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# VANDERBILT *Report*

## Accelerating the cure process

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R.T. Vanderbilt Company, Inc.



*With the introduction of three new liquid accelerators for latex, a complete line of activated dithiocarbamates is available to the compounder from R.T. Vanderbilt Co., Inc.*

*Today's industrial demands call for products that will meet special processing and end use requirements.*

### The Products

The SETSIT® line of ultra accelerators consists of proprietary water-soluble/water-miscible activated dithiocarbamates. They are easy to use and are freeze/thaw stable. Three new SETSIT grades were introduced in the last two years, bringing the number of liquid accelerators of this type to six.

The original product is **SETSIT 5**. It facilitates compounding and delivers the high tensile strengths that are associated with BUTYL ZIMATE® (zinc dibutyldithiocarbamate - ZnDBC) slurries and dispersions. In addition, it allows for fast and accurate volume measurements, since it is more convenient to fill a glass container to a certain level than to weigh and transfer viscous dispersions.

Accelerators are frequently withheld from the mix until just before use; rapid incorporation of the liquid accelerator (SETSIT 5) expedites factory operations and provides a degree of flexibility. Manufacturers who pre-disperse 'packages' of zinc oxide, sulfur, antioxidant and accelerator are not able to adjust the level of accelerator to conform to line speeds, oven dwells, seasonal variations, etc.

Eliminating the accelerator from this dispersion 'package', and adding it separately, allows for larger ball mill or attritor batch sizes. The liquid product does not settle or separate. No remixing is necessary, and housekeeping is neat and clean.

When higher levels of SETSIT 5 are added to natural rubber latex compounds, their viscosity increases upon standing. This characteristic is a symptom of precure. **SETSIT 9** was developed to inhibit precure in natural rubber latex compounds and, to a lesser extent, SBR latex compounds. However, while it inhibits precure and delivers high tensile strength compounds, SETSIT 9 will not initiate cure at room temperature.

**SETSIT 104** combines the best qualities of SETSIT 5 and SETSIT 9. The possibility of precure is greatly reduced, and the latex films continue to cure to their potential at room temperature following a fast oven cure.

Latexes cured with **SETSIT 055** have lower levels of nitrosamines and nitrosatable amines. **OCD-157\*** was developed to avoid the bitter taste of latex balloons imparted by some rubber accelerators. **SETSIT 981** was developed to comply with the requirements of Title 21 CFR Part 177.2600, Rubber Articles Intended for Repeated Use (in Contact with Food).

\*At the present time, commercial quantities of OCD-157 can be purchased only in certain countries outside the United States. Sample quantities for research and/or laboratory evaluation are available worldwide.

# Properties

<b>SETSIT 5</b>	General purpose. Should be used at low levels to avoid precure in natural rubber latex. Precure is not a problem in synthetic latexes like Neoprene and acrylonitrile.
<b>SETSIT 9</b>	Will not cure at room temperature, but high tensile strength is developed when oven cured.
<b>SETSIT 104</b>	Develops fast oven and room temperature cures.
<b>SETSIT 055</b>	Designed for low nitrosamine generation.
<b>OCD-157</b>	Designed to reduce the bitter taste of latex balloons. Also, low nitrosamine generation meets BGA requirements.
<b>SETSIT 981</b>	All ingredients comply with the requirements of Title 21 CFR Part 177.2600, Rubber Articles Intended for Repeated Use in Contact with Food.

## A Study

To determine the optimum use levels of the various accelerators, a study was performed with natural rubber latex. In addition to the SETSITs, BUTYL NAMATE® (sodium dibutyldithiocarbamate - NaDBC) and BUTYL ZIMATE (ZnDBC) were included as controls. As shown in the recipe below, six different levels of accelerator were added to the high modulus compound; four different levels of accelerator were added to the low modulus compound. The different levels of zinc oxide and sulfur distinguish the two compounds.

