CONCERNS IN THE APPLICATION OF MODIFIED BITUMEN

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Polymer-modified bitumen roofing materials combine a traditional built-up roofing practice with single-ply roofing technology. Modified bitumen roofing materials use asphalt as a base, which brings about the familiarity with built-up roofing in that asphalt and reinforcing fabrics are contained in a roll and manufactured in the plant under controlled conditions. Polymer additives are blended with hot asphalt prior to sheet manufacture; the end product is referred to as *modified bitumen.*

The use of modified bitumen has grown dramatically in the United States, especially within the last decade. For the purpose of this paper, a modified bitumen is defined as a prefabricated, reinforced waterproof sheet that is composed of asphalt bitumen, polymer modifiers and reinforcing fabrics, and which has been manufactured under controlled conditions. Coal tar bitumen is also used but is limited in quantity. Modified bitumen mopping asphalts, also available, are not covered in this paper.

The primary development of modified bitumen roofing took place in Europe in the 1960s. Many different sheets were made available by European manufacturers, reflecting the different climates, equipment, available materials and skills used to install roofing products. Many different modified bitumen sheets were developed in Italy, where specialized blends of atactic polypropylene (APP) were made with select asphalts. Specialized blends of modified asphalts containing styrene copolymers (SBS) were also made in Europe. France and West Germany were the primary suppliers of this type of product.

Modified bitumen membranes are the thickest of the single-ply roofing materials available today, normally ranging from 120 to 170 mils in thickness. Some sheets are available in a 60-mil thickness and have self-adhering capability. Typical roll widths are 36 inches or a nominal 39 inches, the nominal 39-inch roll width is more than likely produced from a 1 meter width machine, which points to a European origin. This paper will deal with the application concerns of those modified bitumen sheets requiring either hot asphalt or torching for installation.

EARLY USE IN THE UNITED STATES

In the early 1970s, roofing contractors became aware of the growing use of modified bitumen sheets in Europe. The United States' experience with single-ply roofing, however, was at a low point, since the first generation of single-ply products developed in the United States met with limited success due to installation and performance problems. In 1972 an SBS-modified bitumen roofing product that was self-adhering came onto the market. In 1975 an APP-modified bitumen product that had a European origin was developed and marketed in the United States. Both the National Roofing Contractors Association (NRCA) and the Midwest Roofing Contractors Association (MRCA), through their technical and research committees, began to look into the possibilities that modified bitumen sheets were available for installation. Both of these products were manufactured in Europe and shipped into the United States in container quantities.

By the late 1970s the single-ply technology began to spread, with modified bitumen roofing being the last to develop. This was more than likely due to the lack of manufacturing plants in the United States. The production of SBS-modified bitumen roofing in the United States began in 1978, with an APP-modified bitumen plant coming on line shortly thereafter.

By 1981, it was estimated that 5 percent of the commercial roofing materials being used in the United States were comprised of modified bitumen products. By 1987, it was estimated that about 16 percent of the commercial roofing materials consumed were modified bitumen. At that time it was estimated that the torch-applied products accounted for approximately 11 percent and the mopped-down products accounted for approximately 5 percent of the market, according to the 1987-88 NRCA industry survey.

The projected share of the commercial market for modified bitumen roofing in 1988 is approximately 17 to 18 percent, with 12 percent utilizing torch-applied sheets and 6 percent using the mopped-down product. It should be noted that 70 percent of the 1988 projected commercial roofing market will involve reroofing, either recovering (26 percent) or replacing (44 percent). This leaves the 1988 new construction market with a 30 percent share.

MODIFIED BITUMENS CURRENTLY AVAILABLE

At this time it appears that roofing contractors are installing sizable amounts of modified bitumen roofing. This is reflected in the number of manufacturers providing different modified bitumen sheets to the roofing industry. For instance, the first volume of the *Roofing Materials Guide,* published by the National Roofing Contractors Association in February 1983, listed a total of 17 different manufacturers of modified bitumen. From these 17 manufacturers, 34 different modified bitumen roll products were available to roofing contractors.

In the 13th volume of the *Roofing Materials Guide,* published in August 1988, there are now 40 manufacturers of modified bitumen products offering 175 different types of prefabricated modified bitumen roofing sheets. Further analysis of the manufacturers present in February 1983 shows five of the original 17 listed are no longer producing modified bitumen products.

