

A Functional Fluid

This invention concerns a functional fluid, preferably a gear oil, that is compatible with water-based functional fluids used in metalworking operations.

Functional fluids are primarily used to prevent metal-to-metal contact between moving metal parts. Functional fluids also act by reducing friction and protecting against corrosion, thereby increasing the working life of the metal parts.

Functional fluids such as gear oils are used in, for example, worm gear boxes as transmission fluids in cars and in machine presses that deform metal sheets, such as tin coated steel or aluminium sheets, to produce deformed components such as metal cans. Known gear oils that are currently used in the deformation of steel or aluminium are based on mineral oils. Although mineral oil fluids are good gear oils, they contaminate water based functional fluids that are also used in the production of the metal cans. Also, residues from the gear oil can remain on the cans, which then need to be removed by, for example, expensive, high energy cleaning processes, before the cans can be finished with, for example, lacquers or paints. The mineral oils can also contaminate the cleaning fluids used in the cleaning processes, which means that the cleaning fluids need to be disposed of by following environmental guidelines and regulations. This can be costly and time-consuming.

As mentioned above, water based functional fluids are also used in the production of cans. The water based functional fluids can include, for example, deformation fluids that are used primarily to provide lubricity during deformation of the tin coated

steel or aluminium. The deformation fluid also protects against corrosion and bacterial and fungal infestation. The deformation fluid can be used as both a 'prelube' to coat the metal steel prior to deformation and a lubricant and coolant during the deformation process. The deformation fluid does not include any mineral oil.

One aim of the present invention is to provide an improved functional fluid.

A further aim of the present invention is to be able to produce a can in a can-forming process that is sufficiently clean (i.e. sufficiently free from mineral oil residue) that cleaning processes such as high energy cleaning processes are not required before the can is lacquered or painted.

A further aim of the present invention is to provide a functional fluid such as a gear oil that is compatible with water based functional fluids that are also used in metal working operations.

A further aim of the present invention is to provide a functional fluid that does not cause as much contamination as functional fluids based on mineral oils.

A further aim of the present invention is to provide a functional fluid that exhibits improved corrosion inhibition.

A further aim of the present invention is to provide a functional fluid that exhibits improved anti-wear properties.

A further aim of the present invention is to provide a synthetic functional fluid that exhibits improved compatibility with water based functional fluids.

In accordance with the present invention there is provided a functional fluid comprising a water soluble polyalkylene glycol.

In accordance with the present invention there is also provided use of a water soluble, functional fluid comprising polyalkylene glycol, in a metal forming operation that uses water based functional fluids.

The functional fluid preferably also comprises an alkyl phosphate acid ester. The alkyl phosphate acid ester is preferably non-amine neutralised.

The polyalkylene glycol preferably has a molecular weight of less than 2,900, more preferably less than 2,000.

The functional fluid is preferably a metal working functional fluid, more preferably a gear oil. The functional fluid may also be a machine slideway lubricant or hydraulic fluid.

The non-amine neutralised, alkyl phosphate acid ester preferably comprises from 1 to 18, preferably from 5 to 9, more preferably 5 to 7, carbon atoms. The non-amine neutralised, alkyl phosphate acid ester preferably comprises a high proportion,

preferably greater than 70%, of linear chains of carbon atoms. The non-amine neutralised, alkyl phosphate acid ester can also be:

- (i) a mono-alkyl phosphate acid ester;
- (ii) a di-alkyl phosphate acid ester;
- (iii) a mixture of mono- and di-alkyl phosphate acid esters; and
- (iv) a mixture of (i), (ii) and (iii) listed above.

The non-amine neutralised, alkyl phosphate acid ester can comprise free phosphoric acid and precursors.

The non-amine neutralised, alkyl phosphate acid ester is preferably a pentyl, hexyl, heptyl, octyl or nonyl phosphate acid ester or a mixture thereof. Preferably the alkyl phosphate acid ester predominantly contains pentyl or heptyl phosphate acid esters or a mixture thereof. By the term 'predominantly', we mean greater than 50%, preferably greater than 60%, more preferably greater than 70%, even more preferably greater than 80% and most preferably greater than 90%, by total weight of alkyl phosphate acid ester. The non-amine neutralised, alkyl phosphate acid ester can be a mixture of mono- and di-alkyl phosphate acid esters.

If the functional fluid of the present invention leaves residues on deformed components in metal working operations, the residues can be easily removed using a reduced energy cleaning process such as a hot or cold water wash, which is cheap and convenient to use when compared to high energy alkali cleaning processes.

