

Determination of the volume swelling of FFKM, FKM and HNBR elastomers in Saraline Paraffins

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by

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Summary

The volume swell of FFKM (Kalrez), FKM (Viton) and HNBR elastomers in three different Saraline oils were determined by means of exposure experiments.

The investigation revealed a maximum volume swell of 2 % for Kalrez and 3.6 % for Viton after full saturation in all Saraline oils at temperatures up to 100 °C.

A maximum volume swell of HNBR of approximately 5 % was measured at temperatures below and at 60 °C for all three oils. At 100 °C full saturation of HNBR in Saraline 185 V and in Saraline 200 was not yet reached during the test period of 62 days. The max. volume swell of HNBR at 100 °C measured after 62 days was 22 % in Saraline 185 V and 10 % in Saraline 200. HNBR in Sarapar 147 showed a slight volume decrease after 62 days at 100 °C, which indicates leaching out of elastomer components. None of the exposed elastomers showed visible chemical degradation.

Amsterdam, October 2006

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1. Introduction

On request of Shell MDS, Malaysia, Shell Global Solutions International performed immersion tests to evaluate the compatibility of elastomer material to Saraline oils (base oil for drilling mud).

Liquids that diffuse into and through polymers can swell the polymer matrix and/or dissolve components of the polymer compound. Both interactions are accompanied by a decrease of the material properties. Whereas swell is a reversible reaction and properties will recover after drying, dissolving and leaching out of components could cause a permanent change of material properties. The polymer – fluid interaction is influenced by temperature, fluid concentration and the exposure time.

The swell of HNBR, FFKM (Kalrez) and FKM (Viton) in three different grades of the Paraffin oils was determined by measuring the weight and volume changes after exposure at different temperatures and during a defined period of exposure.

2. Objectives

- Determination of the maximum saturation and the volume swell of HNBR, Viton and Kalrez elastomers by Saraline oils after an agreed maximum period of exposure time.
- Establish possible chemical degradation of exposed elastomers.

3. Scope of work

- Exposure test according to ISO 1817:2005 (modified);
- Determination of weight and volume changes after exposure;
- Visual inspection of the elastomers after exposure;
- Predict swelling behaviour at 0 °C by extrapolation.

4. Materials

Shell MDS delivered 2 litres each of 3 grades of Saraline oil (MSDSs are attached in the Appendix). Commercially available O-rings were used as specimens. The O-rings were purchased from Eriks O-ring supplier and details are listed in Table 1.

5. Experiments and measurements

After the preparation specimens were inserted into containers¹ filled with the undiluted paraffin medium and stored in temperature cabinets as listed in Table 2. After the appropriate exposure time specimens were removed, dried with a tissue to remove adhering liquid and weighted on a precision balance. Density was determined according ISO 1183-1(method A, based on the Archimedean principle) and the volume was calculated by:

$$V = W / \rho.$$

V: volume, m³.

W: weight, kg.

ρ : Density, kg/m³.

The mean of these values were calculated from all three specimens. Changes of the weights, the densities and the volumes were calculated and the volume increase is the volume swell.

¹ For exposure temperatures 23 and 60 °C stoppered glass bottles were used and for 100 °C temperatures stainless steel autoclaves.

After measurements the specimens were set back into the containers and exposure continued. The experiments were terminated after 62 days of exposure. Specimens were visually inspected to establish a possible visible degradation after exposure to the paraffin oils.

6. Results

The results of all exposure tests are listed in Tables 3-11. Graphs of volume swell are shown in Figures 1-3.

6.1 Saturation

Kalrez and Viton have reached their maximum saturation in all three oils before termination of the exposure tests after 62 days. During the same exposure period HNBR has not yet reached this steady state in Saraline 185 V and Saraline 200 at 100 °C (see Figure 3).

6.2 Weight uptake

The weight of all elastomers increased during the exposure. The increases are very small for Kalrez where the maximum uptake lays between 0 and > 1 % in all media and at all temperatures, even after 62 days of exposure.

Viton shows a very similar behaviour, except in Saraline 185 V where the weight increases with 1.3 % at 100 °C after 62 days.

HNBR absorbed significantly more of all three media and there are also significant differences when exposed to the different paraffins.

6.2.1 HNBR in Sarapar 147

When exposed at 23 °C a maximum weight was reached after 27 days with 3.0 % uptake. At 60 °C the maximum weight uptake was already reached after 1 day of exposure and decreased with longer exposure time to about 3.4 %. At 100 °C the weight reached a maximum after 1 day and then steadily decreased with increasing exposure time to 2.1 % after 62 days.

6.2.2 HNBR in Saraline 185 V

When exposed at 23 °C the maximum weight was reached after 6 days with 2.1 % uptake and stayed around that level during further exposure. At 60 °C the maximum weight uptake was already reached after 1 day of exposure and stayed around this level during further exposure. The weight uptake did not reach a maximum at 100 °C and is still increasing after 62 days. The highest measured value at this temperature is 17.3 % after 62 days of exposure.

6.2.3 HNBR in Saraline 200

When exposed at 23 °C the maximum weight was reached after 27 days with 2.1 % uptake and stayed around that level up to 62 days. At 60 °C the maximum weight uptake was already reached after 1 day of exposure and stayed around this levels during further exposure. After 62 days of exposure at 100°C the weight had been increased with 6.9 %. It is likely that the steady state was not reached for that test.

6.3 Density decrease

The density of Kalrez in the as received condition is 1.999, of Viton 1.904 and of HNBR 1.178 kg/m³. Absorption of a liquid generally causes a decrease of the density. Density values decreased for Kalrez, Viton and HNBR during exposure to all three oils.

6.3.1 Kalrez

The density changes are very small for Kalrez (0.5 – 1.4 %) for all temperatures.

6.3.2 Viton

The density of Viton decreased in Sarapar 147 on average with 0.2 – 0.8 % at all temperatures, in Saraline 185V and in Saraline 200 at 23 and 60 °C with 0.1 – 1.1 % and at 100 °C with 2 %.

6.3.3 HNBR

The density of HNBR in Sarapar 147 decreased with up to 2 % at all exposure temperature. In Saraline 185 V the density decreased with about 1.4 % at 23 °C and 1.7 % at 60 °C respectively. At 100 °C the density decreased with 2.7 %.

In Saraline 200 the density of HNBR decreased with 1.4 % at 23 °C, with 1.8 % at 60 °C and with 2.6 % at 100 °C.

6.4 Volume swell

6.4.1 Kalrez

The volume swell of Kalrez is similar in all three Saraline oils and very low. The volume increases at 23 °C with about 1 %, at 60 °C between 1 and 2 % and at 100 °C with about 2 %.

6.4.2 Viton

Viton shows a low volume swell in the same order as Kalrez does, except in Saraline 185 V and Saraline 200 at 100 °C where the volume increases with 3.4 % and 2.6 % resp. after 62 days of exposure.

6.4.3 HNBR

The volume of HNBR in Sarapar 147 swells between 4.2 – 5.4 % at all three test temperatures.

In Saraline 185 V HNBR swells with 3.6 % at 23 °C and 4.2 % at 60 °C. At 100 °C the volume swell is considerably higher and reaches about 22 % after 62 days. Full saturation with this oil was not reached during the 62 days of exposure and therefore it is expected that longer exposure will cause larger volume swell of HNBR in this liquid.

In Saraline 200 HNBR swells with 3.6 % at 23 °C and 4.6 % at 60 °C. At 100 °C the volume swell is higher and reaches 9.8 % after 62 days of exposure. At 100 °C full saturation was not reached during the exposure and it is expected that longer exposure will cause larger volume swell of HNBR in Saraline 200.

6.5 Visual inspection

Inspection of all exposed specimens by binocular revealed no signs of visual chemical degradation.

7. Discussion

FFKM (Kalrez) and FKM (Viton) contain polar groups in their highly stable backbone chains and are therefore considerably resistant to most mineral oil based fluids at different temperature ranges. This good resistance has been demonstrated for Kalrez and Viton with the above described immersion tests. The absorption of Saraline paraffin oils by these elastomers depends on the applied temperature and the resulting volume swell is low (Table 12 and 13). A maximal swell of Kalrez of 2 % was observed at 100 °C in all tested oils. Viton shows a somewhat more pronounced volume swell of 3.4 and 2.6 % at 100 °C in both, Saraline 185 V and Saraline 200 oils. It is likely that mechanical properties of these exposed elastomers have changed during exposure, but it is expected that these changes are only marginal and reversible.

The swelling behaviour of HNBR depends on the content of Nitrile side groups of the highly saturated backbone chains. Although HNBR also contains polar groups in its backbone chain, it is more sensitive to mineral oils when compared with Kalrez and Viton, especially to aromatic hydrocarbons, due to the less stable C-H bonds. This investigation revealed a significant higher volume swell of HNBR when compared with Kalrez and Viton. The maximum volume swell of HNBR is on average below 5 % (see Table 13) at temperatures at and below 60 °C for all Saraline oils, but shows considerable variations for the different oils and relative high volume swell at 100 °C.

The exposure of HNBR in Saraline 185 V and Saraline 200 at 100 °C did not reach the maximum saturation after 62 days, but already showed a moderate to high volume swell. It is expected that swell will increase during further exposure. The volume swell in Sarapar 147 subsequently decreased after a maximum of 6.5 % after 3 days to 4.2 % after 62 days. It is most likely that the oil has leached some ingredients out of the elastomer and this has led to decrease of the swell by shrinkage of the elastomer compound. A consequence of this leaching effect could be a permanent modification of material properties.

For the application of elastomer seals a general rating is used by many seals manufacturers². According to this rating the following recommendations for the application of elastomers in Saraline oils can be done:

Sarapur 147:	FFKM	temp. < 100 °C recommended;
	FKM	temp. < 100°C recommended;
	HNBR	temp. <60 °C parts probably still useful in most static and dynamic applications;
	HNBR	temp. > 60 °C not recommended (due to the leaching effect).
Saraline 185V:	FFKM	temp. < 100 °C recommended;
	FKM	temp. < 100 °C recommended;
	HNBR	temp. < 60 °C recommended;
	HNBR	temp. > 60 °C not recommended.
Saraline 200:	FFKM	temp. < 100 °C recommended;
	FKM	temp. < 100 °C recommended;
	HNBR	temp. <60 °C recommended;
	HNBR	temp. 60 – 100 °C - ³ .