Continuing with the analysis, it is also significant that of the 175 different modified bitumen roofing sheets current-

ly available, 52 now list their origin as the United States, as summarized below:

- United States 52
- Italy 53
- France 19
- Great Britain 12
- West Germany 9

This accounts for the majority (145) of the 175 different modified bitumen roll products available. The countries of origin of the remaining 30 modified bitumen sheets are either Canada, Netherlands, Denmark, Puerto Rico, Austria, or, unspecified. Therefore, of the modified bitumen products currently available in the United States, 30 percent were developed domestically by 1988. This leads to several observations: (1) the modified bitumen market is maturing in the United States and (2) a large number of modified bitumen products that were originally developed in Europe are still in use today, indicating satisfactory performance.

In further analyzing the data contained in the August 1988 *Roofing Materials Guide*, it was found that SBS products account for 55 percent of the listing, with APP products accounting for 35 percent of those currently available. The remaining 10 percent are composed of unspecified polymer blends. These figures should not be confused with the volume of SBS or APP previously mentioned. Table 1 gives a complete listing of generic materials available.

Within the vast array of modified bitumen products currently available, it was found that 47 percent of the listings show a plain surfacing, with granule or mineral accounting for 44 percent of the product listing. Table 2 gives a complete listing of surfacing materials used, along with the number of products available using them.

MODIFIED BITUMEN SPECIFICATIONS

One of the confusions that exists in roofing technology today pertains to the description of modified bitumen roof membranes. Many designers, manufacturers and roofing contractors refer to modified bitumen as a single-ply product. Others refer to modified bitumen as a prefabricated roll product that is used as part of a multi-layer roof membrane. Based on a data analysis of the 40 different manufacturers and 175 different modified bitumen roll products listed in the August 1988 *Roofing Materials Guide*, it is apparent that the vast majority of modified bitumen roofing specifications are two-ply. As shown in Table 3, there are 798 different modified bitumen roof membrane specifications currently published. Further review of the data presented in Table 3 shows that the number of one-ply specifications listed is nearly equal to the number of three-ply specifications. Approximately 5 percent of the specifications currently available call for a four-ply membrane.

Based on the above data, it is apparent that modified bitumen roof membrane construction in the United States is basically a two-ply roof membrane system. The first ply may or may not contain a modified bitumen sheet: a fiber glass felt meeting ASTM D2178, Type IV is most often used. However, we see a growing market for the use of a modified bitumen base ply used as part of the two-ply specification.

APPLICATION CONCERNS

Based on the product and specification data cited above, five of the 40 modified bitumen manufacturers listed were contacted to determine what application concerns and experiences they were having with modified bitumen. Additionally, the 1987 NRCA Project Pinpoint[1] database was also referred to, which gave us the roofing contractor's input regarding application concerns and performance.

The 1987 Project Pinpoint data indicated that contractors had very few callbacks or problems with BUR and modified bitumen type membranes. The technical departments of the five different modified bitumen manufacturers all expressed similar application concerns. The following is a list of their concerns that involve workmanship. A discussion of manufacturing concerns that could affect field application is presented later in this section.

Lap Integrity

The application concern for APP-modified bitumen sheets was generally found to be that of overheating. A properly heated APP lap should show a small bleed line of bitumen, generally within ¼ inch to ½ inch. Lap joints found to have excessive bleed out (up to 2 inches) are obviously overheated, destroying the membrane integrity and displacing the reinforcing fabric along the roll.

If no bleed out is observed, the lap needs to be probed. Some manufacturers and roofing contractors like to "butter" the edge of the lap, which may or may not be appropriate for the situation at hand. If insufficient heat was present to weld the APP materials in the lap, a buttered lap edge simply (but temporarily) covers up a defective lap. As the roof membrane weathers and thermally cycles, the buttered lap edge will eventually open, exposing the defective lap. On the other hand, if a bleed line is present there is no need to do any more work on the APP lap.

The SBS laps are normally mopped in ASTM D312, Type III or Type IV asphalt, which should be at or above its EVT. Again, the presence of a bleed line will normally signify that good adhesion has taken place between the mopping asphalt and the SBS sheet. However, a false lap may still be present if the installer laid out the mopping asphalt at too cold a temperature. An SBS lap installed with a hot bleed line will be drawn down tight, visually confirming a good lap. The point of application temperature for the mopping asphalt should be a minimum of 400 F or higher, if the manufacturer requires it. Since asphalt cool-off rates can be rapid, it is apparent that the point of application temperature for the asphalt should be well within the EVT range; generally this may be 425 F or more, depending on the EVT of the mopping asphalt.

