Calflo*AF

VS

Competitive Heat Transfer Fluids

A study of the oxidative and thermal stability of heat transfer fluids

*Trademark of Petro-Canada

Oxidative Stability Test

In this oxidative stability test (modified IP48*), glass tubes filled with thermal fluid were heated at 200 ± 0.1°C for 24 hours. Air was bubbled through each tube (15 ± 0.25 L/h) over this time period. Physical characteristics of the oxidized fluids were measured. Three tubes of each sample fluid were oxidized. Two were fully analyzed, the third was used for visual comparison.

*Oxidation time extended from 12 to 24 hrs to facilitate testing; 34 grams of sample used as equivalent to ~40mL.

Table 1: Fluid analysis

	Calflo AF	**A world leader in industrial lubricants**	**A specialty HTF competitor**
Evaporation loss, %	8.42 (13.05)[1]	25.54 (25.78)	5.54 (10.85)
Kinematic viscosity @ 40°C (unoxidized oil), cSt., ASTM D445	32.43 (32.29)	18.84 (18.88)	34.65 (34.37)
Kinematic viscosity @ 40°C (oxidized oil), cSt., ASTM D445	49.44 (72.36)	28.72 (31.20)	363.2 (506.64)
% viscosity increase	52.46 (124.0)	52.44 (65.28)	948.2 (1374)
TAN (oxidized oil), mg KOH/g, ASTM D664	3.99 (6.20)	3.16 (2.56)	16.94 (12.26)
Naphtha insoluble matter[2], wt%	0	1.023	6.886
Naphtha insoluble, $CHCl_3$ soluble matter[3], wt%	0	0.878	6.886

[1] Data in brackets correspond to measurements obtained under same test protocol at an independent laboratory.
[2] Determined by treating a sample of the oxidized fluid with naphtha, filtering and weighing the residue as per Petro-Canada Method 359-4.
[3] Determined by the subsequent washing of the naphtha insoluble matter with $CHCl_3$ as per PCM 359-4.

A single tube sample of each of the oxidized fluids was diluted with heptane and filtered. The separated solids were then air dried and weighed (Figure 1).

Figure 1. Residue remaining on filter paper (left to right): Calflo AF, A world leader in industrial lubricants, specialty heat transfer fluid competitor.

Table 2: Results of filtration

	Calflo AF	**A world leader in industrial lubricants**	**A specialty HTF competitor**
Weight of sample filtered (g)	26.9111	20.9843	14.0196
Weight of deposit (g)	0.0046	0.2956	1.1630
Heptane insolubles, wt%	0.017	1.409	8.296

Oxidative Stability Test

Table 3: A modified IP48 study (24 hours, 200°C, 15 L/hr air flow) conducted at an independent research facility.

	CALFLO AF			A world leader in industrial lubricants			A specialty heat transfer fluid competitor		
	A(1)	A(2)	**AVG.**	B(1)	B(2)	**AVG.**	C(1)	C(2)	**AVG.**
Evaporation loss, % (weight of fluid lost after oxidation/weight of fluid before oxidation x 100)	14.52	11.58	**13.05**	24.43	27.14	**25.78**	11.28	10.42	**10.85**
Kinematic Viscosity @ 40°C (unoxidized oil), cSt., ASTM D445	32.29	32.29	**32.29**	18.88	18.88	**18.88**	34.37	34.37	**34.37**
Kinematic Viscosity @ 40°C (oxidized oil), cSt., ASTM D445	69.66	75.05	**72.36**	30.33	32.08	**31.20**	577.58	435.71	**506.64**
Viscosity ratio (viscosity after oxidation/viscosity before oxidation)	2.16	2.32	**2.24**	1.61	1.70	**1.66**	16.80	12.68	**14.74**
Viscosity increase, % [(viscosity after oxidation – viscosity before oxidation) / viscosity before oxidation] x 100	115.7	132.4	**124.0**	60.65	69.92	**65.28**	1580	1168	**1374**
Ramsbottom Carbon residue (unoxidized oil), %wt, ASTM D524	0.06	0.06	**0.06**	0.05	0.05	**0.05**	0.06	0.06	**0.06**
Ramsbottom Carbon residue (oxidized oil), %wt, ASTM D524	0.44	0.51	**0.48**	1.04*	0.96*	**1.00**	2.46*	2.15*	**2.30**
Increase in carbon residue after oxidation, %wt (final – initial)	0.38	0.45	**0.42**	0.99*	0.91*	**0.95**	2.40*	2.09*	**2.24**
TAN (oxidized oil), mg KOH/g, ASTM D664	6.10	6.30	**6.20**	2.31	2.81	**2.56**	12.66	11.86	**12.26**

*Ramsbottom carbon residue procedure was modified due to splattering for the competitive samples as follows: 1) The sample was heated to charge the syringe, 2) The Ramsbottom bulb was preheated before inserting into the block, 3) The sample weight was reduced by approximately 70%.

<u>**Thermal Stability Test**</u>

The Cincinnati Milacron test (Procedure A, modified*) consisted of heating 200 mL of each thermal fluid in separate beakers at 135 ± 3°C in a convection oven for 168 hours. Prior to heating, polished copper and steel rods were placed in the beaker with the rods touching. After 168 hours, the rods were inspected for deposits and lacquer and then rated against heat test standards on a scale from 1 to 10 where 10 indicates highly fouled rods (Figure 2). The quantity of sludge produced and the viscosity change in the fluid were also determined.

* Aluminum test fixture was not used.

Table 4: Fluid and rod analyses

	Calflo AF	**A world leader in industrial lubricants**	**A specialty HTF competitor**
Kinematic viscosity @ 40°C (before heating), cSt., ASTM D445	32.43	18.84	34.65
Kinematic viscosity @ 40°C (after heating), cSt., ASTM D445	33.19	19.43	45.28
% viscosity change	2.34	3.13	30.68
Rating for copper rod	2	9	3
Weight of sludge deposit on copper rod, mg	1.2	4.3	2.0
Metal loss on copper rod, mg	0.6	6.7	1.1
Rating for steel rod	2	8	3
Weight of lacquer deposit on steel rod, mg	1.7	7.0	0.0
Metal loss on steel rod, mg	-0.1	1.3	-0.1
Total sludge (mg/100mL)	8.7	77.7	10.8
ΔTAN, mg KOH/g (TAN after heating – TAN before heating), ASTM D664	0	0.16	0

Figure 2: Cincinnati Milacron scale