The non-amine neutralised, alkyl phosphate acid ester is available from, for example, Elf Atochem, Albright and Wilson and Bayer.

The polyalkylene glycol will usually have a viscosity at 40°C within the range of 20 to 10,000 centistokes and a viscosity at 100°C within the range of 3 to 2,000 centistokes.

The polyalkylene glycol may be based on the reaction product of a 1,2-oxide (vicinal epoxide) with water, alcohol or aliphatic polyhydric alcohol containing from 2 to 6 hydroxyl groups and from 2 to 8 carbon atoms per molecule.

The polyalkylene glycol is available from Inspec ('BREOX') and Dow Chemicals ('SYNALOX').

The functional fluid may also comprise the following usual additives: extreme pressure agents; anti-foaming additives; anti-wear additives; corrosion inhibitor additives; anti-oxidants; metal passivators; and vapour phase corrosion inhibitors.

Functional fluids comprising water soluble polyalkylene glycols exhibit surface active properties. This presents the formulator with a challenge to provide the same level of corrosion inhibition, anti-wear and extreme pressure properties as obtained with mineral, ester and polyalphaolefin based lubricants.

The functional fluid of the present invention preferably comprises:

from 0.10 to 99.00%, more preferably 70 to 99%, of polyalkylene glycol;

from 0.01 to 5.00%, more preferably 0.10 to 1.00%, of phenolic antioxidant;
from 0.01 to 5.00%, more preferably 0.10 to 1.00%, of aminic antioxidant;
from 0.01 to 1.00% of benzotriazole;
from 0.005 to 1.00%, more preferably 0.005 to 0.5% of antifoam;
from 0.00 to 5.00%, more preferably 0.1 to 1.0%, of polysulphide; and
from 0.01 to 5.0%, more preferably 0.15 to 1.0%, of alkyl phosphate acid ester.

The functional fluid exhibits compatibility with aqueous based metalworking fluids without affecting their function.

The functional fluid should contain no mineral oil. However, the functional fluid may contain insignificant amounts of mineral oil. Therefore, contamination of metal working fluids with mineral oil, or significant amounts of mineral oil, is avoided, and expensive and time-consuming cleaning processes are not required.

The present invention will now be described with reference to the following examples:

Example

Formulation

The following formulations were prepared:

Additive Type	Trade Mark (Brand Name)	Supplier	Example 1	Example 2
Polyalkylene glycol	Breox Synalox	Inspec Dow Chemicals	98.86%	99.26%

Phenolic antioxidant	BHT Irganox L135 Hitec 4702	Bayer Ciba Additives Ethyl Petroleum Additives	0.30%	0.30%
Aminic antioxidant	Irganox L57 Vanlube 81 Additin RC 7001	Ciba Additives KKGreeff Rhein Chemie	0.10%	0.10%
Benzotriazole	Irgamet BTA-m Preventol CI 8-100	Ciba Additives Bayer	0.03%	0.03%
Antifoam	Mobilad C402	Mobil	0.01	0.01
Alkyl phosphate acid ester	alkyl acid phosphates e.g. Albrite amyl acid phosphate, Albrite heptyl acid phosphate, Albrite hexyl acid phosphate and Albright octyl acid phosphate	Albright and Wilson/ Elfatochem/	0.35%	0.35%
Polysulphide	Additin RC 2540	Rhein Chemie	0.40%	-

Method

The polyalkylene glycol based fluid was placed into a blending vessel and the benzotriazole, antioxidant, polysulphide, antifoam and alkyl phosphate were added. The mixture was heated, while mixing, to between 45°C and 50°C to dissolve the benzotriazole and butylated hydroxy toluene (BHT). The mixture was then mixed until the product was homogeneous, clear and bright.

The functional fluid prepared above may be prepared with, for example, the following viscosity grades: 150cSt, 220cSt, 320cSt and 460cSt.

The functional fluid prepared in the above example had a viscosity grade of 150cSt.

Tests

The following tests were conducted on the functional fluids prepared above.

Corrosion Test

The steel pin corrosion test was carried out in accordance with ASTM D-665B (10% synthetic sea water at 60°C for 24 hours). Examples 1 and 2 gave no rust at 0.35% of alkyl phosphate acid ester. This level of corrosion protection is usually difficult to achieve with polyalkylene glycol based fluid due to surface activity and competition for the metal surface with corrosion inhibitors and antiwear additives.

