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APPENDICES

Appendix I SAE J300-97 Engine oil viscosity classification.

SAE Viscosity grade	Low-temperature (°C) cranking viscosity, cP max.	Low-temperature (°C) pumping viscosity, cP max. with no yield stress	Low-shear-rate kinematic viscosity (cSt) at 100 °C min.	Low-shear-rate kinematic viscosity (cSt) at 100 °C max.	High-shear-rate viscosity (cP) at 150 °C and 10^6 s^{-1} min.
0W	3250 at -30	60000 at -40	3.8	-	-
5 W	3500 at -25	60000 at -35	3.8	-	-
10 W	3500 at -20	60000 at -30	4.1	-	-
15 W	3500 at -15	60000 at -25	5.6	-	-
20 W	4500 at -10	60000 at -20	5.6	-	-
25 W	6000 at -5	60000 at -10	9.3	-	-
20	-		5.6	< 9.3	2.6
30	-		9.3	< 12.5	2.9
40	-		12.5	< 16.3	2.9 (0W-40, 5W-40 and 10W-40 grades)
40	-		12.5	< 16.3	3.7 (15W-40, 20W-40, 25W-40, 40 grades)
50	-		16.3	< 21.9	3.7
60	-		21.9	< 26.1	3.7

MOTORCYCLE FOUR CYCLE GASOLINE ENGINE OIL
PERFORMANCE CLASSIFICATION (JASO T 903)
IMPLEMENTATION MANUAL

NOTICE
The quality, performance and labeling of the Motorcycle Four Cycle Gasoline Engine Oil notified and filed under this JASO Engine Oil Performance Classification Implementation System, is classified and guaranteed based upon the judgment and responsibility of the company (the lube oil supplier) which submitted the specified notification documents for filing. The company shall assume all liabilities resulting therefrom. Accordingly, under this system, the JASO Engine Oil Standards Implementation Panel (the "Panel") does not guarantee the quality or performance of the oil, and takes no responsibility with regard to such matters. In the case where any problems associated with the quality, performance, or labeling of the motorcycle 4-cycle oil arise, the company that has utilized the JASO Motorcycle 4-Cycle Oil Standards shall itself resolve the problems. In order to facilitate the proper use of the JASO Motorcycle 4-cycle Oil Standards, the Panel requests that the users of the standards fully understand both this manual and the guidelines for utilizing the standards.

1. Foreword

This manual has been prepared as a part of the activities of the JASO Engine Oil Standards Implementation Panel (the "Panel"). The panel has been voluntarily organized by various industry associations and academic societies in Japan concerned with engine oils in order to promote in Japan and other countries the proper Motorcycle Four Cycle Gasoline Engine Oil Performance Classification Standards (JASO T 903) (the "JASO Motorcycles Four Cycle Oil Standards" or "JASO T 903 Standards"). These standards were established by the Society of Automotive Engineers of Japan (the "JSAE"). The purpose of this Manual is to explain the procedures to enable those who distribute, supply or otherwise offer for sale, four stroke oils for motorcycles in the course of trade or business (collectively "Suppliers"), to take the steps necessary to submit and have filed with the Panel notification documents in accordance with the JASO Motorcycle Four Cycle Oil Standards.

In this manual, the term "Four Cycle Engines" means four stroke cycle engines using gasoline as fuel, and the term "Four Cycle Oil" means lubricating oil for four cycle engines.

In reply to an inquiry from the Automotive/Lubricant Joint Committee ("ALJC"), a committee of the Petroleum Association of Japan ("PAJ") and the Japan Automobile Manufacturers Association, Inc. ("JAMA"), this submission and filing system was drafted by the Motorcycle Four Cycle Engine Oil Working Group. The latter group itself was set up by the "JASO Engine Oil Standards Implementation Panel" (formerly, the JASO Two Cycle Oil Standards Implementation Panel)", a subsidiary organization of the ALJC and established with the approval of each of the above mentioned committees.

2. Purpose of Implementation System

In recent years, automotive oil quality requirements have tended toward lower viscosity and lower friction to achieve better fuel economy. There are concerns that such low friction and low viscosity oils cause clutch slippage and gear pitting wear in motorcycle transmissions. Therefore, a test method to evaluate oils and a set of performance classifications for motorcycle four cycle engine oils have been established by the JASO.