² 0 – 5 % volume swell: little or minor effect, recommended.
 5 – 10 % volume swell: minor to moderate effect, parts probably still useful in most static and dynamic applications.
 10 – 20 % volume swell: moderate to severe effect, parts useful in some static applications only.
 Volume swell >20 %: not recommended

³ No rating possible because full saturation was not reached during exposure.

The Arrhenius methodology was used to predict the swelling behaviour of the elastomers at 0°C. The volume swell is plotted against the exposure temperature (Figure 4) for all exposure experiments. The found linear relationship allows an extrapolation of the swell rate to 0°C. The values of the calculated volume swell at 0°C are listed in table 13.

8. Conclusions

- Full saturation of Kalrez and Viton in all three tested Saraline oils already occurred after 24 - 72 hrs of exposure.
- A maximum volume swell of 2 % was measured for Kalrez and of 3.6 % for Viton in all Saraline oils at temperatures up to 100 °C.
- A maximum average volume swell of HNBR of about 5 % was measured at temperatures at and below 60 °C in Saraline 185 V and Saraline 200.
- Full saturation of HNBR at 100 °C in Saraline 185 V and Saraline 200 did not occur during the test period of 62 days.
- The volume swell of HNBR at 100 °C is about 22 % in Saraline 185 V and about 10 % in Saraline 200.
- HNBR in Sarapar 147 showed after 62 days a slight decrease of its volume swell at 100 °C, indicating leaching out of elastomer components.
- None of the exposed elastomers showed visible chemical degradation.
- The swell behaviour at 0 °C, extrapolated from linear regression, are found to be almost negligible for Viton and very low for Kalrez in all three oils.
- The volume swell of HNBR at 0 °C is calculated to be 5.0 % in Sarapar 147, 1.4 % in Saraline 185 V and 2.2 % in Saraline 200.

Amsterdam, October 2006

mv

Table 1 *Elastomer specimens subjected to exposure tests.*

Elastomer	Eriks designation	Dimensions: inside diameter x width
HNBR (hydrogenated acrylonitrile-butadiene elastomer)	88625 047	114.02 x 1.78 mm (chopped in pieces of about 40 mm length)
Viton (FKM or fluorocarbon elastomer)	51414	19.15 x 1.78 mm
Kalrez Spektrum (FFKM or perfluorocarbon elastomer)	AS-568A K#19 Compound 6375	20.35 x 1.78 mm

Table 2 *Experimental conditions*

Saraline Oil, grade	Elastomer, type	Temperature, °C	Specimen, amount	Exposure time, days
Sarapar 147 SRF no.OIL2-06004	HNBR	23	3	1, 3, 6, 13, 27, 62
Saraline 185 V SRF no.OIL1-06003	Viton	60	3	
Saraline 200 SRF no.OIL3-06002	Kalrez	100	3	

Table 3 Weight uptake, change of density and volume swell of Kalrez in Sarapar 147

Exposure of Kalrez to Sarapar 147												
Exposure time		Temperature 23 °C				Temperature 60 °C				Temperature 100°C		
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Density change, %	Volume change, %
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	24	0.4	-0.5	0.9	0.6	0.1	0.5	0.4	-0.9	1.4	-0.9	1.4
3	72	0.4	-1.4	1.8	0.3	-0.5	0.9	0.7	-1.4	2.1	-1.4	2.1
6	144	0.2	-0.2	0.4	0.4	-0.4	0.8	0.3	-0.3	0.5	-0.3	0.5
13	312	0.0	0.0	0.0	0.1	-1.0	1.1	0.5	-1.1	1.6	-1.1	1.6
27	648	0.4	-0.6	0.9	0.4	-0.2	0.6	0.5	-0.7	1.3	-0.7	1.3
62	1488	0.3	-0.6	0.9	0.5	-0.8	1.3	0.6	-1.3	1.9	-1.3	1.9

Table 4 Weight uptake, change of density and volume swell of Kalrez in Saraline 185 V

Exposure of Kalrez to Saraline 185 V													
Exposure time		Temperature 23°C					Temperature 60°C			Temperature 100°C			
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	24	0.3	-0.5	0.8	0.4	-0.3	0.7	0.5	-1.1	1.6			
3	72	0.2	-0.3	0.4	0.2	-0.6	0.8	0.6	-0.6	1.2			
6	144	0.3	-0.2	0.5	0.3	-1.0	1.3	0.6	-1.0	1.6			
13	312	0.3	-0.2	0.5	0.6	-0.7	1.3	0.5	-1.0	1.5			
27	648	0.3	-0.5	0.9	0.5	-0.6	1.1	0.7	-1.0	1.7			
62	1488	0.3	-0.5	0.9	0.5	-0.9	1.4	0.8	-1.1	1.9			

Table 5 Weight uptake, change of density and volume swell of Kalrez in Saraline 200

Exposure of Kalrez to Saraline 200														
Exposure time		Temperature 23°C					Temperature 60°C					Temperature 100°C		
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1	24	0.2	-0.5	0.7	0.4	-0.6	1.0	0.7	-1.8	2.5				
3	72	0.2	-0.2	0.5	0.3	-0.3	0.6	0.3	-1.0	1.4				
6	144	0.4	-0.8	1.2	0.3	-0.7	1.0	0.5	-1.1	1.6				
13	312	0.2	0.0	0.3	0.6	-1.0	1.6	0.4	-0.9	1.3				
27	648	0.4	-0.7	1.0	0.3	-0.5	0.8	0.5	-1.3	1.8				
62	1488	0.3	-0.9	1.3	0.7	-1.4	2.1	0.4	-1.4	1.8				

Table 6 Weight uptake, change of density and volume swell of Viton in Sarapar 147

Exposure of Viton to Sarapar 147														
Exposure time		Temperature 23°C					Temperature 60°C					Temperature 100°C		
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1	24	0.3	0.1	0.1	0.6	0.4	0.2	0.5	-0.7	1.2				
3	72	0.0	-0.1	0.1	0.0	0.0	0.0	0.8	-1.4	2.3				
6	144	0.1	-0.1	0.1	0.1	-0.1	0.2	0.4	-0.3	0.8				
13	312	-0.1	0.5	-0.5	-0.3	-0.8	0.5	0.4	-0.6	1.0				
27	648	0.3	-0.3	0.6	0.2	-0.1	0.4	0.5	-0.4	0.9				
62	1488	0.1	-0.2	0.4	0.3	-0.7	0.9	0.4	-0.8	1.2				

Table 7 Weight uptake, change of density and volume swell of Viton in Saraline 185 V

Exposure of Viton to Saraline 185 V												
Exposure time		Temperature 23°C					Temperature 60°C				Temperature 100°C	
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Density change, %	Volume change, %
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	24	0.2	-0.3	0.5	0.3	0.4	0.0	0.3	-1.4	1.8		
3	72	0.2	-0.1	0.3	0.0	0.1	0.0	0.5	-0.9	1.4		
6	144	0.3	-0.3	0.6	0.1	-0.2	0.3	0.3	-1.0	1.3		
13	312	0.3	0.0	0.2	0.3	-0.2	0.5	0.5	-1.6	2.1		
27	648	0.3	-0.4	0.7	0.3	-0.1	0.4	1.0	-1.8	2.8		
62	1488	0.2	-0.5	0.7	0.2	-0.2	0.4	1.3	-2.0	3.4		

Table 8 Weight uptake, change of density and volume swell of Viton in Saraline 200

Exposure of Viton to Saraline 200													
Exposure time		Temperature 23°C					Temperature 60°C			Temperature 100°C			
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	24	0.1	-0.4	0.6	0.0	0.0	0.1	0.1	-1.1	1.2			
3	72	0.2	-0.1	0.3	0.1	-0.1	0.2	0.2	-0.8	1.0			
6	144	0.4	-0.8	1.2	-0.1	-0.3	0.2	0.3	-0.9	1.2			
13	312	0.2	0.1	0.1	0.2	-0.7	0.9	0.2	-0.7	0.9			
27	648	0.2	-0.6	0.9	0.2	-0.6	0.8	0.2	-1.8	2.0			
62	1488	0.1	-0.1	0.3	0.4	-1.1	1.5	0.5	-2.0	2.6			

Table 9 Weight uptake, change of density and volume swell of HNBR in Sarapar 147

Exposure of HNBR to Sarapar 147														
Exposure time		Temperature 23°C					Temperature 60°C					Temperature 100°C		
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1	24	1.0	-0.7	1.7	4.7	-1.1	5.9	3.5	-2.4	6.1				
3	72	1.5	-0.7	2.2	3.6	-1.4	5.1	3.7	-2.7	6.5				
6	144	1.6	-1.2	2.9	3.5	-1.6	5.2	2.8	-2.2	5.2				
13	312	1.9	-1.1	3.0	2.6	-2.5	5.3	2.6	-1.7	4.3				
27	648	3.0	-1.8	4.9	3.5	-1.4	5.0	2.6	-1.6	4.3				
62	1488	2.5	-1.9	4.5	3.4	-1.9	5.4	2.1	-2.0	4.2				

Table 10 Weight uptake, change of density and volume swell of HNBR in Saraline 185 V

Exposure of HNBR to Saraline 185 V												
Exposure time		Temperature 23°C					Temperature 60°C			Temperature 100°C		
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Density change, %	Volume change, %
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	24	0.7	-0.3	1.0	2.8	-1.3	4.1	3.8	-2.9	8.0	-2.9	8.0
3	72	1.1	-0.6	1.7	3.1	-1.6	4.8	3.7	-2.6	7.5	-2.6	7.5
6	144	1.6	-1.1	2.7	3.0	-1.8	4.9	3.5	(0.4*)	(4.1*)	(0.4*)	(4.1*)
13	312	2.1	-0.2	2.3	1.3	-0.8	2.1	7.1	-2.1	10.5	-2.1	10.5
27	648	2.3	-1.1	3.4	2.8	-1.6	4.5	13.3	-2.3	17.1	-2.3	17.1
62	1488	2.2	-1.4	3.6	2.4	-1.7	4.2	17.3	-2.7	21.8	-2.7	21.8

