



TECHNICAL RÉPORT CÈOM-13

RESEARCH COMPOUNDING OF NITROSO RUBBER

by

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FOREWORD

Presently available commercial rubbers do not meet all of the needs of military equipment. Special rubber compounds are required in many items to assure their global operational capabilities. This is particularly true of those items containing rubber that must be in contact with gasoline, such as lightweight gasoline hose that can be reeled at -65°F, flexible gasoline containers that have a 10,000-gallon capacity and are easy to handle, and lightweight insulated boots that are soft and flexible at -65°F, all of which help to improve the efficiency not only of the military man but also of his equipment.

The Army is continuing to conduct research on the development of new kinds of rubber that can be compounded to increase its military capability. Nitroso rubber is one such product. Nitroso rubber was first produced in the laboratories of the Minnesota Mining and Manufacturing Company under Government contract. It has now been made in pilot-plant quantity by the Thickol Chemical Corporation under U. S. Army Natick Laboratories Contract No. DA19-129-AMC-69. Research compounding has been performed at the U. S. Army Natick Laboratories to develop information that the rubber technologist can use for detail compounding for specific enditem application.

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ABSTRACT

Nitroso rubber, a copolymer of trifluoronitrosomethane and tetrafluoroethylene, has been made in pilot-plant quantity by the Thiokol Chemical Corporation under Army Contract DA19-129-AMC-69. Research compounding studies have been made on this pilot-plant production rubber. A variety of cross-linking (vulcanization) agents were investigated, the most effective of which was triethylenetetramine. Of a series of reinforcing fillers used, the best physical properties were obtained with HiSil 303. However, a silicone-treated HiSil 233 gave comparable results.

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The curing characteristics of the nitroso rubber made in the pilot plant at the Thiokol Chemical Corporation were different from those of the material prepared in the laboratory of the Minnesota Mining and Manufacturing Company. Based on the research compounding studies made, there is no indication that rubber compounds having excellent physical properties can be made from the Thiokol Chemical Corporation nitroso rubber.

RESEARCH COMPOUNDING OF NITROSO RUBBER

1. Introduction

Rubber research and development is of vital importance for the success of military operations under all climatic conditions. Presently available rubbers limit the operational capabilities of many military items under extreme temperature conditions. Nitroso rubber, a new copolymer that has emerged from the research and development program, has potentiality for improving the temperature dependence of many of these items.

Nitroso rubber is a copolymer of trifluoronitrosomethane and tetrafiuoroethylene that was developed under Contract DA19-129-QM-1684 with the Minnesota Mining and Manufacturing Company. This work (1,2,3)established the basic properties of the material and indicated that only amines will cross-link it.

The physical properties obtained from amine vulcanized (cross-linked) nitroso rubber were poor as compared to many other synthetic rubbers. It was believed that a more complete compounding study than had previously been possible because of the scarcity of the nitroso rubber would improve these properties. Therefore, work was initiated, under Contract No. DA19-129-AMC-69, for the Thiokol Chemical Corporation to develop techniques for producing this rubber in pilot plant quantities. By means of these techniques, approximately 200 pounds of rubber was produced. This report is concerned with the research compounding of this rubber.

2. Materials and Test Methods

The Thiokol Chemical Corporation produced six batches of nitroso rubber that were used in this study. These rubbers, all copolymers of trifluoronitrosomethane and tetrafluoroethylene, were made in the pilot plant of the company.

Compounding studies have been conducted on only two of the batches.

- Minnesota Mining and Manufacturing Company, Arctic Rubber. Research Rept. (Contract DA19-129-QM-1684) 23 Dec 1962
- Montermoso, J.C., C.B. Griffis, A. Wilson and G.H. Crawford. Vulcanization and Properties of Nitroso Rubber. Rubber and Plastics Age, <u>42</u> (5) May 1961
- 3. Griffis, C.B. and M.C. Henry. Mitroso Rubbers. Rubber and Plastics Age, <u>46</u> (1) Jan 1965

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Their physical properties and the test methods used are as follows:

Tensile strength
- 1
Ultimate elongation D412-62T
Stress at 300% elongation
Hardness D676-59T
Mooney viscosity D1646-63

The differential thermal analysis data were obtained with a **D**u Pont Model 900 differential thermal analyzer under the following conditions:

