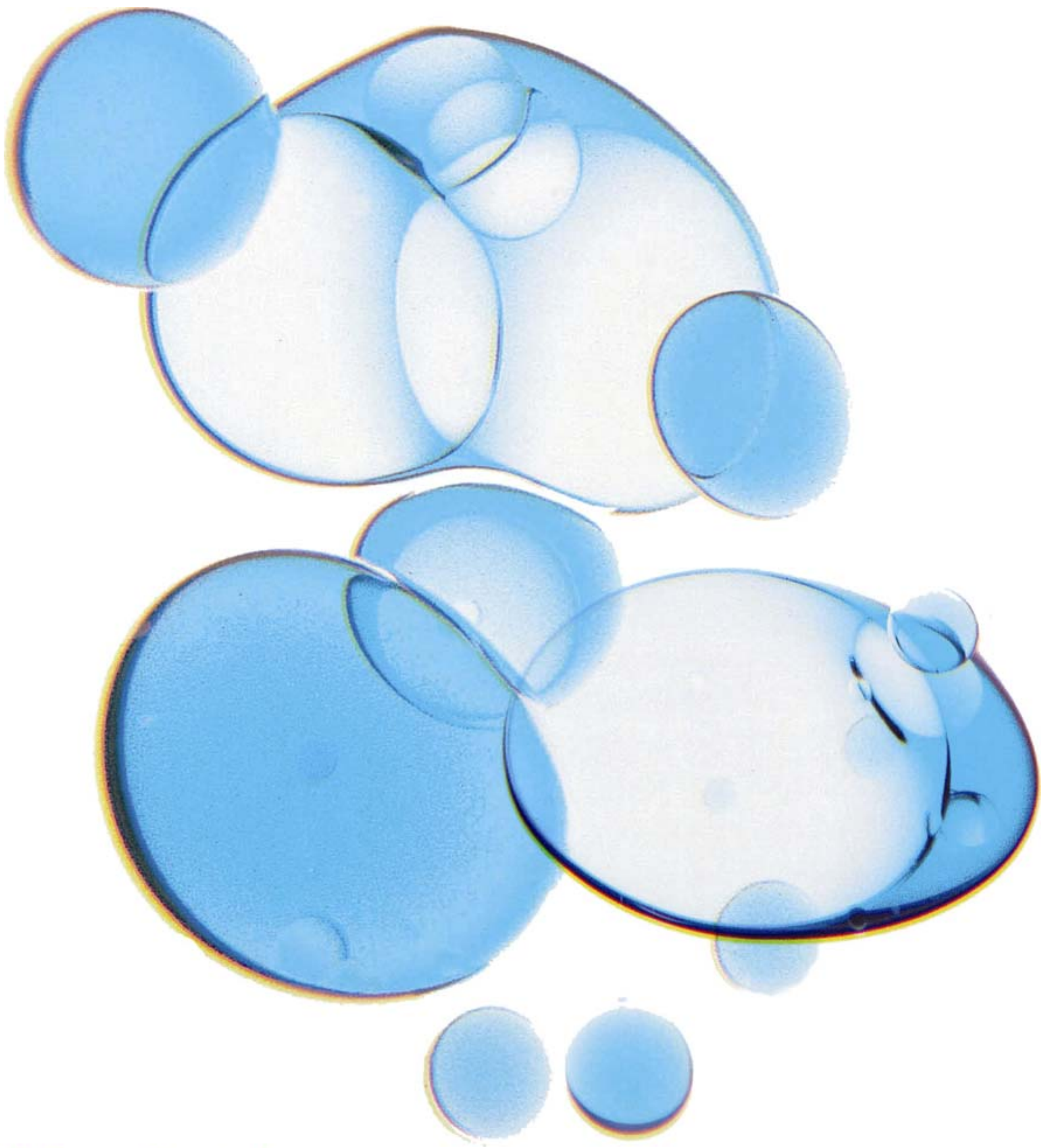
GE
Advanced Materials

Process Additives

Antifoams



GE Bayer Specialties

GE Advanced Materials Silicones

Americas

GE Silicones
Worldwide HQ:
Wilton, CT

- R&D
- Application development
- Basic manufacturing
- Finishing
- Corporate
  (Schenectady, NY)