### BASE COMPOUNDS (100 phr)

<b>Accelerator</b>	<b>High Modulus Variable</b>	<b>Low Modulus Variable</b>
62% High Ammonia Natural Rubber	161	161
10% Potassium Hydroxide	5	5
5% Potassium Caseinate	10	10
50% Sulfur Dispersion	2	1
50% Zinc Oxide Dispersion	6	1
50% Octylated Diphenylamine	2.6	2.6

The compounds were mixed in the conventional manner and then poured onto glass plates and leveled. After three days drying at room temperature, the films were stripped and oven dried for 15 min. @ 38°C. Normal curing was accomplished in an oven with circulating hot air for 20 min. @ 93°C. Following the required 24 hour aging at room temperature, dumbbells were stamped and physical properties were determined.

Figure 1:

### Modulus vs. Accelerator Level

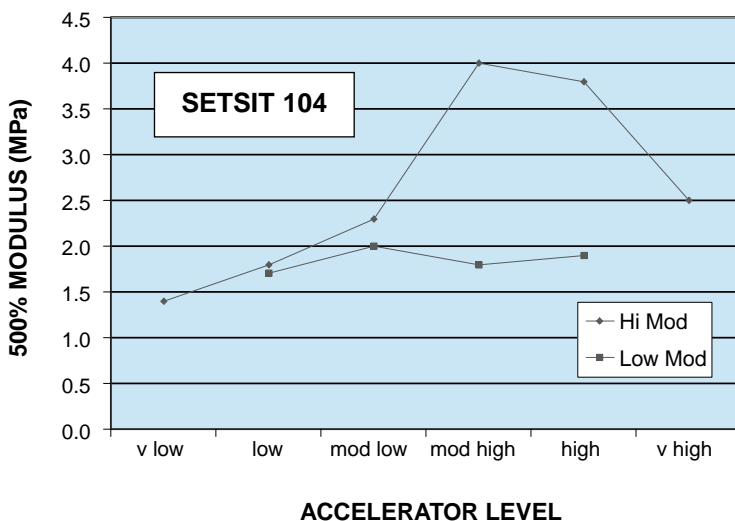
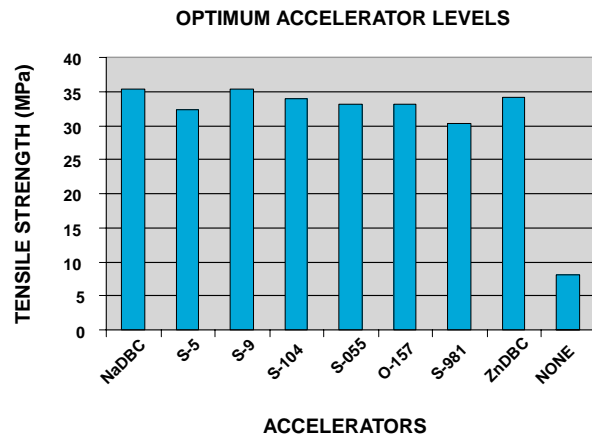


Figure 1 plots the accelerator level against the 500% modulus, and clearly shows the difference between high and low modulus compounds. It also reveals that there is an upper accelerator level in the high modulus compound, above which the modulus diminishes with increased amounts of accelerator.

Tensile strength was used as a measure of cure, and the optimum level of accelerator was noted when the tensile strength was maximum. The range is defined as all levels of accelerator that deliver a tensile strength of 21 MPa or greater, in accordance with the Standard Malaysian Glove Scheme (SMG). While the accelerator's range easily meets the SMG's requirements for both compounds, higher levels of accelerator are required to produce the optimum tensile strengths in the low modulus compounds (see Figures 2 and 3).

