Bluestar Silicones' Oils 47
Technical information

Bluestar Silicones. Delivering Your Potential.

BLUESTAR SILICONES

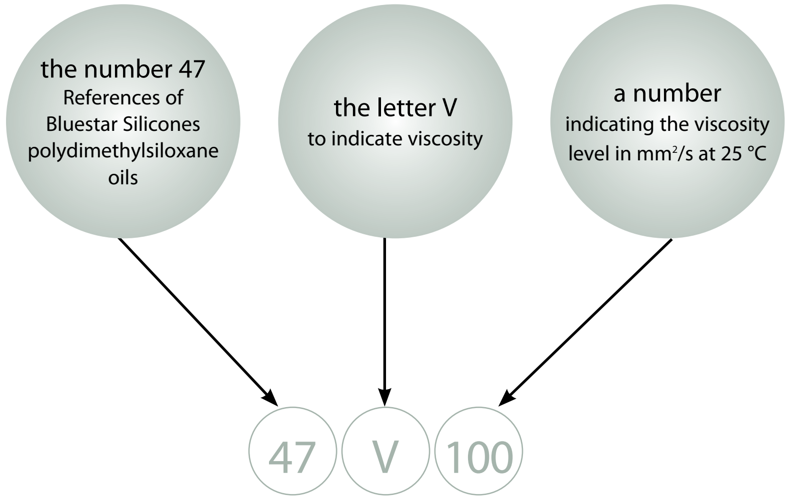
Contents

Introduction

Bluesil™ Oils 47 are polydimethylsiloxane oils and are a major category of silicones sold by Bluestar Silicones.
They are constituted of linear molecular chains of varying lengths whose groups comprise alternating silicon and oxygen atoms (the Si-O-Si siloxane bond). The silicon atoms are saturated by methyl groups – CH_3.
Whilst the carbon chains of organic substances generally have low resistance to external influences, the stability of the Si-O bonds is basically comparable to that of inert mineral silicates.

Nomenclature

The Bluesil™ Oils 47 nomenclatures are constituted:



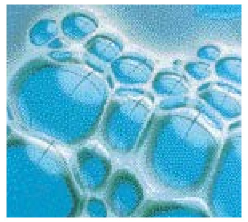
Examples:
- Oil 47 V 100 is an oil with a viscosity of 100 mm²/s.
- Oil 47 V 1,000,000 is an oil of viscosity 1,000,000 mm²/s

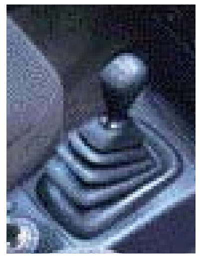
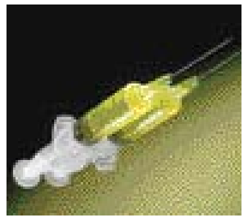
The Bluesil™ Oils 47 range covers a viscosity range of 1 to 1,000,000 mm²/s.

Applications of Bluestar Silicones' Oils 47

There are many different applications of these products.
For information, we can mention a few of them such as:



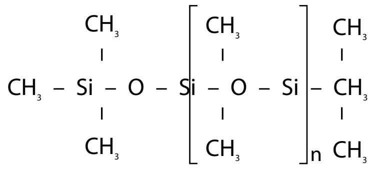




- Plasticizers for silicone elastomers (sealants, RTV, etc.)
- Foam control agents
- Additives for Styrene-Butadiene foams
- Release and demolding agents
- Lubricants
- Textiles softeners
- Sewing thread lubricant
- Emulsions for off-set printing
- Components for household products and polishes for wood, leather, metals, floors, cars
- Usage in cosmetics, shampoos, creams
- Lubrication of medical equipment
- Medical uses, excipient, active ingredient
- Treatment and water repellency of fillers
- Dielectric fluids
- Hydraulic, damping and gearbox fluids
- Heating fluids (up to temperatures of around 160° C)
- Cooling fluids

Chemical structure of Bluestar Silicones' Oils 47

They have the following general formula



The viscosity of these oils increases with their polymerization degree, which corresponds to value of the "n" index as shown in graph N°1 (viscosity of Bluesil™ Oils 47 according to degree of polymerization).

Bluesil™ Oils 47 are still liquid at ambiant temperatures for a value of the "n" index of around 2,000. For greater values these oils gradually tend to gums (viscosity > 500 000 cp).

All of these oils are mixtures of polysiloxane chains that are quite regularly distributed around the average molecular mass. For example, graph N°2 shows a distribution of molecular masses in a Bluesil™ Oil 47 of viscosity 10 mm^2/s, obtained by gel permeation chromatography.

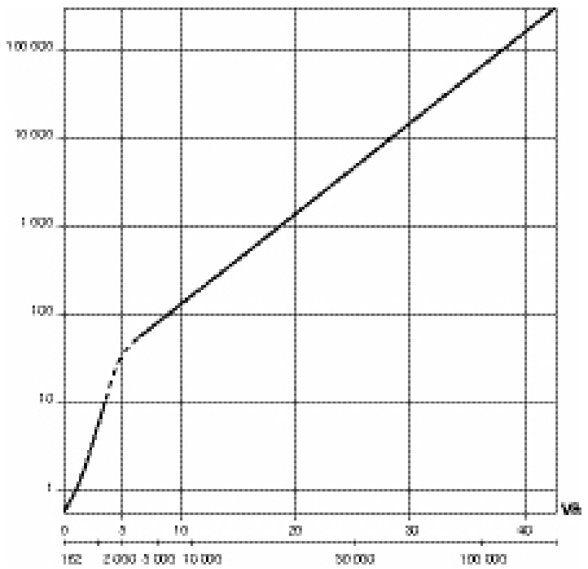
The average molecular mass increases as a function of the degree of polycondensation "n", therefore is a function of their viscosity as shown in table N°1 (molecular mass of Bluesil™ Oils 47 as a function of viscosity).

Table 1
Molecular mass of Bluesil™ Oils 47

Oils		Molecular mass (g.mol^{-1})
47 V	5	900 to 1 100
47 V	10	1 500 to 1 800
47 V	20	2 800 to 3 200
47 V	50	7 000 to 8 000
47 V	100	10 000 to 12 000
47 V	300	18 000 to 20 000
47 V	500	28 000 to 30 000
47 V	1 000	38 000 to 40 000
47 V	12 500	about 80 000
47 V	60 000	about 125 000
47 V	100 000	about 145 000

Graph 1

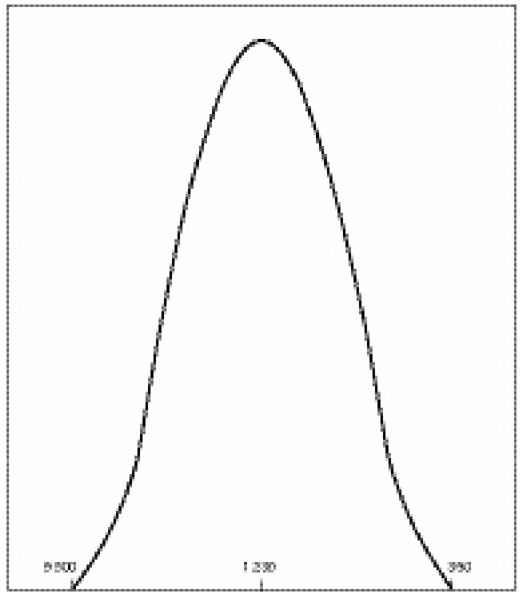
Viscosity of polydimethylsiloxane oils as a function of degree of polymerization "n"