Europe

GE Bayer Silicones
JV 50.1 % GE : 49.9 % Bayer
European HQ:
Leverkusen, Germany

- R&D
- Application development
- Basic manufacturing
- Finishing

Pacific

GE Toshiba Silicones
JV 51 % GE : 49 % Toshiba
Asian HQ:
Ohta, Japan

- R&D
- Application development
- Basic manufacturing
- Finishing

GE Bayer Silicones

Joint Venture

- 50.1 % GE, 49.9 % Bayer in Europe, Middle East, Africa, India
- 800 people
- Headquartered in Leverkusen, Germany

Major Locations

- Leverkusen, Germany:
  - Monomer
  - Intermediates
  - Finishing
- Bergen op Zoom, Netherlands:
  - Sealants Finishing
  - -European Logistics Centre
- Lostock, United Kingdom:
  - HTV Rubber Compounding Centre
- Bangalore, India:
  - Sealants Packaging
  - Rubber Compounding
  - Fluids Finishing

Our Program

Foam is a mass of bubbles created when certain types of gas are dispersed into a liquid and the dispersion is then stabilized. High-strength films of liquid surround the bubbles, forming large volumes of foam (see plot 1). While the actual cause of foam is a complicated study in physical chemistry, its existence presents serious problems in both the operation of industrial processes and the quality of finished products. If not properly controlled, foam can reduce equipment capacity and increase processing time and expense. Typically foam occurs in blending or mixing, reflux and distillation steps, filtration and filling.
Foam can be controlled by making basic changes in the process itself or by using mechanical defoaming equipment. However, chemical defoamers have proven to be the most versatile, effective and economical solution to the problem.

An effective chemical defoaming agent must meet the following requirements:

- Possess lower surface tension than the system to which it is dosed.
- Disperse readily in the system.
- Possess poor or low solubility (incompatibility) in the system.
- Be inert.
- Leave no substantial residue or odour.
- Meet FDA and USDA requirements where applicable.
- Be certified kosher and pareve where applicable.

Silicone antifoams meet all these requirements most effectively. Due to their efficient way of foam destruction (see plot 2), they are also cost competitive.

Silicone Antifoam Selection

Silicone antifoams are extensively used where product or process foaming problems are encountered. This selector guide describes a complete line of GE Advanced Materials - Silicones antifoams, which have been found particularly useful in many applications. In selecting the best type and quantity of silicone defoamer, each application must be assessed separately. Some of the factors to be considered in the selection process are:

Factor	Options
• Chemical nature of the foam-forming agent	→ Aqueous / Non-aqueous.
• Temperature	→ High / low
• pH-value	→ High / low
• Compatibility	→ Clear appearance / turbid formulation
• Dosing accuracy	→ Concentration of Antifoam
• Processing equipment involved	→ Low Shear / High Shear
• End use of product containing the antifoam	→ Food contact / Sensitive to de-wetting

It is therefore best to evaluate several antifoams in each system to determine type and concentration needed to assure optimum results. To accommodate variables within individual systems, GE Advanced Materials - Silicones offers a broad selection of antifoam products. We recommend running a small series of trials under simulated conditions, like in the medium to be defoamed using a similar mechanical impact and temperature like in the process. To narrow the initial selection of products table 1 contains the physical properties and table 2 is a selector tool providing a condensed overview of the relative performance of our products with respect to the most important variables mentioned above.
For your better understanding some more information: two basic antifoam types, non-aqueous and aqueous antifoams, are available.

Non-Aqueous Antifoams

- Compounds: 100% active fluid products and formulations of fluids containing specially prepared active ingredients boosting the defoaming performance.

Aqueous Antifoams

- Concentrates: Water dispersible systems of high active content designed for formulators or processes with high dosing accuracy.
- Emulsions: Ready-to-use water-based products of various active content, which provide easy dispersibility for maximum defoaming efficiency.

