# RHODORSIL® OIL 604 V 50

## Use in submurged transformers

**Description**

The following dielectric liquids are used to provide insulation and cooling in submerged transformers:

- Mineral oils, which have the disadvantage of being inflammable,
- Silicone oils, esters, etc.

**RHODORSIL OIL 604 V 50** is a dielectric liquid consisting of polydimethylsiloxane, whose purity has been checked especially for electrotechnical applications.

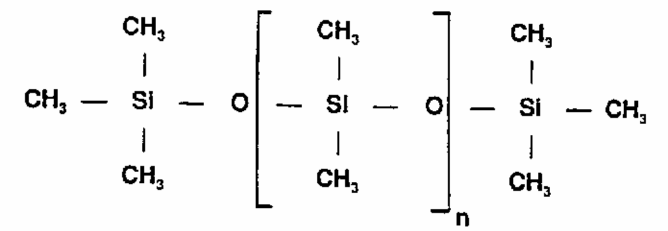
**RHODORSIL OIL 604 V 50** is mainly used as an insulation and cooling medium for transformers and, more generally, for all medium tension equipment (switch boxes, chokes, capacitors, resistors, etc.) when environmental or fire safety problems arise, such as in public places, built-up areas, basements, proximity to water streams, etc.

**RHODORSIL OIL 604 V 50** offers the following advantages:

- Excellent dielectric properties
- Excellent thermal stability
- Remarkable chemical inertia and strength
- Good heat transfer properties
- Non-propagation of fire
- Not dangerous for man or the environment

**General characteristics identificarion**

**RHODORSIL OIL 604 V 50** is a linear polydimethylsiloxane having the following general formula:



For a fluid having a viscosity of 50 mm²/s, the number "n" of Si O $(CH_3)_2$ groups is approximately 40 and the molecular weight approximately 3,200.



BLUESTAR SILICONES

# RHODORSIL® OIL 604 V 50

The general characteristics enabling the product to be identified are contained in table 1. Other characteristics, more closely linked to the use as a dielectric fluid, are given in the following tables :

- Tables 2 to 5: Dielectric properties
- Table 6: Heat transfer
- Tables 7 and 8: Fire risk
- Table 9: Compatibility of materials

TABLE 1

**General characteristics**

Appearance........................................................................clear liquid
Coloration (Hazen)..............................................................30 max.
Odour.........................................................................................no
Approx. pH.................................................................................6.7
Density at 25℃ approx.......................... ..............................0.960
Viscosity at 25℃, mm²/s, approx.................. ..............................50
Flash point, ℃ (AFNOR NF T 60 118 standard) ..... ...........280 mm
Melting point, ℃ approx......................... .................................- 50
Refractive index at 25℃ approx................... .........................1.402
Surface tension at 25℃ mN/m, approx.............. .......................20.7
Volatile matter (24 hrs. at 150℃), %............. ......................0.5 max.

## Dielectric properties

Four criteria play a part in the choice of a dielectric fluid for transformers:

- Low dielectric coefficient,
- Low tangent of loss angle,
- High voluminal resistivity
- Above all, high dielectric strength.

These four factors are combined in **RHODORSIL OIL 604 V 50** as is shown in table 2.

### 1 Dielectric loss

The dielectric constant is the tangent of the angle of loss giving an indication of the energy dissipated in a dielectric fluid in the form of heat.

It should be noted that, in the case of the **OIL 604 V 50**, an increase in temperature results in a decrease of the dielectric coefficient - this is beneficial - while the tangent delta remains practically unchanged.

### 2 Dielectric strength

#### *2 - 1 Measurement methods*

Two methods are currently used to measure this value:

- Method CEI 5[1] with spherical electrodes or in an open cup
- ASTM[2] method with flat electrodes.