The implementation system, described in this document, was established to facilitate the choice of appropriate 4-cycle engine oils through the use of these performance classifications.

The use of these standards will help consumers to correctly select four cycle engine oils for motorcycles when purchasing, and will reduce field problems resulting from the choice and the use of inappropriate oil quality.

3. Outline of JASO T 903 Standard

3.1 JASO Test Procedure

The test method shown in Table-1 was developed by the Motorcycle Four Cycle Engine Oil Subcommittee, which was organized within the Motorcycle Committee of the JSAE. This procedure will be used to evaluate four cycle engine oils to confirm that they meet motorcycle oil requirements.

Table-1 Motorcycle 4-Cycle Engine Oil JASO Test Procedure

Test Procedure	JASO Standard No.
Motorcycle-Four-Stroke Cycle Gasoline Engine Oils - Friction properties test for the clutch systems	JASO T 904-98

3.2 Basic Concept of the Performance Classification

The performance level of 4-cycle oils, which meet engine oil performances and required physical and chemical properties, is classified into two grades, MA and MB, according to the test results based on the above-mentioned JASO clutch system friction test. MA/MB grade oils are appropriate for motorcycle 4-cycle engine oils, which are classified by three friction characteristic indices. MB grade is classified as low friction oils for motorcycle 4-cycle engine oils.

3.3 Evaluation Items and Standard Indices for Each Performance Classification

The evaluation items for the JASO test procedure and the standard indices for each performance classification are shown in Table 2.

Table-2 JASO Test Procedure and Standard Indices

Evaluation Item	Test Procedure	Standard Index	
		MA	MB
* DFI (Dynamic Friction Characteristic Index-DFI)	JASO T 904	1.45 or greater	Less than 1.45
* SFI (Static Friction Characteristic Index-SFI)		1.15 or greater	Less than 1.15
* STI (Stop Time Index-STI)		1.55 or greater	Less than 1.55

Note: An oil that does not meet all MA limits is classified as MB.

An oil must be of the quality level of one of the performance classification shown in Table-3.
An oil must also meet the physicochemical requirements shown in Table-4.

Table-3 Quality on Engine Oil Specification

Specifications	Categories
API	SE, SF, SG, SH, SJ
ILSAC	GF-1, GF-2
ACEA	A1, A2, A3
CCMC	G-4, G-5

Table-4 Physicochemical Properties

Item	Test Method		Limit
	JIS	ASTM	
Sulfated Ash, mass%	K2272	D874	1.2 max.
Evaporative Loss, mass%	JPI 5S-41-93	D5800	20 max.
Foaming Tendency, ml (Tendency/Stability) Seq.I Seq.II Seq.III	K 2518	D892	 10/0 max. 50/0 max. 10/0 max.
Shear Stability, mm^2/s xW – 30 xW – 40 xW – 50	JPI 5S-29-88 (Note 1)	D6278	 9.0 min. 12.0 min. 15.0 min
High Temp. High Shear rate Vis.(150deg.C), mPa.s	JPI 5S-36-91	D4683	2.9 min.

Note 1: Test shall be conducted by diesel injector method under the standard test conditions (30 cycles).

Appendix III Chemical and physical properties of viscosity modifier

Test Description	Test method	OCP1	STAR1	STAR2	STAR3
Appearance	BAM 300	amber viscous liquid	hazy viscous liquid	hazy viscous liquid	hazy viscous liquid
Colour - ASTM	ASTM D1500 / IP 196	4.0 max	L 1.5	L2.0	<1.0
Density at 15°C	ASTM D1298 / IP 160, g/ml	0.87	0.87	0.87	0.87
Kinematic Visc at 100°C	ASTM D445 / IP 71, cSt	800	1,350	1,450	1,500
Flash Point - PMC	ASTM D93 / IP 34, degree C	180	180	204	195
Water Content	ASTM D95 / IP 74, % wt	0.05 max	0.05 max	0.05 max	0.05 max

Appendix IV Chemical and physical properties of performance additive

Additive 1

Function: Detergent inhibitor

TESTS AND INFORMATION:

DESCRIPTION	METHODS	MINIMUM	MAXIMUM	TYPICAL	UNITS
Appearance	BAM 300	A dark coloured, viscous liquid.			
Colour - ASTM Dilute	ASTM D 1500 / IP 196	-	-	3.5 Dil	-
Density at 15'C	ASTM D 4052 / IP 365	1.001	1.031	-	g/ml
Kinematic Visc at 100'C	ASTM D 445 / IP 71	-	-	200	cSt
Kinematic Visc at 40'C	ASTM D 445 / IP 71	-	-	4600	cSt
Flash Point - PMC	ASTM D 93 / IP 34	-	-	172	'C
Pour Point	ASTM D 97 / IP 15	-	-	minus 3	'C
Calcium content	ICP-1	0.91	1.11	-	% wt
Magnesium content	ICP-1	1.10	1.34	-	% wt
Nitrogen content	ASTM D 5291	0.56	0.68	-	% wt
Phosphorus content	ICP-1	2.06	2.52	-	% wt
Sodium content	ICP-1	0.49	0.59	-	% wt
Sulphur content	ICP-1	-	-	5.1	% wt
Zinc content	ICP-1	2.29	2.79	-	% wt

Appendix IV Chemical and physical properties of performance additive (ctd.)

Additive 2

Function: Detergent inhibitor supplement

TESTS AND INFORMATION:

DESCRIPTION	METHODS	MINIMUM	MAXIMUM	TYPICAL	UNITS
Appearance	BAM 300	Dark coloured, viscous liquid.			-
Colour - ASTM Dilute	ASTM D1500 / IP 196	-	-	3.0 Dil	-
Density at 15'C	ASTM D4052 / IP 365	0.905	0.935	-	g/ml
Kinematic Visc at 100'C	ASTM D445 / IP 71	-	-	225	cSt
Kinematic Visc at 40'C	ASTM D445 / IP 71	-	-	4000	cSt
Flash Point - PMC	ASTM D93 / IP 34	-	-	186	'C
Pour Point	ASTM D97 / IP 15	-	-	minus 6	'C
Base Number (TBN)	ASTM D2896 / IP 276	-	-	42	mgKOH/g
Calcium content	ASTM D4951 : LZA-ICP-1	0.47	0.57	-	% wt
Nitrogen content	ASTM D5291 : LZA-NI-6	1.07	1.31	-	% wt
Water content	ASTM D 95 / IP 74 (Xylene)	-	0.50	-	%

Appendix V Chemical and physical properties of base oils

150 SN (light base oil)

Solvent refine mineral base oil, API group I

TESTS AND INFORMATION: DESCRIPTION	METHODS	MINIMUM	MAXIMUM	TYPICAL	UNITS
Appearance	BAM 300	Clear, straw coloured liquid.			-
Colour - ASTM	ASTM D1500 / IP 196	-	1.5	-	-
Density at 15'C	ASTM's D1298 or D4052	-	-	0.87	g/ml
Kinematic Visc at 100'C	ASTM D445 / IP 71	5.0	5.6	-	cSt
Kinematic Visc at 40'C	ASTM D445 / IP 71	29.0	32.0	-	cSt
Viscosity Index	ASTM D2270 / IP 226	98	-	-	-
Flash Point - COC	ASTM D92 / IP 36	204	-	-	'C
Flash Point - PMC	ASTM D93 / IP 34	-	-	Report	'C
Pour Point	ASTM D97 / IP 15	-	minus 12	-	'C
Acid / Neut Number	ASTM D974 / IP 139	-	0.05	-	mgKOH/g
Conradson Carbon residue	ASTM D189 / IP 13	-	0.05	-	% wt
Copper Corrosion	ASTM D130 (100'C, 3hr)	-	Class 1	-	-
Noack Volatility	CEC L-40-A-93 / IP 421	-	16	-	% wt
PCA (Poly Cyclic Aromatics)	IP 346 (DMSO extraction)	-	3.0	-	% wt
Sulphur content	ASTM D1552/2622/4294/4927	0.10	0.85	-	% wt

Appendix V Chemical and physical properties of base oils (ctd.)