* Doubtable values

Table 11 Weight uptake, change of density and volume swell of HNBR in Saraline 200

Exposure of HNBR to Saraline 200													
Exposure time		Temperature 23°C					Temperature 60°C				Temperature 100°C		
Days	Hours	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %	Weight change, %	Density change, %	Volume change, %
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	24	1.0	-0.1	1.1	2.4	-1.2	3.6	2.3	-2.7	5.1			
3	72	1.0	0.3	0.7	2.5	-1.5	4.1	2.6	-1.8	4.5			
6	144	1.7	-1.2	2.9	2.5	-1.7	4.2	2.5	-1.5	4.0			
13	312	1.6	-0.2	1.8	2.5	-1.7	4.3	2.2	-2.0	4.3			
27	648	2.1	-1.1	3.2	2.4	-1.6	4.1	2.1	-2.2	4.3			
62	1488	2.1	-1.4	3.6	2.7	-1.8	4.6	6.9	-2.6	9.8			

Table 12

Summary of the weight uptake during exposure tests to several Paraffin drilling fluids

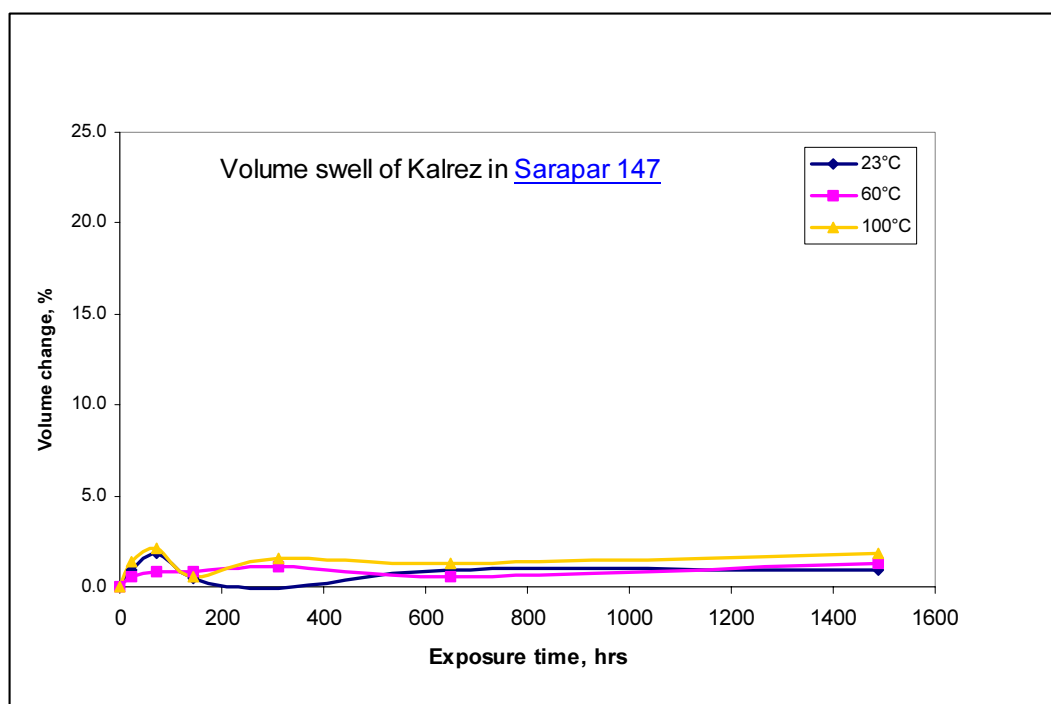
Maximum weight uptake after 62 days of exposure			
Kalrez	Weight change, %		
	Temp. 23°C	Temp. 60°C	Temp. 100°C
Sarapar 147	0.3	0.5	0.6
Saraline 185 V	0.3	0.5	0.8
Saraline 200	0.3	0.7	0.4
Viton	Weight change, %		
	Temp. 23°C	Temp. 60°C	Temp. 100°C
Sarapar 147	0.1	0.3	0.4
Saraline 185 V	0.2	0.2	1.3
Saraline 200	0.1	0.4	0.5
HNBR	Weight change, %		
	Temp. 23°C	Temp. 60°C	Temp. 100°C
Sarapar 147	2.5	3.4	2.1
Saraline 185 V	2.2	2.4	17.3
Saraline 200	2.1	2.7	6.9

Table 13

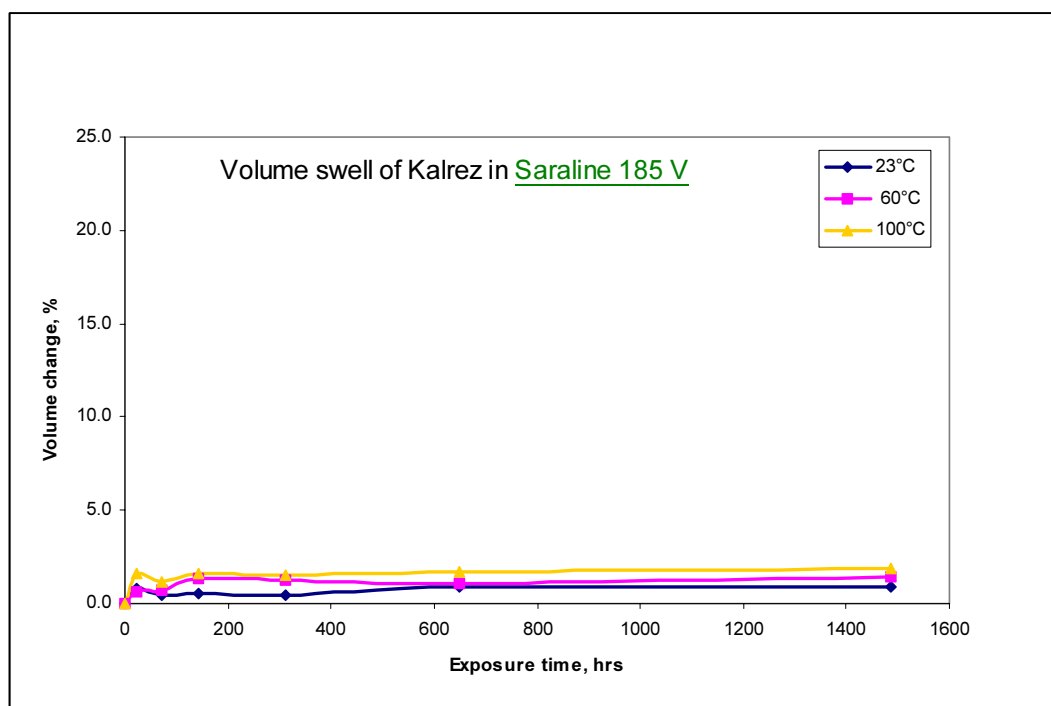
Summary of volume swell during exposure tests to several Paraffin drilling fluids

Maximum volume swell after 62 days of exposure			
Kalrez	Volume swell in Paraffin, %		
Exposure temperature, °C	Sarapar 147	Saraline 185 V	Saraline 200
0	0.7*	0.7*	1.2*
23	0.9	0.9	1.3
60	1.3	1.4	2.1
100	1.9	1.9	1.8
Viton	Volume swell, %		
Exposure temperature, °C	Sarapar 147	Saraline 185 V	Saraline 200
0	0.3*	0.3*	0.1*
23	0.4	0.7	0.3
60	0.9	0.4	1.5
100	1.2	3.4	2.6
HNBR	Volume swell, %		
Exposure temperature, °C	Sarapar 147	Saraline 185 V	Saraline 200
0	5.0*	1.4*	2.2*
23	4.5	3.6	3.6
60	5.4	4.2	4.6
100	4.2	21.8	9.8

