(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 984 927 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
09.11.2011 Bulletin 2011/45

(21) Application number: **07704608.4**

(22) Date of filing: **15.02.2007**

(51) Int Cl.:
H01B 3/20 *(2006.01)*

(86) International application number:
PCT/EP2007/051484

(87) International publication number:
WO 2007/093631 (23.08.2007 Gazette 2007/34)

(54) ELECTRICAL INSULATION OIL COMPOSITION

ZUSAMMENSETZUNG FÜR ELEKTRISCHES ISOLATIONSÖL

COMPOSITION D'HUILE POUR ISOLATION ELECTRIQUE

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **16.02.2006 JP 2006039407**

(43) Date of publication of application:
29.10.2008 Bulletin 2008/44

(73) Proprietor: **Shell Internationale Research Maatschappij B.V.**
2596 HR The Hague (NL)

(72) Inventors:
- **BABA, Yoshiharu**
  Tokyo, Tokyo 135-8074 (JP)
- **TAKAHASHI, Hiroyuki**
  Tokyo, Tokyo 135-8074 (JP)
- **TERAI, Hideto**
  Tokyo, Tokyo 135-8074 (JP)
- **TANAKA, Norimitsu**
  Tokyo, Tokyo 135-8074 (JP)

(74) Representative: **Matthezing, Robert Maarten et al**
Shell International B.V.
Intellectual Property Services
P.O. Box 384
2501 CJ The Hague (NL)

(56) References cited:
GB-A- 1 326 946
JP-A- 6 187 829
US-A- 4 069 166

EP 1 984 927 B1

Description

[0001] The present invention relates to an electrical insulating oil composition.

[0002] Transformers, high-pressure circuit breakers and other high-pressure electrical devices are filled with electrical insulating oil compositions before use-However, it must be possible for such electrical devices to be used maintenance-free for long periods after the start of operation. Similarly, such compositions are required to maintain stable physical properties and electrical properties over a long period.

[0003] It is known that when electrical insulating oil compositions are used for a long period, they deteriorate, causing a decrease in anti-corrosion properties and a decrease in insulating properties due to an increase in the acid value of the electrical insulating oil compositions and the formation of sludge. Hence, with the trend towards higher pressure, larger size and longer service life for high pressure electrical devices, the stability of electrical insulating oil compositions used therein has become more important.

[0004] The IEC (International Electrotechnical Commission) has specified the required performance for electrical insulating oil compositions used for filling transformers, high pressure circuit breakers and other electrical devices, and the performance required for mineral oil insulating oil compositions capable of withstanding long-term use as the standards IEC 296 and IEC 60296.

[0005] Meanwhile, with the advances in mineral oil refining technology, the hydrorefining method has been widely adopted, making it possible to obtain oils from which polycyclic aromatics, unsaturated components, nitrogen content and sulphur content have been adequately removed. At first, it had been considered that it was better for electrical insulating oil composition to contain no nitrogen or sulphur content.

[0006] Subsequently, however, Japanese Laid-Open Patent Application No. 2000-345177 A disclosed that with regard to oxidation stability and other aspects it was preferable for electrical insulating oil compositions to contain a certain amount of these components. Thus, it has been proposed in JP 2000-345177 A that by reducing the resin content in an electrical insulating oil composition to $\leq$ 100 ppm, and also incorporating minute amounts of sulphide-type sulphur content and total nitrogen content, the stability of the electrical insulating oil composition is increased, and increases in electric charge are inhibited.

[0007] In fact, it is extremely difficult to refine a crude oil by petroleum refining processes to a state wherein the nitrogen content or sulphur content are such as to be suitable for use in an electrical insulating oil composition.

[0008] Accordingly, at present, although there have been attempts to adjust the components therein by adding an appropriate combination of additives or the like having a nitrogen content or sulphur content to highly purified refined oils, there are restrictions as to the additives which can be used, depending on the electrical insulating oil specification, moreover, there are cost problems, and production management complications.

[0009] It is therefore highly desirable to be able to obtain an electrical insulating oil composition having a balance of excellent electrical properties, low temperature performance, thermal oxidation stability and anti-corrosion properties by an economical and simple method.

[0010] In the present invention it has been surprisingly found that, through the addition of small quantities of bright: stock oil to hydrorefined mineral oil and/or synthetic hydrocarbon oil, it is possible simply and economically to increase the thermal oxidation stability and obtain electrical insulating oil compositions which are capable of fulfilling the various types of performance required of electrical insulating oil competition in the IEC Standard 296 and the IEC Standard 60296.

[0011] Accordingly, the present invention provides an electrical insulting oil composition having a flash point (PMCC) of 130°C or more and a pour point of -45°C or lower, which composition comprises hydrorefined mineral oil and/or synthetic hydrocarbon oil and in the range of from 0.5 to 10 wt.% of bright stock oil, based on the total weight of the electrical insulating oil composition.

[0012] In a preferred embodiment of the present invention, the Electrical insulating oil composition has a flash point (PMCC) of 135°C or more.

[0013] The hydrorefined mineral oil that may be present in the electrical insulating oil composition of the present invention may be refined by hydrogenating mineral oil. Examples of hydrorefined mineral oils that may be conveniently used include hydrorefined naphthenic mineral oil and hydrorefined paraffinic mineral oil.

[0014] Through the hydrorefining of mineral oils, polycyclic aromatic substances, unsaturated components, sulphur compounds and nitrogen compounds are removed. Compared to the hydrorefined paraffinic mineral oils, the hydrorefined naphthenic mineral oils may have better low temperature flow properties and lower oxidation stability, and, conversely, compared to the hydrorefined naphthenic mineral oils, the hydrorefined paraffinic mineral oils may have inferior low temperature flow properties, but better thermal oxidation stability.

[0015] Examples of synthetic hydrocarbon oils that may be conveniently used in the electrical insulating oil composition of the present invention include polypropylene, polybutene, polypentene and other isoparaffinic synthetic hydrocarbon oils, poly-α-olefins (PAO) falling within Group IV in the API (American Petroleum Institute) base oil classification stated below in Table 1, and Gas to Liquid (GTL) synthetic oils.

[0016] Synthetic hydrocarbon base oils sold by the Shell group under the trade designation "XHVI" may be conveniently

used.

[0017] Japanese Laid-Open Patent Application 52-072706 A and Japanese Laid-Open Patent Application 07-228876 describe methods of manufacturing synthetic hydrocarbon oils that may be conveniently used in the electrical insulating oil composition of the present invention.