The steel pin corrosion test was carried out in accordance with ASTM D-665A (10% deionised water at 60°C for 24 hours). Examples 1 and 2 gave no rust at 0.35% of alkyl phosphate acid ester. This level of corrosion protection is normally achievable with polyalkylene glycol base fluids.

The steel pin corrosion test was carried out in accordance with the ASTM D-665 method with the 10% deionised water or synthetic sea water being replaced with 10% of a 5% solution of a metalworking fluid. The metalworking fluid was CASTROL SYNTILO GX, which is available from Castrol Limited. Further examples were carried out using Iloform PS 300 and PS 301, which are also available from

Castrol Limited. Examples 1 and 2 gave no rust when contaminated with these synthetic non-mineral oil-containing, water based metalworking fluids.

The advantage of using Iloform PS 300 or Iloform PS 301 is that the metalworking fluid uses the same type of basefluid as in the gear oil. Contamination of the gear oil by the Iloform PS 300 or PS 301 maximises fluid function and minimises stability problems because:

- (a) the functional fluids in examples 1 and 2 maintain corrosion protection when contaminated with Iloform PS 300 or PS 301; and
- (b) contamination of the Iloform PS 300 or PS 301 by up to 1.5% of the functional fluids in examples 1 and 2 does not affect, for example, the pH, corrosion protection or stability of the metalworking fluid.

Load Carrying and Antiwear Tests

Timken OK load test was carried out in accordance with ASTM D-2782. Example 1 gave a load carrying OK load of >90 pounds and when contaminated with 5% Iloform PS 300 the OK load was 60 pounds. Example 2 gave an OK load of 45 pounds and, when contaminated with 0.5% Iloform PS 300, the OK load was not affected.

Four Ball Test

This test was carried out in accordance with ASTM D-2783 and D-2266. The results are as follows:

	Weld point, Kg	Load wear index	Scar diameter, mm 20kg/1800rpm/1hr
Example 1	270	81.7	0.23

Example 2	260	63.12	0.34
Limit US steel 244	250 minimum	45 minimum	0.35 maximum

Examples 1 and 2 demonstrate that these formulations have the highest level of performance as gear oils.

FZG Test

This test was carried out in accordance with test method CEC L-07-A-95. A load was applied to the gear teeth in stages and the level of wear was assessed.

	FZG A/8.3/90 fail stage	FZG A/8.3/90 weight loss mg/kwhr
Example 1	>12	0
Example 2	>12	0.14
Limit	12 min	0.27 max

Examples 1 and 2 demonstrated the highest level of performance required by German SEB 181,226, DIN 51354T.2 and Ford U-MC002-8008 specifications.

Oxidation Test

This test was carried out in accordance with ASTM D-2893. Ten litres of dry air each hour for 312 hours at temperatures of 95°C and 121°C were used to demonstrate the excellent thermal stability. Example 1 was tested for 624 hours at 95°C.

At 95°C	Example 1, 312 hours	Example 1, 624 hours	Example 2, 312 hours	Limit
Viscosity change, %	0	1.4	0	7 maximum
Precipitate, mg	0	0	0	0.1 maximum

At 121°C	Example 1, 312 hours	Limit
Viscosity change, %	3.1	7 maximum
Precipitate, mg	0	0.1 maximum

Examples 1 and 2 exhibited excellent thermal stability.

Foam Test

This test was carried out in accordance with ASTM D-892 and a procedure devised by a company called Flender, details of which can be found in test method A25/Fo/Bg, available from Castrol Limited.

The functional fluid prepared above gave the following results:

Fluid	ASTM D-892 ml/ml@sec	Flender, volume increase after 1 minute, %	Limit AGMA 250.04	Flender
Sequence I at 24°C	0/0	-	75/10	-
Sequence II at 93°C	0/0-	-	75/10-	-
Sequence III at 24°C	0/0	-	75/10	-
Volume increase, %	-	7	-	Satisfactory pass=5-15%

The following measurements were also made:

<u>Test</u>	<u>Test Method</u>	<u>Example 1</u>	<u>Example 2</u>	<u>Limit</u>
Viscosity @ 40°C, cSt	ASTM D445	150	150	135 to 165
Viscosity @ 100°C, cSt	ASTM D-445	29	29	-
VI	ASTM D-445	233	233	-

Flash point, °C (PMC)	ASTM D-93	192	192	-
Flash point, °C (COC)	ASTM D92	252	252	200 min
Air release @ 90°C, mins	IP313	7.1	7.1	9 max
Pour point, °C	ASTM D-97	-33	-33	-9 max