1



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TABLE 2

**Dielectric Properties**

| | RHODORSIL OIL 604 V 50 | MINERAL OIL |
|---|---|---|
| Dielectric coefficient at 50/60 Hz,<br>• at 25 °C<br>• àat 75 °C<br>• at 100°C<br>(CEI 247 - AFNOR NF C 27 210 standards) | 2.7<br>2.6<br>2.5 | 2.2<br>--<br>-- |
| Tangent of loss angle at 50/60 Hz,<br>• at 23 °C<br>• at 75 °C<br>• at 100 °C<br>(CEI 247 - AFNOR NF C 27 210 standards) | $3.10^{-5}$ max.<br>$5.10^{-5}$<br>$3.10^{-5}$ | $1.10^{-4}$<br>--<br>-- |
| Voluminal resistivity, in Ω.cm,<br>(ASTM D 1169, CEI 247 and AFNOR NF C 27 210 standards)<br>• at 23 °C<br>• at 75 °C<br>• at 100 °C | $1.10^{15}$ min.<br>$8.10^{14}$<br>$1.10^{14}$ | $2.5.10^{13}$<br>--<br>-- |
| Dielectric strength, in kV at 23 °C [(3)]<br>• According to ASTM D 877 standard (flat electrodes, spacing 2.54 mm)<br>• According to CEI publication n°156 (AFNOR NF C 27 221 standard) (spherical electrode, spacing 2.5 mm) | 40 min.<br>50 min. | 40 to 55<br>50 to 70 |

[1] CEI publication No. 156 or AFNOR NF C 27 221

[2] ASTM D 87 standard.

[3]According to the literature, the dielectric strength remains unchanged up to 150°C.

**N.B.** *The values indicated in the tables for silicon and mineral oils are either measurement results or literature data. Hence they should be considered as approximate figures, as they are likely to change according to the quality or source of the product.*

With CEI type spherical electrodes, the indicated distance is obtained only between the two extreme points of the cups. As soon as we move away from these points, the length of the track to be followed by the arc increases. Hence it is only the very narrow stream of liquid joining these extreme points which is subject to the maximum field.

On the other hand, with ASTM type flat electrodes, all points on the electrode are at an equal distance from the opposite electrode. Hence, it is the whole cylinder of liquid between the electrodes which is subject to the field. The volume of the exposed liquid is much greater than previously, and consequently the probability of discovering a fault is greater and the result is automatically more reliable. Roughly speaking, we can achieve a factor of 1.2 to 1.5 between the results of these two methods.

*Hence, it is always important to specify the method used.*

### *2 - 2 The influence of humidity*

During its manufacture, **RHODORSIL OIL 604 V 50** is degassed under vacuum at elevated temperatures and contains only a few mg/kg (or ppm) of water. It is, however, important to keep in mind, that silicone oils, exposed to damp air, quickly absorb humidity until equilibrium thanks to the great facility of distribution of gas and vapors in silicones in general. The quantity of water in the oil is always proportional to the relative humidity of the air (HENRY's law).

Hence, it is essential to take care during preparation of a silicone oil sample for analysis, so as to avoid humidity take up.

It is preferable not to leave the containers or drums of **RHODORSIL OIL 604 V 50** open unnecessarily, so as to avoid water take up. The solubility of water in **RHODORSIL OIL 604 V 50** is higher than in other dielectrics.

At saturation, the following values of mg water /kg of dielectric (or ppm) can be observed.

TABLE 3

**Solubility of water in dielectrics (1)**

| **Temperature,** | **Water content mg/kg** | |
|---|---|---|
| **°C** | **RHODORSIL OIL 604 V 50** | **MINERAL OIL** |
| 0<br>25<br>55 | --<br>200<br>600 | 20<br>70<br>330 |

(1) *Water metering by the standard Karl Fischer method is not applicable in the case of silicone oils because of a secondary reaction. Bluestar Silicones has developed a modified method which is available on request.*

Consequently, the water content, by which the dielectric strength of the oil is affected, is at the equilibrium higher for **RHODORSIL OIL 604 V 50** than for other dielectrics. It has been observed that the decisive factor causing the decrease in dielectric strength is not the absolute value of water in the dielectric, but its percentage in relation to saturation.