Comment: the straight part of the graph corresponds to the A.J. BARRY relation for molecular masses > 2500:
$\log n_{cSt} = 1{,}00 + 0{,}0123\ M^{0{,}5}$

Graph 2

Molecular mass by EDC* of a polydimethylsiloxane oil of viscosity 10 mm²/s



* Exclusion Diffusion Chromatograph

Distribution of molecular masses
Average molecular mass
In weight Mp ≈ 1560 g/mol
In number Mn ≈ 1210 g/mol
Polydispersion index
Mp/Mn = 1,29

N.B.: $\overline{Mn}$: Average mass by number

$$\overline{Mn} = \frac{\Sigma(niMi)}{\Sigma(ni)} = \frac{\Sigma(ci)}{\Sigma\left(\frac{ci}{Mi}\right)}$$

Where ni and ci respectively represent the number and concentration by weight of each molecule of mass Mi

$\overline{Mp}$: average mass by weight

$$\overline{Mp} = \frac{\Sigma(niMi^2)}{\Sigma(niMi)} = \frac{\Sigma(ciMi)}{\Sigma(ci)}$$

The sum Σ is carried out from i = 1 (monomer) to i = ∞, i representing the degree of polymerization (number of groups)

Polydispersion index
The ratio $\overline{Mp}/\overline{Mn}$ is equal to 1 for strictly monodisperse polymers

General properties of Bluestar Silicones' Oils 47

The polysiloxane chains very flexible due to the wide range in value of possible angles in the Si-O-Si group; this flexibility allows lateral groups to occupy the space in an exceptional number of positions. In addition, the rotary freedom of the methyl group around the Si-C bond is maintained even at extremely low temperatures. The macromolecular chains will be arranged in loosely configured spirals with a high amount of internal free space leading to low intermolecular forces and very low interaction between chains.

■ This macromolecular chain structure gives Bluesil™ Oils 47 a very specific set of characteristics and features:

- low pour point (around -50 °C),
- very low glass transition temperature (around -125 °C),
- low viscous pouring activation energy,
- low viscosity (compared to carbon-chain organic products of the same length),
- low variation in viscosity as a function of temperature,
- low surface tension,
- high compressibility,
- excellent peak and prolonged shear strength,
- low and high temperature resistance,
- resistance to oxidation and hydrolysis,
- excellent ageing resitance (oxygen-ozone-water-light-UV),
- chemically inert (no risk of corrosion),
- very limited combustibility.

■ These properties open up a very wide range of applications:

- demolding or release agents,
- hydraulic, heat transfer and dielectric fluids,
- lubricants,
- foam control agents,
- active components in maintenance product formulations,
- active components in cosmetic, pharmaceutical or food preparations.

N.B.: in cosmetic, pharmaceuticals and food applications, Bluesil™ Oils 47 of controlled are sold under the names of Mirasil DM, Silbione DM GMP and Silbione 70047.

These oils are discribed in separate documentation.

Characteristics of Bluestar Silicones' Oils 47

The table on page 9 gives the characteristics of Bluesil™ Oils 47.
The values given are average values and not specifications.

Characteristics / Oils	41 V 0.65	47 V 3	47 V 5	47 V 20	47 V 50	47 V 100	47 V 350	47 V 500	47 V 1000	47 V 5000 to V 600000
Viscosity at 25 °C (mm²/s)	0,65	3	5	20	50	100	350	500	1000	5000 to 600000
Specific gravity at 25 °C	0,760	0,890	0,910	0,950	0,959	0,965	0,970	0,970	0,970	0,973
Flashpoint at °C (closed cup)	- 4	75	120	240	280	> 300	> 300	> 300	> 300	> 300
Freezing point at °C	- 67	- 80	- 65	- 60	- 55	- 55	- 50	- 50	- 50	- 45
Refractive index at 25 °C	1,375	1,395	1,397	1,400	1,402	1,403	1,403	1,403	1,403	1,404
Surface tension (mN/m)	15,9	18,9	19,7	20,6	20,7	20,9	21,1	21,1	21,1	21,1
Expansion coefficient between 25 °C and 100 °C (cm³/cm³. °C)	$1,34.10^{-3}$	$1,16.10^{-3}$	$1,15.10^{-3}$	$1,07.10^{-3}$	$1,05.10^{-3}$	$9,45.10^{-4}$	$9,45.10^{-4}$	$9,45.10^{-4}$	$9,45.10^{-4}$	$9,45.10^{-4}$
Specific heat (Joules/g, °C)	2,9	NA	NA	1,63	1,46	1,46	1,46	1,46	1,46	1,50
Thermal conductivity (Watt/m. °C)	0,10	0,11	0,12	0,14	0,16	0,16	0,16	0,16	0,16	0,16
Viscosity/temperature coefficient	0,31	NA	0,55	0,59	0,59	0,60	0,62	0,62	0,62	0,62
Dielectric strength (kV/mm)	14	14	14	14	15	16	16	16	16	18
Dielectric constant at 25 °C between 0.5 and 100 kHz	2,18	2,50	2,59	2,68	2,80	2,80	2,80	2,80	2,80	2,80
Loss angle at 25 °C 0,5 kHz100 kHz	NA	 1.10^{-5}	2.10^{-5} 1.10^{-5}	4.10^{-5} 1.10^{-5}	2.10^{-4} 1.10^{-4}	2.10^{-4} 1.10^{-4}	2.10^{-4} 1.10^{-4}	2.10^{-4} 1.10^{-4}	2.10^{-4} 1.10^{-4}	2.10^{-4} 1.10^{-4}
Volume resistivity at 25 °C (ohm/cm)	NA	1.10^{15}	1.10^{15}	1.10^{14}	1.10^{14}	1.10^{15}	1.10^{15}	1.10^{15}	1.10^{15}	1.10^{15}

(NA: not available)

Notes:

□ At the start of the table is oil 41 V 0.65 which can be assimilated to hexamethyldisiloxane a Bluesil™ Oils 47 with the index "n" equal to 0.

The formula is as follows:

$$\begin{array}{ccccc} & CH_3 & & CH_3 & \\ & | & & | & \\ CH_3 - & Si & - \ O \ - & Si & - CH_3 \\ & | & & | & \\ & CH_3 & & CH_3 & \end{array}$$

□ Oil 604 V 50 is a version of 47 V 50 oil, manufactured specially for dielectric uses.

□ The viscosity/temperature coefficient is obtained by the following formula:

$$1 - \frac{\text{viscosity at 100 °C}}{\text{viscosity at 40 °C}}$$

□ The percentage of silicon in Bluesil™ Oils 47 of viscosity greater than or equal to 1,000 mm²/s is basically equal to 37.5%.

■ Obtaining a Bluesil™ Oil 47 with a viscosity between two others.

It is possible to prepare products of intermediary viscosities by mixing two Bluesil™ Oils 47 (these oils are miscible with one another in all proportions). Use graph 3 below according to the following indications:

1. Choose the viscosity grades to be mixed: to obtain an oil of intermediary viscosity it is best to mix two oils with close viscosities.