* Calculated by linear regression using the Arrhenius methodology

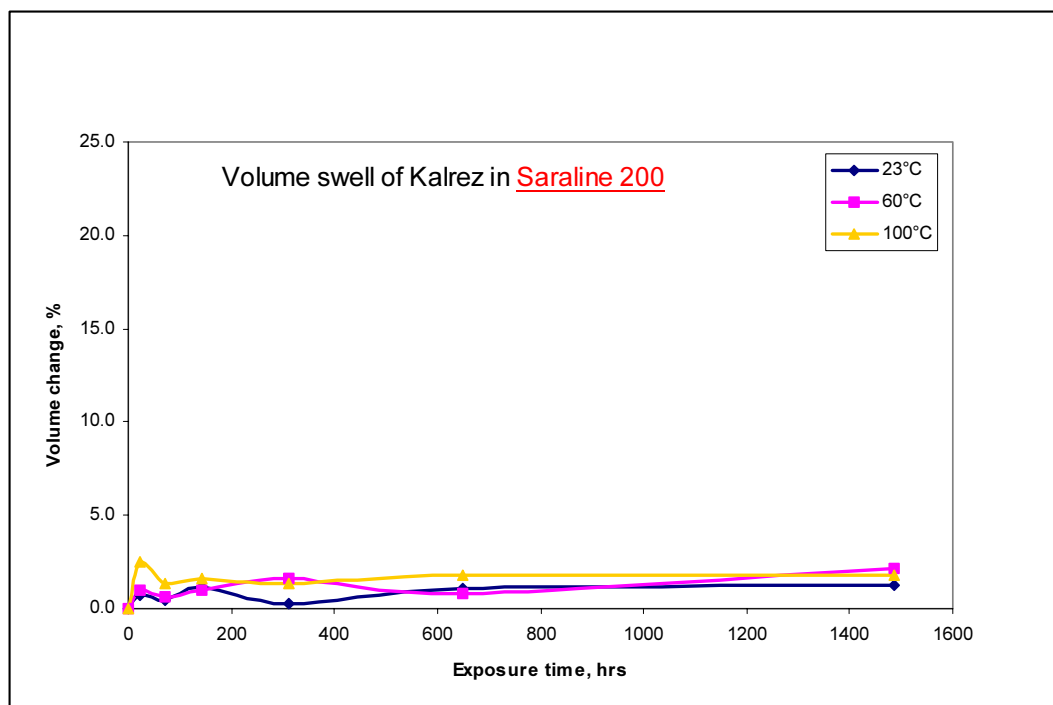


(a) Volume swell of Kalrez in Sarapar 147



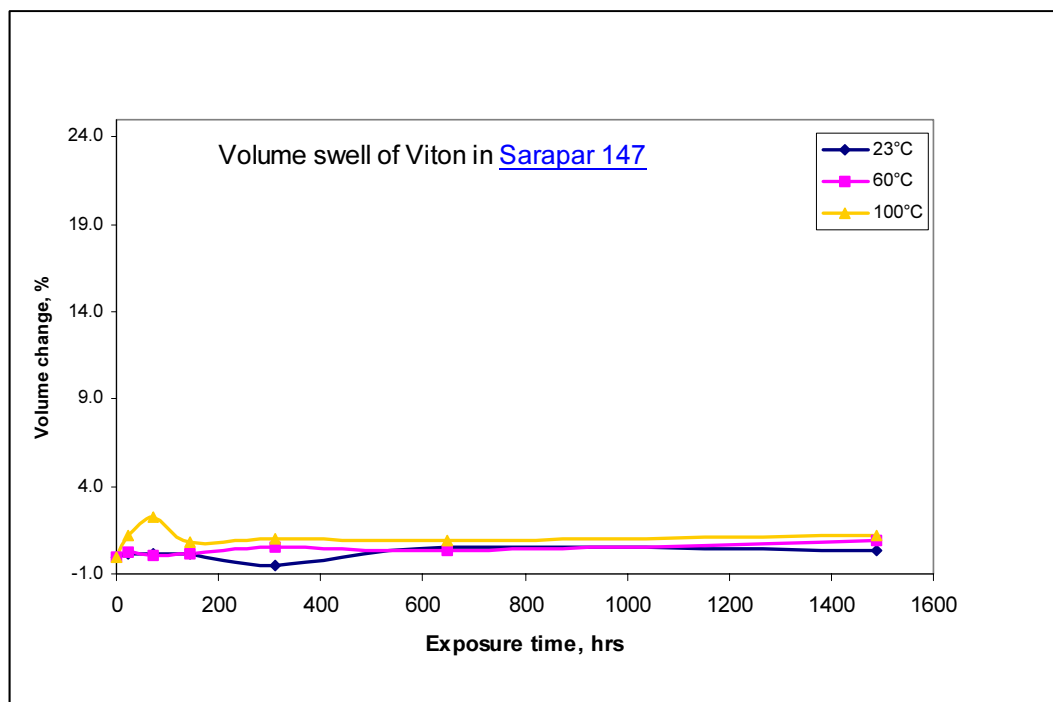
(b) Volume swell of Kalrez in Saraline 185 V

Figure 1 Volume swell of Karez in Saraline oils as function exposure time



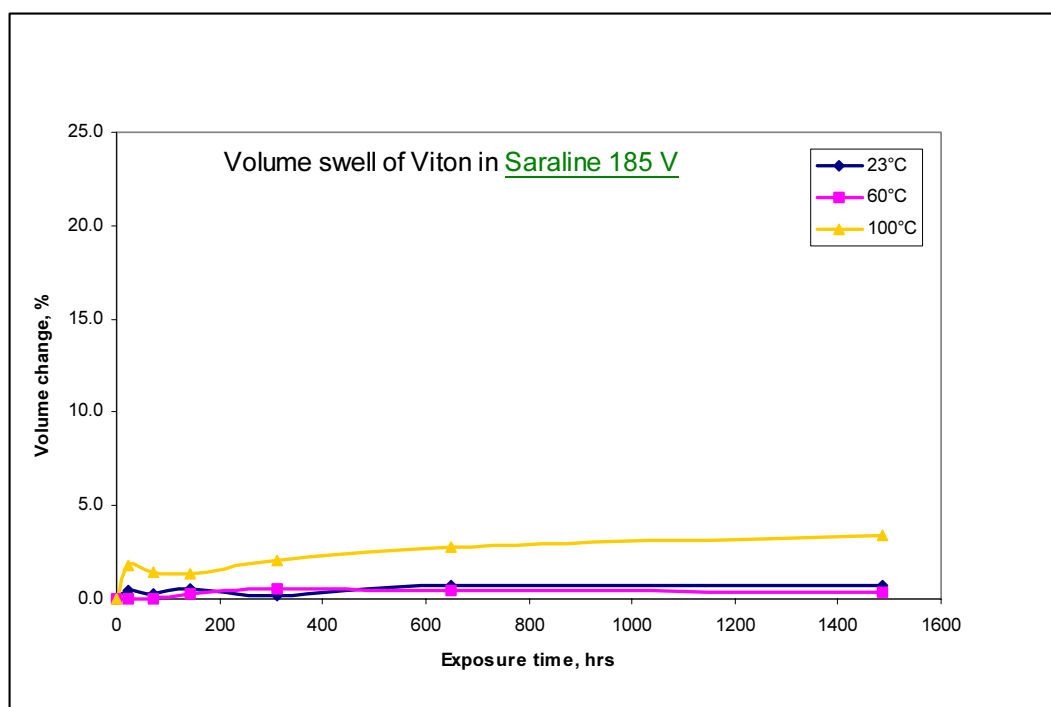
(c) Volume swell of Kalrez in Saraline 200

Figure 1 (Cont'd)