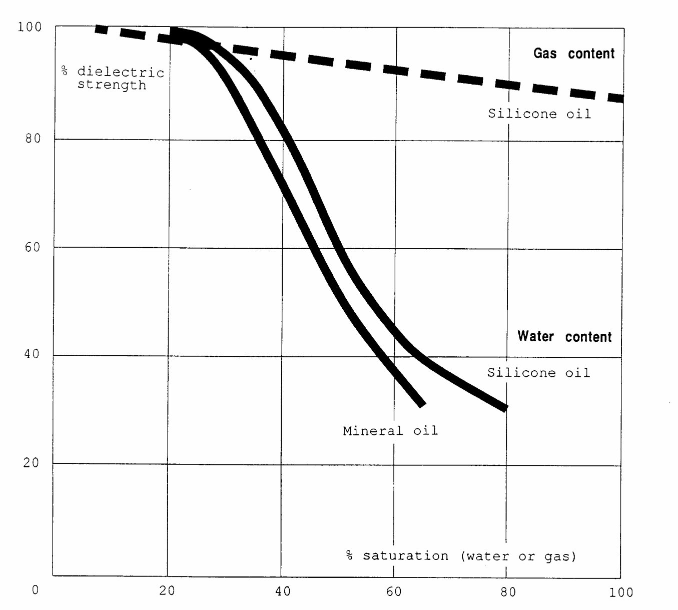
We demonstrate this behaviour by adopting a graphical visualisation (graph 1):

- X axis : water content (%) in relation to saturation
- Y axis: Dielectric strength (%) in relation to the maximum dielectric strength of a perfectly dry dielectric liquid.

**RHODORSIL OIL 604 V 50** behaved identically, or even slightly better than a mineral oil (see graph 1). In both cases, there is practically no observable decrease in dielectric strength up to saturation of 25%.

GRAPH N°1

**Changes in dielectric strength**
**in relation to the water or gas content.**




This means that **RHODORSIL OIL 604 V 50** containing 50 ppm of water (50 mg of water/kg of oil) still retains a dielectric strength which is very little different from that of dry oil. Beyond this point, desiccant treatment has to be carried out as for other dielectrics. The same installations as for mineral oils can be used. The treatment consists of heating the oil under vacuum so as to eliminate water and gases. The dielectric should also be filtered on a dry filter paper. However, it should be borne in mind that:

- **RHODORSIL OIL 604 V 50** has a vapor tension of less than $10^{-2}$ mm Hg at 200℃ So it can be treated at up to 200℃ under a vacuum of 1mmHg.

- We do not recommend to use the same installation for the treatment of both, mineral oils and **RHODORSIL OIL 604 V 50,** because a pollution by a small quantity of mineral oil rapidly reduces the fire resistance of silicone liquids, although it does not greatly affect the dielectric properties, as can be seen from the following figures in table 4.

The presence of traces of silicone in mineral oil is not detrimental to its general properties, but may cause frothing during drying and degassing operations.

TABLE 4

**Properties of mixtures of mineral transformer oil with RHODORSIL OIL 604 V 50**

| Characteristics measured | Measurement standard | OIL 604 V 50 | OIL 604 V 50 + 2 % of mineral oil | OIL 604 V 50 + 5 % of mineral oil | MINERAL OIL |
|---|---|---|---|---|---|
| Dielectric coefficient | AFNOR NF C 27 210 | 2.70 | 2.70 | 2.68 | 2.20 |
| Tangent of loss angle | AFNOR NF C 27 210 | $5.10^{-5}$ | $6.10^{-5}$ | $7.5.10^{-5}$ | $9.7.10^{-5}$ |
| Voluminal resistivity Ω.cm | AFNOR NF C 27 210 | $1.10^{15}$ | $1.5.10^{14}$ | $9.10^{12}$ | $2.5.10^{13}$ |
| Dielectric strength kV | AFNOR NF C 27 221 | 70 | 67 | 65 | 40 |
| Flash point, °C, (open cup ) | AFNOR NF T 60 118 | 315 | 247 | 216 | 145 |

***2.3. Solubility of gases in RHODORSIL OIL 604 V 50***

As for water, we also observe higher gas solubilities in silicone liquids than in other dielectrics.

TABLE 5

| Temperature | Solubility ( volume % ) | | |
|---|---|---|---|
| °C | Oxygen | Nitrogen | Air |
| 25<br>120 | 27<br>21 | 17<br>15 | 19<br>16 |

In addition, **RHODORSIL OIL 604 V 50** very quickly reaches the equilibrium with the ambient atmosphere, and consequently dielectric measurements are always taken on an oil which is saturated in air.
It has also been shown that the dielectric strength is little affected by the dissolved gas content. We can see in graph 1, that a silicone oil saturated with air retains 90% of the dielectric strength which it would have had without the gas.

**2.4. Voluminal resistivity**

The voluminal resistivity of **RHODORSIL OIL 604 V 50** is the highest in comparison with mineral oil.

**Heat transfer**

The comparative figures are shown in table 6.