Sample size:	4mm	Atmosphere:	Ar ₂ @ 760mm
Reference:	glass beads	Temperature scale:	50
Program mode:	heat	Temperature scale:	0.5
Rate of heating:	10 ⁰ /min	Base line slope:	0

3. Results and Discussion

It was immediately noted that the properties of the vulcanizates produced from the new lot of nitroso rubber (Thiokol) were not similar to those of the compounds from the carlier rubber (Minnesota Mining and Mfg. Cc.) even though the compounding recipe used was the same. For example, while tensile strengths of 1000 psi or more had readily been obtained from the earlier rubber (MMM), tensile strengths of 300 psi represented the maximum obtainable from the Thiokol rubber. There were differences in curing characteristics (scorch time, time of cure, and cure index) as well. To compensate for these differences, a series of amine cure studies was made.

The compounding and curing recipes, cure times and temperatures, and subsequent physical properties of various compounds of batch 5702 are given in Tables I and II, and of batches 5702 and 5675 in Tables III and IV. Table I gives the test results of amine-cured, HiSil 303-filled vulcanizates and Table II the results with amine-cured, carbon black-filled vulcanizates. Table III lists the vulcanizates with amine cures and amine and filler variations, and Table IV those with other than amine cures.

In the Table I series (HiSil 303 filler), the triethylenetetramine (TETA) was varied from 1.25 to 5 pphr (parts per hundred rubber) and the hexamethylenediamine carbamate (Diak #1) from 1 to 2.5 pphr. Press cure temperatures varied from 220° to 260° F. The Thermax black filler which had been found to increase the rate of cure of the Thiokol rubber, was tried in combination with the HiSil 303 in compound 57. This vulcanizate proved to be too weak to test. Compound 79, which had the smallest amount of TETA (1.75 pphr), was the best of this series but even this showed a tensile strength of only 245 psi. In the second series using the amine cure (Table II), various carbon black fillers were used: medium thermal (MT) furnace black "Thermax", an easy-processing channel (EPC) black, and a high-abrasion furnace (HAF) black. Press cure temperatures varied from 130° to 250° F. None of the black fillers gave vulcanizates that were superior to those using HiSil 303 (Table I) or to those using Linde Silicone treated HiSil 233 or Silstone 101. When the curing time was kept below 250° F, only the HAF black among the black-filled compounds produced sponging. At 210° F, the HAF Jlack compound did not sponge but it failed to cure.

Table III describes the compounds made with a variety of amine crosslinking agents, fillers, and stabilizers. It had been found that the addition of more than 2 pphr of triethylenetetramine usually produces sponging and always lowers the tensile strength. Sponging often is not readily discernible; sometimes it can be detected only by means of a microscope. To insure against sponging, compound 14 was made using only 1 pphr of triethylenetetramine and 0.33 pphr of hexamethylenediamine carbamate. To achieve maximum cure with this low level of curative, the compound was press-cured for 240 minutes at 210° F and then oven-cured for 24 hours at 195° F. The tensile strength of this compound (300 psi) was the highest obtained with the Thiokol nitroso rubber. Compound 14 showed no signs of sponging. None of the other variations produced a vulcanizate with more than 200 psi tensile strength.

Table IV shows the results when compounds were vulcanized with other than amine cross-linking agents. None of these vulcanizates could be tested; from visual examination none appeared to have been cured.

To determine the curing characteristics of the nitroso rubber, the viscosity, not only of batches 5702 and 5675 but also of the remaining four batches, was determined on the Mooney viscometer (Table V). Batch 5675 gave the lowest result, a viscosity of only 22. The curing characteristics of a variety of compounds are given in Table VI. Compounds 12 and 13, which represent MMM and Thiokol nitroso rubbers, respectively, showed great differences in curing characteristics. Compound 7 is a compound in which 1 pehr of 1,4 cyclohexane bis (methylamine) replaced 1 pphr trigthylenetetramine and then 3 pphr of zinc oxide stabilizer was added. This compound gave the best curing characteristics, hence the same formula was used in a series of compounds (8,9,11, and 12) in which the fillers were varied by the use of different carbon blacks and the effect of zinc fluoride was investigated.