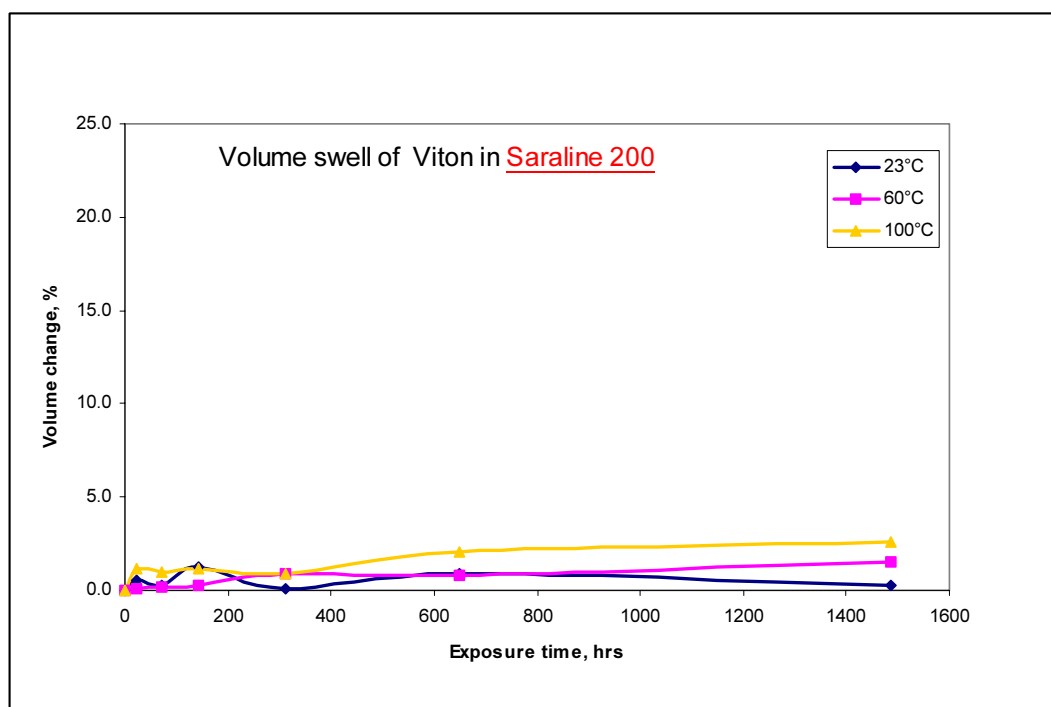


(a) Volume swell of Viton in Sarapar 147

Figure 2 Volume swell of Viton in Saraline oils as function exposure time

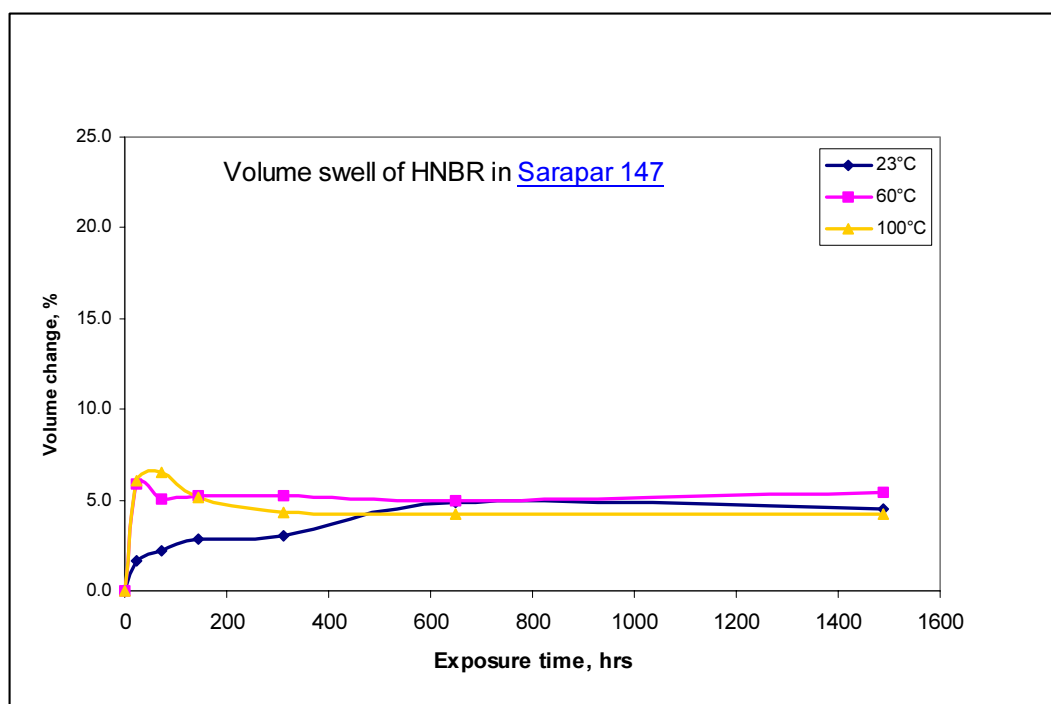


(b) Volume swell of Viton in Saraline 185 V

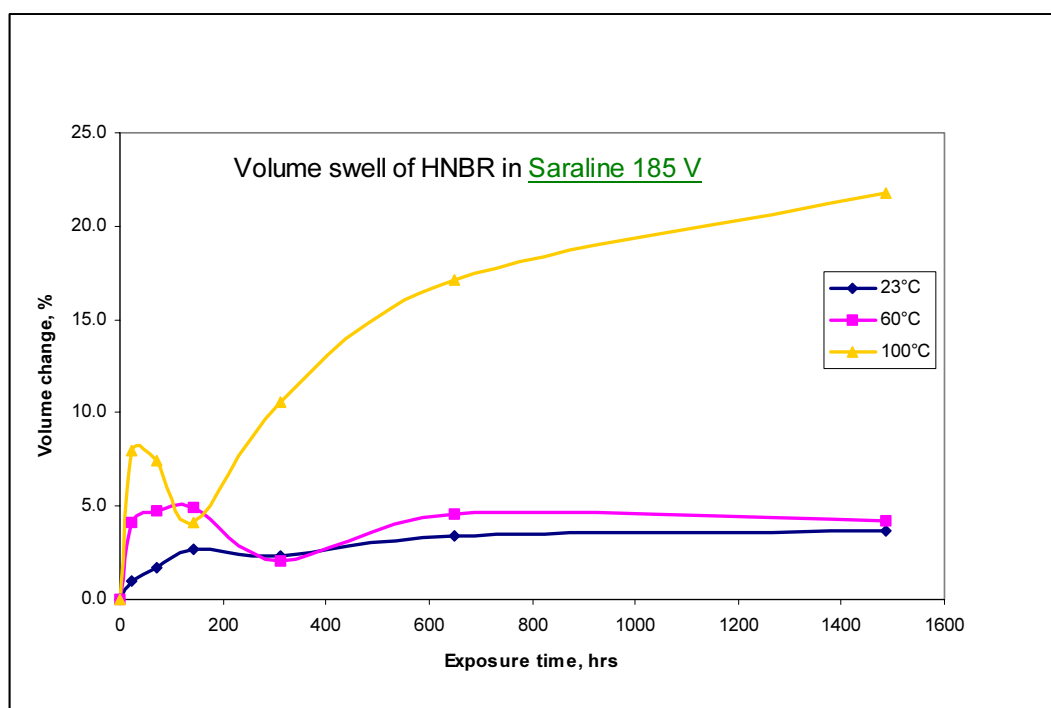


(c) Volume swell of Viton in Saraline 200

Figure 2 (Cont'd)

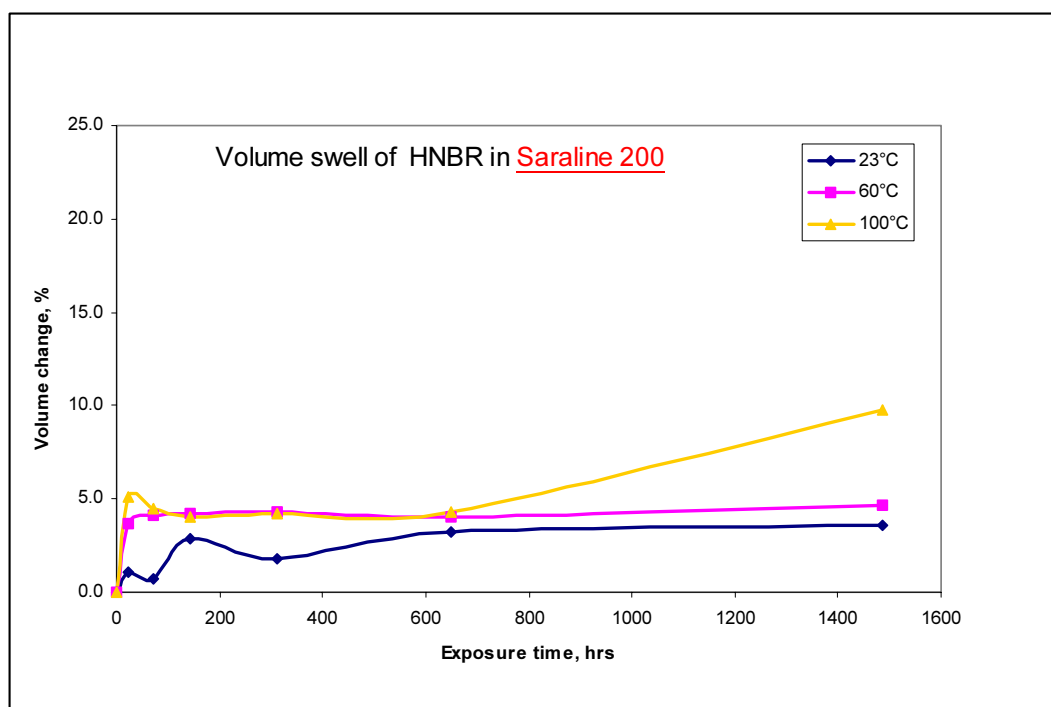


(a) Volume swell of HNBR in Sarapar 147



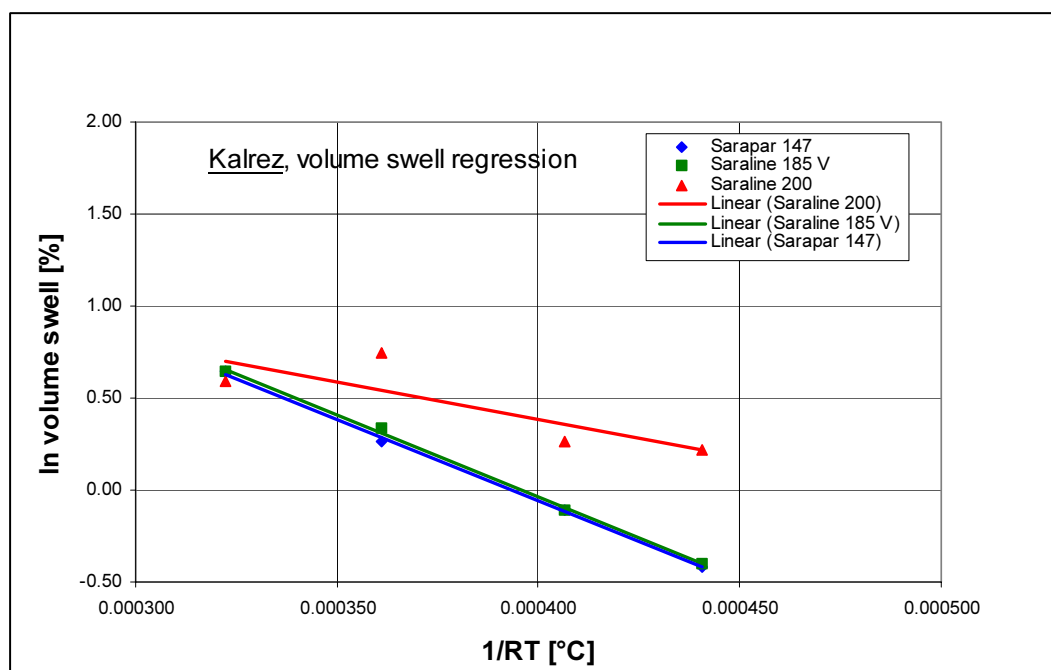
(b) Volume swell of HNBR in Saraline 185 V

Figure 3 Volume swell of HNBR in Saraline oils as function exposure time



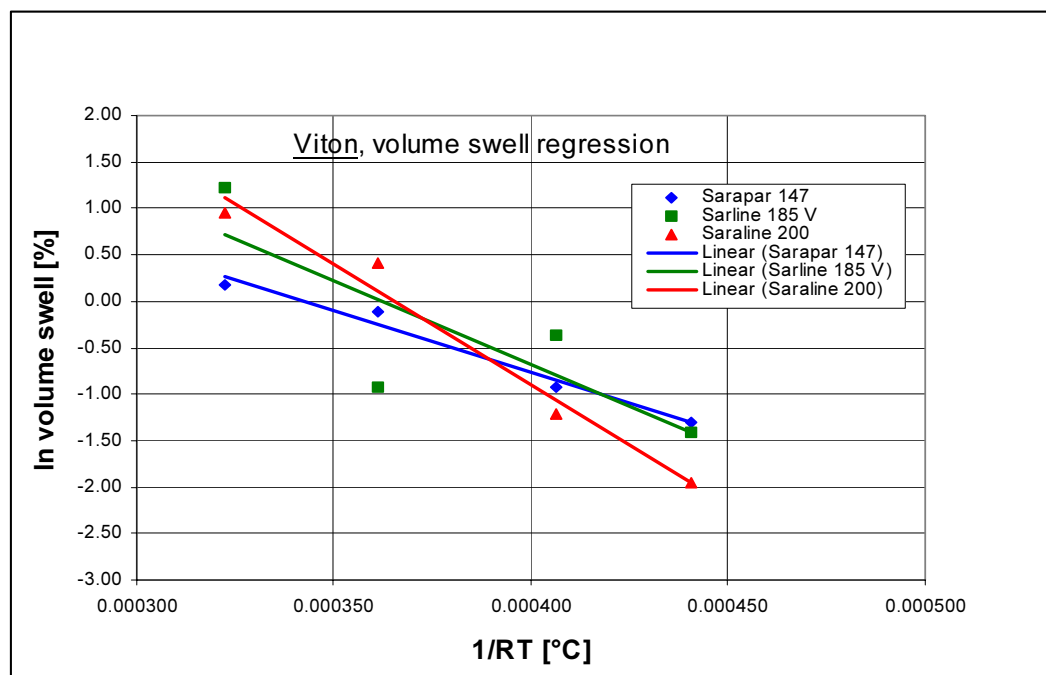
(c) Volume swell of HNBR in Saraline 200

Figure 3 (Cont'd)