Thermal Stability,

0°C and 50 °C cycles

stable

stable stable

Copper corrosion

@100°C/3 hrs

ASTM D130

class1

class 1 class 2 max

Shear stability,

viscosity loss

DIN 51382

@250 cycle/100°C, %

6.8

-

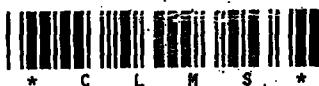
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Claims

1. A functional fluid comprising a water soluble, polyalkylene glycol.
2. The functional fluid claimed in claim 1, wherein the polyalkylene glycol is present in an amount from 0.1 to 99.0%, preferably from 70 to 99%, by total mass of the functional fluid.
3. The functional fluid as claimed in claims 1 or 2, wherein the functional fluid also comprises an alkyl phosphate acid ester.
4. The functional fluid as claimed in claim 3, wherein the alkyl phosphate acid ester is present in an amount from 0.01 to 5.0%, preferably from 0.15 to 1.0%, by total mass of the functional fluid.
5. The functional fluid as claimed in claims 3 or 4, wherein the alkyl phosphate acid ester is non-amine neutralised.
6. The functional fluid as claimed in any one of the preceding claims, wherein the polyalkylene glycol has a molecular weight of less than 2,900, preferably less than 2,000.
7. The functional fluid as claimed in any one of claims 3-6, wherein the alkyl phosphate acid ester comprises from 1 to 18, preferably from 5 to 7, carbon atoms.

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8. The functional fluid as claimed in any one of claims 3-7, wherein the alkyl phosphate acid ester comprises a high proportion, preferably greater than 70%, of linear chains of carbon atoms.
9. The functional fluid as claimed in any one of claims 3-8, wherein the alkyl phosphate acid ester is selected from one of the following groups:
- (i) a mono-alkyl phosphate acid ester;
 - (ii) a di-alkyl phosphate acid ester;
 - (iii) a mixture of mono- and di-alkyl phosphate acid esters; and
 - (iv) a mixture of (i), (ii) and (iii) listed above.
10. The functional fluid as claimed in any one of claims 3-9, wherein the alkyl phosphate acid ester is a pentyl, hexyl, heptyl, octyl or nonyl phosphate acid ester or a mixture thereof; preferably the alkyl phosphate acid ester is predominantly a pentyl or heptyl phosphate acid ester or a mixture thereof.
11. The functional fluid as claimed in claim 10, wherein the alkyl phosphate acid ester is a mixture of mono- and di-alkyl phosphate acid esters.
12. The functional fluid as claimed in any one of the preceding claims, wherein the polyalkylene glycol has a viscosity at 40°C within the range of 20 to 10,000 centistokes, and a viscosity at 100°C within the range of 3 to 2,000 centistokes.
13. The functional fluid as claimed in any one of the preceding claims, wherein the polyalkylene glycol is based on the reaction product of a 1,2-oxide (vicinal

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epoxide) with water, alcohol or aliphatic polyhydric alcohol containing from 2 to 6 hydroxyl groups and from 2 to 8 carbon atoms per molecule.

14. The functional fluid as claimed in any one of the preceding claims, the functional fluid comprising:

from 0.10 to 99.00%, more preferably 70 to 99%, of the polyalkylene glycol defined in any one of the preceding claims;

from 0.01 to 5.00%, more preferably 0.10 to 1.00%, of phenolic antioxidant;

from 0.01 to 5.00%, more preferably 0.10 to 1.00%, of aminic antioxidant;

from 0.01 to 1.00% of benzotriazole;

from 0.005 to 1.00%, more preferably 0.005 to 0.5% of antifoam;

from 0.00 to 5.00%, more preferably 0.1 to 1.0%, of polysulphide; and

from 0.01 to 2.0%, more preferably 0.15 to 1.0%, of the alkyl phosphate acid ester defined in any one of the claims 3-13.

15. The functional fluid as claimed in any one of the preceding claims, wherein the functional fluid is a machine tool lubricant such as a gear oil, a hydraulic fluid or a slideway lubricant.

16. The functional fluid as claimed in any one of the preceding claims, wherein the fluid is free from significant amounts of mineral oil; the fluid preferably being free from mineral oil.

17. Use of a functional fluid comprising polyalkylene glycol, in a metal forming operation that uses water based, functional fluids.





18. Use of the functional fluid claimed in any one of claims 1-16 as a fluid exhibiting compatibility with a water based, metalworking fluid comprising the same or different polyalkylene glycol base fluid.

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