

# Technical Information for Performance Solutions

## Mold Shrinkage of MILLATHANE® 76 and MILLATHANE® E34

**Topics:**

- Mold Shrinkage
- Procedure
- Effect of Filler Loading and Filler Type
- Effect of Cure System
- Effect of Millathane® Grade
- Effect of Mold Shape

Mold shrinkage is the difference between the dimensions of the rubber mold and the cured rubber part. Mold shrinkage for rubber compounds will typically range from 1.5 to 3.0%, depending on the polymer, formulation, and molding conditions. It's important to know the mold shrinkage of the rubber compound especially when molding parts with critical dimensional tolerances.

This publication reports on a study of the mold shrinkage of Millathane 76 and Millathane E34 compounds, with varying filler levels (mercapto silane-treated clay, Nucap 100G\*, was used) and comparisons of Millathane 76 to Millathane E34, N990 black to Nucap 100G, and sulfur to peroxide cure (with and without TMPTMA coagent). Compound formulas were as follows:

	Sulfur cures	Peroxide cures
Millathane® 76 or E34	100	100
Zinc stearate	0.5	
Stearic acid		0.25
Nucap 100G or N990 Black	As noted	As noted
DBEEA (TP-95*)	5	5
Struktol WB222*	1	1
MBTS	4	
MBT	2	
Thanecure® ZM	1	
Sulfur	1.5	
DiCup 40C*		2
SR-350* (TMPTMA)		0/10

Compounds were tested for cure rate and were cured at three different temperatures (150°C, 160°C, and 175°C) in washer (OD/ID) and bar molds to measure mold shrinkage.

\*Trademarked products of the following suppliers: Nucap 100G = J.M. Huber; TP-95 = Rohm & Haas; Struktol WB222 = Struktol Co.; DiCup 40C = GEO Specialty Chemicals; SR-350 = Sartomer Co.

## Procedure

Compounds were mixed on a laboratory mill in a single pass mix. Samples were cured in the 0.5 inch (1.27 cm) thick shrinkage molds\*\* for  $t_{c90}+5$  minutes as determined by a moving die rheometer (MDR). Data plotted and discussed below is, unless noted otherwise, shrinkage of the bar mold in the lengthwise direction.



Washer and Bar Shrinkage Mold Samples

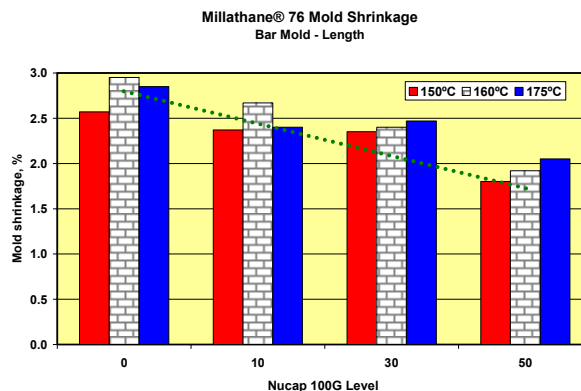
## Effect of Filler Loading and Filler Type

Mold shrinkage is greatly affected by filler loading in rubber compounds, primarily because the filler, which doesn't shrink, dilutes the polymer, which does shrink. We looked at levels up to 50 parts of Nucap 100G in Millathane 76 and saw the shrinkage decrease on the average 0.8% in going from 0 to 50 parts filler. At the higher filler levels (30 and 50 phr), the shrinkage increased slightly as the molding temperature increased.

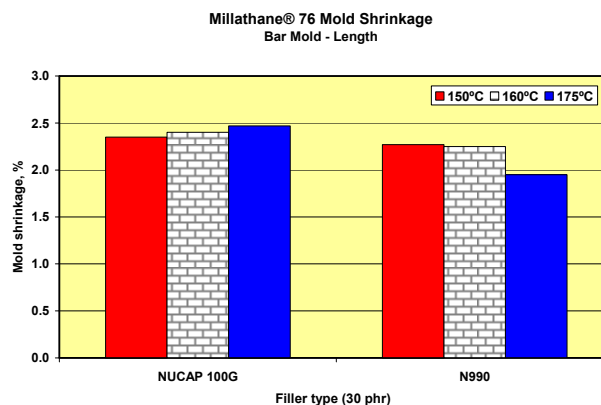
### MILLATHANE® FACTOID:

Did you know that you can cure Millathane® sulfur-cured compounds at as low a temperature as 80°C?

A 70 Shore A Millathane E34 compound with a modified sulfur cure system cured fully after 16 hours at 80°C (176° F).

