



### Plasticizers in Millathane® 76

Millathane® 76 is a polyester millable urethane that finds much utility in soft compounds (for printing rollers and other applications) because of its excellent properties at low hardness. The question has come up in the past as to the benefits of using the higher quality Benzoflex 9-88SG vs. Benzoflex 9-88 in millable urethanes, as the SG version has lower moisture (0.07% vs. 0.1%) and lower hydroxyl number (4-6 vs. 15), both being important properties to keep to a minimum in castable urethanes to avoid cure interference and maximize compatibility.

To investigate this, a study was done to compare these two plasticizers along with other typical plasticizers used in millable urethanes, DBEEA (TP-95), TP-90B, Tegmer 809, DOP and Cumar P-10. The non-black Millathane® 76 formula shown below was used for the study, and all the plasticized compounds were compared to a control compound without plasticizer. All batches were mill mixed and cured and tested per ASTM procedures.

| FORMULATION                        |       |
|------------------------------------|-------|
| Millathane® 76                     | 100.0 |
| Zinc Stearate                      | 0.5   |
| Polyfil HG90                       | 25.0  |
| Akrofax 758                        | 25.0  |
| Ultrasil VN3 (precipitated silica) | 5.0   |
| Struktol WB222 (process aid)       | 1.0   |
| MBTS                               | 4.0   |
| MBT                                | 2.0   |
| Thanecure® ZM                      | 1.0   |
| Sulfur                             | 2.0   |
| Plasticizer                        | 25.0  |

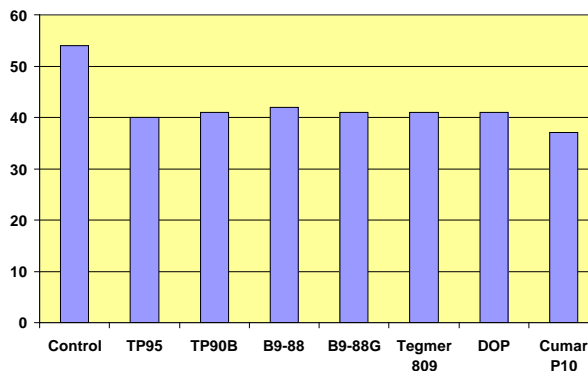
### COMPATIBILITY

The compounds containing DOP and Cumar P10 both showed some oily surface bloom, with the DOP bloom feeling greasy and the Cumar P-10 bloom feeling tacky to the touch. Other compounds were dry with no signs of plasticizer bleed. This indicates that 25 parts is beyond the solubility limit of these plasticizers in this Millathane® 76 compound; lower levels of these plasticizers would be less likely to bleed/bloom from the compound.

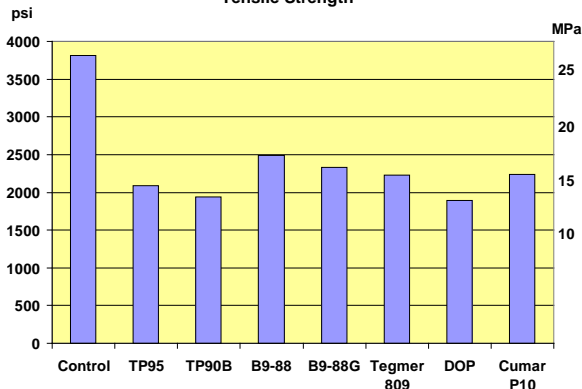
### CURED PROPERTIES

**Hardness:** The control compound, without plasticizer, tested 54 Shore A and the compounds with 25 parts of the various plasticizers dropped the hardness to 40-42 Shore A (a softening of about 1 Shore A point per 2 parts of plasticizer) except for the Cumar P10 compound which was somewhat softer than the others, at 37 Shore A. (See charts on page 2.)

Hardness, Shore A



Tensile Strength



**Tensile Strength:** The control compound gave 3810 psi tensile, with the plasticized compounds having 1890-2490 psi tensile. The Benzoflex 9-88 and 9-88SG, along with the Tegmer 809 and Cumar P-10, had higher tensile than the compounds with TP-95, TP-90B, and DOP.



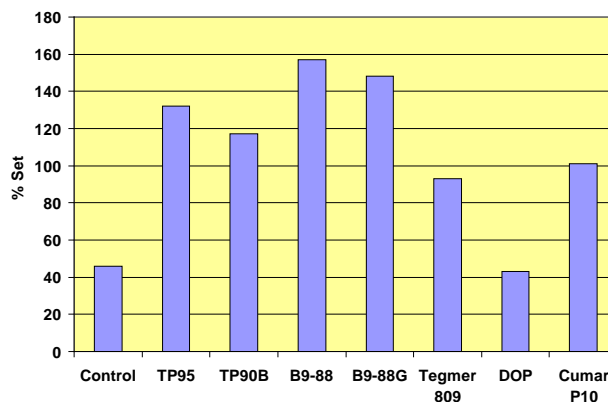
### Plasticizers in Millathane® 76 (cont.)

**Tear Strength:** Data (not shown) indicated the compounds with Benzoflex 9-88 and 9-88SG and Tegmer 809 gave the best tear strengths.

**Resilience:** Data (not shown) showed the Cumar P-10 not affecting the Bashore resilience while the other plasticizers increased the resilience of the Millathane 76 compound, with TP-95 and TP-90B having the greatest effect.

