standard System such as melting of the pre-polymer and curative and drying of the filler which do not need to be performed with the Crosslink Systems making the difference in required steps even larger.

Fig 1. STANDARD LOW DUROMETER PROCESSING FLOW DIAGRAM:

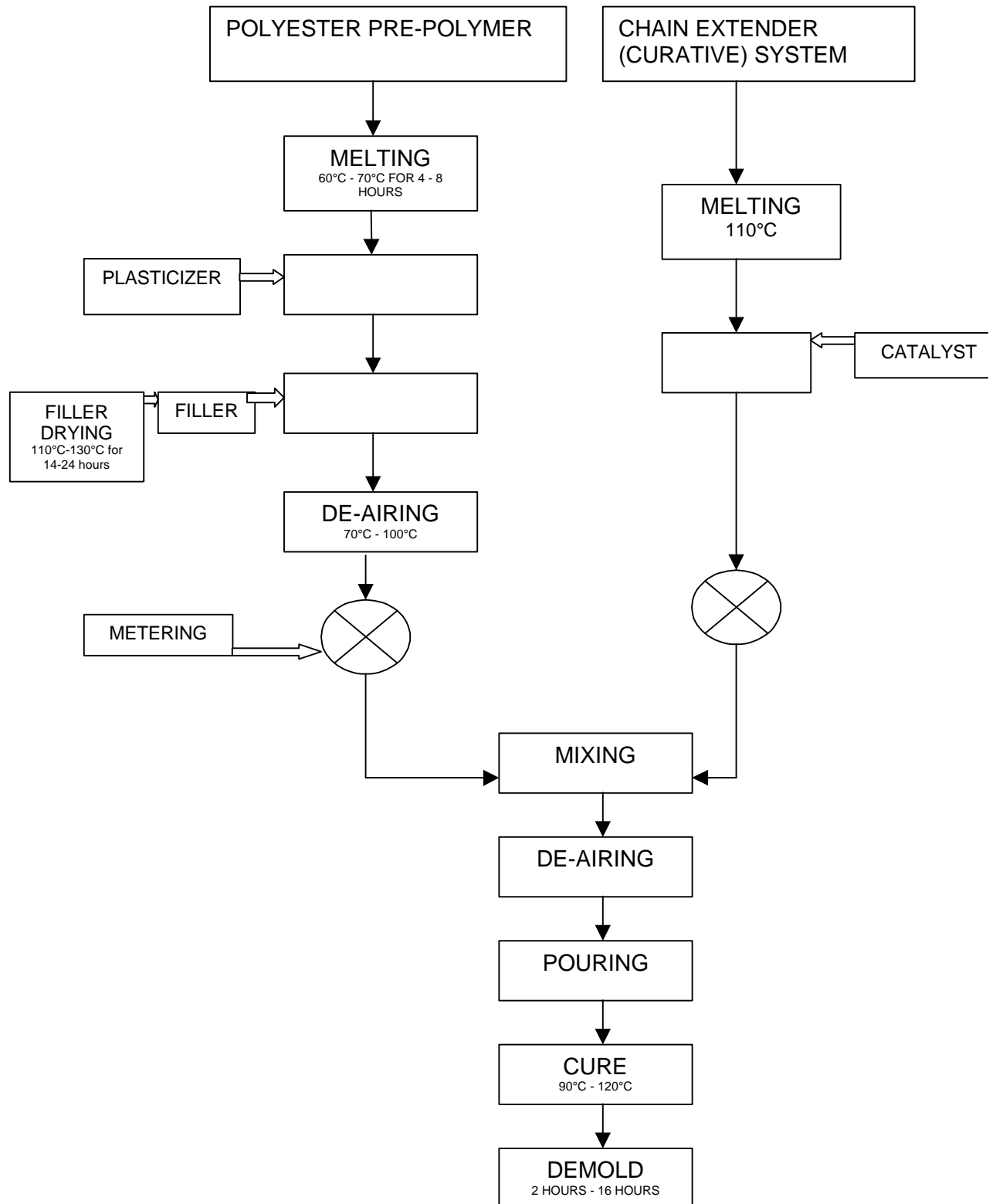
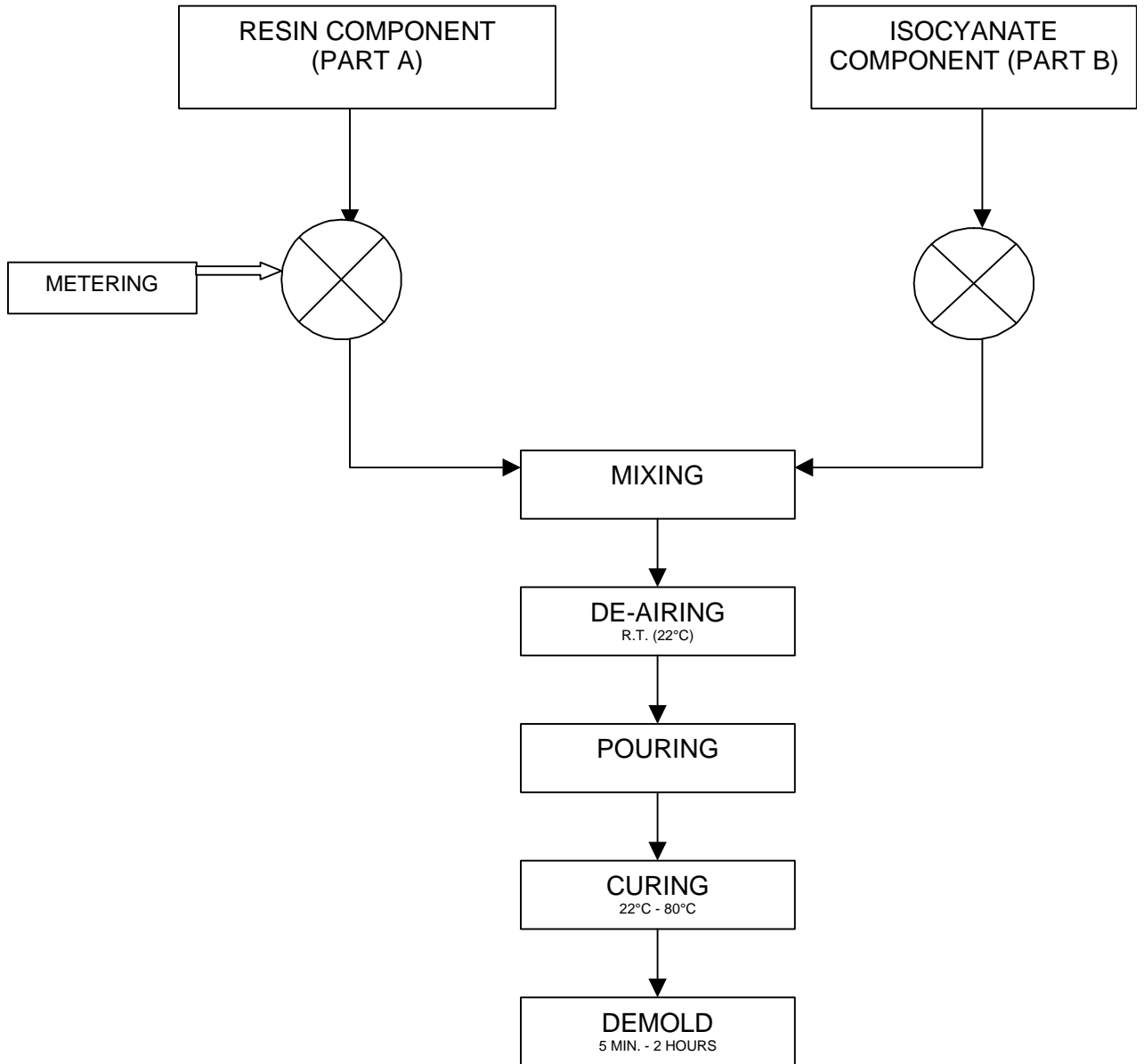