One application concern common to all prefabricated modified bitumen sheets is the Tjoint where three sheets come together. Installation crews must be trained to check the tri-lap areas carefully.

Cold weather application may call for special handling of modified bitumen (using heated rolls); temperatures below 45 F may hinder workmanship. High winds may also cause problems with torches or induce rapid cooling of the mopping asphalt.

MEMBRANE ATTACHMENT

The predominant experience with the manufacturers' field inspectors was that APP materials are underheated in the body of the roll (and overheated at the lap edges as cited above). Depending on the type and configuration of torches being used, it is apparent that contractors may need to fine-tune their equipment. It should also be realized that im-

proved versions of mobile torching equipment are now available. The newer equipment gives a more uniform application of heat to the roll from edge to edge. The precise mechanics of adjusting and operating the torching equipment is beyond the scope of this paper.

Similar to the application experience with APP roll goods, the predominant application concern for membrane attachment with SBS sheets was also found to be cold mopping asphalt. The attachment of an SBS material is directly related to the asphalt temperature. Cold mopping asphalt (below 400 F) may lead to voids and holidays in securing the membrane. Blisters can occur, which can be perceived as a problem by the owner. Blistering of modified bitumen sheets has not been a general performance concern to date. The presence of a smooth or granule/mineral surface does accentuate any void or blister, indicating improper membrane attachment. The owner may then incorrectly believe roof failure is imminent.

Flashing

The predominant application concerns for modified bitumen flashing were found to fall into two categories. With regard to SBS sheets, applicators are not getting the sheet fully embedded in hot asphalt. Since all reinforcement materials have a degree of memory, the flashing material will pop out or back away from the surface it was contoured to fit. Again, this may lead to owner dissatisfaction and/or premature flashing failure.

The torch-applied APP membrane flashing was found to have two application concerns: the use of cant strips, and torching safety at the interface of the roof deck and wall where open flames may be drawn down into the space below.

Elimination of the cant strip has resulted in problems occurring at the horizontal/vertical interface (roof deck and wall). The use of perlite insulation cant strips has greatly reduced the fire hazard associated with torching operations in this vicinity. The use of the cant strips accommodates the transition of the membrane from the horizontal to the vertical.

Coatings

The need for a surface coating still exists with some modified bitumen membranes. The coatings are required to achieve a fire rating and/or weathering protection. Application concerns still exist with coating of APP membranes. Applicators should follow the coating manufacturer's instructions closely; membranes are normally required to "weather in" for a period of 30 to 60 days. As in the past, coatings generally will not perform well under ponded water; designers, contractors and building owners should be aware of this.

Membrane Slippage

Slippage of some modified bitumen roof membranes has, for the most part, occurred with SBS roof sheets installed in mopping asphalt. This has primarily occurred on roofs with slopes exceeding 1 in 12. However, roof decks with a slope greater than ½ in 12 may present a slippage potential, depending on the degree of attachment. In some cases, the asphalt used may have had a low softening point. If the initial softening point of the asphalt is lower than the specified ASTM type, or if the asphalt was subject to fall-back during heating, slippage may occur. Slippage will most certainly occur if, in addition to the presence of a slope, the mopping asphalt rapidly cooled; membrane slippage will then occur during warm weather. Several manufacturers have switched to using certified loads of ASTM D312, Type IV asphalt. Depending on the geographic location and source of crude oil, manufacturers and roofing contractors need to be concerned with this potential problem.

For slopes exceeding 1 ½ in 12, prudent use of wood nailers should be used, similar to that followed for BUR construction.

Incompatibility of mopping asphalt with the SBS membrane materials may also occur. Manufacturers of SBS modified bitumen membranes have been sensitive to the potential problem of incompatibility with different asphalts. At this time, there is a limited experience and scarcity of test data regarding compatibility.

Slippage has been seen to occur with APP membranes that were attached with mopping asphalt. Again, slopes of 1 in 12 along with insufficient temperature in the mopping asphalt were seen to guarantee slippage. The APP-modified bitumen material has a higher softening point than SBS-modified bitumen, requiring more latent heat to achieve attachment. The present of a granule or mineral surfacing on modified bitumen may lead contractors to erroneously assume that they are installing an SBS product, since most SBS materials have a granule or mineral surfacing.