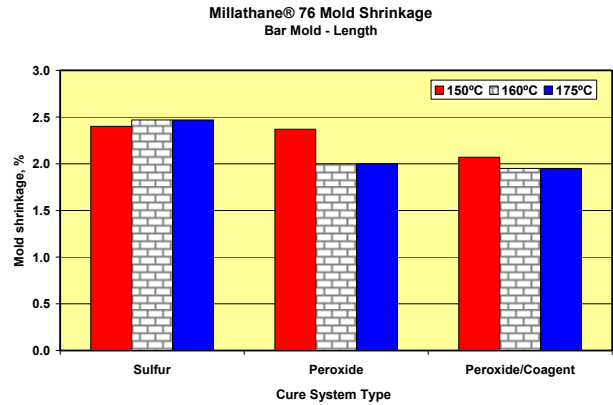


N990 was compared to Nucap 100G at 30 phr. Mold shrinkages were roughly comparable, although the shrinkage of the N990 compound seemed to decrease slightly as molding temperature increased.



## Effect of Cure System

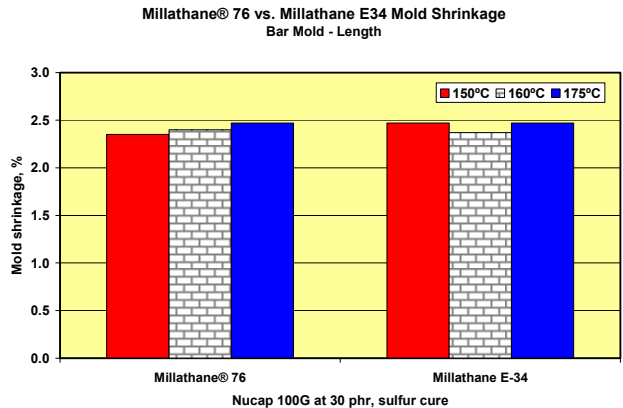
The peroxide cure system, using 2 phr of DiCup 40C, gave slightly lower mold shrinkage than the sulfur cure system. Mold shrinkage of the sulfur cured compound seemed constant over the three molding temperatures, while with the peroxide and peroxide/coagent cures, the two higher temperatures gave slightly lower mold shrinkage than the 150°C cures.



## Effect of Millathane® Grade

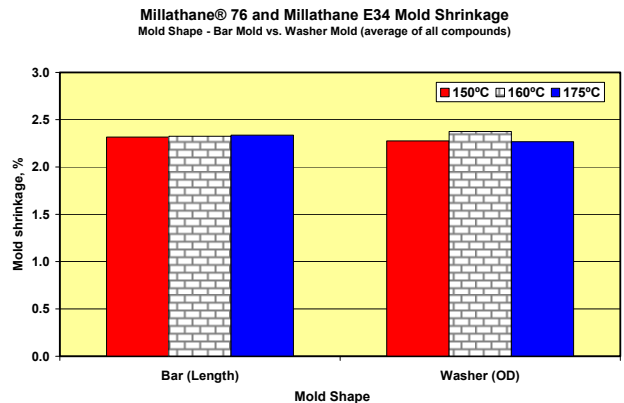
**MILLATHANE®**  
**FACTOID:**  
 Did you know that our food-grade urethane Millathane® 26 can be compounded to hardnesses over 95 Shore A? Blends of difunctional and trifunctional coagents gave good properties at these high hardnesses.

Millathane E34 was compared to Millathane 76 in the sulfur cured compound with 30 phr of Nucap 100G. Similar mold shrinkage was seen with both polymers at all three temperatures.



## Effect of Mold Shape

The data above discusses the shrinkage value obtained from length measurements of samples cured in the bar mold. Similar results were obtained with the washer (doughnut-shaped) mold. The chart shows the mold shrinkage of the bar length and the washer OD, averaging all the compounds in this study. The averaged data show comparable mold shrinkage of the two types of molded samples.



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**SUMMARY**

1. Mold shrinkage for typical Millathane® millable urethane compounds is generally 2.2 to 2.5%.
2. Mold shrinkage decreases with increasing filler loading and N990 black had similar mold shrinkage to the silane-treated clay Nucap 100G.
3. Millathane E34 gave similar mold shrinkage to Millathane 76 in the same, sulfur-cured formulation.
4. Overall, there was not a significant effect of molding temperature on mold shrinkage, with some minor exceptions (noted above).

Note: Details on the cured properties, cure characteristics, and shrinkage values can be obtained by contacting us for the full report.

\*\*Shrinkage mold dimensions were: Washer mold: Outside Diameter—2.998 in. (76.15 mm), Inside Diameter—2.000 in. (50.80 mm), Depth—0.503 in. (12.78 mm). Bar mold: Length—4.000 in. (101.6 mm), Width—0.752 in. (19.10 mm), Depth—0.502 in (12.75 mm).

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