NAPHTHENIC BASE OILS FOR HIGH PERFORMANCE, HIGH VISCOSITY INDEX HYDRAULIC FLUIDS APPLICATIONS

TRACK OR CATEGORY

Synthetics & Hydraulic Fluids III

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INTRODUCTION

In this follow-up of last year's STLE paper, we show how Naphthenic speciality wax-free base oils bring value to Hydraulic fluid formulations for low temperature application in aviation and mobile applications. Wax-free NSP are a good starting point, as the low viscosity naphthenic base oils have pour point and kinematic viscosity rivalled only by PAO, but brings much higher solvency, supporting high VI Improver additive treat rate, and are available at a small fraction of the cost of other base fluids. Typical aviation hydraulic fluid formulations would have a low starting base oil viscosity, e.g. a KV @ -54 °C of 400 cSt, combined with high treat rates of VII yielding final fluid VI in the range of 250 to 400, and with a KV @ -54 °C of less than 3000 cSt, meeting e.g. British Defence Standard 91-48/2. Other outdoor and mobile hydraulic applications utilize VG 15, 22 and 32, which in a similar fashion can be made from low viscosity base oils and appropriate VI Improvers. A range comprising 15 model hydraulic fluids of VG 15, 22 and 32 have been prepared and studied. The results for kinematic viscosity, foaming tendency, air release and demulsibility are discussed and formulation guidelines developed.

HIGH VI HYDRAULIC FLUID STUDY

In this study, we prepared model hydraulic fluids in three viscosity grades: HVLP 15, HVLP 22 and HVLP 32. Three commercially available VI Improvers were utilized, and one ZDDP-containing additive package. Three different ultra-low viscosity naphthenic base oils, and two low to mid viscosity naphthenic base oils were utilized as base fluids, Table 1.

Table 1. Five different Naphthenic base fluids utilized in this study.

	T 3	NS 3	S3B	T9	BT 12
KV, 40 °C (cSt)	3.7	2.8	2.9	9.0	12.5
KV, 100 °C (cSt)	1.3	n/a	1.2	2.2	2.7
PP (°C)	<-70	<-70	<-70	-57	-51
FP (°C) (PM)	104	94	105	144	154

Model Hydraulic Fluids VG 15

The typical properties of the five different VG 15 model fluids prepared using Viscoplex 7-300 as VI Improver are given in Table 2.

Table 2. Five model fluids in the VG 15 range. T3, NS 3 and S3B are 3 cSt base oils, T 9 is a 9 cSt base oil and VG12 is based on BT 12, a Naphthenic blend.

Blend code	% Base oil	% VP 7-300	% Lz 5703	KV 40 °C	KV 100 °C	VI	PP	FP
T3HF15	86,1	13,1	0,86	**15,0**	5,31	**348**	-72	**104**
NS3HF15	83,3	15,9	0,86	**14,4**	5,59	**406**	-72	**90**
S3HF15	83,1	16,0	0,85	**14,8**	5,74	**405**	-72	**100**
T9HF15	94,4	4,8	0,85	**15,1**	3,85	**156**	-60	**145**
VG12HF15	97,8	2,	0,83	**15,4**	3,45	**96**	-54	**150**

Starting from a low viscosity, more VI Improver is employed (13-16%), and the resulting product VI is very high, in the range of 350 to 400. The Pour Point (ASTM D 97) and the Flash Point (ASTM D 93, Penske-Martin) are also given in Table 2. The low temperature kinematic viscosity (KV) was determined, at a range of temperatures, from – 30 °C to – 54 °C.