[0018] The afore-mentioned hydrorefined mineral oils and synthetic hydrocarbon oils may be used alone. However, the pour point, kinematic viscosity, thermal oxidation stability and the like of the electrical insulating oil composition of the present invention may be optimally adjusted by appropriate combination of several substances.

[0019] The hydrorefined mineral oil and/or synthetic hydrocarbon oil used in the electrical insulating oil composition of the present invention each have a preferred kinematic viscosity at 40°C in the range of from 8.0 to 24 mm^2/s.

[0020] Preferred hydrorefined mineral oils may be selected from hydrorefined naphthenic mineral oils and/or API base oil classification Group II or Group III hydrorefined paraffinic mineral oils.

[0021] Preferred synthetic hydrocarbon oils may be selected from isoparaffinic synthetic oils, GTL synthetic oils and poly-α-olefins (PAO) belonging to API base oil classification Group IV or mixtures thereof.

[0022] Since the kinematic viscosity of bright stock oil is relatively high compared to hydrorefined mineral oils and/or synthetic hydrocarbon oils, it is particularly preferred that the intrinsic kinematic viscosity of the hydrorefined mineral oil and/or synthetic hydrocarbon oil at 40°C is 16 mm^2/s or less, more preferably 12 mm^2/s or less if hydrorefined mineral oil or synthetic hydrocarbon oil is used alone with bright stock oil.

[0023] If combinations of hydrorefined mineral oil and synthetic hydrocarbon oil are used with bright stock oil, the respective kinematic viscosity of the hydrorefined mineral oil and the synthetic hydrocarbon oil is each preferably in the range of from 8.0 to 24.0 mm^2/s, more preferably in the range of from 8.0 to 20.0 mm^2/s.

TABLE 1

Class	Sulphur content wt.%	Saturated content wt.%	Viscosity index
Group I	> 0.03	< 90	80 - 120
Group II	≤ 0.03	≥ 90	80 - 120
Group III	≤ 0.03	≥ 90	≥ 120
Group IV	poly-α-olefin		
Group V	Substances not belonging to Groups I-IV (esters, etc.)		

[0024] The bright stock oil added to the afore-mentioned hydrorefined mineral oil and/or synthetic hydrocarbon oil may be obtained by further distilling under reduced pressure the atmospheric pressure residual mineral oil obtained when paraffinic mineral oil is distilled at atmospheric pressure from crude oil, and performing deasphalting, solvent extraction and solvent dewaxing processes on that reduced pressure residual oil. That is to say, said bright stock oil may be a heavy mineral oil base oil fraction obtained by reduced pressure distillation of the residual paraffinic mineral oil from atmospheric distillation of crude oil, and deasphalting, solvent extraction and solvent dewaxing treatment of the residual oil obtained.

[0025] The bright stock oil used in the present invention is preferably a base oil belong to API base oil classification Group I, with total sulphur content in the range of from 0.4 to 2.0 wt.%, mercaptan sulphur content of 100 wt. ppm or less, sulphide-type sulphur content of 0.5 wt.% or less, total nitrogen content in the range of from 100 to 500 wt. ppm, basic nitrogen content of 300 wt. ppm or less, and total content of polar components (IP368) in the range of from 30 to 70 wt.%.

[0026] Various sulphur compounds and nitrogen compounds are concentrated in said bright stock oil by the distillation and solvent extraction processes. Through the use of in the range of from 0.5 to 10 wt.% of said bright stock oil in the electrical insulating oil composition of the present invention, preferably in the range of from 0.5 to 8.0 wt.%, based on the total weight of said electrical insulating oil composition, the afore-mentioned sulphur content and nitrogen content are incorporated in appropriate quantities in the electrical insulating oil composition. Hence, it is possible to markedly improve the thermal oxidation stability thereof. If the afore-mentioned mercaptan sulphur and sulphide-type sulphur contents become too high, then the corrosivity may become higher, which is undesirable. Further, if the basic nitrogen content exceeds 300 wt. ppm, then the oxidation stability performance may decrease.

[0027] The electrical insulating oil composition of the present invention has a preferred kinematic viscosity at 40°C in the range of from 8.0 to 16.0 mm^2/s, more preferably in the range of from 8.0 to 12.0 mm^2/s. With a kinematic viscosity at 40°C of less than 8.0 mm^2/s, a satisfactory flash point may not be obtained. If the kinematic viscosity at 40°C exceeds 16.0 mm^2/s, then the circulation efficiency of the electrical insulating oil composition in a transformer may decrease, the cooling effect may become inadequate, and overheating may occur.

[0028] The electrical insulating oil composition of the present invention may comprise one or more antioxidant additives. Antioxidants that may be conveniently used are phenolic or aminic antioxidants.

[0029] Examples of phenolic antioxidants that may be conveniently used in the electrical insulating oil composition of the present invention include 4,4'-methylenebis(2,6-di-tert.-butylphenol), 4,4'-bis(2,6-di-tert.-butylphenol), 4,4'-bis(2-methyl-6-tert.-butylphenol), 2,2'-methylenebis(4-ethyl-6-tert.-butylphenol), 2,2'-methylenebis(4-methyl-6-tert.-butylphenol), 4,4'-butylidenebis(3-methyl-6-tert.-butylphenol), 4,4'-isopropylidenebis(2,6-di-tert.-butylphenol), 2,2'-methylenebis (4-methyl-6-nonylphenol), 2,2'-isobutylidenebis(4,6-dimethyl-phenol), 2,2'-methylenebis(4-methyl-6-cyclohexylphenol), 2,6-di-tert.-butyl-4-methylphenol, 2,6-di-tert.-butyl-4-ethylphenol, 2,4-dimethyl-6-tert.-butylphenol, 2,6-di-tert.-butyl-α-dimethylamino-p-cresol, 2,6-di-tert.-butyl-4(N,N'-dimethylaminomethylphenol), 4,4'-thio-bis(2-methyl-6-tert.-butylphenol), 4,4'-thiobis(3-methyl-6-tert.-butylphenol), 2,2'-thiobis-(4-methyl-6-tert.-butylphenol), bis(3-methyl-4-hydroxy-5-tert.-butylbenzyl) sulphide, bis(3,5-di-tert.-butyl-4-hydroxybenzyl) sulphide, 2,2'-thio-diethylenebis[3-(3,5-di-tert.-butyl-4-hydroxyphenyl) propionate], tridecyl-3-(3,5-di-tert.-butyl-4-hydroxyphenyl) propionate, pentaerythrityl-tetrakis[3-(3,5-di-tert.-butyl-4-hydroxyphenyl) propionate], octyl-3-(3,5-di-tert.-butyl-4-hydroxyphenyl) propionate, octadecyl-3-(3,5-di-tert.-butyl-4-hydroxyphenyl) propionate, octyl-3-(3-methyl-5-tert.-butyl-4-hydroxyphenyl) propionate.