Non-aqueous Antifoams are intended for defoaming in non-water based systems like organic solvents and mineral oils. They are 100% active materials, so they do not introduce water into these systems. In many cases a dilution of the silicone compound in a suitable organic solvent is advisable to reduce the actives content for a more accurate dosing and decrease the viscosity for an easier handling. Formulators can use these grades to manufacture their own antifoam emulsions.

Aqueous antifoams are formulated as emulsions or concentrates to allow an easy dilution in systems based on water or polar solvents. To suit different needs regarding dosing accuracy and handling they are available at various concentrations.

The impact of dosing and handling are often underestimated when chemical antifoams are used:

- Dosing: Silicone Antifoams are often sufficient at 10 to 100ppm active material level, this equals 50 to 500g of a 20% Emulsion for one metric ton of defoaming media, whereas only 10 to 100g would be needed of an 100% active material. If the dosing equipment is not very accurate, we recommend to use 10 or 20% active antifoams, the higher dosing volume will reduce the error potential. With precise dosing equipment, we recommend higher concentrations, since they offer a better cost performance ratio.
- Handling: Compounds need emulsification prior usage in aqueous media. In addition, viscosities of Compounds and Concentrates are typically in the range of 3000 to 100000mm^2/s. The handling of such high viscosities requires adequate equipment. More diluted Emulsions are in the range of 40 to 3000 mm^2/s depending on active content and formulation and are therefore much easier to handle and can be diluted with simple stirring equipment.

Silicone Antifoam Mechanism

Many mechanisms are discussed for antifoam performances. The most wildly accepted for state of the art silicone antifoams is the bridging mechanism. When foam is generated, in the first step gas bubbles are introduced into the foaming media by shear or generated by boiling (Plot 1A). Due to their low density they flotate to the surface and accumulate there, separated by comparably thick layers of water (Plot 1B) – the *wet bubble foam* (Kugelschaum) is formed.

The gravity drains the liquid from between the bubbles and they deform due to strong surface forces to polyhedral shapes (Plot 1C) – the *polyeder foam*.

Silicones possess a unique combination of fluidity at high molecular weights, low surface tension and hydrophobic properties. Therefore, if a silicone antifoam droplet is entrapped in the foam lamella during the drainage process, it is able to bridge both foam films (Plot 2A & B). Thus it forms a weak spot, where the foam film can rupture. The mechanical shock will also cause adjacent foam cells to collapse (Plot 2C).

The released silicone AF droplet can now step into action again, therefore delivering excellent performance at very low concentrations of active material.

Performance Measurement

The performance of antifoams is not easy to measure, since it depends strongly various factors, like on the nature of the foaming media, the temperature, the shear rate and many others.