500 SN (heavy base oil)

Solvent refine mineral base oil, API group I

TESTS AND INFORMATION: DESCRIPTION	METHODS	MINIMUM	MAXIMUM	TYPICAL	UNITS
Appearance at 25°C	BAM 300	Clear & bright, straw coloured liquid.			
Colour - ASTM	ASTM D1500 / IP 196	-	4.0	-	-
Density at 15°C	ASTM D1298 or 4052	-	-	Report	g/ml
Kinematic Visc at 100°C	ASTM D445 / IP 71	-	-	10.8	cSt
Kinematic Visc at 40°C	ASTM D445 / IP 71	94.0	98.0	-	cSt
Viscosity Index	ASTM D2270 / IP 226	95	-	-	-
Flash Point - COC	ASTM D92 / IP 36	237	-	-	°C
Flash Point - PMC	ASTM D93 / IP 34	-	-	Report	°C
Pour Point	ASTM D97 / IP 15	-	minus 6	-	°C
Acid / Neutral Number Each Delivery	ASTM D974 / IP 139	-	0.05	-	mgKOH/g
Copper Corrosion Type Approval	ASTM D130 (100°C, 3 hr)	-	Class 1	-	-
Conradson Carbon Residue Information	ASTM D189 / IP 13	-	0.15	-	% wt

Appendix VI Calculated base oil ratios.

1%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL
OCP1	150 SN	56.36	50.95	44.46	40.19%	33.66	30.43%	24.97	22.57%	12.53	11.33%	3.30	2.98%
	500 SN	43.64	39.45	55.54	50.21%	66.34	59.97%	75.03	67.83%	87.47	79.07%	96.70	87.42%
STAR1	150 SN	61.70	0.00	49.71	44.94%	38.82	35.09%	30.06	27.17%	17.52	15.84%	8.22	7.43%
	500 SN	38.30	34.62	50.29	45.46%	61.18	55.31%	69.94	63.23%	82.48	74.56%	91.78	82.97%
STAR2	150 SN	64.16	58.00	51.86	46.88%	40.68	36.77%	31.70	28.66%	18.83	17.02%	9.28	8.39%
	500 SN	35.84	32.40	48.14	43.52%	59.32	53.63%	68.30	61.74%	81.17	73.38%	90.72	82.01%
STAR3	150 SN	61.20	55.32	48.92	44.22%	37.77	34.14%	28.80	26.04%	15.95	14.42%	6.42	5.80%
	500 SN	38.80	35.08	51.08	46.18%	62.23	56.26%	71.20	64.36%	84.05	75.98%	93.58	84.60%

2%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	%BASE OIL
OCP1	150 SN	56.36	50.95%	44.46	40.19%	33.66	30.43%	24.97	22.57%	12.53	11.33%	3.3	2.98%
	500 SN	43.64	39.45%	55.54	50.21%	66.34	59.97%	75.03	67.83%	87.47	79.07%	96.7	87.42%
STAR1	150 SN	61.7	55.78%	49.71	44.94%	38.82	35.09%	30.06	27.17%	17.52	15.84%	8.22	7.43%
	500 SN	38.3	34.62%	50.29	45.46%	61.18	55.31%	69.94	63.23%	82.48	74.56%	91.78	82.97%
STAR2	150 SN	64.16	58.00%	51.86	46.88%	40.68	36.77%	31.7	28.66%	18.83	17.02%	9.28	8.39%
	500 SN	35.84	32.40%	48.14	43.52%	59.32	53.63%	68.3	61.74%	81.17	73.38%	90.72	82.01%
STAR3	150 SN	61.2	55.32%	48.92	44.22%	37.77	34.14%	28.8	26.04%	15.95	14.42%	6.42	5.80%
	500 SN	38.8	35.08%	51.08	46.18%	62.23	56.26%	71.2	64.36%	84.05	75.98%	93.58	84.60%

Appendix VI Calculated base oil ratios (ctd.).

3%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL	15.4 cSt	% BASE OIL	16.2 cSt	% BASE OIL
OCP1	150 SN	66.57	59.51	54.21	48.46	42.99	38.43	33.97	30.37	21.05	18.82	11.46	10.25	1.67	1.49%		
	500 SN	33.43	29.89	45.79	40.94	57.01	50.97	66.03	59.03	78.95	70.58	88.54	79.15	98.33	87.91		
STAR1	150 SN	78.09	69.81	65.3	58.38	53.69	48	44.34	39.64	30.97	27.69	21.04	18.81	10.91	9.75%	3.4	3.04%
	500 SN	21.91	19.59	34.7	31.02	46.31	41.4	55.66	49.76	69.03	61.71	78.96	70.59	89.09	79.65	96.6	86.36
STAR2	150 SN	79.08	70.70	66.4	59.6%	54.91	49.09	45.66	40.82	32.41	28.97	22.58	20.19	12.54	11.21	5.1	4.56%
	500 SN	20.92	18.70	33.6	30.04	45.09	40.31	54.34	48.58	67.59	60.43	77.42	69.21	87.46	78.19	94.9	84.84
STAR3	150 SN	74.72	66.80	62.25	55.65	50.94	45.54	41.83	37.4	28.8	25.75	19.12	17.09	9.25	8.27%	1.93	1.73%
	500 SN	25.28	22.60	37.75	33.75	49.06	43.86	58.17	52	71.2	63.65	80.88	72.31	90.75	81.13	98.07	87.67