[0030] The content of the one or more antioxidant additives is preferably less than 2 wt.%, more preferably less than 1 wt.%, even more preferably less than 0.6 wt.% and most preferably less than 0.4 wt.%, based on the total weight of the electrical insulating oil composition.

[0031] In a preferred embodiment of the present invention, the electrical insulating oil composition comprises in the range of from 0.01 to 0.4 wt.% of phenolic antioxidant, based on the total weight of the electrical insulating oil composition.

[0032] In other embodiments of the present invention, it is preferred that the electrical insulating oil composition comprises in the range of from 0.01 to 0.08 wt.% or in the range of from 0.08 to 0.4 wt.% of phenolic antioxidant, based on the total weight of the electrical insulating oil composition.

[0033] Further additives that may also be present in the electrical insulating oil composition of the present invention are dependent upon the specific application of the electrical insulating oil composition.

[0034] Through the addition of bright stock oil to the afore-mentioned hydrorefined mineral oil and/or synthetic hydrocarbon oil, it is possible to obtain electrical insulating oil compositions conforming with IEC (International Electrotechnical Commission) Standard 296, Class II, in that on maintaining for 168 hrs at 100°C in IEC oxidation stability test method 61125A, sludge formation is 0.1 wt.% or less, and the acid value is 0.4 mg KOH/g or less.

[0035] Accordingly, in a preferred embodiment, the present invention provides an electrical insulating oil composition having a flash point (PMCC) of 130°C or more and a. pour point of -45°C or lower, which composition comprises hydrorefined mineral oil and/or synthetic hydrocarbon oil and in the range of from 0.5 to 10 wt.% of bright stock oil, and which composition conforms with IEC (International Electrotechnical Commission) Standard 296, Class II, in that after 168 hrs at 100°C in IEC oxidation stability test method 61125A, sludge formation is 0.1% or less, and the acid value is 0.4 mg KOH/g or less.

[0036] Further, through the addition of bright stock oil to the afore-mentioned hydrorefined mineral oil and/or synthetic hydrocarbon oil, it is possible to obtain electrical insulating oil compositions conforming with IEC Standard 60296, Type U, in that on maintaining for 164 hrs at 120°C in IEC oxidation stability test method 61125C, sludge formation is 0.8 wt. % or less, and the acid value is 1.2 mg KOH/g or less.

[0037] Accordingly, in a preferred embodiment, the present invention further provides an electrical insulating oil composition having a flash point (PMCC) of 130°C or more, more preferably of 135°C or more and a pour point of -45°C or lower, which composition comprises hydrorefined mineral oil and/or synthetic hydrocarbon oil and in the range of from 0.5 to 10 wt.% of bright stock oil, and which composition conforms with IEC Standard 60296, Type U, in that after 164 hrs at 120°C in IEC oxidation stability test method 61125C, sludge formation is 0.8 wt.% or less, and the acid value is 1.2 mg KOH/g or less.

[0038] Moreover, in a preferred embodiment through the addition of bright stock oil, and the further addition of in the range of from 0.01 to 0.4 wt.%, more preferably in the range of from 0.08 to 0.4 wt.% of an antioxidant, preferably a phenolic antioxidant, to the afore-mentioned hydrorefined mineral oil and/or synthetic hydrocarbon oil, it is possible to obtain electrical insulating oil compositions conforming with IEC Standard 60296, Type I, in that on maintaining for 500 hrs at 120°C in IEC oxidation stability test method 61125C, sludge formation is 0.8 wt.% or less, and the acid value is 1.2 mg KOH/g or less.

[0039] Accordingly, in a preferred embodiment, the present invention further provides an electrical insulating oil composition having a flash point (PMCC) of 130°C or more, more preferably of 135°C or more and a pour point of -45°C or lower, which composition comprises hydrorefined mineral oil and/or synthetic hydrocarbon oil, in the range of from 0.5 to 10 wt.% of bright stock oil and in the range of from 0.01 to 0.4 wt.%, more preferably in the range of from 0.08 to 0.4 wt.% of an antioxidant, preferably a phenolic antioxidant and which composition conforms with IEC Standard 60296, Type I, in that after 500 hrs at 120°C in IEC oxidation stability test method 61125C, sludge formation is 0.8 wt.% or less, and the acid value is 1.2 mg KOH/g or less.

[0040] Further, in the same way, through the addition of bright stock oil, and the further addition of in the range of from

0.01 to 0.4 wt.%, more preferably in the range of from 0.01 to 0.08 wt.% of an antioxidant, preferably a phenolic antioxidant, to the afore-mentioned hydrorefined mineral oil and/or synthetic hydrocarbon oil, it is possible to obtain electrical insulating oil compositions conforming with IEC Standard 60296, Type T, in that on maintaining for 332 hrs at 120°C in IEC oxidation stability test method 61125C, sludge formation is 0.8 wt.% or less, and the acid value is 1.2 mg KOH/g or lest.

[0041] Accordingly, in a preferred embodiment, the present invention further provides an electrical insulating oil composition having a flash point (PMCC) of 130°C or more, more preferably of 135°C or more and a pour point of -45°C or lower, which composition comprises hydrorefined mineral oil and/or synthetic hydrocarbon oil, in the range of from 0.5 to 10 wt.% of bright stock oil and in the range of from 0.01 to 0.4 wt.%, more preferably in the range of from 0.01 to 0.08 wt.% of an antioxidant, preferably a phenolic antioxidant and which composition conforms with IEC Standard 60296, Type T, in that after 332 hrs at 120°C in IEC oxidation stability test method 61125C, sludge formation is 0.8 wt.% or less, and the acid value is 1.2 mg KOH/g or less.

[0042] That is to say, the present invention provides an electrical insulating oil composition which conforms to one or more of the following standards:- IEC (International Electrotechnical Commission) Standard 296 (Class II), IEC Standard 60296 (Type U), IEC Standard 60296 (Type I) and IEC Standard 60296 (Type T).

[0043] The present invention further provides for the use of an electrical insulating oil composition as hereinbefore described in order to conform with one or more of IEC (International Electrotechnical Commission) Standard 296 (Class II), IEC Standard 60296 (Type U), IEC Standard 60296 (Type I) and IEC Standard 60296 (Type T).