Fig 2. CROSSLINK TECHNOLOGY'S LOW DUROMETER PROCESSING FLOW
DIAGRAM:



Processing Temperatures:

Because the pre-polymer and the curative in the Standard System are solids at room temperature and require considerably high temperatures to melt (60°C-110°C), the whole process for the Standard System must be performed at these elevated temperatures. The pre-drying of the filler must also be performed at temperatures greater than 100°C. The cure curve or Viscosity Build-Up for the Standard System is presented in fig.3.

The Crosslink Systems are easily processed at room temperature, however, with the addition of modest amounts of heat to the resin/isocyanate mix, the cure profile of these systems can be greatly modified. The cure profiles of the Crosslink Systems at various temperatures are presented in figures 4 through 7. From these graphs, it can be seen that it is possible to obtain a range for pot-life from under 1 minute to 25 minutes, depending on the temperature of the mixed components.

fig.3.STANDARD VISCOSITY BUILD-UP

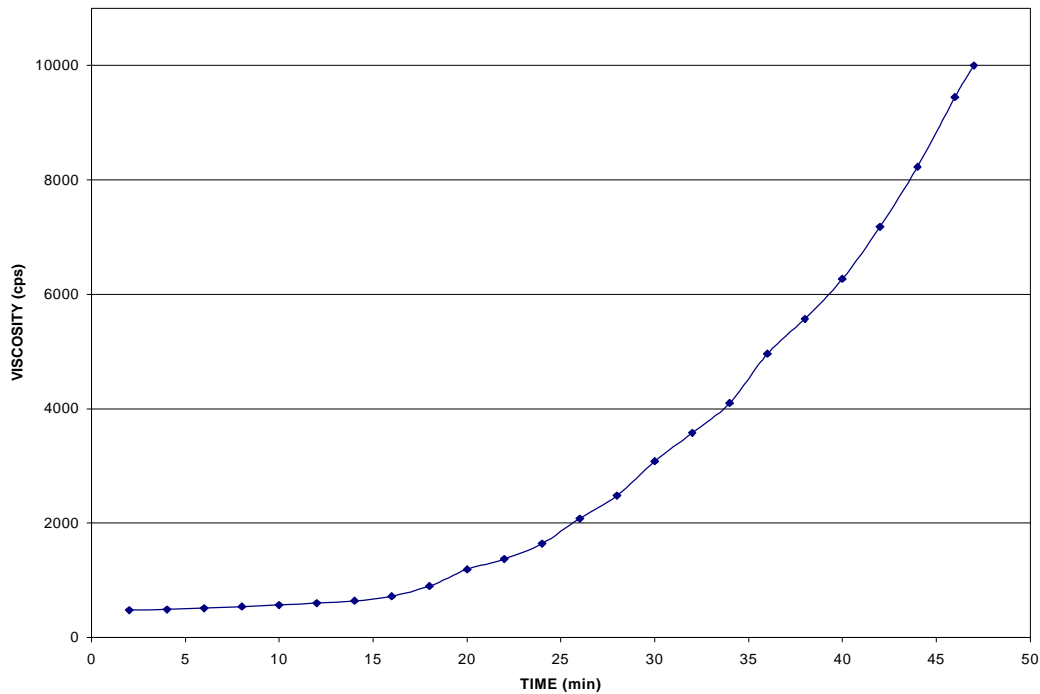


fig.4. Effect of Mix Temperature on Viscosity Build-Up of Crosslink's CLC 1A-010

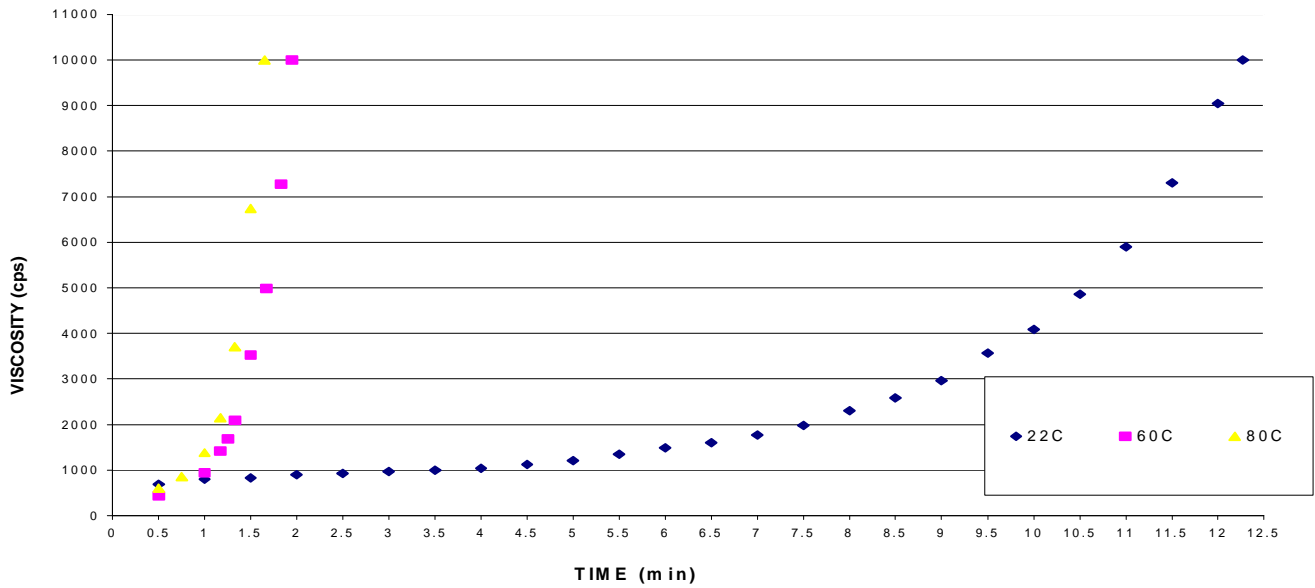


fig.5. Effect of Mix Temperature on Viscosity Build-Up of Crosslink's CLC 1A-020

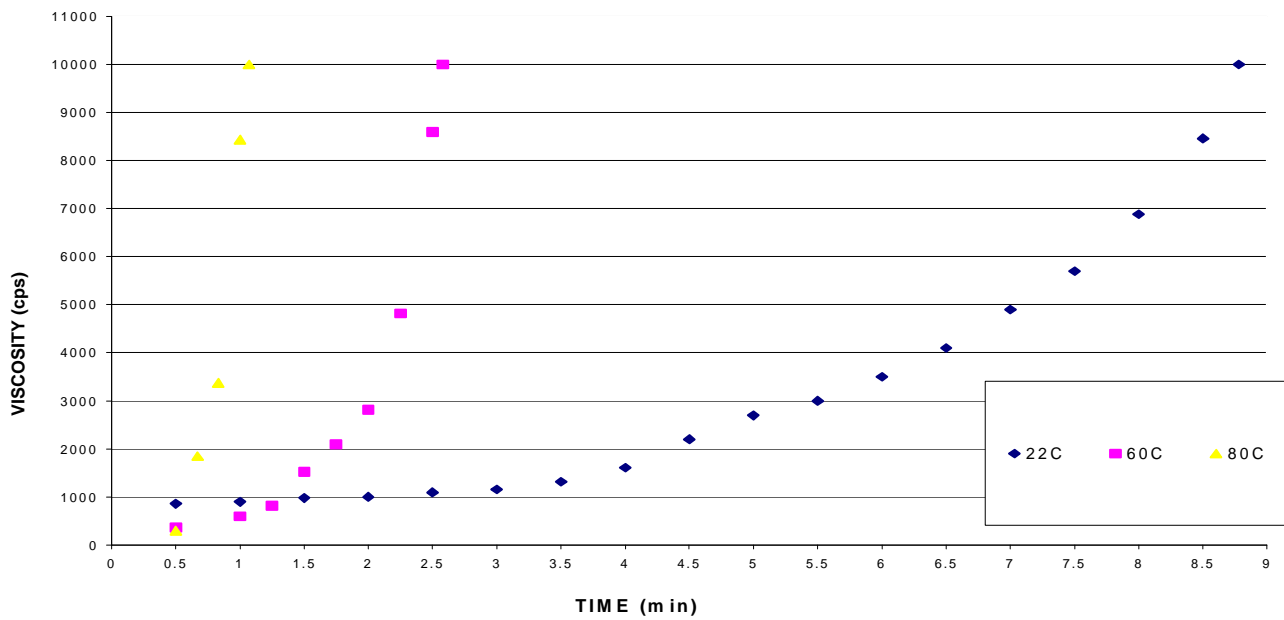


fig.6. Effect of Mix Temperature on Viscosity Build-Up of Crosslink's CLC 1A-030

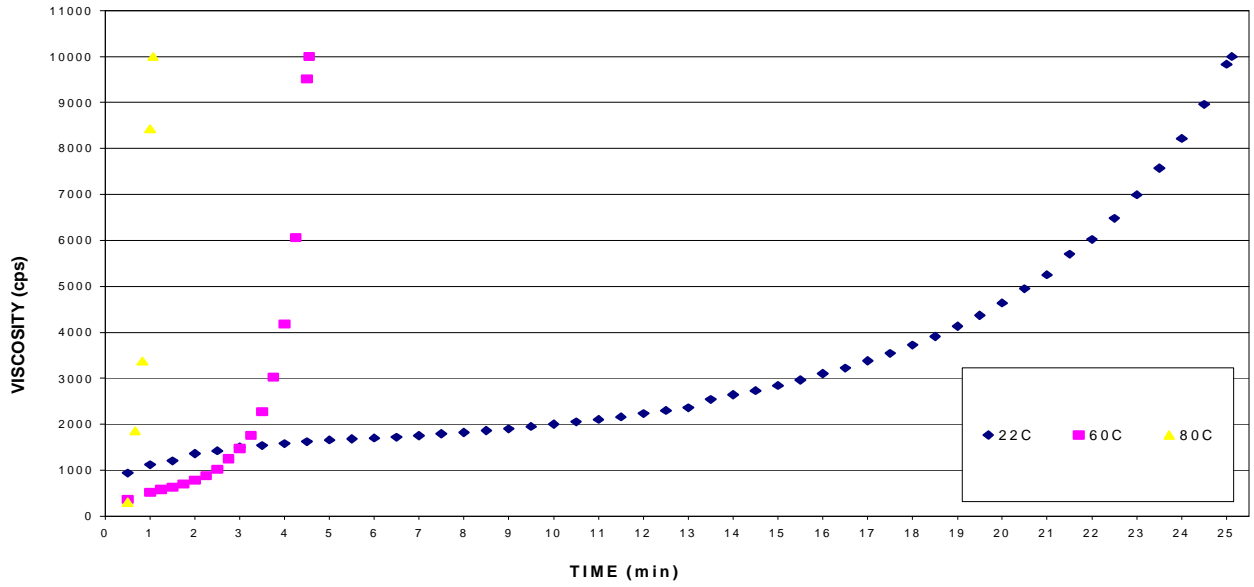
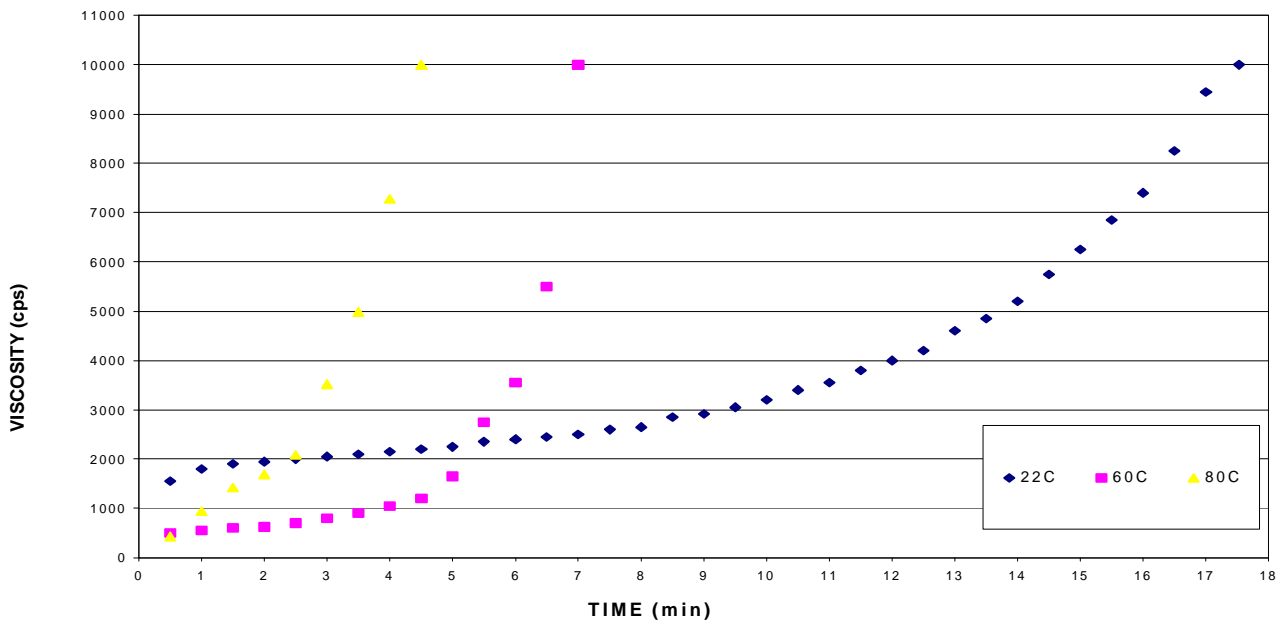