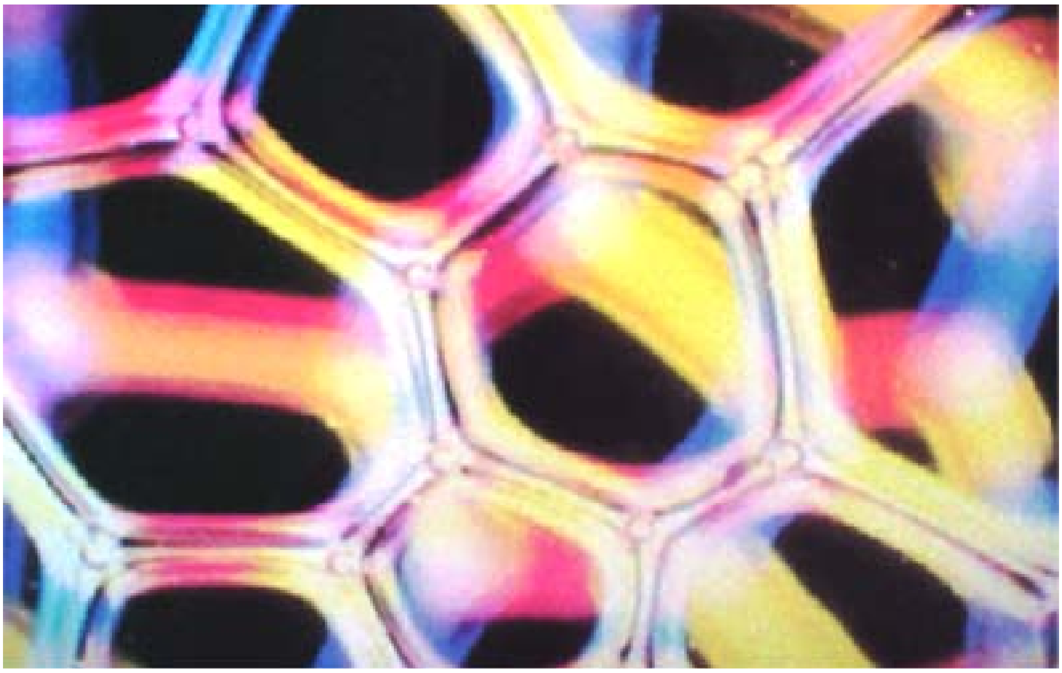
The most widely used test is the shake test, in which an antifoam is added to a foaming media in a closed container and shaked either by hand or – more reliable – by an automatic equipment for a defined time period or number of shakes. This test is mainly able to measure the knockdown performance of antifoams, which describes its efficiency to destroy existing foam. To measure the persistence this test needs to be repeated for several times or longer shaking periods to measure the ability of the antifoam to maintain its performance and withstand shear.

A better way to measure the defoaming performance is the recirculation test. A cylindrical container with a bottom outlet is filled to approximately $^1/_{3rd}$ of its volume with the foaming medium. The outlet is connected to a pump, which pumps the foaming liquid out of the container and reinjects it at the top opening.

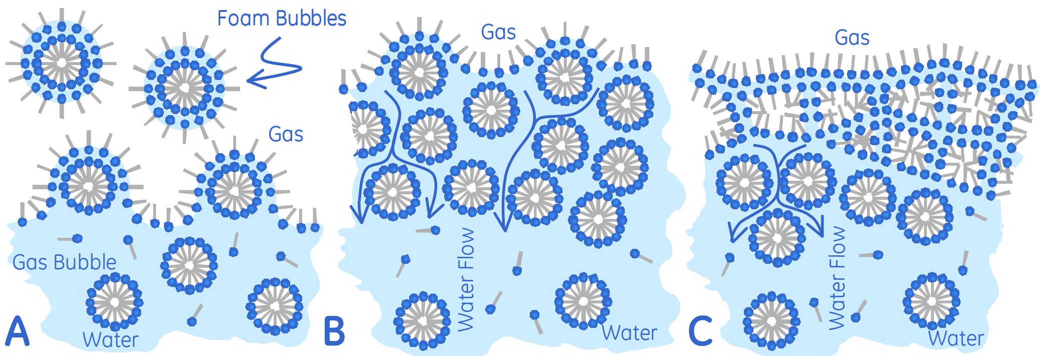
After starting the pump the stream of back flowing liquid leads to a quick buildup of foam. When the foam reaches the top of the container the antifoam is added. The foam starts to collapse and the time of collapse and lowest foam height is monitored. This reflects the knockdown ability of the antifoam. While continuing the recirculation the foam will start to rise again. The longer it needs until the foam reaches the top again the more persistent the antifoam is.

To be able to provide the performance indications provided in table 2 experiments have been conducted in anionic and nonionic surfactant solutions at different pH-values and temperatures.