Inside a transformer, two phenomena act in the elimination of calories: conduction and convection.

**1 Conduction**

Transfer of calories takes place between neighboring molecules without any movement of material. For a given material, its propensity for this type of heat transmission is expressed by the coefficient of thermal conductivity.

This coefficient is very favorable for **RHODORSIL OIL 604 V 50** since, for 1,000 calories transferred by silicone oil, in the same conditions mineral oil only transfers 860.

Hence **OIL 604 V 50** absorbs calories very well and very quickly when it is in contact with a hot surface, or transmits them very well when in contact with a cold surface. However, another phenomenon plays an important role: convection.

**2 Convection**

This is the transfer of heat due to the movement of a fluid. The elements of the fluid in contact with the hot material are heated by conduction; they then carry away the heat stored within them and are replaced by others which are then, in turn, heated, etc. Little by little, the fluid temperature rises at the expense of the hot material.

The fluid movement can be created artificially (by a pump) or it can also be due to natural convection. The latter is caused by the differences in density which are subject to the differences in temperature. The higher the temperature difference, the higher the speed of fluid circulation.

**In this case, the greater density variation of silicone oil is a very favorable characteristic.**

Three main factors affect these convection phenomena:

- the viscosity of the dielectric fluid which controls its circulation,
- the specific heat of the fluid which controls the quantity of calories transported,
- the coefficient of cubic expansion.

TABLE 6

**Heat transfer**

| | **RHODORSIL OIL 604 V 50** | **MINERAL OIL** |
|---|---|---|
| Kinematic viscosity (1) mm²/s, approx.<br>• at - 20 ℃<br>• at 0 ℃<br>• at 25 ℃<br>• at 100 ℃ | 140<br>85<br>50<br>16 | 720<br>125<br>25<br>3 |
| Dynamic viscosity(2) mPa.s, approx<br>• at - 20 ℃<br>• at 0 ℃<br>• at 25 ℃<br>• at 100 ℃ | 141<br>83.8<br>48<br>14.2 | 657<br>112.7<br>22.2<br>2.3 |
| Density at 25 ℃, approx | 0.960 | 0.887 |
| Coefficient of cubic expansion, $K^{-1}$, approx | $10.4.10^{-4}$ | $6.3.10^{-4}$ |
| Thermal conductivity (3) at 25 ℃, W/(m.K), approx | 0.15 | 0.13 |
| Specific heat constant (4)<br>• J/g.K, approx<br>• $J/cm^3.K$, approx | 1.525<br>1.46 | 2.04<br>1.81 |
| Freezing point , ℃, approx | - 50 | - 45 |

*Dynamic viscosity is a product of the kinematic viscosity and the density.*
*(1) 1 mm²/s = 1cSt*
*(2) 1 mPa.s = 1cPo*
*(3) 1 W/(m.K) = 2.39.10-3 cal.cm/s.cm². ℃*
*(4) 1 J/g.K = 0.239 cal/g. ℃*

### *2.1. Viscosity*

It is the viscosity which makes the oil circulate more or less easily, and consequently partly contributes to the extent by which calories are transmitted to the outside. The value to be taken into consideration is that of the viscosity at the operating temperature; however, it is well known that the viscosity of silicone oils decreases less than that of other fluids, producing a disadvantage (see graph No 2).

We can consider roughly that, at 100℃, a silicone oil will circulate 5 or 6 times slower than a mineral oil, all other things being equal.

To obtain a clear idea, it should also be noted that, from 25 to 100℃, the circulation speed of a mineral oil is multiplied by 5, and that of a silicone oil by only 3.

On the other hand, at low temperatures, the viscosity of silicone oil is very much lower than that of mineral oils, which is an advantage for cold start-up (such as for transformers installed on locomotives). See viscosity/temperature graph, page 11.

### *2.2. Specific heat constant*

The specific heat constant of a silicone oil is lower than that of a mineral oil. This is a slight advantage.

### *2.3. Coefficient of cubic expansion*

The coefficient of cubic expansion represents the influence of temperature on the volume of a body and, consequently, on its density. Temperature changes have a higher effect on silicon oils.

As an example, at 100℃, a mineral oil will be subj ect, in relation to 25℃, to an increase in volume (or conversely, a reduction in density) of about 5%, and the silicone oil of about 8%. This larger volume variation with temperature will cause the user to provide a greater volume of expansion. On the other hand convection movements are facilitated.