2. Select the lower viscosity at the left axis of the graph.

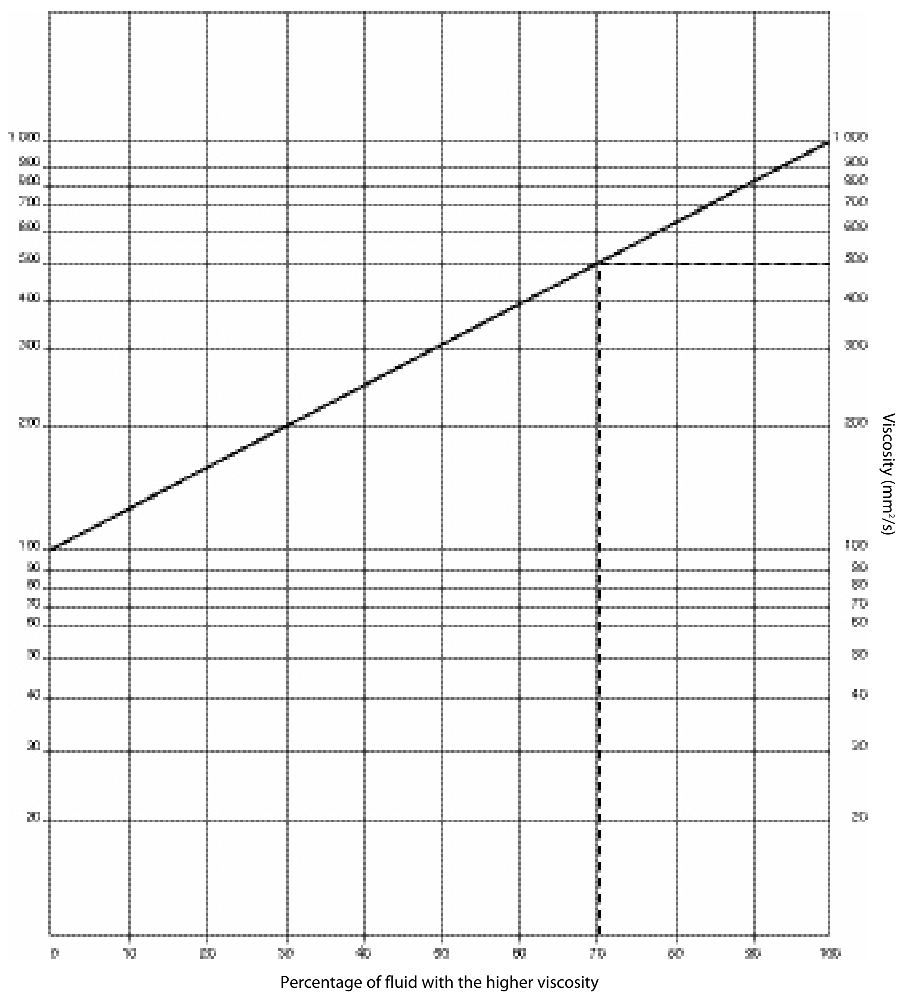
3. Select the upper viscosity on the right of the graph.

4. Connect the two points with a straight line.

5. Find the intersection of this straight line with the horizontal line corresponding to the required viscosity.

By plotting a vertical line passing through this point the bottom of the graph gives the percentage by weight of fluid with the highest viscosity. It must be completed with a low viscosity fluid up to 100%.
In the example given on graph N°3, mixing 70% of oil 47 V 1000 with 30% of oil 47 V 100 gives a fluid of viscosity 500 mm²/s.
This graph covers fluids with viscosities of between 20 and 1,000 mm²/s.
If you want to use it for Bluesil™ Oils 47 with higher viscosities you must multiply the given viscosity values by 100.

Graph 3
Graph to estimate the viscosity of Bluesil™ Oils 47 mixtures



$$\%_{\eta L} = \exp\left[\frac{\log \eta_H - \log \eta_L}{\log \eta_T - \log \eta_L}\right]$$

η_H: viscosity high
η_L: viscosity low
η_T: targeted viscosity

Physical properties of Bluestar Silicones' Oils 47

1. Volatile content

The vapor pressure, and consequently the volatility, is very low for Bluesil™ Oils 47 with a viscosity above 50 mm²/s. Calculating of volatile matter is carried out under well defined conditions: apparatus, time, temperature, sample weight, etc.

For information purposes please find the following values of volatile content measured according to standard ASTM D 2595.

Standard method: 10g oil – 24 hours – 150 °C – air circulation: 2 L/min.

Bluesil™ Oils 47 of average viscosity (V50 to 1,000): % volatile content < 0.5%
Bluesil™ Oils 47 of high viscosity (> V1000): % volatile < 2.0%

The volatile content of Bluesil™ Oils 47 is expressed as a percentage of weight loss.

N.B.: at this temperature we only measure the volatile matter existing in the oil, there is none generated by thermal breakdown of the molecule. The values given are not specifications.

2. Heat stability

Due to the large amount of energy in the Si-O bond and the configuration of the siloxane chain, Bluesil™ Oils 47 have outstanding stability to oxidation and heat breakdown.

□ In the presence of air, oxidation phenomena with Bluesil™ Oils 47 start to be observed around 200 °C. They are seen in terms of the break down of silicon-carbon bonds with cross linking of the chains, and an increase in viscosity until a gel is formed. At 150 °C in the presence of air, Bluesil™ Oils 47 are very stable.

□ In the absence of air or in an inert gas, Bluesil™ Oils 47 can be used up to 300 °C above clivage of siloxane chain begins with formation of volatile compounds and reduction in polymer viscosity.

3. Flammability

□ Flashpoint: Bluesil™ Oils 47 with viscosity greater than 50 mm²/s have flashpoints superior of 300 °C in a closed cup and 315 to 330 °C in an open cup (measured using standardized tests). For viscosities lower than 100 mm²/s, the flashpoint reduces with viscosity.

□ Fire point: Bluesil™ Oils 47 have fire points that are much higher than their flashpoints: for viscosities of greater than or equal to 50 mm²/s, the fire points are around 350 °C. For viscosities lower than 50 mm²/s the fire points reduce with viscosity.

□ Self ignition point: for Bluesil™ Oils 47 of viscosity greater than or equal to 50 mm²/s the self ignition point is around 450 °C.

4. Low temperature behavior

The low temperature behavior of Bluesil™ Oils 47 is given by the pour point: the temperature at which the product reaches a viscosity at which it can no longer run. This point cannot be defined with as much precision as the freezing point of a pure body.

The pour point of Bluesil™ Oils 47 of viscosity greater than or equal to 300 mm²/s is of around -50 °C. For lower viscosities the pour point value reduces with viscosity.