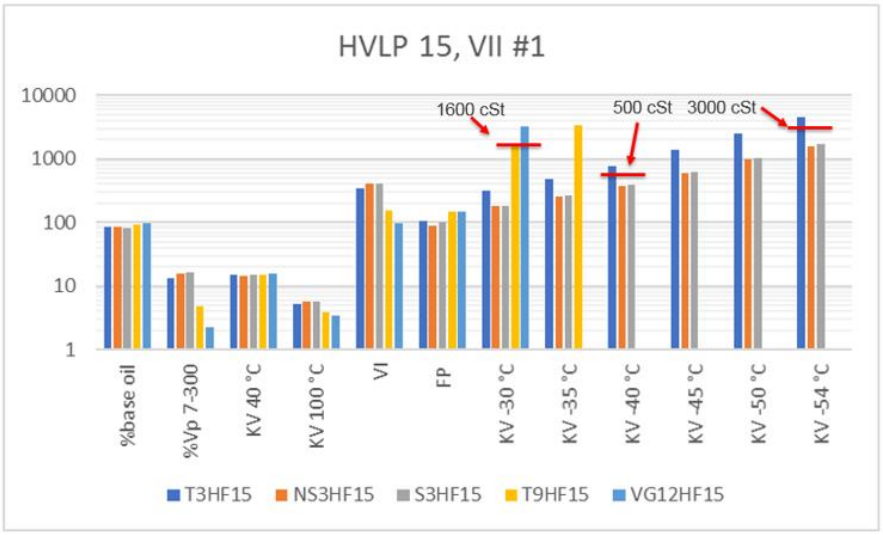

Figure 1. Low temperature properties of the model hydraulic fluids. Viscoplex 7-300 and five different low viscosity Naphthenic base oils.

Figure 1 shows the results for the HVLP 15 type model hydraulic fluid. Several of the model HVLP 15 formulations meet the requirements of relevant technical standards like the British defence Standard 91-48, see Table 3, or the Swedish Standard 15 54 34 [1], winter grade VG 15 terrestrial hydraulic fluids limit of 1600 cSt.

Table 3. Some of the requirements from British Defence Standard 91-48.

Kinematic Viscosity	Units	
at 100 °C at 40 °C at minus 40 °C at minus 54 °C	cSt cSt cSt cSt	Min 4.0 Min 13.0 Max 500 Max 3000
Flash Point (D 93)	°C	Min 81
Pour Point (D 97)	°C	Max minus 60

Physical properties
Important physical properties for hydraulic fluids are foaming tendency (ASTM D 892), air release properties (ASTM D 3427) and water separation or demulsibility (ASTM D 1401). The key issue to investigate is how the high VI Improver treat rate affect these other physical properties. The pure base fluid typically sometimes displays high, light foam, and very fast air release and demulsibility; the foam improves upon formulation and one of two of the latter usually deteriorate to some extent. In Table 4, results for two of the VG 15 fluids are given.

Table 4. Physical properties of the S3 B and NS 3-based formulations, ISO 111 58 maximum limits for reference.

Test	Unit	S3HF15	NS3HF15	ISO 111 58, HV	Method
Foam I @ 24 °C	ml/ml	60/0	50/0	150/0	ASTM D 892 ISO 6247:1998
Foam II @ 93 °C	ml/ml	40/0	30/0	80/0	ASTM D 892 ISO 6247:1998
Foam III @ 24 °C	ml/ml	60/0	50/0	150/0	ASTM D 892 ISO 6247:1998
Air Release	min	<1	<1	5	ASTM D 3427 ISO 9120
Demulsibility	min	10	10	30/20*	ASTM D 1401 ISO 6614
Oil/water/ emulsion	ml	40/40/0	40/40/0	40/37/3	ASTM D 1401 ISO 6614

These two model fluids display very good properties, with low foam, rapid air release and fast and complete demulsibility, despite having a VI Improver content of 16%.

Summary of test results for the VG 15 fluids
Three ultra-low viscosity base oils (NYNAS T 3, NS 3 and S 3 B), and two low viscosity base oils, NYNAS T 9 and BT 12 were utilized. The VI Improver Viscoplex 7-300 and a ZDDP-containing hydraulic fluid additive package, were utilized to make the model hydraulic fluids. Two HVLP 15 formulations, based on NS 3 and S 3B, meet British Defence Standard 91-48 for low temperature properties, i.e. the Pour Point and KV limits at – 40 °C and – 54 °C. Four out of five model hydraulic fluids meet the Swedish Standard 155434 VG 15 low temperature requirements.
The physical chemistry characterization shows low foam, fast air release and good demulsibility, which is a good starting point for formulations. This kind of hydraulic fluids serve many important purposes in aviation applications, and terrestrial hydraulics under winter conditions in arctic or high-altitude geographies..

REFERENCES
[1] Swedish Standard SS 15 54 34:2015, “Hydraulic Fluids – Technical requirements, environmental properties and test methods”

KEYWORDS

Base Stocks:Mineral Base Stocks, Lubricants:Hydraulic Fluids, Lubricant Physical Analysis:Low Temperature..