Hence, we can see that, among the measurable physical values which specify the cooling capacity, one value is clearly favorable to **RHODORSIL OIL 604 V 50**: its thermal conductivity.

Another is somewhat favorable: the reduction in density which helps convection. The three others are unfavorable to silicone oil. However, we must remember that the elimination of calories takes place in reality by successive transfers:

- from the windings to the fluid,
- from the fluid to the sheet metal,
- throught the sheet metal,
- from the sheet metal to the air.

The last two transfers do not depend on the quality of the dielectric fluid. The sheet metal/air transfer is in any case the worst one, and this to an extend that, in practice, it is above all this transfer which limits cooling.

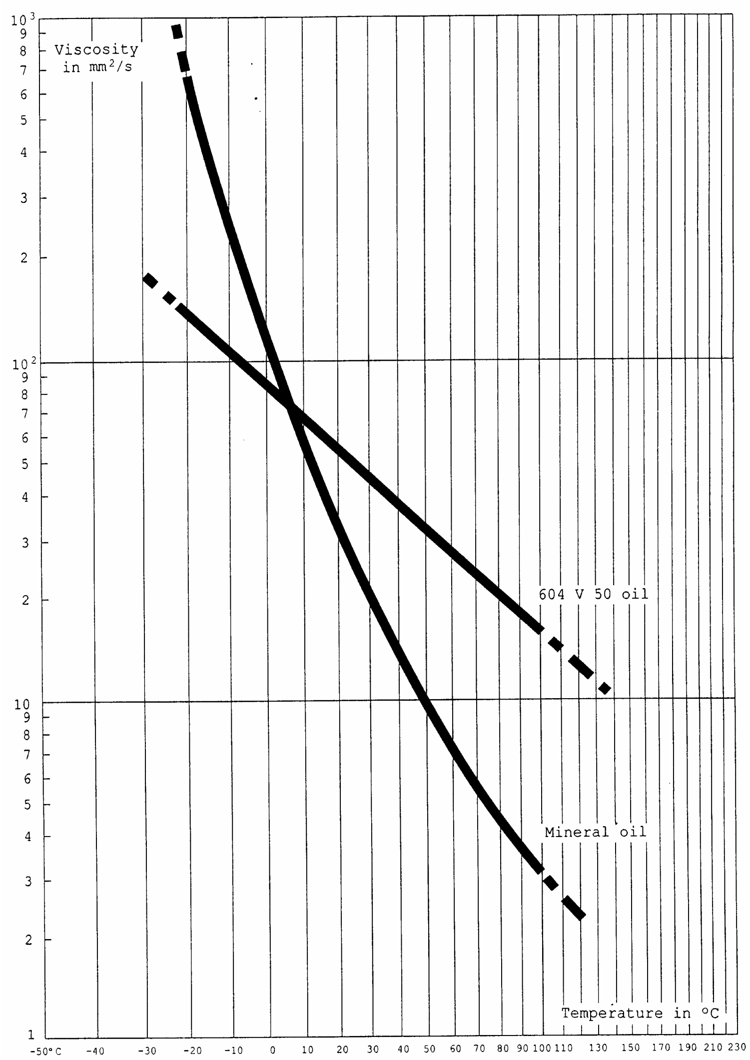
This leads us to the conclusion that cooling by **RHODORSIL OIL 604 V 50** is satisfactory.

Experience confirms that, if we make no change to the construction of the transformer, the simple fact of replacing mineral oil by silicone oil produces a maximum temperature which is increased by 5 to 15℃ depending on the load and th e highest temperature drop in the radiators. This indicates a lower thermal flow.

On the other hand, we can retain the same operating temperature by simply making a few minor modifications to the diameters of channels and dielectric circulation pipes.

GRAPH N°2

**Viscosity variation as a function of temperature.**




**Behavior when subject to fire**

## 1. Traditional tests

Table 7 shows some values concerning the evaluation of the fire risk.

The flash, fire and spontaneous ignition points are higher than those of mineral oil. We can also see that the gap between the flash point and the fire point is greater for a silicone oil than for a mineral oil. These facts indicate that the former will be more difficult to ignite.

The limit oxygen index (LOI) is the minimum oxygen content necessary to allow combustion which has started to be sustained. As air contains 21% of oxygen, a body with an oxygen index greater than 21 should not burn in air.

