Consumer Solutions

XIAMETER™ Silicone Rubber

Compounding Guide

Foreword

This simple compounding guide has been designed to help compounders and fabricators that are operating in the Silicone High Consistency Rubber market to meet their specific customer's products needs and performance requirements.

Custom compounding offers the possibility and the flexibility to formulate and prepare silicone rubber compounds that will meet at the best your customer's specifications with a minimum inventory and related cost savings.

This guide aims to make custom compounding simple as much as possible. Here you will find the basic information to generate the most sophisticated silicone rubber compounds starting from XIAMETER™ high quality raw materials.

A few examples of formulation are included and can be considered a starting point to generate your own knowledge and uniqueness in tailored formulations.

Silicone rubber compounding creates an almost endless variety of possible formulating possibilities to achieve the most different requirements and specifications set by the parts manufacturers or specifiers.

By becoming familiar with the various properties and characteristics of the entire XIAMETER™ family of silicone rubber products you will have at your disposal a complete approach to compounding versatility.

Compounding Equipment

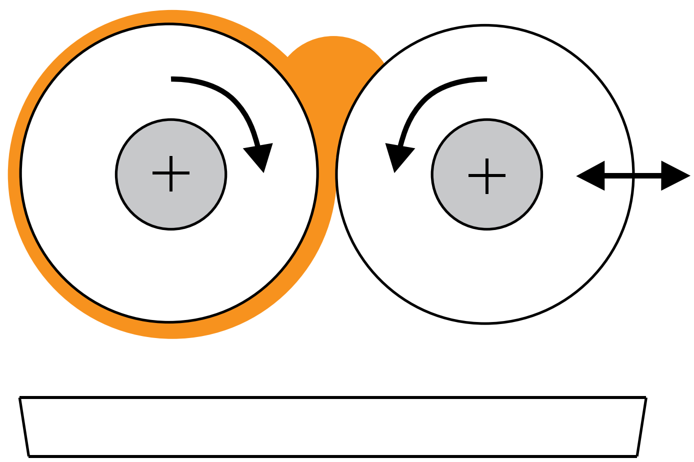
For quite large batch productions Silicone Rubber compounding operation is generally performed on closed mixers.

Medium and small batch productions can be however performed on a two-roll mixing mill, a several decades old but yet valid and flexible machine, that is still widely used today in Silicone Rubber Fabrication operation and in many laboratories, and is basically consisting of two robust rotating rolls with smooth stainless steel hardened surface.

Cold water circulating in the hollow part of both rolls may be necessary depending on equipment size in order to keep silicone rubber temperature below 55°C (130°F).

Two nylon coated cheek plates will avoid silicone rubber to get contaminated during the mixing process by picking up dirt and gear grease from sides of rolls.

The gap between rolls should be adjustable and one roll should rotate faster than the other with a 1.2:1 to 1.4:1 ratio.



The above Figure shows a schematic side view of a two-roll mill. Fast roll is on the left side, right side slow roll can be moved toward or away from fast roll in order to adjust gap and allow a bank to be formed on top for mixing action.

A pan on the bottom will collect crumbs of material falling down during process. These should be immediately recovered and re-added in the bulk. If they were left in the pan for a while they would no longer smoothly mix in and disperse, resulting in lumps and surface imperfections on the cured parts.

Compounding Process

The two-roll mill is loaded with Silicone Rubber Base having care of keeping material initially on the slow roll, then gap between rolls should be reduced.

Material will be plasticized when it will transfer to fast roll and will then be ready for adding other ingredients such as extenders, pigments, modifiers, and any other type of additives, following a defined sequence.

A number of cross blends will be necessary in order to well disperse the various ingredients. This consists of removing all or part of the band, rotating it by 90° and re-adding it in. The vulcanizing agent should be last added ingredient.

Ground quartz powders can be added in significant quantities with only a marginal effect on crepe-hardening.