5. Viscosity – Rheology

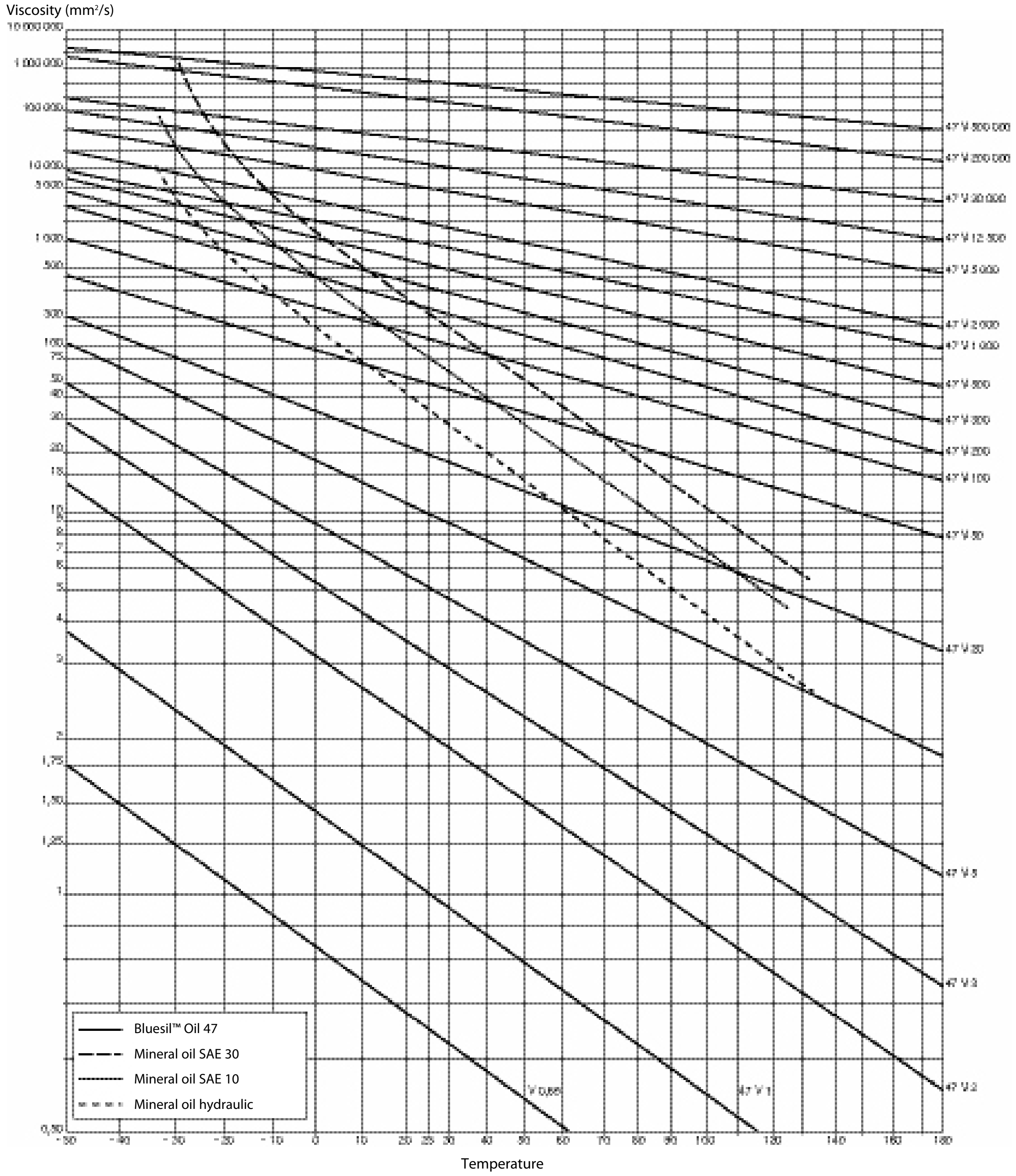
■ Influence of temperature

The variation in viscosity of Bluesil™ Oils 47 as a function of temperature is much lower than that of organic or mineral oils;

Example: viscosity in mm²/s

	-25 °C	+25 °C	+120 °C	Viscosity/ temperature coefficient
Oil 47 V 100	350	100	22	0.60
Mineral oil	5000	100	5	0.82

Graph 4
Bluesil™ Oils 47
Variation in viscosity as a function of temperature



Graph N°4 shows the variations in viscosity as a function of temperature for Bluesil™ Oils 47 from V 0.65 to V 500,000.

The law governing variation of viscosity between -50 °C and +250 °C for oils 47V20 to 47V1000 is as follows:

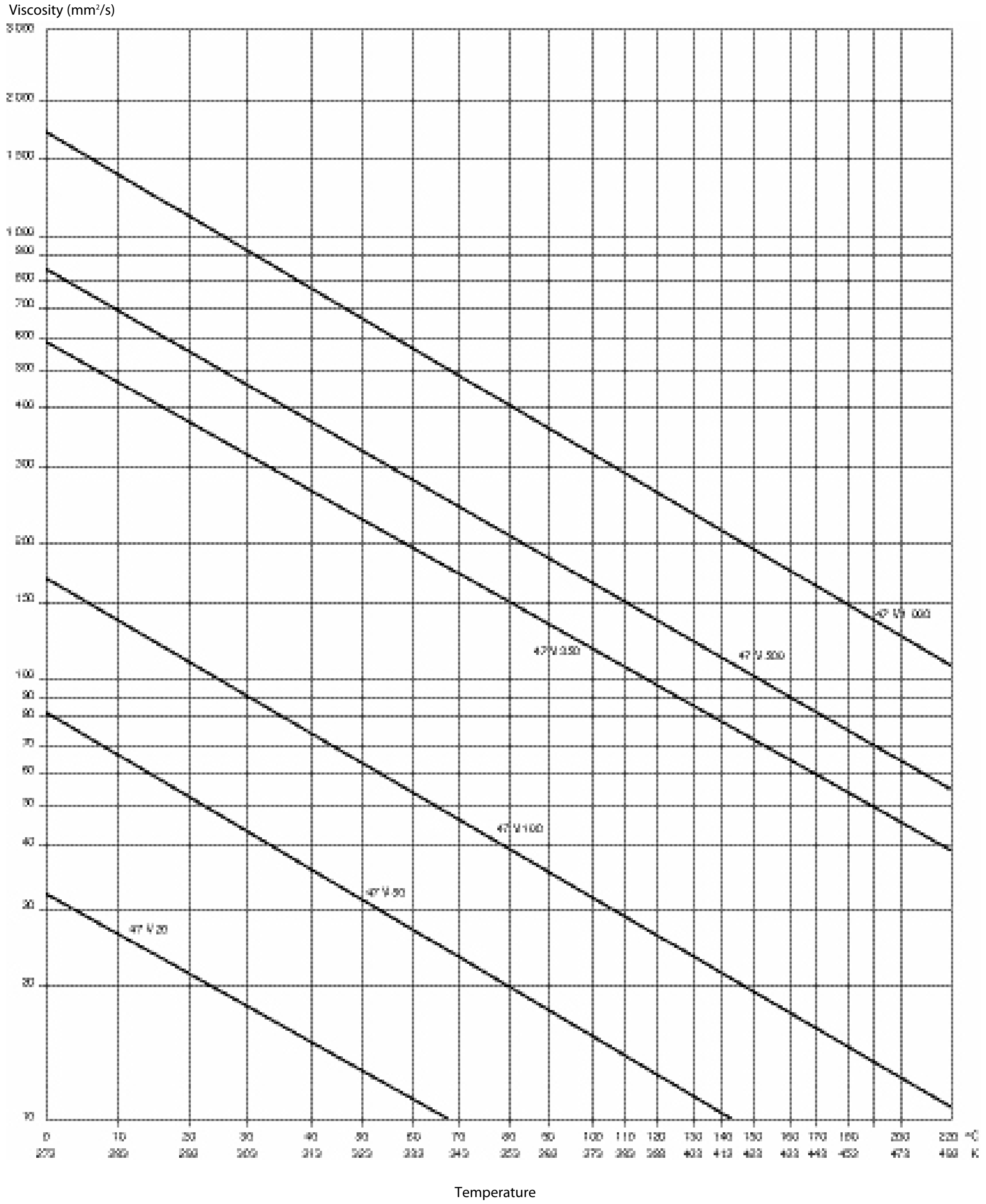
$$n = \eta° \exp \left[B \left(\frac{1}{T} - \frac{1}{T°} \right) \right]$$

T° = 298K
T in K
B = 1863 K
η° = viscosity at 25 °C
η : mm²/s

See graph N°4b

Graph 4 b

Bluesil™ Oils 47 V 20 to V 1 000
Variation in viscosity as a function of temperature



■ Rheological shear behavior

At shear values that are commonly encountered (10^3 s^{-1}) Bluesil™ Oils 47 behave as newtonian fluids up to a viscosity of around 1,000 mm^2/s, in other words the viscosity (or the ratio of the shear strain to the speed gradient) is constant and independent of the velocity gradient. In this case, the apparent viscosity is identical to the extrapolated viscosity at zero speed gradient.