[0044] The present invention further provides the use of the composition as hereinbefore described as an electrical insulting oil for application in one or more of transformers, regulators, circuit breakers, power plant reactors, shunt reactors, switch gears, cables and electrical equipment.

[0045] The present invention will be described with reference to the following Examples which are not intended to limit the scope of the invention in any way.

EXAMPLES

[0046] As the hydrorefined mineral oils, mineral oils and synthetic hydrocarbon oils, the base oils A-J and bright stock oil having the properties shown in Table 2, Table 3 and Table 4 were prepared.

Base Oils A-J and Bright Stock Oil

[0047] The properties of the base oils A-J and the bright stock oil are stated in Table 2, Table 3 and Table 4 on the basis of the following criteria.

(1) Flash point: as per JIS K 2265 (PMCC: Pensky-Martens closed method, and COC: Cleveland open method).
(2) Kinematic viscosity (40°C), kinematic viscosity (100°C): as per ASTM D445.
(3) Pour point: as per ASTM D97.
(4) Acid value: as per ASTM D974.
(5) PCA (PCA content): as per BS2000P-346.

TABLE 2

	(Units)	Base oil A	Base oil B	Base oil C	Bright stock oil
Appearance		Clear	Clear	Clear	Clear
Density (15°C)	g/cm^3	0.9040	0.8300	0.8324	0.9014
Flash point (COC)	°C	146	140	200	324
Flash point (PMCC)	°C	138	135	182	266 or more
Kin. viscosity (40°C)	mm^2/s	8.628	9.310	12.54	485.9
Kin. viscosity (100°C)	mm^2/s	2.203	2.250	3.103	31.53
Pour point	°C	-55.0	-55.0	-24.0	-10.0
Acid value	mg KOH/g	0.00	0.00	0.01	0.01

(continued)

	(Units)	Base oil A	Base oil B	Base oil C	Bright stock oil
PCA content	wt.%	1.1	0.0	0.2	1.4
Total sulphur content	wt.%	≤ 0.0005	≤ 0.0001	0.0001	1.05
Sulphide-type sulphur	wt.%	≤ 0.0005	≤ 0.0001	≤ 0.0001	0.39
Mercaptan sulphur	wt.%	≤ 0.0001	≤ 0.0001	≤ 0.0001	0.0041
Total nitrogen content	ppm	≤ 1	≤ 1	≤ 1	235
Basic nitrogen content	ppm	≤ 1	≤ 1	≤ 1	141
n-d-M ring analysis (ASTM D 3238)	Ca%	6.6	0.0	0.0	6.2
	Cn%	60.7	30.0	23.5	25.6
	Cp%	32.7	70.0	76.5	68.2
Base oil type		hydrorefined naphthenic base oil (mineral oil)	isoparaffinic base oil (synthetic oil)	hydrorefined paraffinic base oil (mineral oil) with good low temp. flow properties	solvent-refined paraffin base oil (mineral oil)

TABLE 3

	(Units)	Base oil D	Base oil E	Base oil F	Base oil G	Base oil H
Appearance		clear	clear	clear	clear	clear
Density (15°C)	g/cm^3	0.9067	0.8429	0.8401	0.8709	0.8470
Flash point (COC)	°C	147	178	138	158	168
Kin. viscosity (40°C)	mm^2/s	9.348	9.610	9.129	7.879	9.630
Kin. viscosity (100°C)	mm^2/s	2.285	2.595	2.517	2.194	2.590
Pour point	°C	-55.0	-12.5	-12.5	-27.5	-12.5
Acid value	mg KOH/g	0.01	0.01	0.01	0.01	0.01
Total sulphur content	wt.%	0.04	0.01	0.04	≤ 0.01	0.28
Total nitrogen content	ppm	5	≤ 1	≤ 1	≤ 1	≤ 1
Basic nitrogen	ppm	4	≤ 1	≤ 1	≤ 1	≤ 1
n-d-M ring analysis (ASTM D 3238)	Ca%	9.6	3.0	3.4	7.0	5.4
	Cn%	55.3	30.0	28.0	39.5	28.2
	Cp%	35.1	67.0	68.6	53.5	66.4

(continued)

	(Units)	Base oil D	Base oil E	Base oil F	Base oil G	Base oil H
		hydrorefined naphthenic base oil (mineral oil)	isoparaffinic base oil (mineral oil)	hydrorefined paraffinic base oil (mineral oil)	hydrorefined paraffinic base oil (mineral oil)	paraffinic base oil (mineral oil)

TABLE 4

	(Units)	Base oil I	Base oil J
Appearance		clear	clear
Density (15°C)	g/cm^3	0.8184	0.8186
Flash point (COC)	°C	234	226
Kin. viscosity (40°C)	mm^2/s	16.10	16.40
Pour point	°C	-20.0	≤ 50
Total sulphur content	ppm	≤ 1	≤ 1
Total nitrogen content	ppm	1	≤ 1
Basic nitrogen	ppm	≤ 1	≤ 1
n-d-M ring analysis (ASTM D 3238)	Ca%	0.0	0.0
	Cn%	8.8	10.0
	Cp%	91.2	90.0
		GTL ("XHVI") base oil (synthetic oil)	poly-α-olefin (synthetic oil)

[0048] Using the afore-mentioned base oils A-J and bright stock oil, Examples 1-7, which were electrical insulating oil compositions according to the present invention which not containing antioxidants, were prepared in accordance with the compositions shown in Table 5 and Table 6.

[0049] Furthermore, Examples 8-11, which are electrical insulating oil compositions according to the present invention containing antioxidants, were prepared in accordance with the compositions shown in Table 7.

[0050] Further, for comparison with the afore-mentioned examples, Comparative Examples 1-15 were prepared in accordance with the compositions shown in Tables 8-10.

[0051] With regard to the "clay treatment" referred to in Tables 5-10, activated clay in the stated quantity relative to the oil component was used and these were mixed together by stirring for 15 mints at 30-40°C, and the oil layer separated by pressure filtration. Processing was performed by the usual refining methods for electrical insulating oil compositions for the decolourisation, deodorisation, dewatering and stability improvement of electrical insulating oil compositions.