fig.7. Effect of Mix Temperature on Viscosity Build-Up of Crosslink's CLC 1A-040



Mold Residence Times:

The mold residence times or 'de-mold times ' for the Standard low durometer systems are typically quite long because of the reduced reactivity caused by the high pasticizer and filler levels. These de-mold times can be reduced with the use of catalyst, however, the levels at which these catalysts are required usually have the effect of flattening the cure profiles which means that the pot-life is reduced at a much faster rate than the de-mold time. Therefore, the working life becomes too short to accommodate any further reductions in de-mold time. Also, these high catalyst levels can cause detrimental effects to the physical integrity of the cured elastomer. Figure 8. shows the demold time as a function of mold temperature for the Standard System.

As well as possessing variable working lives as discussed in the previous section, the Crosslink Systems also have variable de-mold times with respect to the temperature of the molds (see figures 9. through 12.). Therefore, combining these two properties of the Crosslink Systems, one could maximize working life and minimize the de-mold times in order to obtain a system with de-mold times that are faster than the working life. For example; if a Crosslink system were mixed at room temperature one could expect a working life around 20 - 25 minutes. Then, casting this mix into a mold which has been pre-heated to 100°C, the expected de-mold time would be roughly five minutes. Using this set up, it is ideally possible to achieve as many as three cycles from the same mold and the same mix.