**Abrasion Resistance (DIN Abrasion):** The control, unplasticized compound lost a mere 46 mm<sup>3</sup> of its volume, indicating excellent abrasion resistance. The plasticized compounds generally had significantly higher abrasion loss except for the DOP-containing compound, which actually lost less than the control (43 mm<sup>3</sup>). This may be due to the lubricating effect of the oily bloom affecting the abrasive used in the test. Of the non-blooming samples, the Tegmer 809 compound had the best abrasion resistance and the Benzoflex 9-88 and 9-88SG compounds the poorest.

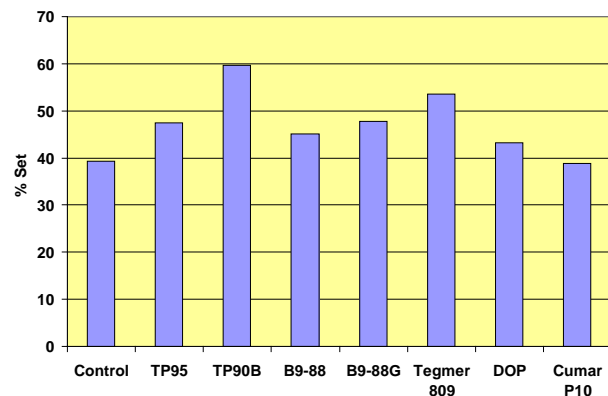
DIN Abrasion (ASTM D5963)



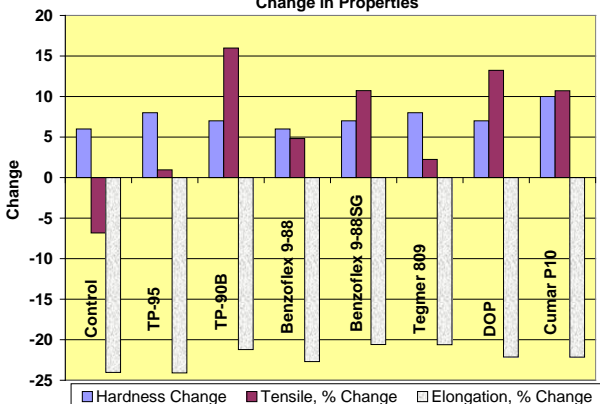
### AGED PROPERTIES

**Compression Set (22 hr/70°C):** The control compound had 39% set; in the plasticized compounds, Cumar P-10 and DOP gave the best set values while TP-90B and Tegmer 809 gave the highest (poorest) set values.

Compression Set, 22 hr/70°C



Oven Aging, 22 hr/70°C  
Change in Properties



**Oven Aging (22 hr/70°C):** All of the compounds hardened a bit as a result of the oven aging, with the Cumar P-10 compound having a little higher hardness gain than the others (+10 points vs. 6-8 points for the others). All of the plasticized compounds gained a little tensile and lost about 20% of their elongation.



### Plasticizers in Millathane® 76 (cont.)

#### SUMMARY

Many ester-type plasticizers can be used in Millathane® 76, and other millable urethanes, with each having their benefits to processing and properties. DBEEA (TP95) is probably the most common plasticizer used in millable urethanes, and it gives very good properties overall. All of the plasticizers evaluated in this study can be used with either sulfur or peroxide cured compounds with the exception of Cumar P-10 which should not be used in peroxide cures. No significant differences were seen in the properties of the Benzoflex 9-88 and Benzoflex 9-88SG compounds. The relative ratings of the effects of these plasticizers in the Millathane 76 compound are as follows:

|                                    | TP95 | TP90B | Benzoflex 9-88 | Benzoflex 9-88SG | Tegmer 809 | DOP | Cumar P10 |
|------------------------------------|------|-------|----------------|------------------|------------|-----|-----------|
| Compatibility at 25 phr            | A    | A     | A              | A                | A          | F   | F         |
| Effectiveness in Lowering Hardness | B    | B     | B              | B                | B          | B   | A         |
| Cured Tensile strength             | C    | C     | A              | A                | B          | C   | B         |
| Cured tear strength                | B    | B     | A              | A                | A          | A   | B         |
| Resilience (A=Highest)             | A    | A     | C              | C                | B          | C   | D         |
| Compression set                    | C    | D     | C              | C                | D          | B   | A         |
| Abrasion resistance                | C    | C     | D              | D                | B          | A   | C         |
| Heat aging                         | A    | A     | A              | A                | A          | A   | B         |

#### Glossary

| Plasticizer                 | Chemical Name                             | Supplier(s)           |
|-----------------------------|---|-----------------------|
| TP95 (DBEEA, Plasthall 226) | Di (butoxy-ethoxy-ethyl) adipate          | Rohm & Haas, Hallstar |
| TP-90B (DBEEF)              | Di (butoxy-ethoxy-ethyl) formal           | Rohm & Haas           |
| Benzoflex B9-88             | Dipropylene glycol dibenzoate             | Velsicol              |
| Benzoflex B9-88SG           | Dipropylene glycol dibenzoate             | Velsicol              |
| Tegmer 809                  | Polyethylene Glycol 400 di-2-ethylhexoate | Hallstar              |
| DOP                         | Diocetyl phthalate                        | Hallstar, others      |
| Cumar P-10                  | Coumarone indene resin                    | Neville Chemical      |