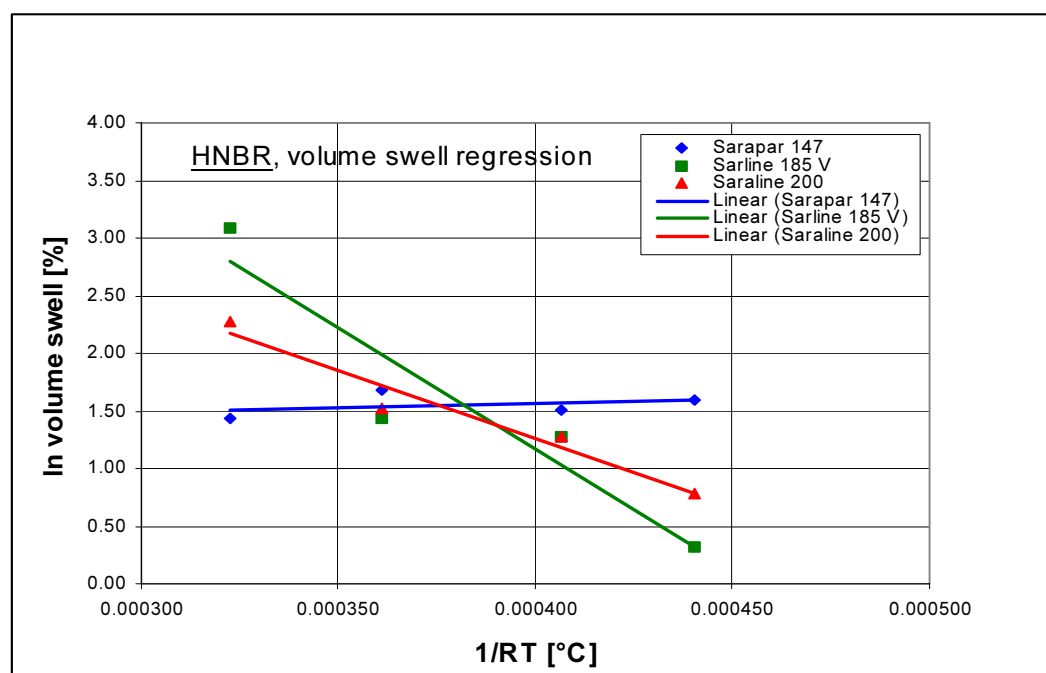


(a) Kalrez, volume swell regression as function of exposure temperature

Figure 4 Arrhenius relationship between volume swell and operation temperature



(b) Viton, volume swell regression as function of exposure temperature



(c) HNBR, volume swell regression as function of exposure temperature

Figure 4 (Cont'd)

Appendix 1 Safety Data Sheet Sarapar 147



Shell MDS (M) Sdn Bhd

Safety Data Sheet

Edition Number: 5
Date Prepared: 01 May 2005
Supersedes: 25 Mar 2004

SDS No. SMDS-08.01a

SHELL SARAPAR 147

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY

Product name: Shell Sarapar 147
Product type: Synthetic Drilling Base Fluid
Supplier: Shell MDS Malaysia Sdn. Bhd.
Address: Tanjong Kidurong, P.O. Box 1084, 97008 Bintulu
Sarawak, Malaysia.
Contact numbers:
Telephone: +60 (86) 292 222
Telex: MA 73113
Fax: +60 (86) 252 211
Emergency telephone number:
24hr Answering Service +60 (86) 292 222

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance Formal Name C13 to C17 Alkanes
Substance Chemical Family Aliphatic Hydrocarbon
CAS Number 90622-45-0
EINECS Number 292-447-5

3. HAZARDS IDENTIFICATION

Human health hazards: May cause lung damage if swallowed.
Safety hazards: Not classified as flammable but will burn.
Environmental hazards: No specific hazards.

4. FIRST AID MEASURES

First Aid - Inhalation: Remove to fresh air. If rapid recovery does not occur, seek medical advice.
First Aid - Skin: Wash skin with water using soap if available. Contaminated clothing must be removed as soon as possible. It must be laundered before reuse. If persistent irritation occurs, seek medical attention.

First Aid - Eye:	Flush eye with water. If persistent irritation occurs, obtain medical attention.
First Aid - Ingestion:	DO NOT DELAY. Do not induce vomiting. Protect the airway if vomiting begins. Give nothing by mouth. OBTAIN MEDICAL ATTENTION IMMEDIATELY.
Advice to physicians:	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Specific hazards:	Combustion products may include carbon monoxide and unburnt hydrocarbons.
Extinguishing media:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable extinguishing media:	Do not use water in a jet. Use of Halon extinguishers should be avoided for environmental reasons.
Other information:	Keep adjacent drums and tanks cool by spraying with water.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Remove all possible sources of ignition in the surrounding area and evacuate all personnel. Do not breathe vapour, mists. Avoid contact with skin, eyes and clothing. Take off immediately all contaminated clothing.
Personal protection:	Wear protective clothing specified for normal operations (see Section 8).
Environmental precautions:	Prevent from entering into drains, ditches or rivers. Use appropriate containment to avoid environmental contamination.
Clean-up methods - small spillage:	Absorb or contain liquid with sand, earth or spill control material. Shovel up and place in a labelled sealable container for subsequent safe disposal. Do not disperse using water.
Clean-up methods - large spillage:	Transfer to a labelled, sealable container for product recovery or safe disposal. Otherwise treat as for small spillage.
Other information:	Local authorities should be advised if significant spillages couldn't be contained. Observe all relevant local regulations. See Section 13 for information on disposal.

7. HANDLING AND STORAGE

Handling:	Avoid contact with eyes, skin and clothes.
Handling temperature:	Between 15 and 45 Deg C.
Storage:	Locate tanks away from heat and other sources of ignition. Do not store in unsuitable, unlabelled or incorrectly labelled containers. Keep container tightly closed in a dry, well-ventilated place away from direct sunlight and other sources of heat or ignition.
Storage temperature:	Between 15 and 45 Deg C.

Tank cleaning:	Cleaning, inspection and maintenance of storage tanks is a specialist operation, which requires the implementation of strict procedures and precautions. These include issuing work permits, gas-freeing of tanks, using a manned harness and lifeline and wearing air-supplied breathing apparatus. Prior to entry and whilst cleaning is underway, the atmosphere within the tank must be monitored using an oxygen meter and/or explosimeter.
Recommended materials:	Use mild steel, stainless steel for containers. Use compressed asbestos fibre, PTFE, Viton A, Viton B for seals and gaskets.
Unsuitable materials:	Natural or butyl rubbers.
Other information:	Ensure that all local regulations regarding handling and storage facilities are followed. Never siphon by mouth.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational exposure standards:	None Established
Respiratory protection:	Not normally required.
Hand protection:	PVC or nitrile rubber gloves if splashes are likely to occur.
Eye protection:	Monogoggles if splashes are likely to occur.
Body protection:	Wear overalls to minimise contamination of personal clothing. Launder overalls and undergarments regularly. Safety shoes or boots - chemical resistant.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid at ambient temperature.
Colour:	Colourless
Odour:	Odourless
Initial boiling point:	typically 255°C
Final boiling point:	typically 295°C
Vapour pressure:	<0.1 kPa at 40°C
Density:	circa 774 kg/m ³ at 15°C
Kinematic viscosity:	2.6-2.8 mm ² /s at 40°C
Vapour density (air=1):	> 5
Pour point:	0 to 10 °C
Flash point:	> 120°C (PMCC)
Aniline Point	> 90°C
Flammability limit - lower:	Circa 0.4%(V/V)
Flammability limit - upper:	Circa 4.3%(V/V)
Auto-ignition temperature:	> 220°C
Explosive properties:	In use, may form flammable/explosive vapour-air mixtures.
Oxidizing properties:	None
Solubility in water:	Insoluble

10. STABILITY/REACTIVITY

Stability:	Stable.
Conditions to avoid:	Heat, flames and sparks.
Materials to avoid:	Strong oxidizing agents.
Hazardous decomposition products:	None known.

11. TOXICOLOGICAL INFORMATION

Basis for assessment:	Passed the 96 hr LC50 Toxicity Test in 1999, LC50 > 150,000 ppm (as per EPA Drilling Fluids Toxicity Test Protocol, March 1993)
Acute toxicity - oral:	LD ₅₀ > 2000 mg/kg.
Eye irritation:	Not irritating
Skin irritation:	Not irritating
Respiratory irritation:	Not irritating
Skin sensitization:	Not expected to be a skin sensitizer.

12. ECOLOGICAL INFORMATION

Basis for assessment:	Passed the Biodegradability in Seawater Test in 1999 – 65.2% degradation relative to ThOD value (as per OECD Guidelines for Testing of Chemicals Biodegradability in Seawater Ref. 306)
Mobility:	Floats on water.
Persistence/degradability:	Inherently biodegradable.
Bioaccumulation:	Data not Available
Ecotoxicity:	Data not Available
Sewage treatment:	Data not Available

13. DISPOSAL CONSIDERATIONS

Precautions:	See Section 8.
Waste disposal:	Waste arising from a spillage or tank cleaning should be disposed of in accordance with prevailing regulations, preferably to a recognised collector or contractor. The competence of the collector or contractor should be established beforehand. Do not dispose into the environment, in drains or in water courses.
Product disposal:	Recycle if possible, otherwise incineration.
Container disposal:	Drain container thoroughly. After draining, vent in a safe place away from sparks and fire.

14. TRANSPORT INFORMATION

Not classified as dangerous for conveyance under UN, IMO, ADR/RID and IATA/ICAO codes

15. REGULATORY INFORMATION

EC Classification:	Harmful.
EC Symbol:	Xn
EC Risk Phrases:	R65 Harmful : may cause lung damage if swallowed.
EC Safety Phrases:	S62 If swallowed , do not induce vomiting; seek medical attention immediately.

16. OTHER INFORMATION

Uses and restrictions: Used as synthetic drilling base fluid

Technical contact point: Norazlam Norbi

Technical contact number:

Telephone: +60 (3) 2091 2218

Fax: +60 (3) 2091 2535

SDS history:

Edition number:	5
First issued:	14/11/1997
Revised:	03/07/2000
Revised:	24/07/2003
Revised:	25/03/2004
Revised:	01/05/2005

SDS distribution: This document contains important information to ensure the safe storage, handling and use of this product. The information in this document should be brought to the attention of the person in your organisation responsible for advising on safety matters.

DISCLAIMER: This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not be construed as guaranteeing any specific property of the product.