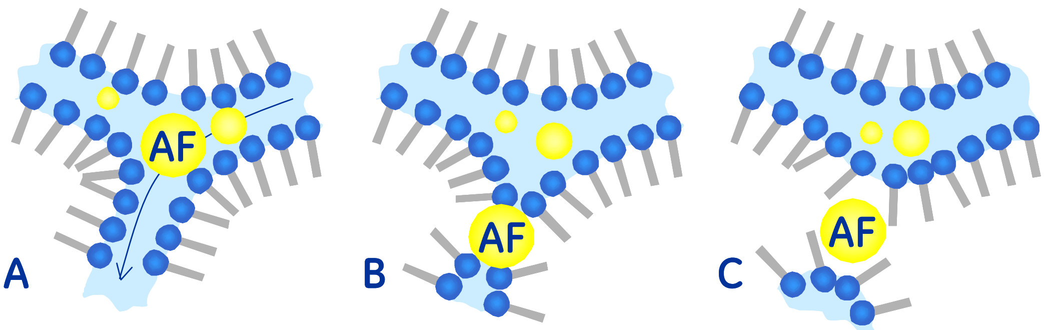
Silicone Antifoam Mechanism



Picture 1: Optical microscopy picture of silicone antifoam droplets in foam films.



Plot 1: *Foam generation: A) Gas is introduced and forms gas and foam bubbles; B) Foam bubbles accumulate and form `wet` bubble foam; C) Water drains out between the bubbles. A stable, `dry` polyhedral-foam is formed.*



Plot 2: *Antifoam working model: A) Silicone antifoam droplets, following the drainage flow, enter foam films; B) Antifoam droplets bridge the foam film, replacing surfactant due to low surface tension of the silicone; C) The foam film ruptures, releasing the silicone for repeated action.*

Physical Data

Property	Method / Unit	AF 9000	AF 100%	SAG* 8110	AF 9010E	SAG* 8700	SAGTEX* DSA	AF 9020E	SAG* 220
Form	-	Silicone	Silicone	Silicone	Emulsion	Emulsion	Emulsion	Emulsion	Emulsion
Appearance	-	Colorless turbid liquid	Colorless turbid liquid	Colorless turbid liquid	Brownish liquid	Milky white liquid	Milky white liquid	Brownish liquid	Milky white liquid
Active	%	100	100	100	10	15	20	20	20
Emulsifier	-	-	-	-	Non-ionic	Non-ionic	Non-ionic	c	Non-ionic
Viscosity	$mm \cdot s^{-1}$	~2000	3000	~100000	~1000	~1500	~1000	~1000	~600
Density	$g \cdot cm^{-3}$	~1	~1	~1	~1	~1	~1	~1	~1
Boiling Temperature	DIN 51356 / °C		>350		~ 100	~ 100	~ 100	~ 100	~ 100
Flash Point	DIN 51376 / °C	>3153)	>350		-**	-**	-**	-**	-**
Ignition Temperature	DIN 51794 / °C		>350		-**	-**	-**	-**	-**

Property	Method / Unit	AF 9030E	AF 3099	AF FA	TP 3611	AF CF55	SAG 290	SAGTEX JSA	SAGTEX PhD
Form	-	Emulsion	Emulsion	Emulsion	Emulsion	Concentrate	Concentrate	Concentrate	Emulsion
Appearance	-	Brownish liquid	White liquid	White liquid	White liquid	White liquid	Opaque liquid	White transp. liquid	Milky white liquid
Active	%	30	30	30	40	50	90	100	45
Emulsifier	-	Non-ionic	Non-ionic	Non-ionic	Non-ionic	Non-ionic		-	Non-ionic
Viscosity	$mm \cdot s^{-1}$	~600	~50	~250	~1400	<3000	3000	~250	~2000
Density	$g \cdot cm^{-3}$	~1	~1	~1	~1	~1	~1	~1	~1
Boiling Temperature	DIN 51356 / °C	~ 100	~ 100	~ 100	~ 100	~ 100	~ 100		
Flash Point	DIN 51376 / °C	-**	-**	-**	-**	-**	>190***		
Ignition Temperature	DIN 51794 / °C	-**	-**	-**	-**	-**	-**		

Typical product data values should not be used as specification. Assistance and specifications are available from GE Bayer Silicones.

* Non-aqueous product, therefore no pH measurement possible.

** Water-based product, starts to boil at ~100°C

*** Closed cup ASTM D 93.

Table 1: Typical product data values of GE Bayer Silicones antifoam products should not be used as specifications. Assistance and specifications are available by contacting GE Advanced Materials - Silicones.