TABLE 5

Composition	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5
Base oil A (wt.%)	80	80	80	60	80
Base oil B (wt.%)	16	-	17	-	-
Base oil C (wit.%)	-	16	-	-	-
Base oil D (wt.%)	-	-	-	25	5
Base oil H (wit.%)	-	-	-	13	13
Bright stock oil (wit.%)	4	4	3	2	2
Clay treatment *	1%	1%	1%	1%	1%
* wt. % relative to amount of oil components used.					

TABLE 6

Composition	Ex. 6	Ex. 7
Base oil A (wt.%)	70.8	71.6
Base oil I (wt.%)	25.5	-
Base oil J (wt.%)	-	24.5
Bright stock oil (wt.%)	3.7	3.9
Clay treatment *	1%	1%
* wt. % relative to amount of oil components used.		

TABLE 7

Composition	Ex. 8	Ex. 9	Ex. 10	Ex. 11
Base oil A (wt.%)	80	80	80	80
Base oil B (wit.%)	16	-	16	-
Base oil C (wt.%)	-	16	-	16
Bright stock oil (wit.%)	3.9	3.9	3.95	3.95
Antioxidant "BHT" (wt.%)	0.1	0.1	0.05	0.05
Clay treatment *	1%	1%	1%	1%
Note: The antioxidant "BHT" is 2,6-di-tert.-butyl-4-methylphenol * wt. % relative to amount of oil components used. "BHT" added to oil components after clay treatment.				

TABLE 8

Composition	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	come. Ex. 4	Comp. Ex. 5
Base oil A (wit.%)	100	-	-	80	80
Base oil B (wt.%)	-	-	-	20	-
Base oil C (wt.%)	-	-	-	-	-
Base oil D (wt.%)	-	-	100	-	-
Base oil E (wt.%)	-	-	-	-	20
Base oil F (wt.%)	-	-	-	-	-
Base oil G (wt.%)	-	100	-	-	-
Base oil H (wt.%)	-	-	-	-	-
Bright stock oil (wt.%)	-	-	-	-	-
Clay treatment *	1%	1%	1%	1%	1%
* wt. % relative to amount of oil components used.					

TABLE 9

Composition	Comp. Ex. 6	Comp. Ex. 7	Comp. Ex. 8	Comp. Ex. 9	Comp. Ex. 10
Base oil A (wt.%)	80	80	80	80	60
Base oil B (wt.%)	-	-	-	-	-
Base oil C (wt.%)	-	-	-	-	-
Base oil D (wt.%)	-	-	-	20	40
Base oil E (wt.%)	-	-	-	-	-
Base oil F (wit.%)	20	-	-	-	-
Base oil G (wt.%)	-	20	30	-	-
Base oil H (wt.%)	-	-	-	-	-
Bright stock oil (wt.%)	-	-	-	-	-
Clay treatment *	1%	1%	1%	1%	1%
* wt. % relative to amount of oil components used.					

TABLE 10

Composition	Comp. Ex. 11	Comp. Ex. 12	Comp. Ex. 13	Comp. Ex. 14	Comp. Ex. 15
Base oil A (wit.%)	70	70	60	80	90
Base oil B (wt.%)	-	-	-	-	-
Base oil C (wt.%)	-	-	-	-	-
Base oil D (wt.%)	-	-	-	-	-
Base oil E (wt.%)	15	20	27	-	-
Base oil F (wt.%)	-	-	-	-	-
Base oil G (wt.%)	-	-	-	-	-
Base oil H (wt.%)	15	10	13	20	10
Bright stock oil (wt.%)	-	-	-	-	-
Clay treatment *	1%	1%	1%	1%	1%
* wt. % relative to amount of oil components used.					

[0052] IEC standard values were used as the standard reference values for the performance of the electrical insulating oil compositions. If these standard reference values were satisfied, then it was considered that long-term stable use over a wide temperature range was possible.

[0053] Accordingly, for the afore-mentioned Examples 1 and 2 (not containing antioxidants), the values of the electrical insulating oil properties were measured, and those results are shown in Table 11 together with the standard reference values for IEC Standard 296, Class II.

[0054] Further, for the afore-mentioned Examples 1, 2, 6 and 7 (not containing antioxidants), the values of the electrical insulating oil properties were measured, and those results are shown in Table 12 together with the standard reference values for IEC Standard 60296, Type U.

[0055] The measurement of the values of the properties, other than (1) to (5), described for the afore-mentioned base oils, was as stated below.

(6) Surface tension: as per ASTM D971.
(7) Corrosive sulphur: as per ASTM D1275.
(8) Water content: as per ASTM D1533.
(9) Oxidation test (168 hrs at 100°C): as per IEC method 61125A.
(10) Oxidation test (164 hrs at 120°C): as per IEC method 61125C.

(11) Insulation breakdown voltage: as per ASTM 1816 (VDE).

[0056] For the afore-mentioned Examples 3-5 (not containing antioxidants), the values of the density and oxidation stability on the basis of the aforesaid IEC Standard 296, Class II (168 hrs at 100°C, IEC method 61125A) were measured, and those results are shown in Table 13.

[0057] For the afore-mentioned Examples 8 and 9 (containing antioxidants), the values of the electrical insulating oil properties were measured, and those results are shown in Table 14 together with the standard values for IEC Standard 60296, Type I.

[0058] The measurement of the values of the properties, other than (1) to (11), described for the afore-mentioned base oils and Examples (not containing antioxidants), was as stated below.

[0059] (12) Oxidation test (500 hrs at 120°C): as per IEC method 61125C.

[0060] Examples 10 and 11 (containing antioxidants) had lower antioxidant contents than Examples 8 and 9, and the values of their electrical insulating oil properties were measured, and those results are shown in Table 15 together with the standard values for IEC Standard 60296, Type T.

[0061] The measurement of the values of the properties, other than (1) to (11), described for the afore-mentioned oils and Examples (not containing antioxidant), was as stated below.

[0062] (13) Oxidation test (332 hrs at 120°C): as per IEC method 61125C.

[0063] For Comparative Examples 1-15, the afore-mentioned oxidation stability on the basis of the afore-mentioned IEC Standard 296, Class II (168 hrs at 100°C, IEC method 61125A) was measured, and those results are shown in Tables 16-18.

Discussion

[0064] For the non-antioxidant-containing electrical insulating oil compositions of Examples 1-7, the values relating to oxidation stability (IEC oxidation test), which is regarded as an important characteristic value, were substantially lower than the IEC Standard 296, Class II, standard reference values (maximum values) or the IEC Standard 60296, Type U standard reference values (maximum values), and said compositions were judged to be excellent as electrical insulating oil compositions.