Appendix 2 Safety Data Sheet Saraline 185 V



Shell MDS (M) Sdn Bhd

Safety Data Sheet

Edition Number: 4
Date Prepared: 01 May 2005
Supersedes: 16 Aug 2004

SDS No. SMDS-04a

SHELL SARALINE 185V

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY

Product name: Shell Saraline 185V
Product type: Synthetic Drilling Base Fluid
Supplier: Shell MDS Malaysia Sdn. Bhd.
Address: Tanjong Kidurong, P.O. Box 1084, 97008 Bintulu
Sarawak, Malaysia.
Contact numbers:
Telephone: +60 (86) 292 222
Telex: MA 73113
Fax: +60 (86) 252 211
Emergency telephone number:
24hr Answering Service +60 (86) 292 222

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance Formal Name C9 to C21 Alkanes, Linear and Branched.
Substance Chemical Family Aliphatic Hydrocarbons
CAS number 90622-53-0

3. HAZARDS IDENTIFICATION

Human health hazards: If swallowed, aspiration into the lungs may cause chemical pneumonitis.
Safety hazards: Not classified as flammable but will burn.
Environmental hazards: None known.

4. FIRST AID MEASURES

First Aid - Inhalation: Remove to fresh air. If rapid recovery does not occur obtain medical attention.
First Aid - Skin: Wash skin with water using soap frequently. Contaminated clothing must be removed as soon as possible. It must be laundered before reuse.

First Aid - Eye:	Flush eye with water. If persistent irritation occurs, obtain medical attention.
First Aid - Ingestion:	DO NOT DELAY. Do not induce vomiting. Protect the airway if vomiting begins. Give nothing by mouth. If breathing but unconscious, place in the recovery position. If breathing has stopped, apply artificial respiration. OBTAIN MEDICAL ATTENTION IMMEDIATELY.
Advice to physicians:	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Specific hazards:	Combustion products may include carbon monoxide and unburnt hydrocarbons. The vapour is heavier than air, spreads along the ground and distant ignition is possible.
Extinguishing media:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable extinguishing media:	Do not use water in a jet. Use of Halon extinguishers should be avoided for environmental reasons.
Other information:	Keep adjacent drums and tanks cool by spraying with water.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Remove all possible sources of ignition in the surrounding area and evacuate all personnel. Do not breathe vapour, mists. Avoid contact with skin, eyes and clothing. Take off immediately all contaminated clothing.
Personal protection:	Wear protective clothing specified for normal operations (see Section 8).
Environmental precautions:	Prevent from entering into drains, ditches or rivers. Use appropriate containment to avoid environmental contamination.
Clean-up methods - small spillage:	Absorb or contain liquid with sand, earth or spill control material. Shovel up and place in a labelled sealable container for subsequent safe disposal. Do not disperse using water.
Clean-up methods - large spillage:	Transfer to a labelled, sealable container for product recovery or safe disposal. Otherwise treat as for small spillage.
Other information:	Local authorities should be advised if significant spillages couldn't be contained. Observe all relevant local regulations. See Section 13 for information on disposal.

7. HANDLING AND STORAGE

Handling:	When using do not eat, drink or smoke. Only use in well-ventilated areas. Take precautionary measures against static discharges. Earth or bond all equipment.
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Handling temperature:	Ambient.
Storage:	Locate tanks away from heat and other sources of ignition. Do not store in unsuitable, unlabelled or incorrectly labelled containers. Keep container tightly closed in a dry, well-ventilated place away from direct sunlight and other sources of heat or ignition. Drums should be correctly stacked to a maximum of 3 high. Prevent ingress of water. Keep in a bunded area. Keep out of reach of children.
Storage temperature:	Ambient.
Product transfer:	Electrostatic charges may be generated during pumping. Ensure electrical continuity by bonding all equipment. Avoid splash filling. Particular care must be taken when 'switch loading' road/rail tankers which have previously contained gasoline. Wait 10 minutes after tank filling before opening hatches or manholes.
Tank cleaning:	Cleaning, inspection and maintenance of storage tanks is a specialist operation, which requires the implementation of strict procedures and precautions. These include issuing work permits, gas-freeing of tanks, using a manned harness and lifeline and wearing air-supplied breathing apparatus. Prior to entry and whilst cleaning is underway, the atmosphere within the tank must be monitored using an oxygen meter and/or explosimeter.
Recommended materials:	Use mild steel, stainless steel for containers. Aluminium may also be used for applications where it does not present an unnecessary fire hazard. Use amine-adduct cured epoxy paint for container linings. Use compressed asbestos fibre, PTFE, Viton A, Viton B for seals and gaskets.
Unsuitable materials:	Materials for the construction of facilities for storing, handling and distributing this product should neither present unnecessary safety hazards nor adversely affect its quality. Examples of materials to avoid are: copper, copper alloys (ferrous and nonferrous). Synthetic materials such as plastics and fibreglass may also be unsuitable, depending on the material specification and intended use. Materials for packages, containers (including containers for the retention or despatch of samples) and container linings must not adversely affect the quality of the product. They must be impermeable and must not be weakened or otherwise affected by the product. Examples of materials to avoid are: natural rubber, polymethyl methacrylate, polystyrene, polyvinyl chloride, polyisobutylene. Polyethylene and polypropylene are also unsuitable unless they are high-density types, which have been specifically tested for compatibility with this product.
Other information:	Ensure that all local regulations regarding handling and storage facilities are followed. Never siphon by mouth.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational exposure standards:	None Established
Respiratory protection:	Not normally required. In a confined space self-contained breathing apparatus may be required.
Hand protection:	PVC or nitrile rubber gloves if splashes are likely to occur.
Eye protection:	Monogoggles if splashes are likely to occur.
Body protection:	Wear overalls to minimise contamination of personal clothing. Launder overalls and undergarments regularly. Safety shoes or boots - chemical resistant.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid at ambient temperature.
Colour:	Colourless
Odour:	Odourless
Initial boiling point:	Circa 200°C
Final boiling point:	Circa 320°C
Vapour pressure:	<0.1 kPa at 40°C
Density:	Circa 780 kg/m ³ at 15°C
Kinematic viscosity:	Circa 2.8 mm ² /s at 40°C
Vapour density (air=1):	> 5
Pour point:	Circa -27°C
Flash point:	> 85°C (PMCC)
Flammability limit - lower:	Circa 1%(V/V)
Flammability limit - upper:	Circa 6%(V/V)
Auto-ignition temperature:	> 220°C
Explosive properties:	In use, may form flammable/explosive vapour-air mixtures.
Oxidizing properties:	None
Solubility in water:	Insoluble

10. STABILITY/REACTIVITY

Stability:	Stable.
Conditions to avoid:	Heat, flames and sparks.
Materials to avoid:	Strong oxidizing agents.
Hazardous decomposition products:	None known.

11. TOXICOLOGICAL INFORMATION

Basis for assessment:	Toxicological studies have not been carried out on this product. Information given is based on a knowledge of available data on the hydrocarbon streams, available data on similar products and on toxicological knowledge of the constituents.
Acute toxicity - oral:	LD ₅₀ >5000 mg/kg. Ingestion may lead to vomiting and aspiration into the lungs, this may result in chemical pneumonitis, which may be fatal.
Acute toxicity - dermal:	LD ₅₀ >2000 mg/kg.
Acute toxicity - inhalation:	LC ₅₀ expected to be >5 mg/l.
Eye irritation:	Expected to be slightly irritating.
Skin irritation:	Expected to be slightly irritating. Repeated exposure may cause skin dryness or cracking.
Respiratory irritation:	Expected to be slightly irritating.
Skin sensitization:	Not expected to be a skin sensitizer
Sub chronic/Chronic Toxicity:	Repeated skin exposure may cause moderate to severe irritation. Repeated inhalation of mists is expected to cause irritation of the respiratory tract.
Carcinogenicity:	Based on compositional analysis of this product, which shows that it contains linear and branched alkanes and virtually no aromatic compounds, dermal application is not expected to produce skin tumours in mice.
Mutagenicity:	In vitro mutagenicity studies have indicated that mutagenic activity for middle distillates is related to 4- to 6-ring polycyclic aromatic content, which is virtually zero in this product. Therefore this product is not expected to be mutagenic.
Reproductive Toxicity:	Not expected to be a developmental toxicant.
Human effects:	Prolonged/repeated contact may cause defatting of the skin, which can lead to dermatitis and may make the skin more susceptible to irritation and penetration by other materials. See Section 4 for information regarding acute effects to humans.

12. ECOLOGICAL INFORMATION

Basis for assessment:	Ecotoxicity/biodegradability studies have been performed on this product. Other information given is based on the knowledge of similar products.
Mobility:	Floats on water. Partly evaporates from water or soil surfaces, but a significant proportion will remain after one day. Large volumes may penetrate soil and could contaminate groundwater.
Persistence/degradability:	Readily biodegradable. Oxidizes rapidly by photochemical reactions in air.
Bioaccumulation:	Not expected to bioaccumulate significantly.

Ecotoxicity:	Poorly soluble mixture. Films formed on water may affect oxygen transfer and damage organisms. Product is not harmful to aquatic organisms, LL/EL ₅₀ > 100 mg/l. (LL/EL ₅₀ expressed as the nominal amount of product required to prepare aqueous test extract)
Sewage treatment:	Not toxic at the limit of water solubility.

13. DISPOSAL CONSIDERATIONS

Precautions:	See Section 8.
Waste disposal:	Waste arising from a spillage or tank cleaning should be disposed of in accordance with prevailing regulations, preferably to a recognised collector or contractor. The competence of the collector or contractor should be established beforehand. Do not dispose into the environment, in drains or in water courses.
Product disposal:	Recycle if possible, otherwise incineration.
Container disposal:	200 litre drums should be drained and returned to the supplier or sent to a drum conditioner without removing or defacing markings or labels. Drums should not be reused without first obliterating all markings.

14. TRANSPORT INFORMATION

Not classified as dangerous for conveyance under UN, IMO, ADR/RID and IATA/ICAO codes

15. REGULATORY INFORMATION

EC Classification:	Harmful.
EC Symbol:	Xn
EC Risk Phrases:	R65 Harmful : may cause lung damage if swallowed.
EC Safety Phrases:	S62 If swallowed , do not induce vomiting; seek medical advice and show this container or label.