Fig.8. STANDARD SYSTEM DE-MOLD TIME AS A FUNCTION OF MOLD TEMPERATURE

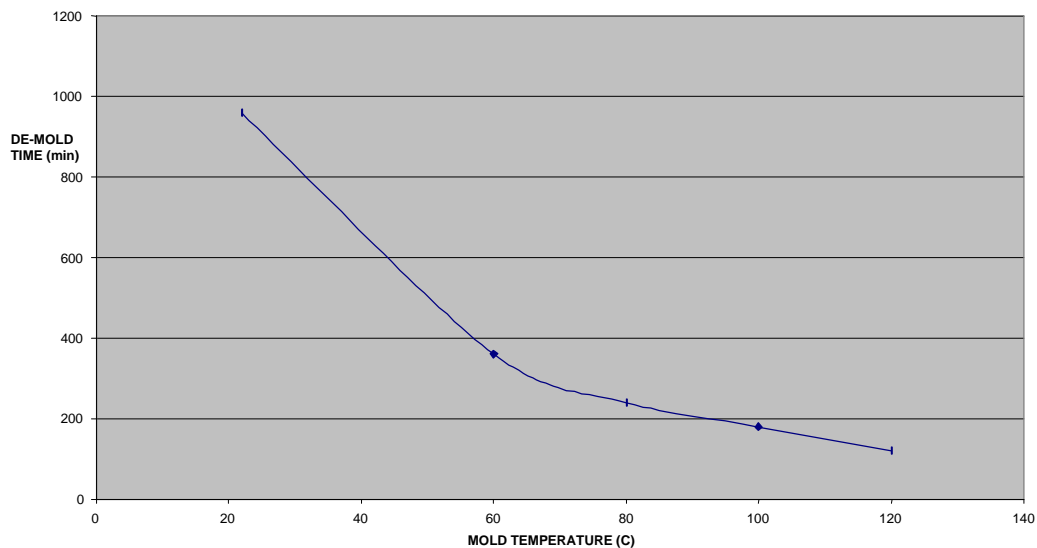


fig.9. CLC 1A-010 DEMOLD TIME AS A FUNCTION OF MOLD TEMPERATURE

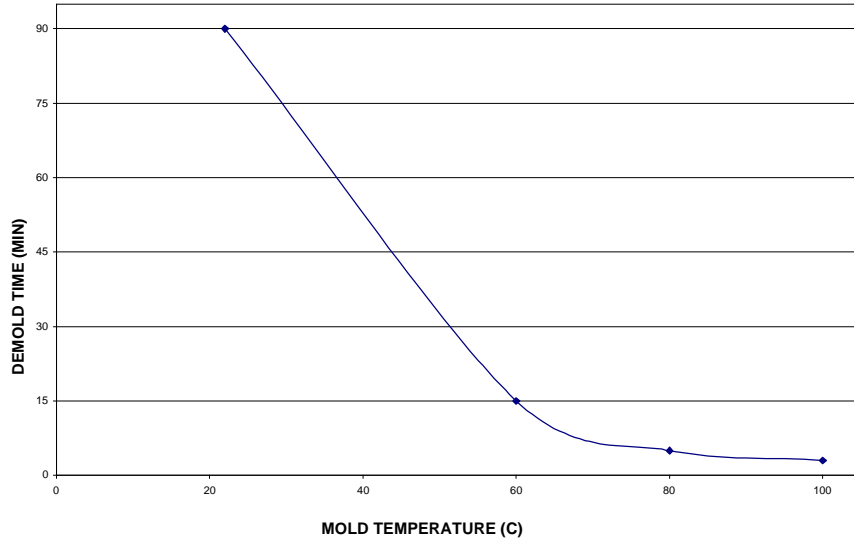


fig.10. CLC 1A-020 DEMOLD TIME AS A FUNCTION OF MOLD TEMPERATURE

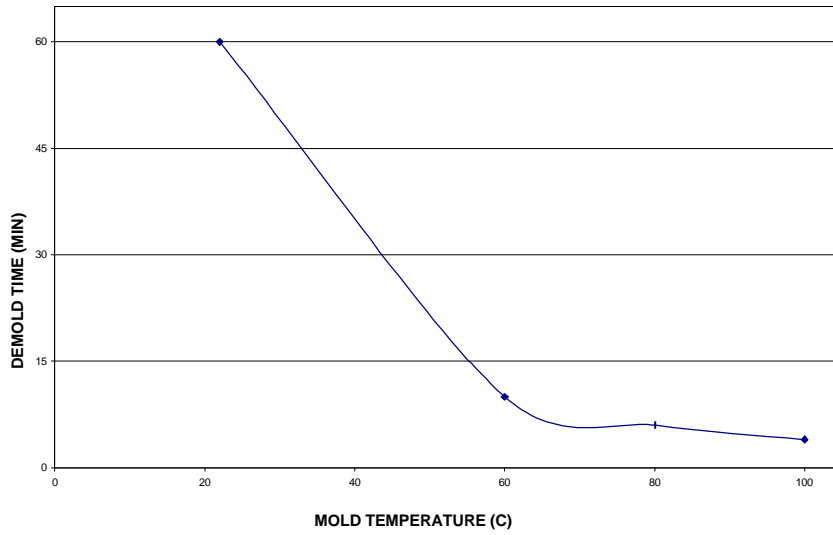


fig.11. CLC 1A-030 DEMOLD TIME AS A FUNCTION OF MOLD TEMPERATURE

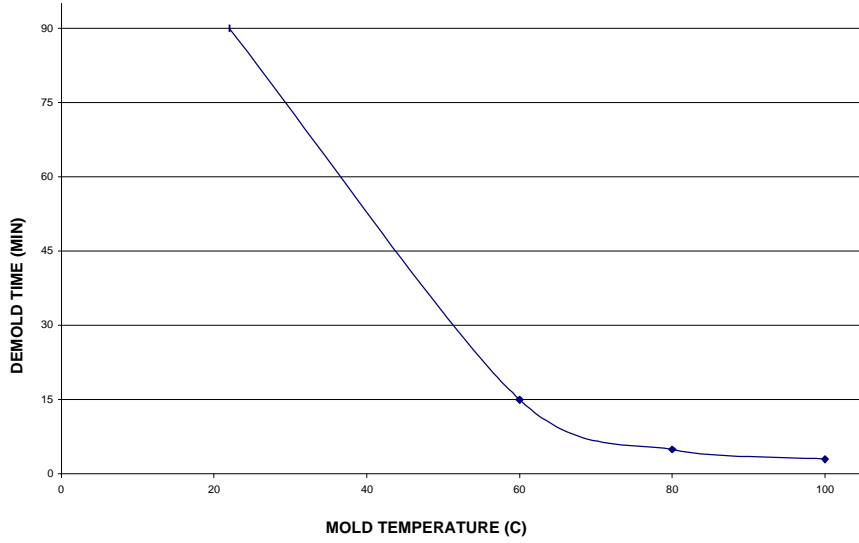
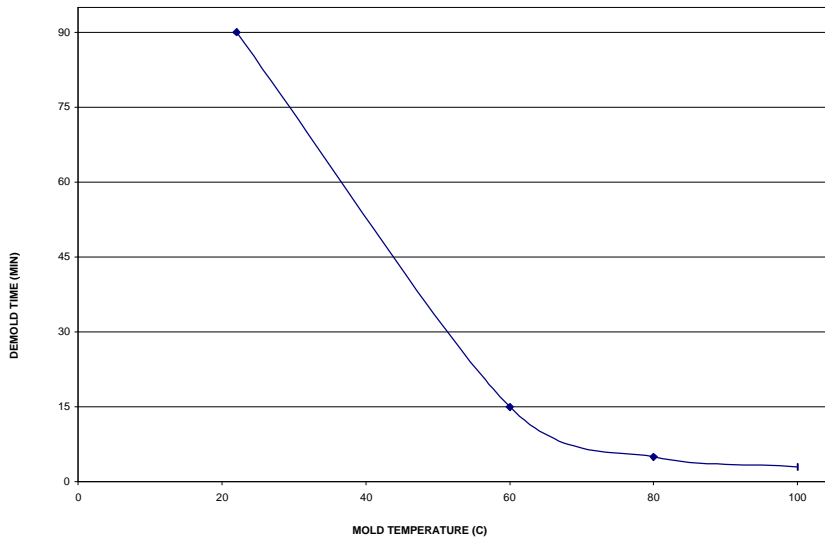


fig. 12. CLC 1A-040 DEMOLD TIME AS A FUNCTION OF MOLD TEMPERATURE



Post-Cure Times and Temperatures:

From the processing instructions of the Standard System, suppliers recommend post-cure schedules of not less than 8-16 hours at 110°C-120°C. These post-cure conditions must be adhered to in order to obtain the physical properties reported for the material. The Crosslink Systems have recommended post-cure schedules of 4 hours at 80°C, 6 hours at 60°C or 24 - 48 hours at room temperature. Higher post-cure temperatures may be used on the Crosslink systems, however, times of less than 4 hours are not recommended.

Physical Property Comparison:

The focus of this study was to evaluate the processing characteristics of the low durometer systems from Crosslink Technology Inc. relative to those of a traditional low hardness system. However, the physical properties of the cured elastomers have been reported in table 3., in order to draw a more complete comparison between the Crosslink Systems and the Standard System.