Property	Type	Nature of the foaming Medium							Performance at pH	
		Anionic			Non-ionic			Organic	Acidic	Alkaline
		KD*	P**	HT***	KD*	P**	HT***			
AF 9000	Compound							+++		
AF 100%	Compound							+++		
SAG 8110	Compound							++++		
FF 160	Compound							+++++		
FF 170	Compound							+++++		
AF 9010E	Aqueous									
AF 9020E	Aqueous	++++	++++	+++	+++++	++++	++++		+	+++
AF 9030E	Aqueous									
SAG 220	Aqueous	++++	++	++	+++++	++++	++++		+++	++
AF 3099E	Aqueous	++++	+++	+++	+	+	+		++	+
AF FA	Aqueous	+++++	+++	+++	+	+	+		++	+
TP 3611	Aqueous	+++++	+++	++++	+	+	++			++
SAG 8700	Aqueous	++++	+++++	+++++	++++	++++	++++		++++	++++
SAGTEX PhD	Aqueous	++	++++	++++	++	++++	++++		++++	++++
SAGTEX DSA	Aqueous	+++++	+++++	+++++	+++++	+++++	+++++		+++++	++++
CF 55	Aqueous	+++++	++++	+++	++	+	+++		++	+

Typical product data values should not be used as specification. Assistance and specifications are available from GE Bayer Silicones.

* Knockdown according to recirculation test.

** Persistence according to recirculation test.

*** Average Performance on Knockdown and persistence at 70°C.

Table 2: Product chooser of GE Bayer Silicones antifoam products. These values have been derived from standard measurements as described in the section "antifoam performance" and are therefore indicative only.

Contact
www.ge.com/advancedmaterials

Regional Information

Europe, Middle East, Africa & India	GE Bayer Silicones GmbH & Co. KG Building V7 D-51368 Leverkusen, Germany	T +00.800.4321.1000	E ebusiness1.gebs@ge.com
North America	World Headquarters 187 Danbury Road Wilton, CT 06897, USA	T 800.295.2392	F 607.754.7517
Latin America	Rodovia Eng. Constàncio Cintra, Km 78.5 Itatiba, SP – 13255-700, Brazil	T +55.11.4534.9650	F +55.11.4534.9660
Pacific	GE Toshiba Silicones 6-2-31 Roppongi Minato-ku Tokyo 106-8550 Japan	T +81.3.3479.5361	F +81.3.3479.5391

Customer Service Centers

Europe, Middle East, Africa & India	GE Bayer Silicones GmbH & Co. KG GE Specialty Materials (Suisse) Sarl	T +00.800.4321.1000	E ebusiness1@ge.com E cs-eur.osi@ge.com
North America	South Charleston, WV 25303, USA • Specialty Fluids • UA, Silanes, Resins, and Specialties • RTV Products-Elastomers • Sealants and Adhesives & Construction	 T 800.523.5862 T 800.334.4674 T 800.332.3390 T 877.943.7325	E cs-na.osi@ge.com F 304.746.1654 F 304.746.1623 F 304.746.1623 F 304.746.1654
Canada	St-Eustache, Quebec • Within U.S. & Canada • Outside U.S. & Canada	 T 800.363.0496 T +450.974.0899	 F +450.974.0380
Latin America	Argentina 6 Chile Brazil Mexico & Central America Venezuela, Ecuador, Peru, Colombia,& Caribbean	T +54.23.2055.2857 T +55.11.4534.9650 T +52.55.5257.6042 T +58.21.2902.5167	F +54.23.2055.2811 F +55.11.4534.9660 F +52.55.5257.6094 F +58.21.2902.5158 E csla.gesosi@ge.com
Pacific	Japan China Korea Singapore	T +81.276.20.6182 T +86.800.820.0202 T +82.2.530.6400 T +65.6220.7022	E helpdesk@getos.co.jp

Worldwide Hotline

T 800.295.2392   T +607.786.8131   T +607.754.7517

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