In fact, the situation is rather more complex. If we supply sufficient energy, we can always manage to make an organic body burn. This figure really shows that, if the atmosphere is impoverished in oxygen, the ease of extinguishing the body will be inversely proportional to the limit oxygen index. We may expect silicone oil to be extinguished more easily than mineral oil.

Another important point is the heat of combustion. It is this heat that allows to maintain the fire and that is responsible for the property damage caused to surroundings. The heat of combustion of silicone oils is very low, which is not surprising considering its composition, shown on page 3. In the elementary form Si O $(CH_3)_2$, the purely organic part, formed from methyl groups alone, only represents 40% of the total weight.

TABLE 7

Fire risks

| | **RHODORSIL OIL 604 V 50** | **MINERAL OIL** |
|---|---|---|
| • Flash point (open cup), ℃, approx. (AFNOR NF T 60 118 standard) | 315 | 145 |
| • Fire point , ℃, approx. (AFNOR NF T 60 118 standard) | 360 | 165 |
| • Spontaneous ignition temperature, ℃, approx. | 440 | 330 |
| • Limit oxygen index (LOI), % O², approx. | 23 | 17 |
| • Heat of combustion, J/g, approx. | 32 100 | 46 050 |
| • Vapor tension, Pa, approx.<br>at 50 ℃<br>at 85 ℃<br>at 200 ℃ | <br><br>--<br>--<br>< 1.3 | <br><br>2<br>--<br>-- |

Other points to be noted:

- the extremely low vapor tension of silicone oil: about 1 Pa, or 1/100 mm Hg at 200℃,
- the SiO skeleton of silicone oil gives rise, in the event of combustion, to silica formation the majority of which stays on the surface of the liquid in the form of a white insulating and protective crust.

On the basis of the measurements taken, the "fire profile" of silicone oils is the following :

- a product which is difficult to set on fire,
- a silica crust formation which slows down the arrival of oxygen, and consequently assists extinction because the oxygen index of silicon oil is high,
- a low quantity of heat produced, and, in addition, a white crust which reflects it to the outside, preventing the temperature of the liquid from rising,
- very low vapor emission,
- finally, we should indicate that the smoke given off during a silicone oil fire is very different from that produced by a mineral oil fire. It is white or light grey (presence of silica), its volume is very small, it is not very dense and non-toxic (absence of CO). Oxygen consumption is also greatly reduced.

**2. Combustion tests**

All the preceding data leads us to think that the fire risk will be lower with a silicone oil. So as to be able to put a figure on this risk and to appreciate the action on the surroundings, the American insurance company (Factory Mutual Research Cooperation) designed and operated a test which can be described as follows:

- the fluid under evaluation is ignited in a wide flat recipient,
- the heat given off by the fire by convection is measured by means of sensors placed over the fire. This quantity of heat given off enables us to calculate the minimum ceiling height in the room which is to contain the transformer,
- in the same way, other sensors placed on the side measure the heat given off by the fire by radiation. This quantity of radiated heat enables us to calculate the distance between the transformer and the walls of the room where it will be installed.

The description of this test and results obtained are being published in various documents by Factory Mutual Research Cooperation; the figures in table 8 are taken from it. They show heat given off by convection and by radiation, the minimum ceiling height and the minimum space between the walls for a transformer with the following characteristics:

315 kVA - length 1 m  width 0.36 m

TABLE 8

**Values obtained by Factory Mutual**

| | Convection heat kW/m² | radiation heat kW/m² | Minimum celling height (m) | Minimum distance between walls (m) |
|---|---|---|---|---|
| Silicone oils | 55 / 65 | 25 / 50 | 2 | < 1 |
| Traditional mineral oil | 550 | 415 | 6 | 3 |
| Heavy hydrocarbons | 540 / 550 | 350 / 450 | 6 | 3 |

CONCLUSIONS OF FACTORY MUTUAL'S TESTS
Thanks to their low combustion heat and high fire point, silicone oils only represent a very low fire risk ("less flammable fluid").

**3. Action of an arc**

As for all dielectrics, starting an arc frees a considerable amount of energy which results in partial decomposition and formation of gas. Several articles have been published on this subject in the specialist press.