With Thermax black as a filler (compound 9), the zinc fluoride improved the curing characteristics of the nitroso rubber, as is shown below:

<u>No.</u>	Compound	Time for Cure (beyond 35 min)
		(min)
8.	No filler, no zinc fluoride	no cure
9.	Thermax black with zinc fluorid	e 5.5
12.	No filler with zinc fluoride	no cure

14.5

11. Thermax black, no zinc fluoride

Zinc fluoride in HAF black filler systems (compounds 13, 14, and 15) did not change the curing characteristics of these compounds to the same degree that it did with the Thermax black and it did not improve the physical properties of the vulcanizates. In compounds 38 and 41, 2.5 pphr of triethylenetetramine and mixtures of carbon black and silicone-treated fillers were used and the temperature was reduced to $210^{\circ}F$ (to eliminate sponging). The cure characteristics produced were excellent but the physical properties were poor.

Results of attempts to identify cross-linking of the nitroso rubber by the use of differential thermal analysis techniques are given in Table VII. Triethylenetetramine was the only material tested that indicated cross-linking, and this occurred at 60° C. Using this method of analysis, the second order transition of -50° C compares with that previously reported⁽¹⁾ on the MMM rubber. Table VII shows that the addition of triethylenetetramine reduced the temperature for the onset of deterioration from 220°C to 200°C. The addition of Diak #1 (hexamethylenediamine carbamate) significantly reduced the temperature for the onset of deterioration. This was also true when other amines were used, and when dicumylperoxide was added.

4. Conclusions

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The Thiokol Chemical Corporation nitroso rubber has different curing characteristics from that made by the Minnesota Mining and Manufacturing Company.

The physical properties of the compounds made and reported here, using the Thiokol Chemical Corporation nitroso rubber, were extremely poor.

The reinforcing fillers HiSil 303 and the silicone-treated HiSil 233 were superior to the medium thermal furnace blacks, the high-abrasion furnace blacks, and the easy-processing channel blacks.

5. <u>Recommendation</u>

It is recommended that no development compounding be performed with the Thiokol Chemical Corporation nitroso rubber.