Manufacturing Concerns That Affect Application

Installation difficulties may occur if the individual modified bitumen rolls become misshapen in transit or storage. Severe application problems have been known to occur with rolls that will not run out in a straight line. Excess mineral, talc surfacing or plastic film separating agents will work against lap seaming and membrane attachment, regardless of the method being used. Ceramic granule surfacing may also be excessive, causing loose granules to come onto the selvage edge and make lap seaming more difficult. Head laps need to have excess or loose granule or mineral particles swept clean before seaming takes place.

Quality control from the manufacturing end may also affect application; for instance, tape splices used to join roll ends of reinforcing fabric in the plant should be culled from the shipment. The modified bitumen that lies over the tape splice will eventually peel off on the roof, causing the designer and roofing contractor to share anxious moments with the building owner. Once tape splices are found on a roof, no one can be sure of where other splice points may be located.

COLD ADHESIVES

A third method of attaching and lapping modified bitumen sheets together involves the use of a cold adhesive. Several different cold adhesive products are available, with many more undergoing development at this time. To successfully attach and join individual modified bitumen sheets together in a roof membrane, the cold adhesives need to offer the applicator a reasonable window of time while also allowing for wide temperature differences to occur. Thus, the cold adhesive material must be usable and possess adhesive quality in hot, dry weather as well as cold, damp environments. The solvents used in the cold adhesive must also be chemically neutral and not cause a breakdown or incompatibility within the modified bitumen sheet itself. One significant ap-

plication concern is the amount of cold adhesive material used in the lap. Thick applications of a cold adhesive within a lap joint are self-defeating. In this instance, using less material is better than using more.

We expect that the development and use of cold adhesives will undergo large growth within the modified bitumen industry.

LAB TESTS

A series of lap strength and elongation tests were conducted on an SBS membrane.[2] Lap tensile strength and elongation evaluations were made on an SBS membrane containing 250 grams per square meter polyester reinforcement. The lap joints were made with two different types of asphalt (ASTM D312, Type I and Type III), forming an adhesive lap as well as torching (cohesive) lap. The lap shear test results are shown in Figure 1 with three different test temperatures used (minus 30 F, 0 F and 30 F). At these low temperatures, it can be seen that a torched lap or cohesive lap developed the most strength, with an adhesive lap of steep asphalt being the weakest. Tests were not run at room temperature, but the data trend is towards convergence, as seen in the right hand of Figure 1, at increasing temperatures.

Elongation data gathered from the same lap shear test is shown in Figure 2. At extremely low temperatures (minus 30 F), it can be seen that adhesive laps do not elongate as well as the cohesive lap. However, at warmer temperatures the elongation behavior is seen to improve. Since roof membranes spend the majority of their service life at higher temperatures, we can see that there is a factor of safety in lap strength and elongation behavior.

Recent lab tests on modified bitumen products[3] has shown that torched APP laps and SBS laps using asphalt as an adhesive produce high tensile strength and strain energy values. The failure mode for the lap shear test recorded was membrane rupture outside of the lap area. This research has also shown that the best SBS adhesion occurs with asphalt temperatures in excess of 400 F, which confirms current specification and practice.

SUMMARY

Modified bitumen products are in wide use as two-ply roof membrane systems. Application concerns are primarily found in the overheating of torch-applied APP at the lap edge, while the interior of the rolls are underheated.

The SBS-modified bitumens were found to have a similar application concern in that the mopping asphalt may be too cold at the point of application.

Lab test data has shown that both torching and mopping asphalt can serve equally well to provide cohesive or adhesive bonding of the laps and membrane sheet.

REFERENCES

[1] Cullen, W.C., "Project Pinpoint: NRCA's Diagnostic Database" *Professional Roofing*, July 1988.

[2] Dupuis, R. M. and Moody, W. R., "Lap Joint Strengths of Loose-Laid and Adhered Single-Ply Roof Systems," *Single-Ply Roofing Technology*, ASTM STP 790, Gumpertz, W.H., Ed., American Society for Testing and Materials, pp. 78–89, 1982.

[3] Berggren, M.A., "Laboratory Evaluation of Different Methods for Adhering SBS Modified Bituminous Roofing and Waterproofing Membranes," presented at ASTM C-24 Symposium on Building Deck Waterproofing, February 1989.