Compound Storage

Once fully mixed a compound may be moved to subsequent vulcanizing process or may be stored and have some rest time according to curing agent at adequate temperature.

However during such rest time compound may be subject to some changes that may positively or less positively impact its performance in terms of processability or physical and mechanical properties. E.g. compression set tends to improve, viscosity tends to increase etc.

Blending

Blending consists of mixing together two or more Silicone Rubber Bases in order to combine their properties and characteristics and is possible for most of our materials.

One of the most common blending examples is mixing of 70 and 60 Shore A bases for obtaining an intermediate 65 Shore A Durometer.

The same concept applies to other physical and mechanical properties such as tensile strength, tear strength, compression set, etc.

Modifiers and Additives

A wide range of modifiers and additives is available to be added in the formulation in order to enhance some of Silicone Rubber typical properties like heat ageing resistance, tear strength or to modify modulus rather than other mechanical or physical properties, such as fluid resistance and meet specific application requirements.

Other additives are used to enhance Silicone Rubber Compound processing characteristics during subsequent part fabrication phase.

Tables under Modifying chapter show use of XIAMETER™ RBM-9002 Rubber Additive to improve heat ageing resistance.

Extenders

Extending is the process of adding fillers, such as diatomaceous earth or ground Quartz powder, to a Silicone Rubber product to reduce cost, increase durometer or fluid resistance to the compound. This is usually performed in a closed mixer.

Most XIAMETER™ Silicone Rubber Bases are designed to accept large amount of extending fillers.

Pigments

Color pigments should be added in the smallest possible quantity to minimize their effect on Silicone Rubber Compound performances. Those pigments need to be heat stable. Pigment Masterbatches offered by XIAMETER™ are easier to disperse in the Silicone Rubber matrix.

Curing Systems

Silicone Rubber can be vulcanized (or cured) in a few ways. Most common way is by means of an Organic Peroxide vulcanizing agent. Below is a list of most commonly used Organic Peroxides for Silicone Rubber vulcanization according to the fabrication process:

Extrusion
di(2,4-dichlorobenzoyl)peroxide

Molding
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane dicumyl peroxide

Peroxide should normally be last added ingredient.

We recommend referring to the vulcanizing agent manufacturer for more detailed information on safe use and storage of peroxides.

An alternative, more efficient curing system is Addition Cure. Vulcanizing speed is faster than peroxide cure and compound mechanical properties are higher.

XIAMETER™ Addition Cure package (see Tables 6 and 7) includes:

XIAMETER™ RBM-9200 Inhibitor

XIAMETER™ RBM-9201 Crosslinker

XIAMETER™ RBM-9202 Catalyst

These should be added in sequence: Inhibitor should be well dispersed before Catalyst is added. Crosslinker should be added for last.

Formulating

A compound formulation consists of a list of materials. This means that many of above described ingredients (bases, extenders, additives, modifiers, pigment and curing system) will have to be combined together in order to obtain the desired results in terms of processability, physical and mechanical properties.

This, in turn, means there may be interactions and sometimes conflicts between these ingredients, e.g. if di(2,4-dichlorobenzoyl) peroxide is used with carbon black based pigment this will cause progressive loss of peroxide reactivity, hence compound should be vulcanized just after mixing process.

XIAMETER™ has many specialized bases with different properties that may be used for unique applications that may fit your needs. You may want to check the following hyperlinks to download our Selector Guides.

XIAMETER™ Silicone Rubbers

HCR Bases Selector Guide – Americas

HCR Bases Selector Guide – Asia (Chinese)

HCR Bases Selector Guide – Japan (Japanese)

HCR Bases Selector Guide – Europe

Testing

Materials in following Tables were tested according to Dow Corporate Test Methods (CTM), which in most cases are similar to ASTM (American Society or Testing and Materials) standards. Copies of CTMs are available on request.