1. Minnesota Mining and Manufacturing Co., op. cit.

TABLE I

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COMPOUNDING RECIPES AND TEST RESULTS AMINE CURES - HISIL 303 FILLER

					Com	Compound Number	mber		
Ingredient Parts by Weight	79	50	51	51	57	58	60	64	65
Nitroso, Thiokol 5702	100	100	100	100	100	100	100	100	100
Triethylenetetramine	1.25		m	m	ო	1.5	S	1.5	1.5
Hexamethy lenediamine									
carbamate	2.5	2	1.25	1.25	-	2	1		
H1S11 303	15	20	15	15	i j	15	15	7.5	10
Mg O					Ś				
Zn silicate fluoride				ومحتدي	ŝ				
MT black					15				
Sodium borate								7.5	
Press cure (time min/									
temp OF)	60/250	60/220	60/260	60/230	60/220	60/260	60/220	60/220	60/220
Oven cure (cime hr/									
temp ^{OF)}	16/212	16/212				64/212			
Tensile strength,(psi)		200			ţo	100	175	το	р
Ultimate elongation(%)		100]		স	300	260	Ŋ	2
Stress at 300% elong.	230		pə	pə					
(psi)			Buc	ฮินด	Sə: M)) {		ЭД М	гәд м
Hardness, Shore A	57	80	ods	ods	roc	60	67	00:	00:
		-				~~~		ļ	7

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TABLE II

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COMPOUNDING RECIPES AND TEST RESULTS AMINE CURES - CARBON BLACK FILLERS

					Compo	Compound Number	her				
Ingredient	10	4		-	ļ			Ċ	0	;	
	×^	3		2		81	19	22	23	7	32
	100	100	100	100	100	100	100	100	100	100	100
Silstone 101										20	20
Tricthy lenetetramine	3	3	3	e C	1.5	1.5		8	ო	2.5	2.5
Hexamethy lenediamine											
carbamate			~	-4		-1	2		1		 1
1,4 Cyclohexane											I
bi4(methylamine)					4	-		1			
2n0	ო	e	3	C)	e	e	1	3	ſ	~	(m)
Zinc fluoride				1		I)	•))
HAF black				15	25	17	17	17	17		
MT black	15	15	15			00	00	- 30	8		
Linde silicone-	-						ł))		
treated Hi Sil				<u> </u>	-				10		
Press curs (time min/											
temp or)	60/250	60/250 60/210	60/220	60/200	60/220 60/200 60/200 60/200 60/200	60/200	60/200	60/200	60/200	60/240	60/210
Oven cure (time min/											
temp of)	16/212							16/200	16/200		
	125	100	140	100	210	200	160	06	200	250	220
Ultimate elongation(2) Sturre & 2007 clock	290	400	490	370	100	160	225	490	350	750	650
		06	100	1	ı			1	1	001	
Hardness, Shore A	36	30	28	40	62	50	35	38	50	37	41

*Sponged

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TABLE II (cont'd) Compounding Recipes and Test results Amine Cures - Carbon black fillers

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				C	puncduo	Compound Number				
Ingredient Parts by Weight	33	34	35	36	3.7	38	39	40	41	42
Nitrowo, Thiokol 5702	100	100	100	100	100	100	001	100	100	100
Silstone 101	20	10	10	10	10	10	07	10	10	10
Triethylenstetramine	2.5	2.5	2.5	2.5	2.5	2.5	2,5	2.5	2.5	2.5
Hexamethylenediamine carbamate	L L	-		7		-		-	-	-
ZnO	S	ო	ო	ო	r,	ო	e	ო	ę	ς
MT black		20	10	10						
EPC black					10	10	10			
HAF black								10	10	10
Press cure (time min/temp ^{OF})	60/180	60/240	60/210	60/240 60/210 60/180 60/240	60/240	60/210	60/ 180	60/210 60/180 60/240	60/210	60/180
Tensile strength (psi)	50	150	200	100	100	150	150	þəg	sst Ngyk	sst Veak
Ultimate elongation (2)	026	200	600	950	200	550	600	ŝuo		
	ç	D	07	77	07	22	62	ds	בט בט	

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TABLE III

COMPOUNDINC RECIPES AND TEST RESULTS AMINE CURES - AMINE AND FILLER VARIATIONS

						о С	Compound Number	Number					
	lngredient Parts by Weight	1	2	3	14	4	<u>م</u>	9	7	15	ω	21	24
	Thiokol	100	100	100	100	30	00.	001		00	001		
	NILTOSO, INIOKOL 3702 Zno	e				100	00 2 2 2	001	001	001	0 m		001
	Tricthy lonotetramine	2	n	ŝ	~1	n			7	ო	2		Ś
	Hexamethy lened i amine												
	carbamato			2	0.33	1	2		~	ო			
				-4									
	11,4 Cyclonexane bis (mothulamine)							Ś	2	~	~		
	HISII 233	15		15				•	r)))	
			15										
