



INDUSTRIAL GEAR OIL MODELS BASED ON HIGH-VISCOSITY NAPHTHENIC BASE OILS AND VISCOSITY INDEX IMPROVERS

TRACK OR CATEGORY

Gears II

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INTRODUCTION

Naphthenic base oils for industrial lubricants offer benefits with regards to solvency and low temperature properties. Naphthenic base oils do not, however, on their own have the required Viscosity Index (VI) required in the common ISO VG grades for many industrial lubricants. In, for example, Industrial Gear Oil standards such as ISO 12925-1 and DIN 51517-3, a minimum viscosity index of 90 or 85 is required. Therefore, to be able to formulate gear oils, we have created a set of model base fluids meeting these Viscosity (KV) and Viscosity Index (VI) requirements. We made a range of ISO VG classes from NYNAS T 110, BT 150, T 400 and T 600 with the addition of Viscosity Index Improvers (VII), Viscosity Modifiers (VM) or high VI base fluids. We managed to meet KV and VI requirements for ISO VG 150, 220, 320, 460, 680 and 1000. We intend to share these results with formulators eager to explore the span of opportunities offered by Naphthenic base oils in industrial lubricant applications.

A MODEL GEAR OIL STUDY

On average, Industrial Gear Oils account for almost 3% of the global lubricants market. Total global consumption is expected to reach well over 1 million tonnes by 2020, with Naphthenic oils poised to increase their market share in this application.

Industrial gear oils are generally formulated with 95-98% of base oil. The other 2-5% often consists of an industrial gear oil additive package. A traditional Industrial Gear oil in the VG range 150 to 460 is typically formulated from paraffinic Bright Stock and SN 500/600 in different proportions according to the needs of the different Viscosity Grades.

For the upper viscosity grades, ISO VG 680, 1000 and 1500, Viscosity Modifiers (VM) like PIB, or Viscosity Index Improvers (VII:s) are employed to create viscosities above what can be reached using typical paraffinic Bright Stock (KV at 40 °C ca 500 cSt)

Naphthenic base oils for industrial lubricants offer benefits with regards to high additive solvency and low temperature properties. Naphthenic base oils do not, however, on their own have the required Viscosity Index (VI) required in the common ISO VG grades for many industrial lubricants. In, for example, Industrial Gear Oil standards such as ISO 12925-1 and DIN 51517-3, a minimum viscosity index of 90 or 85 is required.

Therefore, to be able to formulate gear oils based on Naphthenic specialty base oils, we have created a set of model base fluids meeting these Kinematic Viscosity (KV) and Viscosity Index (VI) requirements. We have shown that all ISO VG classes relevant for industrial gear oils indeed can be formulated from NYNAS T 110, BT 150, T 400 and T 600 with the addition of Viscosity Index Improvers (VII), Viscosity Modifiers (VM) or high VI base fluids.

We managed to meet KV and VI requirements for seven ISO VG classes: 150, 220, 320, 460, 680, 1000 and 1500 in at least one of the model base fluid formulations in each ISO VG class.

Five (5) different commercially available viscosity modifiers were successfully employed, Table 1. The required content of VII, VM or high VI base fluid needed in each model formulation varied from 7% to 43%, and the average treat rate level was around 10-15%.

Table 1. An overview of viscosity modifiers investigated.

VII or VM Name	Polymer or Fluid Type
#1 OPAG	PAG base fluid, liquid. Fatty alcohol poly-glycol ether. KV 90 cSt at 40 °C, VI 191.
#2 BIO	Complex ester, KV 40 000 cSt at 40 °C, VI 290
#3 PAMA	PAMA, liquid. Dissolved in highly refined mineral oil. (PSSI): 43. KV 30 000 cSt at 40 °C, VI 240.
#4 OCP	OCP, liquid. Ethylene/propylene co-oligomer. KV 37 500 cSt at 40 °C, VI 300.
#5 EEB	Synthetic base stock, KV 1000 cSt at 40 °C, VI 227.

Some examples of successful formulations are:

- NYNAS T 110 and #2 BIO, 12%, makes ISO VG 320
- NYNAS BT 150 and #3 PAMA, 12%, makes ISO VG 320
- NYNAS T 400 and #4 OCP; 11%, makes ISO VG 460
- NYNAS T 600 and #2 BIO, 15%, makes ISO VG 1500

Please see Table 2 for more examples

Table 2. Select model systems reaching the KV and VI of the ISO VG class indicated

Base Oil	Additive	Treat rate (%)	ISO VG
T 400	#1 OPAG	43	150
T 110	#3 PAMA	7	220
T 110	#2 BIO	12	320
BT 150	#3 PAMA	12	320
T 400	#4 OCP	11	460
T 400	#3 PAMA	10	680
T 600	#5 EEB	27	680
T 400	#2 BIO	15	1000
T 600	#2 BIO	15	1500

We thus can propose starting formulations for industrial gear oils, and other industrial lubricant and greases needing high base oil viscosity. A wide viscosity range, 150 to 1500 cSt, utilizing four different high viscosity Naphthenic base oils and five different VI Improvers representing different chemical compositions, have been made. We are now ready to share these results with formulator eager to explore the span of opportunities offered by Naphthenic base oils in industrial lubricant applications. Please contact your Nynas representative for further details and tips!

KEYWORDS

Base Stocks:Mineral Base Stocks, Additives:VI Improvers, Lubricant Physical Analysis:Viscosity-Temperature.