MODIFYING

Table 1 - Modifying XIAMETER™ RBB-2003-50 Silicone Rubber with XIAMETER™ RBM-9002 Rubber Additive

Press cure molded 10 minutes @ 170°C, Oven post cured 4 hours @ 200°C			
XIAMETER™ RBB-2003-50 Silicone Rubber	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 50% paste	parts	1.0	1.0
XIAMETER™ RBM-9002 Rubber Additive	parts		1.0
After 70 hours @ 225°C			
Durometer change	points	3	-8
Tensile Strength change	%	-55	-23
Elongation change	%	-50	6
After 72 hours @ 250°C			
Durometer change	points	NA	-3
Tensile Strength change	%	NA	-53
Elongation change	%	NA	-34

Table 2 - Modifying XIAMETER™ RBB-2003-70 Silicone Rubber with XIAMETER™ RBM-9002 Rubber Additive

Press cure molded 10 minutes @ 170°C, Oven post cured 4 hours @ 200°C			
XIAMETER™ RBB-2003-70 Silicone Rubber	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 50% paste	parts	1.0	1.0
XIAMETER™ RBM-9002 Rubber Additive	parts		1.0
After 70 hours @ 225°C			
Durometer change	points	6	0
Tensile Strength change	%	-50	-38
Elongation change	%	-73	-19
After 72 hours @ 250°C			
Durometer change	points	NA	2
Tensile Strength change	%	NA	-70
Elongation change	%	NA	-61

MODIFYING

Table 3 - Modifying XIAMETER™ RBB-2002-50 Base with XIAMETER™ RBM-9002 Rubber Additive and extending

Press cure molded 10 minutes @ 177°C, Not post cured				
XIAMETER™ RBB-2002-50 Base	parts	100.0	100.0	100.0
XIAMETER™ RBM-9002 Rubber Additive	parts		1.0	1.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 45% paste	parts	1.0	1.0	1.0
MIN-U-SIL 5 Microns	parts			50.0
Initial Properties				
Gravity		1.14	1.14	1.40
Durometer	Shore A	47	47	59
Tensile	MPa	7.9	9.1	5.6
Elongation	%	607	617	374
Modulus 100%	MPa	0.8	0.9	1.8
Tear strength B	N/mm	15	13	15
Tear strength C	N/mm	24	22	24
Compression set (22 hours @ 175°C)	%	16	15	12
After 70 hours @ 225°C				
Durometer change	points	19	7	8
Tensile strength change	%	-20	-6	-1
Elongation change	%	-69	-14	-43
After 168 hours @ 250°C				
Durometer change	points	Brittle	11	13
Tensile strength change	%	Brittle	-50	-26
Elongation change	%	Brittle	-53	-65

MODIFYING

Table 4 - Modifying XIAMETER™ RBB-2030-40 Base with XIAMETER™ RBM-9002 Rubber Additive

Press cure molded 10 minutes @ 170°C, Oven post cured 4 hours @ 200°C			
XIAMETER™ RBB-2030-40 Base	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 45% paste	parts	1.0	1.0
XIAMETER™ RBM-9002 Rubber Additive	parts		1.0
Initial properties			
Gravity		1.10	1.10
Durometer	Shore A	42	42
Tensile	MPa	7.1	7.8
Elongation	%	587	633
Modulus 100%	MPa	0.8	0.1
Tear strength B	N/mm	11	12
Tear strength C	N/mm	24	24
After 70 hours @ 225°C			
Durometer change	points	-4	-2
Tensile strength change	%	-40	-16
Elongation change	%	-17	0
After 168 hours @ 250°C			
Durometer change	points	Brittle	1
Tensile strength change	%	Brittle	-59
Elongation change	%	Brittle	-32

Table 5 - Modifying XIAMETER™ RBB-2030-80 Base with XIAMETER™ RBM-9002 Rubber Additive