4%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL	15.4 cSt	% BASE OIL
OCP1	150 SN	66.57	58.85	44.46	39.30%	33.66	29.76%	24.97	22.07%	12.53	11.08%	3.3	2.92%		
	500 SN	33.43	29.55	55.54	49.10%	66.34	58.64	75.03	66.33	87.47	77.32	96.7	85.48%	100	88.40%
STAR1	150 SN	61.7	54.54	49.71	43.94%	38.82	34.32%	30.06	26.57%	17.52	15.49	8.22	7.27%		
	500 SN	38.3	33.86	50.29	44.46%	61.18	54.08%	69.94	61.83%	82.48	72.91	91.78	81.13%	100	88.40%
STAR2	150 SN	64.16	56.72	51.86	45.84%	40.68	35.96%	31.7	28.02%	18.83	16.65	9.28	8.20%		
	500 SN	35.84	31.68	48.14	42.56%	59.32	52.44%	68.3	60.38%	81.17	71.75	90.72	80.20%	100	88.40%
STAR3	150 SN	61.2	54.1	48.92	43.25%	37.77	33.39%	28.8	25.46%	15.95	14.1	6.42	5.68%		
	500 SN	38.8	34.3	51.08	45.15%	62.23	55.01%	71.2	62.94%	84.05	74.3	93.58	82.72%	100	88.40%

Appendix VI Calculated base oil ratios (ctd.).

5%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL	15.4 cSt	% BASE OIL
OCP1	150 SN	66.57	58.18%	44.46	38.86%	33.66	29.42%	24.97	21.82%	12.53	10.95%	3.3	2.88%		0.00%
	500 SN	33.43	29.22%	55.54	48.54%	66.34	57.98%	75.03	65.58%	87.47	76.45%	96.7	84.52%	100	87.40%
STAR1	150 SN	61.7	53.93%	49.71	43.45%	38.82	33.93%	30.06	26.27%	17.52	15.31%	8.22	7.18%		0.00%
	500 SN	38.3	33.47%	50.29	43.95%	61.18	53.47%	69.94	61.13%	82.48	72.09%	91.78	80.22%	100	87.40%
STAR2	150 SN	64.16	56.08%	51.86	45.33%	40.68	35.55%	31.7	27.71%	18.83	16.46%	9.28	8.11%		0.00%
	500 SN	35.84	31.32%	48.14	42.07%	59.32	51.85%	68.3	59.69%	81.17	70.94%	90.72	79.29%	100	87.40%
STAR3	150 SN	61.2	53.49%	48.92	42.76%	37.77	33.01%	28.8	25.17%	15.95	13.94%	6.42	5.61%		0.00%
	500 SN	38.8	33.91%	51.08	44.64%	62.23	54.39%	71.2	62.23%	84.05	73.46%	93.58	81.79%	100	87.40%

6%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL
OCP1	150 SN	100	86.40%	86.58	74.81%	74.24	64.14%	64.31	55.56%	50.1	43.29%	39.54	34.16%
	500 SN	0	0.00%	13.42	11.59%	25.76	22.26%	35.69	30.84%	49.9	43.11%	60.46	52.24%
STAR1	150 SN							95.74	82.72%	79.58	68.76%	67.57	58.38%
	500 SN							4.26	3.68%	20.42	17.64%	32.43	28.02%
STAR2	150 SN							91.45	79.01%	76.58	66.17%	65.54	56.63%
	500 SN							8.55	7.39%	23.42	20.23%	34.46	29.77%
STAR3	150 SN					95.43	82.45%	84.97	73.41%	70.01	60.49%	58.9	50.89%
	500 SN					4.57	3.95%	15.03	12.99%	29.99	25.91%	41.1	35.51%

Appendix VI Calculated base oil ratios (ctd.).