16. OTHER INFORMATION

Uses and restrictions:	Used as synthetic drilling base fluid
Technical contact point:	Norazlam Norbi
Technical contact number:	
Telephone:	+60 (3) 2091 2218
Fax:	+60 (3) 2051 2535

SDS history:

Edition number: 4
First issued: 10/07/2003
Revised: 03/03/2004
Revised: 16/08/2004
Revised: 01/05/2005

SDS distribution:

This document contains important information to ensure the safe storage, handling and use of this product. The information in this document should be brought to the attention of the person in your organisation responsible for advising on safety matters.

DISCLAIMER: This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not be construed as guaranteeing any specific property of the product.

Appendix 3 Safety Data Sheet Saraline 200



Shell MDS (M) Sdn Bhd

Safety Data Sheet

Edition Number: 4
Date Prepared: 01 May 2005
Supersedes: 24 Jul 2003

SDS No. SMDS-04.2

SHELL SARALINE 200

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY

Product name: Shell Saraline 200
Product type: Synthetic Drilling Base Fluid
Supplier: Shell MDS Malaysia Sdn. Bhd.
Address: Tanjong Kidurong, P.O. Box 1084, 97008 Bintulu
Sarawak, Malaysia.
Contact numbers:
Telephone: +60 (86) 292 222
Telex: MA 73113
Fax: +60 (86) 252 211
Emergency telephone number:
24hr Answering Service +60 (86) 292 222

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance Formal Name Alkanes, Mixture of Paraffin
Substance Chemical Family Aliphatic Hydrocarbons
CAS number 90622-53-0

3. HAZARDS IDENTIFICATION

Human health hazards: If swallowed, aspiration into the lungs may cause chemical pneumonitis.
Safety hazards: Not classified as flammable but will burn.
Environmental hazards: None known.

4. FIRST AID MEASURES

First Aid - Inhalation: Remove affected person from contaminated area and seek medical advice.
First Aid - Skin: Wash skin with water using soap if available. Contaminated clothing must be removed as soon as possible. It must be laundered before reuse.

First Aid - Eye:	Flush eye with water. If persistent irritation occurs, obtain medical attention.
First Aid - Ingestion:	DO NOT DELAY. Do not induce vomiting. Protect the airway if vomiting begins. Give nothing by mouth. If breathing but unconscious, place in the recovery position. If breathing has stopped, apply artificial respiration. OBTAIN MEDICAL ATTENTION IMMEDIATELY.
Advice to physicians:	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Specific hazards:	Combustion products may include carbon monoxide and unburnt hydrocarbons. The vapour is heavier than air, spreads along the ground and distant ignition is possible.
Extinguishing media:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable extinguishing media:	Do not use water in a jet. Use of Halon extinguishers should be avoided for environmental reasons.
Other information:	Keep adjacent drums and tanks cool by spraying with water.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Remove all possible sources of ignition in the surrounding area and evacuate all personnel. Do not breathe vapour, mists. Avoid contact with skin, eyes and clothing. Take off immediately all contaminated clothing.
Personal protection:	Wear protective clothing specified for normal operations (see Section 8).
Environmental precautions:	Prevent from entering into drains, ditches or rivers. Use appropriate containment to avoid environmental contamination.
Clean-up methods - small spillage:	Absorb or contain liquid with sand, earth or spill control material. Shovel up and place in a labelled sealable container for subsequent safe disposal. Do not disperse using water.
Clean-up methods - large spillage:	Transfer to a labelled, sealable container for product recovery or safe disposal. Otherwise treat as for small spillage.
Other information:	Local authorities should be advised if significant spillages cannot be contained. Observe all relevant local regulations. See Section 13 for information on disposal.

7. HANDLING AND STORAGE

Handling:	When using do not eat, drink or smoke. Only use in well-ventilated areas. Take precautionary measures against static discharges. Earth or bond all equipment.
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Handling temperature:	Ambient.
Storage:	Locate tanks away from heat and other sources of ignition. Do not store in unsuitable, unlabelled or incorrectly labelled containers. Keep container tightly closed in a dry, well-ventilated place away from direct sunlight and other sources of heat or ignition. Drums should be correctly stacked to a maximum of 3 high. Prevent ingress of water. Keep in a bunded area. Keep out of reach of children.
Storage temperature:	Ambient.
Product transfer:	Electrostatic charges may be generated during pumping. Ensure electrical continuity by bonding all equipment. Avoid splash filling. Particular care must be taken when 'switch loading' road/rail tankers which have previously contained gasoline. Wait 10 minutes after tank filling before opening hatches or manholes.
Tank cleaning:	Cleaning, inspection and maintenance of storage tanks is a specialist operation, which requires the implementation of strict procedures and precautions. These include issuing work permits, gas-freeing of tanks, using a manned harness and lifeline and wearing air-supplied breathing apparatus. Prior to entry and whilst cleaning is underway, the atmosphere within the tank must be monitored using an oxygen meter and/or explosimeter.
Recommended materials:	Use mild steel, stainless steel for containers. Aluminium may also be used for applications where it does not present an unnecessary fire hazard. Use amine-adduct cured epoxy paint for container linings. Use compressed asbestos fibre, PTFE, Viton A, Viton B for seals and gaskets.
Unsuitable materials:	Materials for the construction of facilities for storing, handling and distributing this product should neither present unnecessary safety hazards nor adversely affect its quality. Examples of materials to avoid are: copper, copper alloys (ferrous and nonferrous). Synthetic materials such as plastics and fibreglass may also be unsuitable, depending on the material specification and intended use. Materials for packages, containers (including containers for the retention or despatch of samples) and container linings must not adversely affect the quality of the product. They must be impermeable and must not be weakened or otherwise affected by the product. Examples of materials to avoid are: natural rubber, polymethyl methacrylate, polystyrene, polyvinyl chloride, polyisobutylene. Polyethylene and polypropylene are also unsuitable unless they are high density types, which have been specifically tested for compatibility with this product.
Other information:	Ensure that all local regulations regarding handling and storage facilities are followed. Never siphon by mouth.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational exposure standards:	None Established
Respiratory protection:	Not normally required. In a confined space self-contained breathing apparatus may be required.
Hand protection:	PVC or nitrile rubber gloves if splashes are likely to occur.
Eye protection:	Monogoggles if splashes are likely to occur.
Body protection:	Wear overalls to minimise contamination of personal clothing. Launder overalls and undergarments regularly. Safety shoes or boots - chemical resistant.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid at ambient temperature.
Colour:	Colourless
Odour:	Odourless
Initial boiling point:	Circa 175°C
Final boiling point:	Circa 360°C
Vapour pressure:	<0.1 kPa at 40°C
Density:	Circa 800 kg/m ³ at 15°C
Kinematic viscosity:	Circa 4.0 mm ² /s at 40°C
Vapour density (air=1):	> 5
Pour point:	0 °C avg
Flash point:	> 95°C (PMCC)
Flammability limit - lower:	Expected 1%(V/V)
Flammability limit - upper:	Expected 10%(V/V)
Auto-ignition temperature:	Not Available
Explosive properties:	In use, may form flammable/explosive vapour-air mixtures.
Oxidizing properties:	None
Solubility in water:	Insoluble

10. STABILITY/REACTIVITY

Stability:	Stable.
Conditions to avoid:	Heat, flames and sparks.
Materials to avoid:	Strong oxidizing agents.
Hazardous decomposition products:	None known.

11. TOXICOLOGICAL INFORMATION

Basis for assessment:	Toxicological data have not been determined specifically for this product. Information given is based on a knowledge of the toxicology of similar products.
Acute toxicity - oral:	LD ₅₀ >5000 mg/kg.
Acute toxicity - dermal:	LD ₅₀ >2000 mg/kg.
Acute toxicity - inhalation:	LC ₅₀ >5 mg/l.
Eye irritation:	Expected to be non-irritant.
Skin irritation:	Expected to be non-irritant.
Respiratory irritation:	Data not available from animal studies.
Skin sensitization:	Not expected to be a skin sensitizer.
Human effects:	Prolonged/repeated contact may cause defatting of the skin, which can lead to dermatitis. See Section 4 for information regarding acute effects to humans.

12. ECOLOGICAL INFORMATION

Basis for assessment:	Ecotoxicological data have not been determined specifically for this product. Information given is based on a knowledge of the ecotoxicology of similar products.
Mobility:	Floats on water. Partly evaporates from water or soil surfaces, but a significant proportion will remain after one day. Large volumes may penetrate soil and could contaminate groundwater.
Persistence/degradability:	Not Available
Bioaccumulation:	Not Available
Ecotoxicity:	Not Available
Sewage treatment:	Not Available

13. DISPOSAL CONSIDERATIONS

Precautions:	See Section 8.
Waste disposal:	Waste arising from a spillage or tank cleaning should be disposed of in accordance with prevailing regulations, preferably to a recognised collector or contractor. The competence of the collector or contractor should be established beforehand. Do not dispose into the environment, in drains or in water courses.
Product disposal:	Recycle if possible, otherwise incineration.
Container disposal:	200 litre drums should be drained and returned to the supplier or sent to a drum conditioner without removing or defacing markings or labels. Drums should not be reused without first obliterating all markings.

14. TRANSPORT INFORMATION

Not classified as dangerous for conveyance under UN, IMO, ADR/RID and IATA/ICAO codes

15. REGULATORY INFORMATION

EC Classification:	Harmful.
EC Symbol:	Xn
EC Risk Phrases:	R65 Harmful: may cause lung damage if swallowed.
EC Safety Phrases:	S62 If swallowed, do not induce vomiting; seek medical advice and show this container or label.

16. OTHER INFORMATION

Uses and restrictions:	Used as synthetic drilling base fluid
Technical contact point:	Norazlam Norbi
Technical contact number:	
Telephone:	+60 (3) 2091 2218
Fax:	+60 (3) 2091 2535
SDS history:	Edition number: 4
	First Issued: 17/03/1997
	Revised: 03/07/2000
	Revised: 24/07/2003
	Revised: 01/05/2005
SDS distribution:	This document contains important information to ensure the safe storage, handling and use of this product. The information in this document should be brought to the attention of the person in your organisation responsible for advising on safety matters.

DISCLAIMER: This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not be construed as guaranteeing any specific property of the product.

Bibliographic Information

This report has been classified as Restricted and is not subject to US Export Control regulations.

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