Without entering into details, we can say qualitatively:
- for low or medium power arcs, silicone oil gives off less gas than mineral oil,
- for high powers the quantities are similar,

the components are roughly the same, except for the acetylene content which is lower and the carbon monoxide content which is higher for silicone oil than for mineral oil, and the absence of chlorinated products.

# RHODORSIL® OIL 604 V 50

**Temperature resistance**

The temperature resistance of silicone oils is well known and quite extraordinary:

- by differential calorimetric analysis, we can see the beginning of a reaction with oxygen at 200°C,
- by heating the air to 175°C, there is a gelation risk only after 6,000 hours (more than 8 months),
- when heated in air at 150°C, silicone oil is stable practically indefinitely.

We should also remember that the planned operating temperature in transformers is about 100 to 110°C. This relatively low temperature is necessitated by the thermal resistance of other insulators (notably cellulose ones) which are used in the transformers (see following paragraph). With better insulators, we can desigh transformers which work at a higher temperature and are consequently more compact, which represents a great advantage for on-board equipment.

**Resistance of insulating materials in RHODORSIL OIL 604 V 50**

**RHODORSIL OIL 604 V 50** is a bad solvent, and is consequently not aggressive. However, in the presence of insulators commonly encountered in transformers, two phenomena may arise. They may be concomitant or not.

- attack and deterioration of the insulating material,
- change in appearance and reduction of the dielectric properties of the silicone oil.

To guard against these risks, a large number of tests has been carried out. The most important one is the immersion of the equipment to be tested in the oil, then monitoring the dielectric characteristics and periodically examining the equipment and the oil.

Conditions : 18 weeks at 130°C (or 150°C for certain high class insulants)

Sanction: no change in the appearance of the equipment nor the oil, no notable variation in the dielectric properties of the oil.

Table 9 below gives a list of the materials tested to date. The RHODIA CHIMIE Company is quite prepared to carry out any other compatibility tests for its customers if necessary.

**COMPATIBILITY WITH MATERIALS**

The following materials were submerged for 18 weeks in **RHODORSIL OIL 604 V 50**, kept at 130°C. No change in aspect of the material or the oil was observed, nor was any notable variation in the dielectric properties of the oil.

**Flexible materials**
Nomex 410, 411, E 72 (tested to150°C)
Brown paper
Insuldur paper
Terphane sheet
Textinap (impregnated fiberglass sheet)

**Rigid materials**
Epoxy resins:
Araldite B/Hardener 901
Araldite F/Hardener 905
Araldite CY 206/HY 842 hardener

Araldite CY 205/HY 843 hardener
Araldite CY 205/HY 956 hardener
Phenol resins
Permali (phenol resin/wood laminate)

**Seals**
Viton DF 801
Butyl rubber (Joint Français, ref: D 806)
Cork + Neoprene (Cork Manuf. Co. ref: Neolangite 50 and SB 300)
Nitrile rubber seals did not resist.
Elastomer seals swell.

**Varnish paint**
Rembrandtine RL 810
Isonel 51 (Schenectady)

**Glues**
Cyanoacrylic (Loctite ref: "Flash col")
Bericol 201 and 209 NM (Bericol National)

**Enamelled wires**
Polyvinyl formal
Imide polyester
Imide polyester + a layer of finishing amide polyamide

**Note** *The good strength of Nomex papers, calendered or not (unchanged after 16 weeks of immersion at 150°C) should be emphasized. This is the typical example of high class materials which would allow us to make transformers filled with silicone oil operate at higher temperatures without danger.*

**Miscibility of RHODORSIL OIL 604 V 50 with mineral oil**

When it is intended to replace the dielectric fluid in a transformer by **RHODORSIL OIL 604 V 50**, it may be that the tank will not be drained completely. In addition, porous cellular insulators will be impregnated with the original liquid which they will give off slowly later. Hence, it is interesting to know that the two dielectric fluids can be mixed in any proportion. We have already seen the variation of certain properties in relation to the proportion of **RHODORSIL OIL 604 V 50** in mineral oil.

**Transformer maintenance - RHODORSIL OIL 604 V 50 regeneration**

**RHODORSIL OIL 604 V 50** does not oxidize at normal transformer operating temperatures, and even well beyond these temperatures. It is not corrosive; it does not attack other insulating materials. We can consequently expect correct operation over a long period of time without problemes.