[0065] With Examples 1 and 2, the values from the oxidation test by the IEC method 61125A (168 hrs at 100°C) in the IEC Standard 296 and from the oxidation test by the IEC method 61125C (164 hrs at 120°C) in the IEC Standard 60296 were substantially lower than the standard reference values (maximum values) in either of these standards, and the compositions were excellent.

[0066] Further, for Examples 1, 2, 6 and 7, favourable results were obtained for all of the characteristic values stated in Table 11 and Table 12, in particular the kinematic viscosity at 40°C and -30°C, the pour point and acid value, and all compositions satisfied the standard reference values for IEC Standard 296, Type II and/or IEC Standard 60296, Type U.

[0067] Moreover, for the antioxidant-containing electrical insulating oil compositions of Examples 8 and 9, in the IEC method 61125C (500 hrs at 120°C) oxidation test relating to IEC Standard 60296, Type I, the values relating to oxidation stability, which is regarded as an important characteristic value, were each substantially lower than the standard reference values (maximum values) therein, and they were judged to be excellent electrical insulating oil compositions. Further, favourable results were also obtained for the other characteristic values stated in Table 14, in particular the kinematic viscosity, with both compositions satisfying the standard reference values for IEC Standard 60296, Type I.

[0068] Furthermore, with the electrical insulating oil compositions of Examples 10 and 11, which contained small quantities of antioxidant, in the IEC method 61125C (332 hrs at 120°C) oxidation test relating to IEC Standard 60296, Type T, the values relating to oxidation stability, which is regarded as an important characteristic value, were each substantially lower than the standard reference values therein, and said compositions were judged to be excellent electrical insulating oil compositions. Favourable results were also obtained for the other characteristic values stated in Table 15, in particular the kinematic viscosity, and both compositions satisfied the standard reference values for IEC Standard 60296, Type T.

[0069] However, with the substances of Comparative Examples 1-15, in which bright stock oil was not used, in the IEC method 61125A (168 hrs at 100°C) oxidation test relating to the afore-mentioned IEC Standard 296, none of the compositions satisfied the standard reference values for IEC Standard 296, Class II. In other words, the substances of Comparative Examples 1-9 and 15 substantially exceeded the standard reference values (maximum values), and it was judged that the comparative compositions were unsuitable for use as electrical insulating oil compositions. Further, although the compositions of Comparative Examples 10-14 satisfied the standard reference values as regards acid value, said compositions did not satisfy the standard reference values as regards sludge, and it was judged that said comparative compositions could not be used as suitable electrical insulating oil compositions.

TABLE 11

		IEC Standard 296, Class II criteria Standard reference values	Ex. 1	Ex. 2
Antioxidant		not detected	not detected	not detected
Kin. Viscosity (mm^2/s)	40°C	≤ 11.0	10.06	10.73
	-30°C	≤ 1800	1571	1389
Flash point (PMCC)	°C	≥ 130	136	138
Pour point	°C	≤ -45	< -50	< -50
Appearance		clear	clear	clear
Density (20°C)	g/cm^3	≤ 0.895	0.8885	0.8890
Surface tension (25°C)	mN/m	≥ 40	46	46
Acid value	mg KOH/g	≤ 0.03	0.00	0.00
Corrosive sulphur	140°C x 19 hrs	non-corrosive	non-corrosive	non-corrosive
Water content (KF)	mg/kg	≤ 30	10	10
Dielectric loss tangent (90°C)		≤ 0.005	0.0031	0.0028
Oxidation test 100°C x 168 hrs (IEC method 61125A)	sludge (wit.%)	≤ 0.10	0.04	0.04
	acid value (mg KOH/g)	≤ 0.40	0.17	0.15
Insulation breakdown voltage (VDE electrode)	kV	≥ 30	80	80

TABLE 12

		IEC Standard 60296, Type U criteria Standard reference values	Ex. 1	Ex. 2	Ex. 6	Ex. 7
Antioxidant		not detected	not detected	not detected	not detected	not detected
Kin. viscosity (mm^2/s)	40°C	≤ 12	10.06	10.73	11.7	11.8
	-30°C	≤ 1800	1571	1389	1413	1307
Flash point (PMCC)	°C	≥ 135	136	138	145	143
Pour point	°C	≤ -40	< -50	< -50	-45	< -50
Appearance		clear	clear	clear	clear	clear
Density (20°C)	g/cm^3	≤ 0.895	0.8885	0.8890	0.8787	0.8796
Surface tension (25°C)	mN/m	≥ 40	46	46	46	46

(continued)

		IEC Standard 60296, Type U criteria Standard reference values	Ex. 1	Ex. 2	Ex. 6	Ex. 7
Acid value	mg KOH/g	≤ 0.01	0.00	0.00	0.00	0.00
Corrosive sulphur	140°C x 19 hrs	non-corrosive	non-corrosive	non-corrosive	non-corrosive	non-corrosive
Water content (KF)	mg/kg	≤ 30	10	10	10	10
Dielectric loss tangent (90°C)		≤ 0.005	0.0031	0.0028	0.0029	0.0027
Oxidation test 120°C x 164 hrs (IEC method 61125C)	Sludge (wt. %)	≤ 0.8	0.27	0.25	0.25	0.22
	acid value (mg KOH/g)	≤ 1.2	0.39	0.39	0.38	0.35
	Dielectric loss tangent (90°C)	≤ 0.500	0.180	0.184	0.170	0.175
PCA content	wt.%	≤ 3	2.5	2.4	2.3	2.3
Insulation breakdown voltage (VDE electrode)	kV	≥ 30	80	80	80	80

TABLE 13

		IEC Standard 296, Class II criteria Standard reference values	Ex. 3	Ex. 4	Ex. 5
Antioxidant'		not detected	not detected	not detected	not detected
Density (20°C)	g/cm^3	≤ 0.895	0.8877	0.8941	0.8942
Oxidation test 100°C x 168 hrs (IEC method 61125A)	acid value (mg KOH/g)	≤ 0.40	0.15	0.18	0.17
	sludge (wt.%)	≤ 0.10	0.08	0.06	0.04

TABLE 14

		IEC Standard 60296, Type I criteria Standard reference values	Ex. 8	Ex. 9
Antioxidant		0.08 - 0.4 wt.%	0.1 wt.%	0.1 wit.%

(continued)