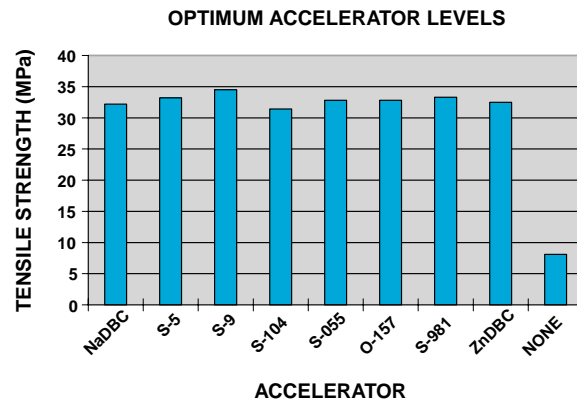
	phr, Wet	
	Optimum	Range
BUTYL NAMATE (NaDBC)	1.0	0.5 - 2.0
SETSIT 5	1.5	1.0 - 4.0
SETSIT 9	2.5	1.25 - 5.0
SETSIT 104	1.5	0.25 - 4.0
SETSIT 055	1.5	0.5 - 3.0
OCD-157	1.0	1.0 - 3.0
SETSIT 981	2.0	1.0 - 6.0
BUTYL ZIMATE (ZnDBC)	2.0	0.5 - 3.0

Figure 2: (High Modulus Compounds)



	phr, Wet	
	Optimum	Range
BUTYL NAMATE (NaDBC)	3.0	0.5 - 3.0
SETSIT 5	3.0	1.0 - 3.0
SETSIT 9	3.75	1.25 - 3.75
SETSIT 104	2.0	0.5 - 3.0
SETSIT 055	2.0	0.5 - 3.0
OCD-157	2.5	0.5 - 3.0
SETSIT 981	4.0	1.0 - 4.0
BUTYL ZIMATE (ZnDBC)	1.0	0.5 - 3.0

Figure 3: (Low Modulus Compounds)



## Five Minute Cure

Standard cure conditions for natural rubber latex compounds in the R.T. Vanderbilt Company's Waterborne Technologies Laboratory are 93°C for 20 minutes. A five minute cure or undercure does not permit optimum physical properties to develop in the film. However, the gradual increase in properties that develops over time at room temperature demonstrates that vulcanization is not a static condition. In natural rubber latex compounds cured with SETSIT liquid accelerators, or BUTYL ZIMATE (ZnDBC), the state of cure (tensile strength) will progress toward a plateau even when removed from the oven prematurely. This can be a manufacturing advantage, since it is possible to decrease the oven curing time by allowing products to continue to vulcanize at room temperature. In the high modulus compounds (Figure 4) all the tensile strength values are above the 21 MPa minimum of the SMG after three days following a five minute cure @ 93°C, and range between 25 and 35 MPa after nine days. While not as active, the low modulus compounds (Figure 5) show tensile strength values that are significantly increased after three days following the same cure conditions.

Figure 4:

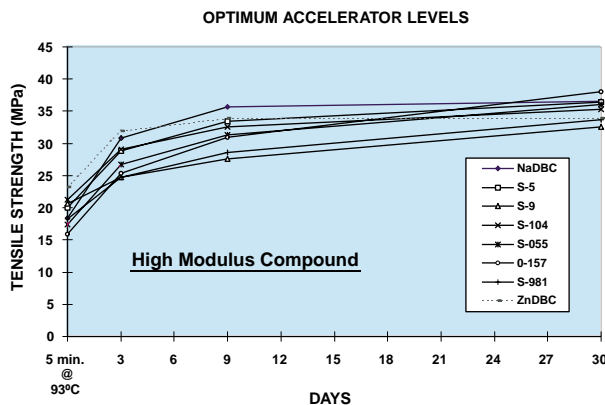
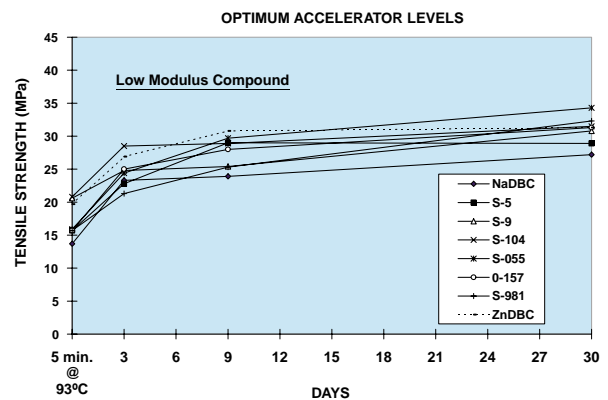


Figure 5:



# Specialty SETSITs

In addition to their intended applications, the three newest SETSITs provide excellent physical properties in latex films. These properties are especially important in low modulus products like surgical gloves, condoms and balloons. Figures 6, 7 and 8 indicate the levels of accelerator that deliver the highest tensile strength to these products. Of equal or perhaps greater importance, they show that the lowest level of accelerator easily exceeds the 21 MPa minimum of the SMG. These charts are part of the SETSIT profiles that are available for each liquid accelerator.