However, for oils of viscosity greater than 1,000 mm^2/s, this ratio is only constant for velocity gradients less than a given value. Beyond this value, which decreases with product viscosity, this ratio is no longer constant: the apparent viscosity becomes lower than the actual viscosity (extrapolated for a zero speed gradient) and the behavior is then said to be "rheo-fluidizing". This change is perfectly reversible and the behavior once again becomes newtonian when the velocity gradient drops back down below the critical value.
The viscosity returns to its initial level even after the product is subject to intensive and prolonged shear conditions.

The table below shows the critical shear levels for four Bluesil™ Oils 47 (at which the change in rheological behavior occurs) and the apparent measured viscosity at a speed gradient equal to 10,000 s^{-1}.

Oils	Critical shear level (in s^{-1})	Apparent viscosity for a speed gradient of 10,000 s^{-1}
Oil 47 V 1 000	2 500	850 mm^2/s
Oil 47 V 12 500	200	4 700 mm^2/s
Oil 47 V 30 000	150	6 000 mm^2/s
Oil 47 V 100 000	30	8 200 mm^2/s

The drop in viscosity increases with the initial viscosity level

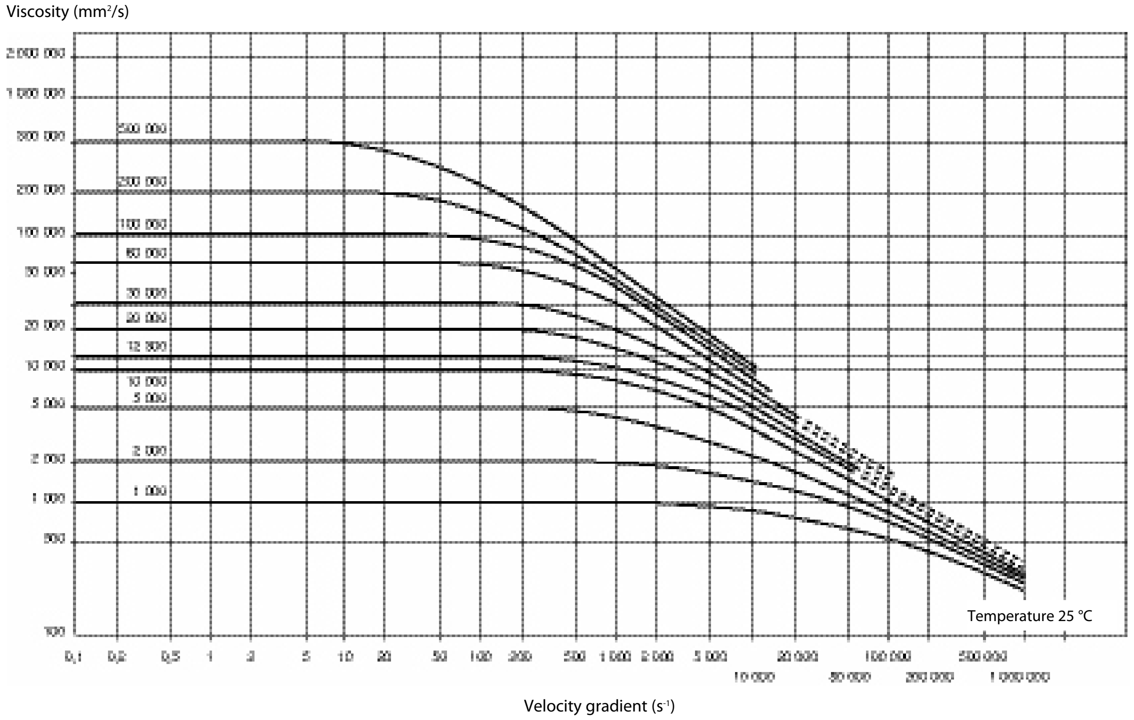
Note: The outstanding resistance of Bluesil™ Oils 47 to intensive and prolonged shear forces gives some interesting applications such as hydraulic and damping fluids.

Graph N°5 shows the variation in viscosity as a function of velocity gradient for viscous oils at constant temperature.

Graph 5

Bluesil™ Oils 47

Variation in viscosity as a function of velocity gradient



■ Influence of pressure on viscosity

Pressure has an influence on the viscosity of Bluesil™ Oils 47:

□ Very low viscosity oils are not affected very much.

□ Those with a viscosity greater then 10 mm²/s are affected to a greater extent.

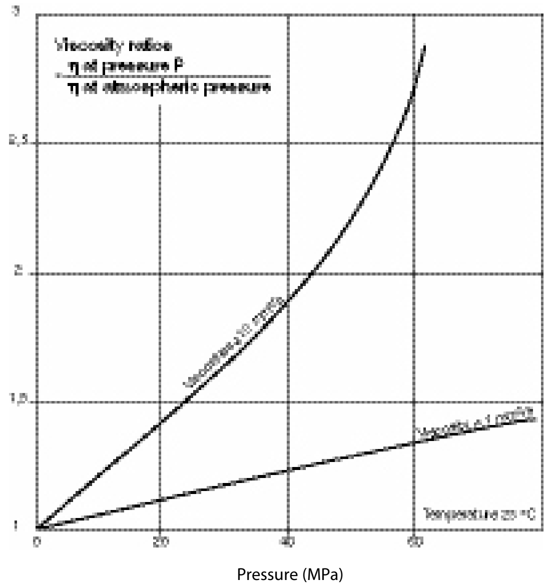
Example:
At a pressure of 200 bars, the viscosity of oil 47 V 1 increases by around 10% and that of Bluesil™ Oils 47 of a viscosity greater than 10 mm²/s by around 40%.
See graph N°6.

N.B.: For mineral oils, pressure has a much greater influence on viscosity. For extreme pressures, Bluesil™ Oils 47 remain fluid whereas mineral oils will become solid.