There is an international standard which was developed by the COMMISSION ELECTROTECHNIQUE INTERNATIONALE, ref. IEC 944, called "GUIDE DE MAINTENANCE DES LIQUIDES SILICONES POUR TRANSFORMATEURS".

This guide proposes:
- for naturally breathing transformers, a visual examination every 6 months to ensure that the drying devices are still effective. If this condition is satisfied, the frequency suggested for checking the liquid is 5 years.
- For completely sealed transformers, the liquid is checked at a maximum every 5 years.

If treatment is necessary, this may be:
- either a vacuum treatment (60 to 80°C - 10 mbar) followed by filtration (5 to 10 μ)

or treatment on a dry molecular sieve (ambient temperature) followed by filtration (5 to 10 μ)

**Resistance to radiations**

The action of radiations on silicones generally produces an ionization of the molecules encouraging the creation of free radicals and the rearrangement of molecular linking. It may produce both a reticulation and a splitting of molecular chains.

For polydimethylsiloxane oils like **OIL 604 V 50**, we know that:

- the nature and the speed of radiations have little importance, the determining factor being the irradiation dose(1)
- the temperature accelerates the effect of radiations.

Generally speaking, the action of radiations increases the viscosity right up to the formation of a gel(2)

This increase in the viscosity is accompanied by the production of gas (methane, hydrogen).
For OIL 604 V 50, we consider:

| | |
|---|---|
| For doses from 1 to 3 Megarads(3) : | no action |
| For doses from 10 to 50 Megarads | limited action |
| For doses above 50 Megarads : | use not recommended |

Hence for an irradiation, a dose flow of 125,000 Rads/hr (source, cobalt 60), the following has been measured on **RHODORSIL OIL 604 V 50**:

| | |
|---|---|
| initial viscosity at 25℃ | 51 mm²/s |
| viscosity at 25℃ after 50 Megarads: | 573.5 mm²/s |
| viscosity at 25℃ after 100 Megarads: | gelled |

*(1) In general, during irradiation tests, the dose flow also plays a role; in the case of oils, this role is probably less important.*

*(2) For polydimethylsiloxanes, the action of radiations becomes more hermful as viscosity rises.*

*(3) 1 Megarad = $10^8$ ergs/gram.*

**Action of Silicone oils on the organism and the environment**

Polydimethylsiloxanic oils hav been used for about forty years in the food industry(4) cosmetics and pharmaceuticals, because of their physiological inertia.

Studies have been published showing that no noxious effect has been observed on the environment, on water life, or on birds and other animals.

Tests of continual oral ingestion by rats, monkeys and man have shown that dimethyl oils are not absorbed by the body, nor by the skin.

As an example, here are some figures for an average viscosity oil like **RHODORSIL OIL 604 V 50:**

| | |
|---|---|
| Acute toxicity | : non-poisonous at 50 ml/kg weight |
| subacute toxicity | : non-poisonous at 5ml/kg per day for 4 days. |

Cases of allergy to silicone oils among the workers are practically unknown.

*(4) The World Health Organization (WHO) has approved the use of dimethyl oils as an anti-foaming agent in food products.*

The only known nuisance is the hydrophobic nature of silicone oil which prevents the wetting of mucous membranes and creates a sensation of dryness. In the event of splashing into the eye, for example, it is essential to wash with a great deal of water. If irritation continues, consult a doctor.

**Packaging**

**RHODORSIL OIL 604 V 50** is delivered in 25 and 200 kg drums,
1 ton containers and in tankers.

# RHODORSIL® OIL 604 V 50

**Storage and shelf-life**

When stored in its original unopened packaging at a temperature of between -20℃ and +50℃, **RHODORSIL OIL 604 V 50** can be used for up to 36 months after the date of manufacture marked on the packaging (DLU).
Comply with storage instructions and the expiry date marked on the packaging.
Past this date, Bluestar Silicones no longer guarantees that the product meets the sales specifications. We recommend keeping the packs in a sheltered place to prevent excessive changes in temperature causing the drums to "breathe", with the consequent risk of humidity entering.

Avoid leaving packings open unnecessarily.

Before opening a packing, wait until its temperature is balanced with that of the surroundings to prevent water condensing on the surface of the liquid.

**Safety**

Consult the Safety Data Sheet for **RHODORSIL OIL 604 V 50.**

Visit our website www.bluestarsilicones.com

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