		IEC Standard 60296, Type I criteria Standard reference values	Ex. 8	Ex. 9
Kin. viscosity (mm^2/s)	40°C	≤ 12	10.04	10.68
	-30°C	≤ 1800	1580	1385
Flash point (PMCC)	°C	≥ 135	135	140
Pour point	°C	≤ -40°C	< -50	< -50
Appearance		clear	clear	clear
Density (20°C)	g/Cm^3	≤ 0.895	0.8885	0.8890
Surface tension	25°C	≥ 40	46	46
Acid value	mg KOH/g	≤ 0.01	0.001	0.001
Corrosive sulphur	140°C x 19 hrs	non-corrosive	non-corrosive	non-corrosive
Water content (KF)	mg/kg	≤ 30	10	10
Dielectric loss tangent (90°C)		≤ 0.005	0.0016	0.0009
Oxidation test 120°C x 500 hrs (IEC method 61125C)	sludge (wit.%)	≤ 0.8	0.52	0.47
	acid value (mg KOH/g)	≤ 1.2	0.52	0.49
	Dielectric loss tangent (90°C)	≤ 0.500	0.245	0.117
PCA content	wt.%	≤ 3	2.5	2.4
Insulation breakdown voltage (VDE electrode)	kV	≥ 30	80	80

TABLE 15

		IEC Standard 60296, Type T criteria Standard reference values	Ex. 10	Ex. 11
Antioxidant		0.01 - 0.08 wt.%	0.05 wt.%	0.05 wt.%
Kin. viscosity (mm^2/s)	40°C	≤ 12	10.13	10.77
	-30°C	≤ 1800	1692	1405
Flash point (PMCC)	°C	≥ 135	135	140
Pour point	°C	≤ -40	< -50	< -50
Appearance		clear	clear	clear
Density (20°C)	g/cm^3	≤ 0.895	0.8887	0.8892
Surface tension	25°C	≥ 40	46	46
Acid value	mg KOH/g	≤ 0.01	0.001	0.001
Corrosive sulphur	140°C x 19 hrs	non-corrosive	non-corrosive	non-corrosive
Water content (KF)	mg\kg	≤ 30	10	10
Dielectric loss tangent 90°C		≤ 0.005	0.0016	0.0009

(continued)

		IEC Standard 60296, Type T criteria Standard reference values	Ex. 10	Ex. 11
Oxidation test 120°C x 332 hrs (IEC method 61125C)	Sludge (wt.%)	≤ 0.8	0.43	0.44
	acid value (mg KOH/g)	≤ 1.2	0.47	0.45
	Dielectric loss tangent 90°C	≤ 0.500	0.215	0.160
PCA content	wt.%	≤ 3	2.5	2.4
Insulation breakdown voltage (VDE electrode)	kV	≥ 30	80	80

TABLE 16

Property		IEC Standard 296, Class II criteria Standard reference values	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5
Oxidation test 100°C x 168 hrs (61125A method)	sludge (wt. %)	≤ 0.10	8.58	1.62	1.63	7.96	8.86
	acid value (mg KOH/g)	≤ 0.40	17.21	1.41	0.92	12.09	11.40

TABLE 17

Property		IEC Standard 296, Class II criteria Standard reference values	Comp. Ex. 6	Comp. Ex. 7	Comp. Ex. 8	Comp. Ex. 9	Comp. Ex. 10
Oxidation test 100°C x 168 hrs (61125A method)	sludge (wt. %)	≤ 0.10	5.95	6.84	5.67	1.35	0.28
	acid value (mg KOH/g)	≤ 0.40	6.77	8.73	7.19	0.81	0.14

TABLE 18

Property		IEC Standard 296, Class II criteria Standard reference values	Comp. Ex. 11	Comp. Ex. 12	Comp. Ex. 13	Comp. Ex. 14	Comp. Ex. 15
Oxidation test 100°C x 168 hrs (61125A method)	sludge (wit. %)	≤ 0.10	0.31	0.30	0.24	0.43	1.57
	acid value (mg KOH/g)	≤ 0.40	0.12	0.13	0.15	0.14	1.01

Claims

1. An electrical insulating oil composition having a flash point (PMCC) of 130°C or more and a pour point of -45°C or lower, which composition comprises hydrorefined mineral oil and/or synthetic hydrocarbon oil and in the range of from 0.5 to 10 wt.% of bright stock oil, based on the total weight of the electrical insulating oil composition.

2. Electrical insulating oil composition according to Claim 1, wherein said composition has a flash point (PMCC) of 135°C or more.

3. Electrical insulating oil composition according to Claim 1 or 2, wherein said composition comprises in the range of from 0.01 to 0.4 wt.% of phenolic antioxidant, based on the total weight of the electrical insulating oil composition.

4. Electrical insulating oil composition according to any one of Claims 1 to 3, wherein said composition comprises in the range of from 0.01 to 0.08 wt.% of phenolic antioxidant, based on the total weight of the electrical insulating oil composition.

5. Electrical insulating oil composition according to any one of Claims 1 to 3, wherein said composition comprises in the range of from 0.08 to 0.4 wt.% of phenolic antioxidant, based on the total weight of the electrical insulating oil composition.

6. Electrical insulating oil composition according to any of Claims 1 to 5, wherein the hydrorefined mineral oil has a kinematic viscosity in the range of from 8.0 to 24 mm^2/s at 40°C and is selected from a hydrorefined naphthenic mineral oil and/or an API base oil classification Group II or Group III hydrorefined paraffinic mineral oil.

7. Electrical insulating oil composition according to any one of Claims 1 to 6, wherein the synthetic hydrocarbon oil has a kinematic viscosity in the range of from 8.0 to 24 mm^2/s at 40°C and is selected from an isoparaffinic synthetic oil, a GTL Synthetic oil, a poly-α-olefin (PAO) belonging to API base oil classification Group IV or a mixture thereof.

8. Electrical insulating oil composition according to any one of Claims 1 to 7, wherein the bright stock oil is a heavy mineral oil base oil fraction obtained by reduced pressure distillation of the residual paraffinic mineral oil from atmospheric distillation of crude oil, and deasphalting, solvent extraction and solvent dewaxing treatment of the residual oil obtained.

9. electrical insulating oil composition according to any one of Claims 1 to 8, which composition conforms to one or more of the following Standards:- IEC (International Electrotechnical Commission) Standard 2.96 (Class II), IEC Standard 60296 (Type U), IEC Standard 60296 (Type I) and IEC Standard 60296 (Type T).