Graph 6

Bluesil™ Oils 47

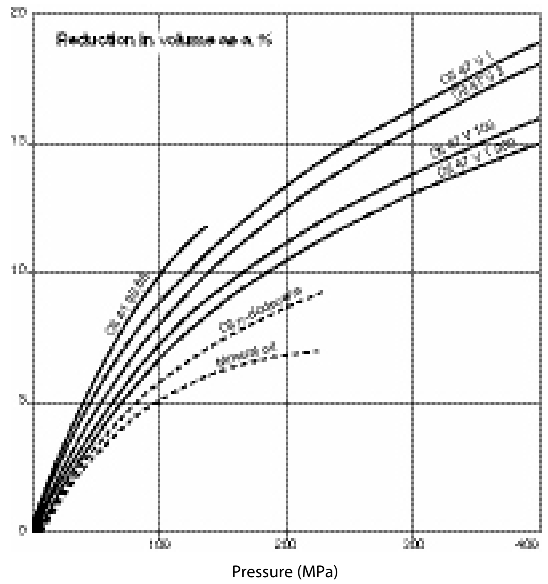
Variation of viscosity with pressure



Graph 7

Bluesil™ Oils 47

Compressibility



6. Compressibility

Bluesil™ Oils 47 are generally speaking much more compressible than mineral oils.

For example, the volume reductions with pressure variations are the following for Bluesil™ Oils 47 V 100 and 47 V 1000, compared with the mineral oil.

Pressure (MPa)	Observed reduction in volume (as a %)		
	Oil 47 V 100	Oil 47 V 1,000	Mineral oil
50	4,5	3,8	3,1
100	7,3	6,5	5,2
200	11,2	10,7	-
350	15,1	14,4	-

The compressibility is even greater for lower fluid viscosities (see graph N°7).
In addition, the compressibility increases with higher temperature.

An average adiabatic compressibility coefficient can be calculated in this pressure interval:

Around 4.4 . 10^{-10} m^2/N for oil 47 V 1000
Around 4.2 . 10^{-10} m^2/N for oil 47 V 100

$$\text{Coeff.} = \frac{(V_1 - V_2)}{V_1\,(P_2 - P_1)}$$

V_1 and P_1 initial volume and pressure
V_2 and P_2 final volume and pressure

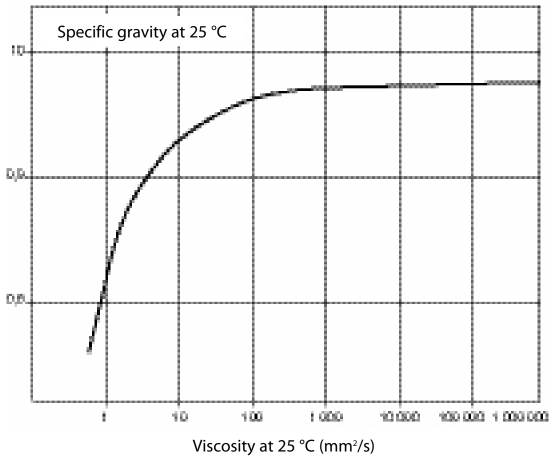
This high compressibility is an advantage in liquid shock absorbing systems but is not a disadvantage in normal hydraulic or damping systems.

7. Specific gravity

■ Influence of viscosity

The specific gravity increases with viscosity up to a value of 0.97 for oil 47 V 300 (see graph N°8).

Graph 8
Bluesil™ Oils 47
Variation in specific gravity as a function of viscosity



■ Influence of temperature

The specific gravity of Bluesil™ Oils 47 varies with oil temperature; the general law governing the variation of specific gravity as a function of temperature is as follows:
Law valid between 0 and 250 °C

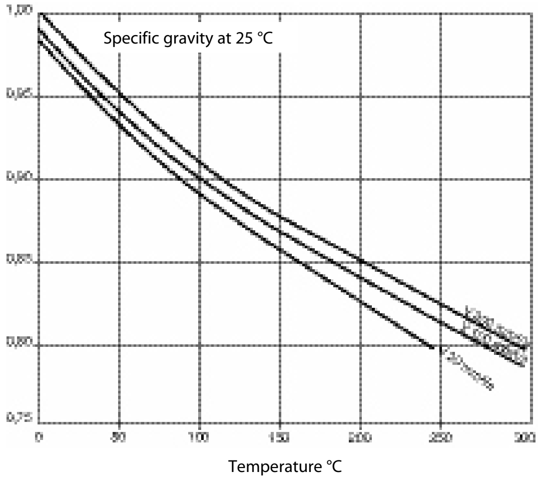
$d = a\,T^3 + b\,T^2 + c\,T + g$

(see graph N°9)

Example

	a	b	c	g
47 V 20	- 7,34.10^{-9}	+ 3,76.10^{-6}	- 1,26.10^{-3}	+ 0,984
47 V 100	- 4,57.10^{-9}	+ 3,00.10^{-6}	- 1,19.10^{-3}	+ 0,991
47 V 300	- 6,18.10^{-9}	+ 3,57.10^{-6}	- 1,21.10^{-3}	+ 0,998

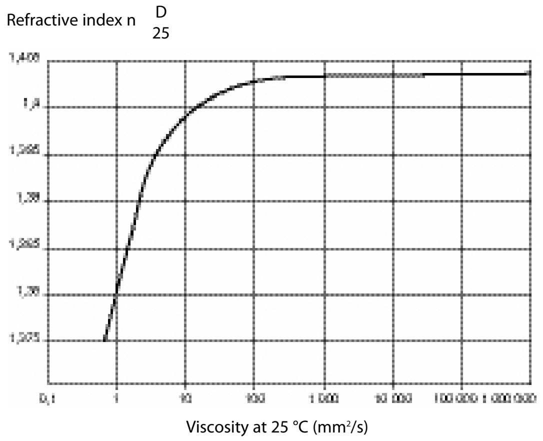
Graph 9
Bluesil™ Oils 47
Variation in specific gravity as a function of temperature



8. Refractive index

The refractive index increases significantly with viscosity below 100 mm²/s, then stabilizes for viscosity above 100 mm²/s (see graph N°10).

Graph 10
Bluesil™ Oils 47
Variation of refractive index as a function of viscosity



9. Surface tension

The remarkably low surface tension varies very little with viscosity and remains virtually constant when the viscosity rises above 300 mm²/s.
(see graph N°11)

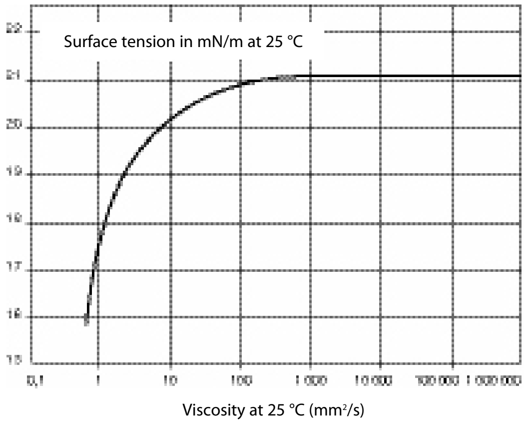
Oils 47 V 5 : 19,7 mN/m at 25 °C
47 V 100: 20,9 mN/m at 25 °C
47 V 300: 21,1 mN/m at 25 °C

For information purposes, water has a surface tension of 72 mN/m at 25 °C.

This extremely low surface tension leads to high surface activity and high spreadability.

N.B.: the surface tension reduces with increasing temperature.