Press cure molded 10 minutes @ 170°C, Oven post cured 4 hours @ 200°C			
XIAMETER™ RBB-2030-80 Base	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 45% paste	parts	1.0	1.0
XIAMETER™ RBM-9002 Rubber Additive	parts		1.0
Initial properties			
Gravity		1.42	1.42
Durometer	Shore A	84	83
Tensile	MPa	7.4	6.4
Elongation	%	89	80
Modulus 100%	MPa	NA	NA
Tear strength B	N/mm	12	13
Tear strength C	N/mm	12	17
After 70 hours @ 225°C			
Durometer change	points	3	5
Tensile strength change	%	-20	-14
Elongation change	%	-27	-25
After 168 hours @ 250°C			
Durometer change	points	7	5
Tensile strength change	%	-4	-27
Elongation change	%	-78	-55

FORMULATING WITH VARIOUS CURING SYSTEMS

Table 6 - XIAMETER™ RBB-2100-50 peroxide cure vs. Addition Cure for Extrusion purpose [1]

Press cure molded Oven post cured		5 min @ 115°C Not post cured	5 min @ 135°C 4 hours @ 200°C
XIAMETER™ RBB-2100-50	parts	100.0	100.0
Di(2,4-dichlorobenzoyl)peroxide 50% paste	parts	1.3	
XIAMETER™ RBM-9200 Inhibitor	parts		0.4
XIAMETER™ RBM-9201 Crosslinker	parts		4.3
XIAMETER™ RBM-9202 Catalyst	parts		0.9
Initial properties			
Durometer	Shore A	51	51
Tensile	MPa	11.7	10.8
Elongation	%	561	710
Tear strength	N/mm	23	32

[1] Shelf life of this formulation will be very short hence it is recommended to use the compound just after mixing.
In case of bubbles amount of Inhibitor and Catalyst may be slightly adjusted.

Table 7 - XIAMETER™ RBB-2100-50 peroxide cure vs. Addition Cure for Molding purpose

Press cure molded Oven post cured		10 min @ 170°C 4 hours @ 200°C	5 min @ 170°C 4 hours @ 200°C
XIAMETER™ RBB-2100-50	parts	100.0	100.0
Dicumyl peroxide 40% paste	parts	1.5	
XIAMETER™ RBM-9200 Inhibitor	parts		2.5
XIAMETER™ RBM-9201 Crosslinker	parts		5.0
XIAMETER™ RBM-9202 Catalyst	parts		0.9
Initial properties			
Durometer	Shore A	50	50
Tensile	MPa	11.6	10.4
Elongation	%	609	765
Tear strength	N/mm	23	35

FORMULATING FOR FLUID RESISTANCE

Table 8 - XIAMETER™ RBB-2003-50 Silicone Rubber and XIAMETER™ RBB-2003-70 Silicone Rubber Fluid resistance

Press cure molded 10 minutes @ 170°C Oven post cured 4 hours @ 200°C		XIAMETER™ RBB-2003-50 Silicone Rubber	XIAMETER™ RBB-2003-70 Silicone Rubber
XIAMETER™ Base	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 50% paste	parts	1.0	1.0
After 72 hours @ 100°C in Water			
Durometer change	points	-1	0
Tensile strength change	%	-13	-14
Elongation change	%	-2	-8
Volume change	%	1	1
After 72 hours @ 150°C in IRM Oil #1			
Durometer change	points	-6	-5
Tensile strength change	%	-16	-18
Elongation change	%	-9	-15
Volume change	%	8	6
After 72 hours @ 150°C in IRM Oil #3			
Durometer change	points	-25	-32
Tensile strength change	%	-45	-23
Elongation change	%	-38	-26
Volume change	%	50	44

Table 9 - XIAMETER™ RBB-2400-50 Silicone Rubber and XIAMETER™ RBB-2400-70 Silicone Rubber Fluid Resistance