Type	No. of Products	(%)
SBS	96	54.9
APP	61	34.9
Blend (SBS/APP)	7	4.0
Nitrile	3	1.7
ECB	1	0.5
Unspecified	7	4.0
	175	100.0

Table 1 Types of modified bitumen available[1]
[1] NRCA Roofing Materials Guide—*Vol. 13, August 1988*

Surfacing	No. of Products	%
Plain—Modified Bitumen	82	46.9
Granule or Mineral	77	44.0
Aluminum (Embossed)	9	5.1
Copper or Stainless (Embossed)	4	2.3
Film (Polyethylene or Tedlar)	3	1.7
	175	100.0

Table 2 Types of surfacing used on modified bitumens[1]
[1]NRCA Roofing Materials Guide—*Vol. 13, August 1988*

Number of Plies	Number of Specifications
1	115
2	529
3	118
4	36
Total	798

Table 3 Modified bitumen membrane ply types with specifications[1]
[1]NRCA Roofing Materials Guide—*Vol. 13, August 1988*

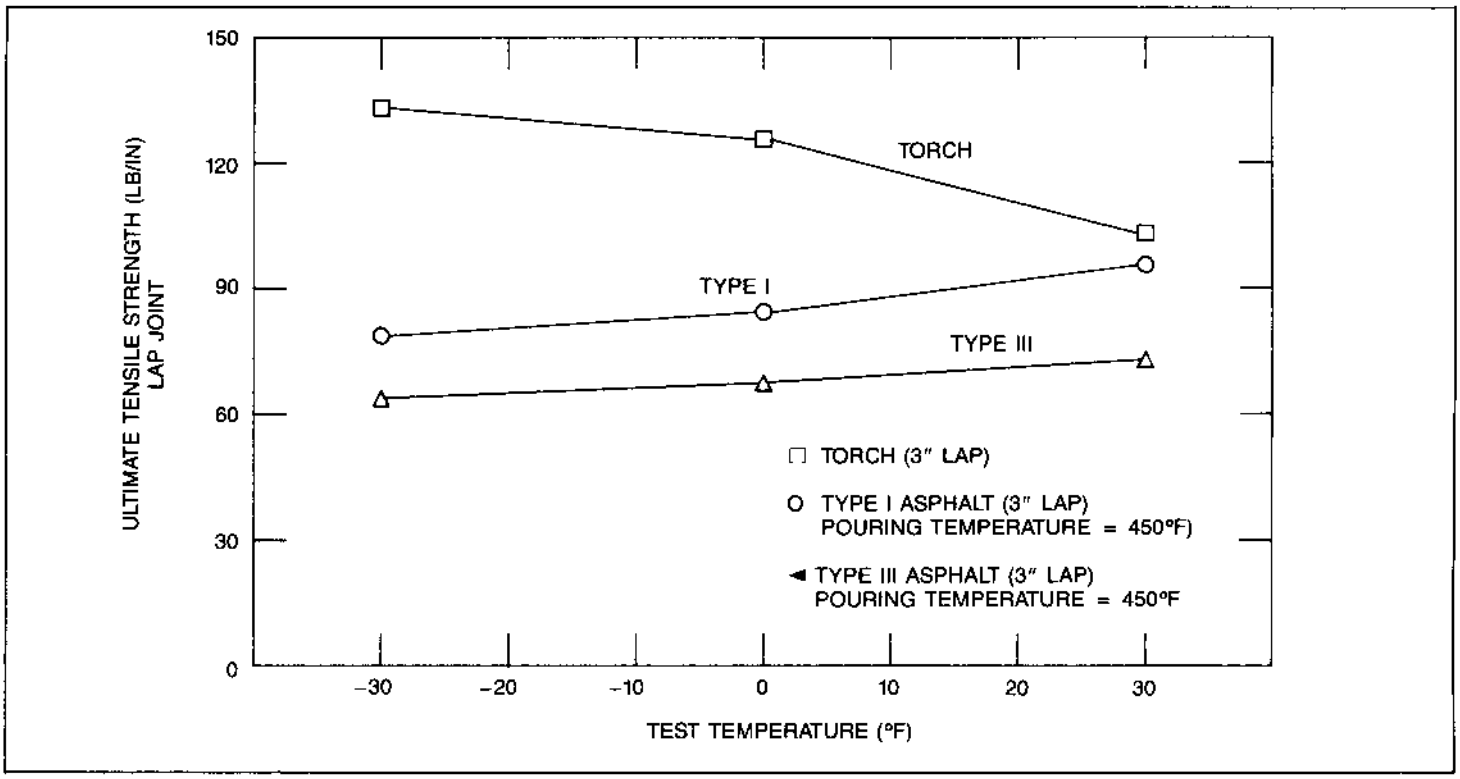

Figure 1 *Lap tensile strength versus temperature behavior*

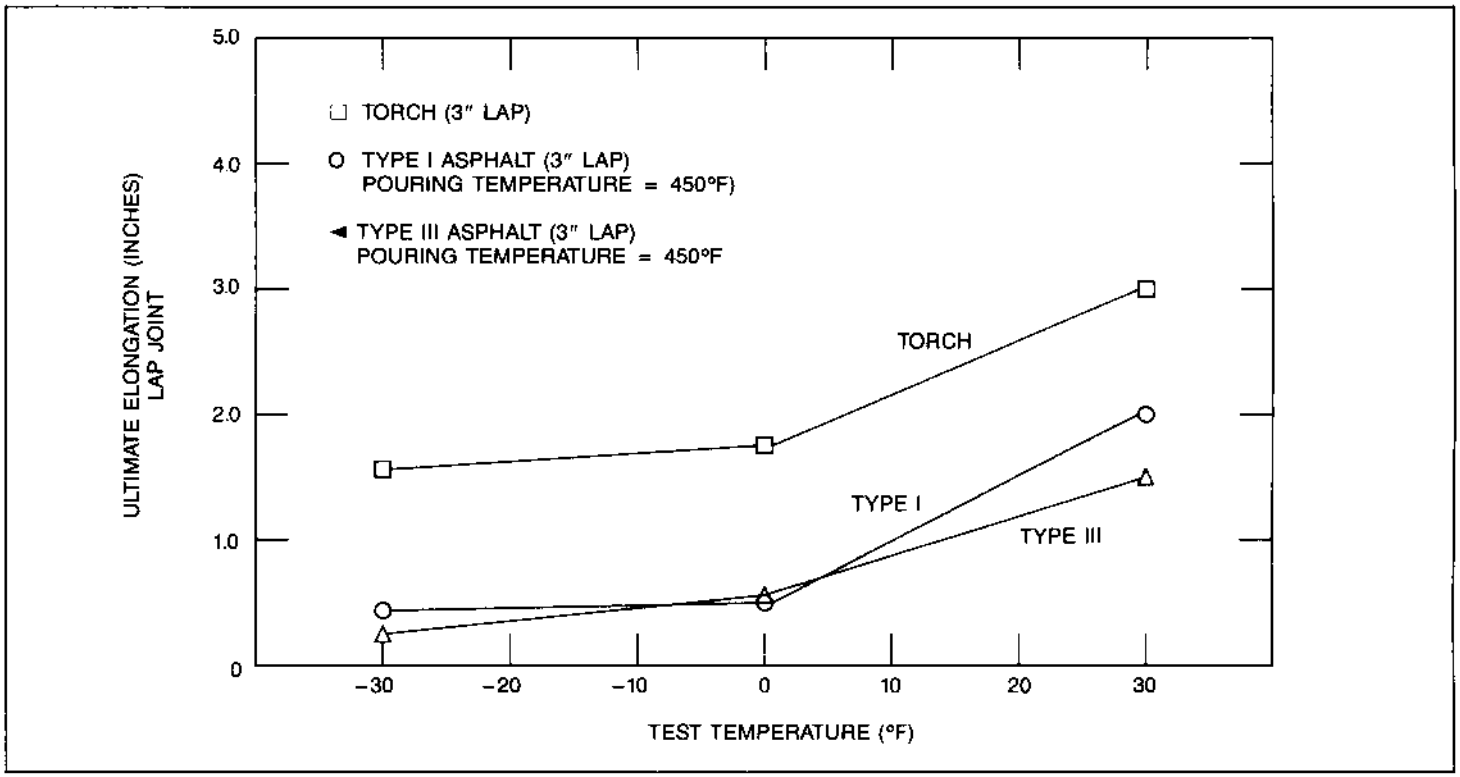

Figure 2 *Lap elongation versus temperature behavior (original length = 5.00″)*