Graph 11
Bluesil™ Oils 47
Variation in surface tension as a function of viscosity



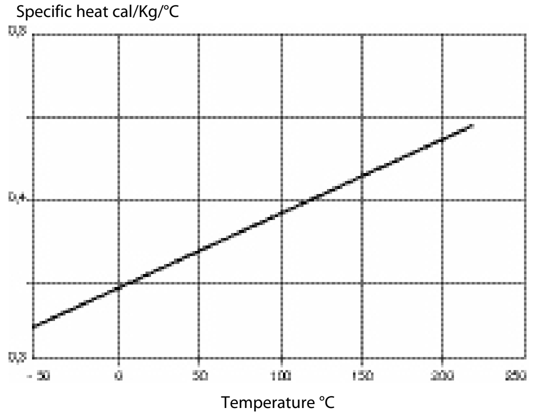
10. Specific heat (or heat capacity)

The specific heat capacity of Bluesil™ Oils 47 of viscosities 50 to 1,000 mm²/s is independent of the viscosity and equal to 0.35 cal./kg/°C (or 1.46 J/g.°C) at 25 °C whereas that of mineral oils is of around 0.51 cal/kg/°C.

This increases with temperature according to the following general law: Cp = a + b.10^{-5} T with a = 0.34708 and b = 43 T in °C, Cp in Kcal/kg/°C.

This law is valid between -50 °C and +220 °C (see graph N°12).

Graph 12
Bluesil™ Oils 47
Variation in specific heat as a function of temperature



11. Thermal conductivity

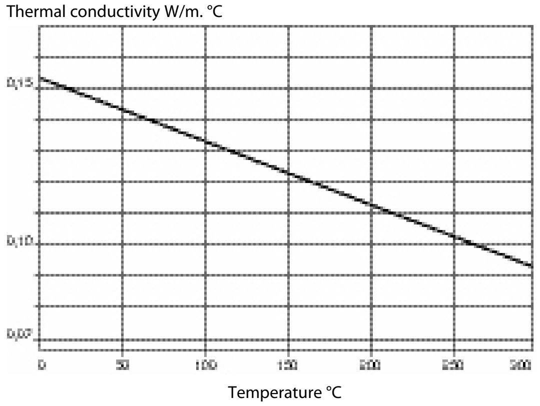
The thermal conductivity of Bluesil™ Oils 47 varies little with temperature in the range 0 °C to +250 °C. It only changes as a function of viscosity for very fluid oils and remains basically constant from a viscosity of 50 mm²/s (see characteristics table p8).

Comment: the thermal conductivity of Bluesil™ Oils 47 is basically identical to that of mineral oils.

The general law governing the variation of thermal conductivity as a function of temperature is as follows:
l = lo + T, l in mW/m. °C

For oils 47 V 50 to V 1,000:
In mW/m. °C l = 156,82 - 0.233 T (T in °C)
In kcal/h.m. °C l = 0,1351 - 2.10^{-4} T

Graph 13
Bluesil™ Oils 47 V 50 to V 1000 Variation in thermal conductivity as a function of temperature



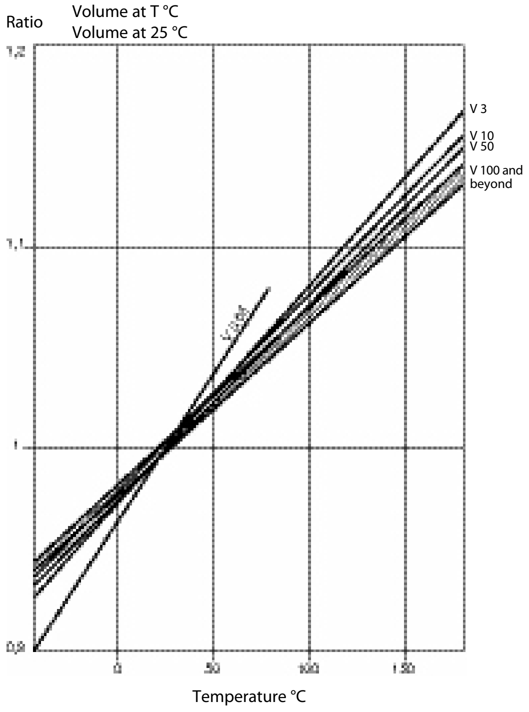
12. Volume expansion coefficient

The volume expansion coefficient expressed in cm^3/cm^3 °C reduces with increasing oil viscosity and remains stable for viscosities greater than 100 mm^2/s. See graph N°14. Mineral oils generally have a lower expansion coefficient.

Example:

	expansion coefficient between 0 and 150 °C.
Oil 47 V 20	$10{,}7.10^{-4}$ (°C)$^{-1}$
Oil 47 V 50	$10{,}5.10^{-4}$ (°C)$^{-1}$
Oil 47 V 100 and above	$9{,}45.10^{-4}$ (°C)$^{-1}$

Graph 14
Bluesil™ Oils 47 Volume expansion as a function of temperature



13. Sound transmission

The sound propagation speed in Bluesil™ Oils 47 is comparable to that measured for most organic compounds.

- This speed increases with viscosity and reaches around 1,000 m/s at 25 °C for an oil of viscosity 100 mm^2/s.
- The variation in speed of sound as a function of temperature is virtually linear as shown in the example below for the oil 47 V 500.

Temperature (°C)	Speed of sound (m/s)
- 20	1 150
+ 20	1 020
+ 80	870

14. Light transmission

Bluesil™ Oils 47 are transparent to visible light. In the ultraviolet range the percentage of light transmission starts to decrease to around 0.33 microns and continues to decrease with wavelength.
At 0.25 microns, 50% of light is transmitted and only 20% at 0.13 microns.

Analysis by infrared spectrography is the quickest and most distinct analytical method for dimethylpolysiloxane fluids.
The spectra are very characteristic and relatively intense. Graph N° 15: IR spectrum for a Bluesil™ Oils 47.

15. Radiation withstand

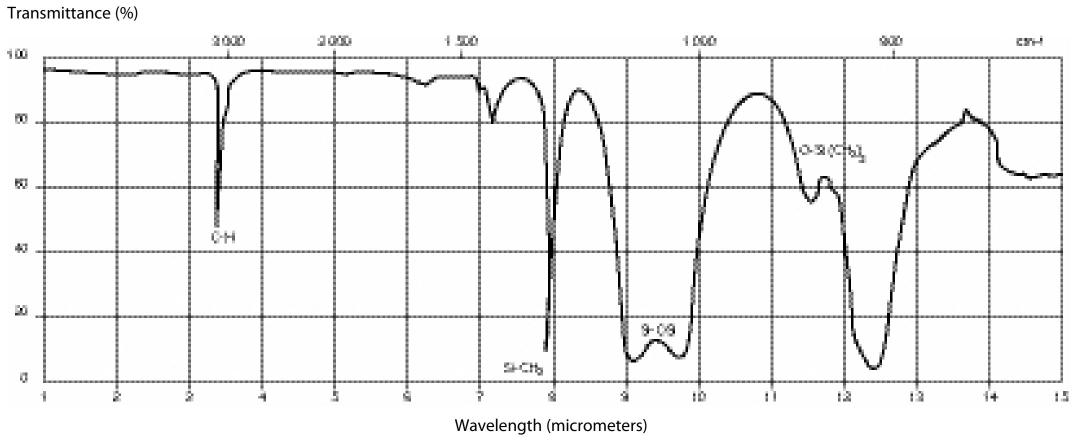
Bluesil™ Oils 47 have relatively poor resistance to γ radiation, however it is better than mineral oils. Their withstand depends on viscosity (less good for viscous oils) and also depends of the quantity and intensity of radiation they are subject to.