Figure 6:

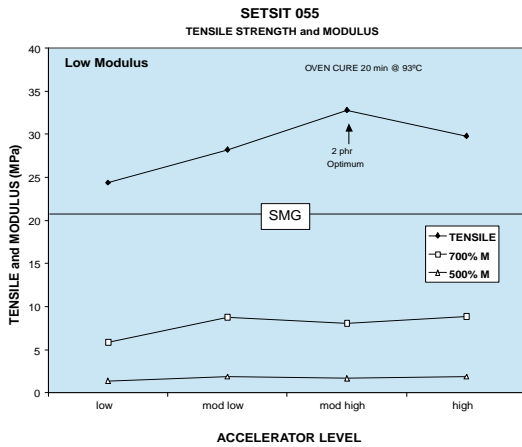


Figure 7:

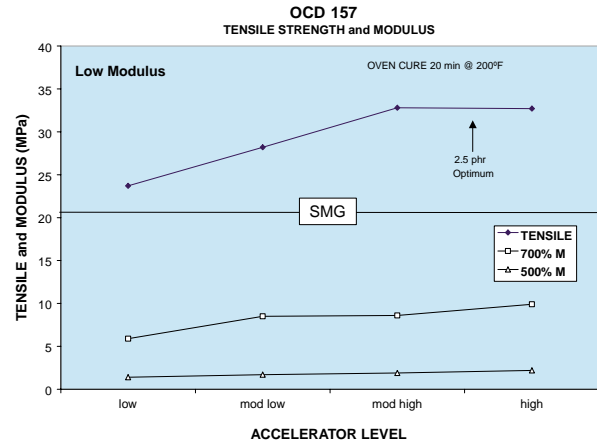
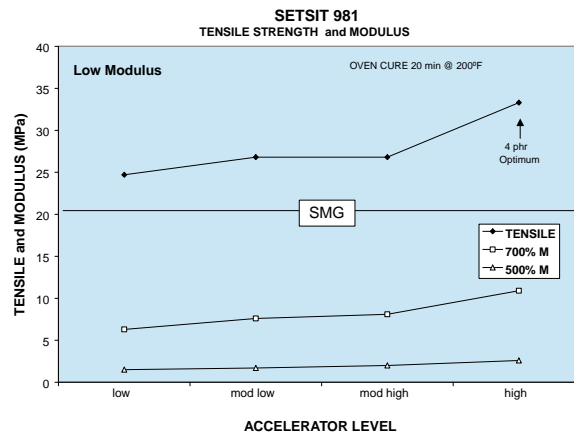


Figure 8:



## Advantages

- A complete line of general purpose and specialty SETSITs is available to meet customer requirements.
- High tensile strengths are easily attainable over a wide range of zinc oxide and sulfur levels. Low levels of accelerator deliver tensile strengths that surpass the minimum requirements of the Standard Malaysian Glove Scheme.
- No preparation or pre-processing is required.
- Accurate volumetric measurements are fast and easy.
- Housekeeping and storage are neat and clean.
- Liquid accelerators are freeze/thaw stable.
- The SETSITs can be rapidly incorporated into latex without mechanical shear. This eliminates agglomerates that cause hot spots and pinholes in films, and minimizes the possibility of mechanical destabilization of the compound.
- By eliminating the accelerator from the masterbatch, larger dispersion batches are possible. As a result, the state of cure can be modified by adjusting the level of liquid accelerator.
- Room temperature curing after oven cure allows for shorter oven dwells.

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