SYSTEM	STANDARD	CLC 1A-010	CLC 1A-020	CLC 1A-030	CLC 1A-040
HARDNESS (SHORE)	33A	10A	20A	30A	40A
100% MODULUS (psi)	94	32	63	97	166
300% MODULUS (psi)	293	62	145	245	386
ULT. TENSILE (psi)	850	107	259	685	975
ULT. ELONGATION (%)	412	610	535	421	497
DIE 'C' TEAR (pli)	55	15	24	46	75
D-470 SPLIT TEAR (pli)	8	4	7	9	16
BASHORE REBOUND (%)	25	51	54	60	63

As can be seen in the table, the physical properties of the Standard System and the corresponding hardness of the Crosslink System agree quite well. The tensile and modulus values of the Standard System are slightly higher and the elongation and split tear values are slightly higher for the Crosslink System CLC 1A-030. These variances are to be expected from the small hardness difference.

SUMMARY:

The series of low hardness elastomers developed by Crosslink Technology Inc. have effectively eliminated many of the time and energy consuming steps associated with most traditional or Standard low durometer urethane systems. Through minimizing process steps and temperatures, efficiencies can be maximized. Perhaps the most interesting feature of the Crosslink Systems are the variable pot-lives and de-mold times available to the processor. The relative ease of use and versatility of these low hardness systems offers processors a great deal of flexibility and potential cost savings in their operations.