16. Vapor pressure

The vapor pressure is very low for Bluesil™ Oils 47 with a viscosity over 50 mm^2/s: around 1.33 Pa at 200 °C (10^{-2} mm Hg).

Low viscosity oils have a significantly higher vapor pressure:
Oil 41 V 0.65: 5.10^3 Pa at 25 °C.

Graph 15
Bluesil™ Oils 47 Infrared spectrum



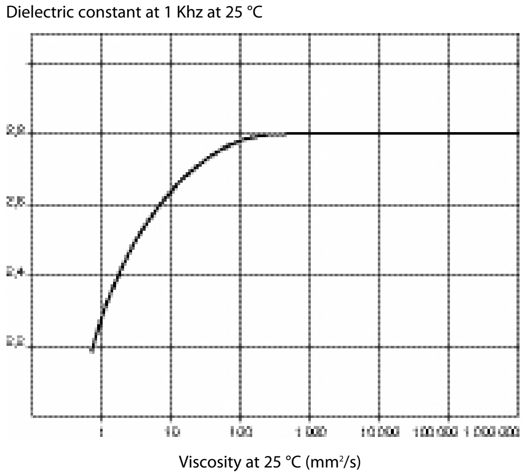
Dielectric properties of Bluestar Silicones' Oils 47

Bluesil™ Oils 47 have remarkable dielectric properties which leads to them being used as electrical insulators in various electrotechnical applications.
One of them, Bluesil™ Oils 604 V 50 is specially intended for filling liquid dielectric type power transformers.

1. Influence of oil viscosity

Dielectric properties at ambient temperature for Bluesil™ Oils 47 are in almost constant for viscosity slightly above 100 mm²/s (see page16).

Graph 16
Bluesil™ Oils 47
Influence of viscosity
on the dielectric constant



2. Influence of frequency and temperature (see graph N° 17)

■ On the dielectric constant

The dielectric constant is of between 2.4 and 2.8 for frequencies varying from 500 Hz to 1 MHz and temperatures varying from 20 °C to 150 °C.

At constant temperature the dielectric constant is virtually independent of frequency.

At constant frequency the dielectric constant reduces with increasing temperature.

■ On the loss angle

This characteristic that is particularly low for Bluesil™ Oils 47, also varies with frequency and temperature.

At constant temperature dielectric losses slightly reduce with increasing frequency in the range of 100 Hz to 1 MHz. Beyond this, they tend to increase as a function of frequency.

At constant frequency dielectric losses increase with temperature and this is even more significant at lower frequencies.

■ On the volume resistivity

This characteristic reduces with increasing temperature.

Example:
Standard Oil
resistivity at .... 25 °C : 1.10^{15} ohm.cm
at .... 175 °C : 1.10^{13} ohm.cm

■ On the dielectric strength

This characteristic reduces with increasing temperature. It should be noted that Bluesil™ Oils 47 do not have very good resistance to a lot of successive strike-overs.

3. Influence of humidity

Humidity, in the form of traces, can affect the dielectric properties of Bluesil™ Oils 47. However Bluesil™ Oils 47 can absorb between 100 and 250 mg water per kilogram when exposed to air at ambient temperature.

Example:
170 mg of water per kilo of Bluesil™ Oils 47 causes a drop in dielectric strength by 10 to 20%; the loss angle increases and the volume resistivity significantly reduces; the dielectric constant is not affected.

In certain cases, it will therefore be necessary to dehydrate oils by heating for 2 to 3 hours at temperatures of 150 – 200 °C in a dry gas atmosphere (air or even better nitrogen) or even by heating under vacuum conditions to around 150 °C. The addition of a drying agent such as anhydrous calcium sulphate or attapulgite, followed by filtration and repeated several times can also be suitable.

4. Influence of foreign bodies

The dielectric properties of Bluesil™ Oils 47 are also affected by the presence of foreign bodies (tar, calamine, various waste products). Care should therefore be taken to ensure the perfect cleanliness of the oils and to purify them by filtration.

Chemical properties
Effects on materials

1. Solubility in solvents

Bluesil™ Oils 47 have good solubility in many solvents:

- Aromatic hydrocarbons (toluene – xylene – naphtha)
- Chlorinated hydrocarbons (trichlorethylene, trichlorethane, methylene chloride)
- Superior alcohols (lauric alcohol, ethyl-2 hexanol, butanol, hexanol)
- Ketones other than acetone (methylethylketone, methylisobutylketone)
- Ether (ethyl, isopropyl)
- Esters (butyl acetate))
- Aliphatic hydrocarbons (hexane – heptane, white spirit)

Bluesil™ Oils 47 are insoluble in:

- Water
- Hydrocarbons oils (oil-vegetable oils-fatty acids)
- Simple alcohols (methanol-ethanol-isopropanol)
- Glycols (ethylene-glycol, propylene-glycol, glycerin)

Solubility depends on the oil viscosity.
Very low viscosity oils may have limited solubility in solvents (alcohol – ketone) in which high viscosity oils would be insoluble.

2. Solubility of gases in Bluesil™ Oils 47

Silicone oils are very permeable to gases. Gas solubility depends on viscosity, temperature and pressure. It also varies with the type of gas.

Example: at ambient temperature and atmospheric pressure we can dissolve in 1 ml of oil 47 V 50.

	at ambiant temperature	at 120 °C
air	0,19 ml/ml	0,16 ml
nitrogen	0,17 ml/ml	0,15 ml
oxygen	0,27 ml/ml	0,21 ml
CO_2	1,0 ml/ml	

3. Coloring

Bluesil™ Oils 47 can be colored using tinting paste.
(usual dosage: 0.25 g/kg)

4. Effects on materials

In spite of being highly chemically inert, Bluesil™ Oils 47 can have an effect on certain materials to various extents.

Several examples are given below:

Effects on rubbers

- Oils with viscosities of less than or equal to 10 mm²/s have a detrimental effect on rubber immersed for prolonged periods.
- Materials containing very little or no plasticizers that are compatible with Bluesil™ Oils 47 are not affected by immersion. Example: neoprene, butyl, natural rubber, fluorinated rubber.
- Materials containing plasticizers can be affected by immersion in a silicone oil. The effect will vary according to the oil viscosity, the material composition, the immersion temperature.

The main effect is a loss of weight and volume, as well as an increase in hardness due to extraction of the plasticizer by the silicone oil. These effects can only be seen after prolonged immersion at temperature and do not prohibit the use of the silicone oils for certain applications, such as demolding, release, etc.

Effects on plastics

Samples immersed in oil 47 V 100 at room temperature

Materials	None	Hardening	Hardening, cracking	Slight cracking	Shrinkage and hardening
Polyamide	•				
Polystyrene	•				
Methacrylates	•				
Polycarbonate	•				
Phenolic	•				
PTFE (teflon)	•				
Cellulose Acetate		•			
Polyacetal			•		
Polyethylene				•	
Polypropylene				•	
PVC					•

Metals and alloys

Metals and alloys	None	Gelling inhibitor (up to 200 °C)	Encourages gelling
Aluminium	•		
Stainless steel	•		
Duralumin	•		
Nickel	•		
Magnesium	•		
Titanium	•		
Zinc	•		
Silver	•		
Copper		•	
Lead		•	
Brass			•
Iron		•	

Acids and bases

Small quantities of strong acids or bases can cause a molecular redistribution of Bluesil™ Oils 47 and accelerate their gelling under oxidizing conditions.
Iron chloride catalyses oil gelling.

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