Patentansprüche

1. Elektrisch isolierende Ölzusammensetzung mit einem Flammpunkt (PMCC) von 130 °C oder mehr und einem

Stockpunkt von -45 °C oder niedriger, wobei die Zusammensetzung hydroraffiniertes Mineralöl und/oder synthetisches Kohlenwasserstofföl und im Bereich von 0,5 bis 10 Gew.-% helles Einsatzmaterialöl, bezogen auf das Gesamtgewicht der elektrisch isolierenden Ölzusammensetzung, umfasst.

2. Elektrisch isolierende Ölzusammensetzung gemäß Anspruch 1, wobei die Zusammensetzung einen Flammpunkt (PMCC) von 135 °C oder mehr aufweist.

3. Elektrisch isolierende Ölzusammensetzung gemäß einem der Ansprüche 1 oder 2, wobei die Zusammensetzung im Bereich von 0,01 bis 0,4 Gew.-% phenolisches Antioxidans, bezogen auf das Gesamtgewicht der elektrisch isolierenden Ölzusammensetzung, umfasst.

4. Elektrisch isolierende Ölzusammensetzung gemäß einem der Ansprüche 1 bis 3, wobei die Zusammensetzung im Bereich von 0,01 bis 0,08 Gew.-% phenolisches Antioxidans, bezogen auf das Gesamtgewicht der elektrisch isolierenden Ölzusammensetzung, umfasst.

5. Elektrisch isolierende Ölzusammensetzung gemäß einem der Ansprüche 1 bis 3, wobei die Zusammensetzung im Bereich von 0,08 bis 0,4 Gew.-% phenolisches Antioxidans, bezogen auf das Gesamtgewicht der elektrisch isolierenden Ölzusammensetzung, umfasst.

6. Elektrisch isolierende Ölzusammensetzung gemäß einem der Ansprüche 1 bis 5, wobei das hydroraffinierte Mineralöl eine kinematische Viskosität im Bereich von 8,0 bis 24 mm^2/s bei 40°C besitzt und aus einem hydroraffinierten naphthenischen Mineralöl und/oder einem API-Basisöl der Klassifizierungsgruppe II oder hydroraffinierten paraffinischen Mineralöl der Gruppe III gewählt ist.

7. Elektrisch isolierende Ölzusammensetzung gemäß einem der Ansprüche 1 bis 6, wobei das synthetische Kohlenwasserstofföl eine kinematische Viskosität im Bereich von 8,0 bis 24 mm^2/s bei 40°C besitzt und aus einem isoparaffinischen synthetischen Öl, einem synthetischen GTL-Öl, einem Poly-α-olefin (PAO), das zur API-Grundöl-Klassifizierungsgruppe IV gehört, oder einer Mischung davon gewählt ist.

8. Elektrisch isolierende Ölzusammensetzung gemäß einem der Ansprüche 1 bis 7, wobei das helle Einsatzmaterialöl eine schwere Mineralöl-Grundölfraktion ist, erhalten durch Destillation unter reduziertem Druck des restlichen paraffinischen Mineralöls aus der atmosphärischen Destillation von Rohöl und Entasphaltierung, Lösungsmittelextraktion und Lösungsmittel-Entwachsungsbehandlung des erhaltenen Restöls.

9. Elektrisch isolierende Ölzusammensetzung gemäß einem der Ansprüche 1 bis 8, wobei die Zusammensetzung einem oder mehreren der nachstehenden Standards entspricht: - IEC (International Electrochemical Commission) Standard 296 (Klasse II), IEC Standard 60296 (Typ U), IEC Standard 60296 (Typ I) und IEC Standard 60296 (Typ T).

Revendications

1. Composition d'huile électriquement isolante ayant un point éclair (PMCC) de 130 °C ou plus et un point d'écoulement de -45 °C ou moins, la composition comprenant une huile minérale hydroraffinée et/ou une huile d'hydrocarbure de synthèse et dans la plage de 0,5 à 10 % en poids d'huile bright stock, par rapport au poids total de la composition d'huile électriquement isolante.

2. Composition d'huile électriquement isolante selon la revendication 1, dans laquelle ladite composition présente un point éclair (PMCC) de 135 °C ou plus.

3. Composition d'huile électriquement isolante selon la revendication 1 ou 2, dans laquelle ladite composition comprend dans la plage de 0,01 à 0,4 % en poids d'antioxydant phénolique, par rapport au poids total de la composition d'huile électriquement isolante.

4. Composition d'huile électriquement isolante selon l'une quelconque des revendications 1 à 3, dans laquelle ladite composition comprend dans la plage de 0,01 à 0,08 % en poids d'antioxydant phénolique, par rapport au poids total de la composition d'huile électriquement isolante.

5. Composition d'huile électriquement isolante selon l'une quelconque des revendications 1 à 3, dans laquelle ladite

composition comprend dans la plage de 0,08 à 0,4 % en poids d'antioxydant phénolique, par rapport au poids total de la composition d'huile électriquement isolante.

6. Composition d'huile électriquement isolante selon l'une quelconque des revendications 1 à 5, dans laquelle l'huile minérale hydroraffinée présente une viscosité cinématique dans la plage de 8,0 à 24 mm^2/s à 40 °C et est choisie parmi une huile minérale naphténique hydroraffinée et/ou une huile minérale paraffinique hydroraffinée du groupe II ou du groupe III de la classification des huiles de base API.

7. Composition d'huile électriquement isolante selon l'une quelconque des revendications 1 à 6, dans laquelle l'huile d'hydrocarbure de synthèse a une viscosité cinématique dans la plage de 8,0 à 24 mm^2/s à 40 °C et est choisie parmi une huile de synthèse isoparaffinique, une huile de synthèse GTL, une poly-α-oléfine (PAO) appartenant au groupe IV de la classification des huiles de base API ou un mélange de celles-ci.

8. Composition d'huile électriquement isolante selon l'une quelconque des revendications 1 à 7, dans laquelle l'huile bright stock est une fraction d'huile de base d'huile minérale lourde obtenue par distillation à pression réduite de l'huile minérale paraffinique résiduelle de la distillation atmosphérique de pétrole brut, et le désasphaltage, l'extraction de solvant et le traitement de déparaffinage au solvant de l'huile résiduelle obtenue.

9. Composition d'huile électriquement isolante selon l'une quelconque des revendications 1 à 8, la composition étant conforme à une ou plusieurs des normes suivantes : norme IEC (International Electrotechnical Commission) 296 (classe II), norme IEC 60296 (type U), norme IEC 60293 (type I) et norme IEC 60296 (type T).

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2000345177 A **[0006]**
- JP 52072706 A **[0017]**
- JP 7228876 A **[0017]**