Press cure molded 10 minutes @ 170°C Oven post cured 4 hours @ 200°C		XIAMETER™ RBB-2400-50 Silicone Rubber	XIAMETER™ RBB-2400-70 Silicone Rubber
XIAMETER™ Base	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 50% paste	parts	1.0	1.0
After 72 hours @ 100°C in Water			
Durometer change	points	-2	-1
Tensile strength change	%	-25	-9
Elongation change	%	-15	-5
Volume change	%	0	1
After 72 hours @ 150°C in IRM Oil #1			
Durometer change	points	-10	-5
Tensile strength change	%	-12	-33
Elongation change	%	4	-24
Volume change	%	1	25
After 72 hours @ 150°C in IRM Oil #3			
Durometer change	points	-23	-29
Tensile strength change	%	-56	-39
Elongation change	%	-41	-35
Volume change	%	56	44

FORMULATING FOR FLUID RESISTANCE

Table 10 - XIAMETER™ RBB-2030-40 Base Fluid resistance

Press cure molded 10 minutes @ 170°C Oven post cured 4 hours @ 200°C			
XIAMETER™ RBB-2030-40 Base	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 45% paste	parts	1.0	1.0
XIAMETER™ RBM-9002 Rubber Additive	parts		1.0
After 70 hours @ 100°C in Water			
Durometer change	points	2	4
Tensile strength change	%	-21	-10
Elongation change	%	-12	-9
Volume change	%	0	0
After 70 hours @ 150°C in IRM Oil #1			
Durometer change	points	-7	-6
Tensile strength change	%	-4	-4
Elongation change	%	-1	0
Volume change	%	5	4
After 70 hours @ 150°C in IRM Oil #3			
Durometer change	points	-18	-17
Tensile strength change	%	-52	-51
Elongation change	%	-43	-43
Volume change	%	52	52

Table 11 - XIAMETER™ RBB-2030-80 Base Fluid resistance

Press cure molded 10 minutes @ 170°C Oven post cured 4 hours @ 200°C			
XIAMETER™ RBB-2030-80 Base	parts	100.0	100.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 45% paste	parts	1.0	1.0
XIAMETER™ RBM-9002 Rubber Additive	parts		1.0
After 70 hours @ 100°C in Water			
Durometer change	points	0	1
Tensile strength change	%	-8	-3
Elongation change	%	-13	-14
Volume change	%	0	0
After 70 hours @ 150°C in IRM Oil #1			
Durometer change	points	-3	-2
Tensile strength change	%	-3	14
Elongation change	%	-10	-3
Volume change	%	3	3
After 70 hours @ 150°C in IRM Oil #3			
Durometer change	points	-15	-14
Tensile strength change	%	-12	-12
Elongation change	%	-39	-20
Volume change	%	25	25

FORMULATING FOR FLUID RESISTANCE

Table 12 - XIAMETER™ RBB-2002-50 Base Fluid resistance [1]

Press cure molded 10 minutes @ 177°C Not post cured				
XIAMETER™ RBB-2002-50 Base	parts	100.0	100.0	100.0
XIAMETER™ RBM-9002 Rubber Addtive	parts		1.0	1.0
2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane 45% paste	parts	1.0	1.0	1.0
MIN-U-SIL 5 Micron	parts			50.0
After 70 hours @ 100°C in Water				
Durometer change	points	3	6	3
Tensile strength change	%	0	-10	5
Elongation change	%	-4	-1	-13
Volume change	%	0	0	0
After 70 hours @ 150°C in IRM Oil #1				
Durometer change	points	-7	-5	-5
Tensile strength change	%	-1	-6	19
Elongation change	%	1	0	-17
Volume change	%	4	5	4
After 70 hours @ 150°C in IRM Oil #3				
Durometer change	points	-24	-24	-25
Tensile strength change	%	-47	-59	-10
Elongation change	%	-39	-43	-27
Volume change	%	53	53	41

[1] For initial properties see page 6, TABLE 3 - Modifying XIAMETER™ RBB-2002-50 Base with XIAMETER™ RBM-9002 Rubber Additive and extending.

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