8	Silstona 101				10	15	15	15	10	12.5	12.5		15
							20			- <u></u>			
	NITTOBO- LTOALED HISII 233											C.21	
	Pross curs (time min/temp												
	0F)	60/240	90/2/06	60/210	240/212	60/190	60/280	60/280	60/280	60/230	60/250	60/200	007.709
	Oven cure (time hrs/temp	16/212	16/212 16/212	16/212	24/195	16/190	16/300	16/212	t	ŧ	16/212	16/200	16/212
	Tensilo strensth (psi)				300			100			200	100	180
	a longation	рәа	рәа	рәа	200	рәб	116	170	рәа	911	200	950	340
	Stress at 300% along (pai)	Buo	Buo	duo	150	Buo	າວ	: \	Buo	กว		ı .	, v
	Hardness, Snore A	ds	ds	ds	+ -	ds	ou	00	ods	ou	0	17	ς Γ

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TABLE III (cont'd)

COMPOUNDING RECIPES AND TEST RESULTS AMINE CURES - AMINE AND FILLER VARIATIONS

Ingredient Parts by Weight 70 Nitroso, Thiokol 5702 100 Triethylenetetramine 2 Hexamethylenediamine 2 Carbamate 2 Bthylenediamine carbamate 2 Sulfur Pyrometallicanhydride Methylene bis (phenyldi-			72	73	74							
by Weight o, Thiokol 5702 ylenetetramine thylenediamine amate nediamine carbamate tallicanhydride tallicanhydride ene bis (phenyldi-			72	73	74	1						
o, Thiokol 5702 ylenetetramine thylenediamine amate nediamine carbamate tallicanhydride ene bie (phenyldi-		 C			Ī	2	76	77	78	79	88	81
ylenetetramine thylenediamine amate nediamine carbamate tallicanhydride ene bis (phenyldi-		3	100	100	100	100	100	100	100	100	100	
thy lenediamine amate nediamine carbamate tallicanhydride ene bis (phenyidi-		4	ac		2						2	~
amate nediamine carbamate tallicanhydride ene bis (phenyidi-												
Sthylenediamine carbamate Sulfur Pyrometallicanhydride Methylene bis (phenyldi-		<u> </u>	5			сл			8		-	
tallicar Dne bis					_			e S				
Pyrometallicanhydride Methylene bis (phenyldi-					1.5	2	~	3	2	-		0.5
	<u></u>		<u>-</u>	Ś								
1505yEnete) Boddium bioschonste				(
Duphon uterrounder												
		 ר	 7	~	~	00	66	00	00	200	ĊĊ	
N, N' - Dicinnamy lidene-)) 	>		2 7	7	- 7	
1,6 hexanadiamine							(1)					
ZnO							,			~		~
Cadmium stearate		<u></u>	<u> </u>							1.5		י
Dipheny Initrosoamine			_								2	
1811 233												15
Disthylans glycol												7
(time min/												
temp ^o F) 60/220	0 60/230		60/230 1	180/212	30/250	30/250	30/250	30/250	30/250	30/250	60/250	60/240
Oven cure (time hra/												
temp "F) -			•			9	•	ı	1	-1		16/212
strength (pei)		100	150	ອງ	ə.	Э.	9	Э	150	8	5	į
Ultimate Ciongation (X) 900 Reveau at 3002 along (Dai) -		400	225	ເຄວ	1113	ເກວ	1110	IND	395	ant) 1 1:	əın:
			 - ``	0	o	0) (. `		5	5
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TABLE IV COMPOUNDING RECIPES AND TEST RESULTS OTHER THAN AMINE CURES

		J	Compound Number	Number			
Ingredient Parts by Weight	82	83	84	85	86	87	88
Nitroso, Thickel 5675 Nitroso, Thickel 5702	100	100	100	001	100	100	100
ŭ La	ν <i>ν</i>	L) 					
Hexamethylenediamine carbamate Disthylthioures MAPO		- 9 5					
HISII 303 Buzsn C12			15 3	15	15	15	15
DiCup 40c Trimethylolpropane trimethacryla Durometol#cochuduid	Ű			σ m			
						-1	
Cadox BSC paste							ጉ ጣ
Press cure (time min/temp ^{OF})	60/240	60/250	60/300	60/300	60/250	60/250	60/250
Tensile strength (psi) Ultimate elongation (%) Stress @ 300% elong (psi) Hardness, Shore A	o cure	o cure	o crite	eure c	eure	əınə d	etus o
	ŭ	NU	JU	bu	ou	Su	ou

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TABLE V

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MOONEY VISCOSITY OF VARIOUS BATCHES OF NITROSO RUBBER

Thickol Chemical Corporation Batch Identification	Mooney Viscosity (ML-4+1 @ 212 ^O F)
5702	35
5812	35
5812 (9/14/64)	36
5812 (9/15/64)	35
5812 (Part #3)	36
5675	22

TABLE VI

CURE CHARACTERISTICS AS DETERMINED WITH MOONEY VISCOMETER (LARGE ROTOR)

12 13 7 8 12 13 7 8 amate 1 100 22 2 3 3 3 2 2 3 10 10 12.5 100 100 10 10 12.5 100 100 10 1 3 3 1 1 1 3 3 1 1 1 3 3 1 215 215 250 250 11.5 70 56 13 50 10 5 14.5						Compound	Compound Number				
amate 1 100 2 2 3 3 amate 1 1 1 1 1 1 1 3 10 10 10 10 100 100 100 100 100 10 10 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 15 15 1 3 3 3 3 3 3 3 3 1 1 3 1 3 1 1 1 1 215 215 250 250 250 250 8 14,.5 2.775 4,.2 50 10 5 14,.5 2.775 4,.2 2.775 4,.2	Ingredient Parts by Weizht	12	13	7	8	6	11	12	13	14	15
3 3 3 2 2 3 3 3 10 10 1 1 1 1 1 1 3 10 10 10 100 100 100 100 100 1 1 1 1 1 1 1 1 1 1 100 100 100 100 100 100 100 100 1 1 3<	Nitroso, MMM 9690		100								
amate 1 1 1 1 1 1 1 3 10 10 10 10 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 10 1 1 3 3 3 3 3 3 3 3 1 3 1 3 1 3 1 1 1 1 3 1 3 1 3 1 1 1 215 215 250 250 250 250 250 8 11.5 70 56 13 20 8 8 50 10 5 14.5 2.75 4.2	Triethy lenetetramine	m	ო	3	3	e	ო	e	e	ო	ო
3 10 10 12.5 100 10 10 10 <th>Hexamethylenediamine carbamate</th> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-1</td> <td>~1</td> <td>1</td> <td></td> <td>4</td>	Hexamethylenediamine carbamate						-1	~1	1		4
100 100 100 100 100 1 1 1 1 1 1 3 3 3 3 1 3 3 3 3 1 3 1 1 1 1 3 1 3 1 1 3 1 3 1 215 215 250 250 250 11.5 70 56 13 20 50 10 5 14.5 2.75	Silicone-treated HiSil 233	10	10	12.5							
lamine) 3 3 3 15 15 15 3 3 3 3 3 3 3 3 1 1 3 1 3 3 3 3 3 215 215 250 250 250 250 250 250 11.5 70 56 13 20 8 8 50 10 5 14.5 2.75 4.2	Nitroso, Thiokol 5702	100		100	100	100	100	100	100	100	100
lamine) 3 3 3 3 3 215 215 250 250 250 250 215 215 250 250 250 250 11.5 70 56 13 20 8 50 10 5 14.5 2.75 4.2	Zinc fluoride										-
lamine) 3 3 3 3 1 1 3 1 1 215 215 250 250 250 215 70 56 13 20 11.5 70 56 13 20 50 10 5 14.5 2.75 4.2	Thermax					15	15		1		1
lamine) 1 3 1 1 215 215 250 250 250 215 70 56 13 20 11.5 70 56 13 20 50 10 5 14.5 2.75	ZnO			ന	e	ę	ო	ıŋ	ო	m	m
215 215 250 250 250 11.5 70 56 13 20 8 50 10 5 14.5 2.75 4.2	1.4.Cyclohexane bis(methylamine)	_		7	e		-	-)
215 215 250 250 250 250 11.5 70 56 13 20 8 50 10 5 14.5 2.75 4.2	HAF black)	1	 1	•	15	12	12.5
11.5 70 56 13 20 8 50 10 5 14.5 2.75 4.2	Temp. of test (^o F)	215	215	250	250	250	250	250	250	250	250
50 10 5 14.5 2.75 4.2	Minimum viscosity	11.5	70	56	13	20	œ	6	68	54	5
	Scorch time (ts min)	20	10	ŝ	14.5	2.75	4.2	11.5	7	7.2	4.3
100 26.5 18 - 5.5 -	Time of cure (t35 min)	100	26.5	18	•	5.5	•	14.5	19.2	14.3	1
16.5 13 - 2.75 -	Cure index (TA30-t35-t5)	S	16.5	13	1	2.75	ı	Ś	12.2	7.1	1

NOTE: Sarrated, large rotor used.

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(cont	
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TABLE	
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CURE CHARACTERISTICS AS DETERMINED WITH MOONEY VISCOMETER (LARGE ROTOR)

					Comp	Compound Number	nber	1			
Ingreatent Parte by Weight	16	61	20	21	24	32	35	38	41	20	15
Nitroso, Thiokal 5702	100	100									
Tristhy lengtathaning)) 1))		2,0		100	ruu	100	001	001
Hexamethy lened iamine)			_	n	2.2	2.5	2.5	2.5	2	~
carbamate		2	7			-	-	-		, 	
1,4 Cyclohexane bis	1	1			4	-	-4		-	V	1.25
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TABLE VII

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DIFFERENTIAL THERMAL ANALYSIS RESULTS

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Thiokol 5702 with TETA	-49	60	200
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5702 wi	•	ı	168
5702 -	1	•	137
Thiokol 5702 - dicumylperoxide	1	ı	133
Thiokol 5702, TETA, Diak #1, DPG, CAB-O-Sil	1	ı	138
Tg = Second order transition temperature Tc = Onset of crosslinking temperature Td = Onset of degradation temperature			

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