6%VM TYPE	Base oil	15.4 cSt	% BASE OIL	16.2 cSt	% BASE OIL	17.7 cSt	% BASE OIL	19.1 cSt	% BASE OIL	20.5 cSt	% BASE OIL	21.8 cSt	% BASE OIL
OCP1	150 SN	28.77	24.86%	20.79	17.96%	7.11	6.14%						
	500 SN	71.23	61.54%	79.21	68.44%	92.89	80.26%						
STAR1	150 SN	55.33	47.81%	46.25	39.96%	30.68	26.51%	17.62	15.22%	5.72	4.94%		
	500 SN	44.67	38.59%	53.75	46.44%	69.32	59.89%	82.38	71.18%	94.28	81.46%		
STAR2	150 SN	54.27	46.89%	45.92	39.67%	31.61	27.31%	19.59	16.93%	8.64	7.46%		
	500 SN	45.73	39.51%	54.08	46.73%	68.39	59.09%	80.41	69.47%	91.36	78.94%		
STAR3	150 SN	47.56	41.09%	39.15	33.83%	24.75	21.38%	12.65	10.93%	1.64	1.42%		
	500 SN	52.44	45.31%	60.85	52.57%	75.25	65.02%	87.35	75.47%	98.36	84.98%		

7%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL
OCP1	150 SN			97.35%	83.14%	84.82%	72.44%	74.75%	63.84%	60.32%	51.51%	49.61%	42.37%
	500 SN			2.65%	2.26%	15.18%	12.96%	25.25%	21.56%	39.68%	33.89%	50.39%	43.03%
STAR1	150 SN									90.36%	77.17%	75.91%	64.83%
	500 SN									9.64%	8.23%	24.09%	20.57%
STAR2	150 SN									90.65%	77.42%	79.18%	67.62%
	500 SN									9.35%	7.98%	20.82%	17.78%
STAR3	150 SN							100%	85.40%	84.46%	72.13%	72.69%	62.08%
	500 SN							0%	0.00%	15.54%	13.27%	27.31%	23.32%

Appendix VI Calculated base oil ratios (ctd.).

7%VM TYPE	Base oil	15.4 cSt	% BASE OIL	16.2 cSt	% BASE OIL	17.7 cSt	% BASE OIL	19.1 cSt	% BASE OIL	20.5 cSt	% BASE OIL	21.8 cSt	% BASE OIL
OCP1	150 SN	38.69	33.04%	30.59	26.12%	16.7	14.26%	5.05	4.31%				
	500 SN	61.31	52.36%	69.41	59.28%	83.3	71.14%	94.95	81.09%				
STAR1	150 SN	67.17	57.36%	50.24	42.90%	31.51	26.91%	15.78	13.48%	14.6	12.47%		0.00%
	500 SN	32.83	28.04%	49.76	42.50%	68.49	58.49%	84.22	71.92%	85.4	72.93%		0.00%
STAR2	150 SN	67.48	57.63%	58.8	50.22%	43.93	37.52%	31.45	26.86%	20.08	17.15%	10.38	8.86%
	500 SN	32.52	27.77%	41.2	35.18%	56.07	47.88%	68.55	58.54%	79.92	68.25%	89.62	76.54%
STAR3	150 SN	60.69	51.83%	51.79	44.23%	36.53	31.20%	23.73	20.27%	12.07	10.31%	2.12	1.81%
	500 SN	39.31	33.57%	48.21	41.17%	63.47	54.20%	76.27	65.13%	87.93	75.09%	97.88	83.59%

8%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL
OCP1	150 SN					96.08	81.09%	85.65%	72.29%	70.72%	59.69%	59.64%	50.34%
	500 SN					3.92%	3.31%	14.35%	12.11%	29.28%	24.71%	40.36%	34.06%
STAR1	150 SN											97.57%	82.35%
	500 SN											2.43%	2.05%
STAR2	150 SN											97.76%	82.51%
	500 SN											2.24%	1.89%
STAR3	150 SN									98%	82.71%	84.78%	71.55%
	500 SN									2%	1.69%	15.22%	12.85%

Appendix VI Calculated base oil ratios (ctd.).

8%VM TYPE	Base oil	15.4 cSt	% BASE OIL	16.2 cSt	% BASE OIL	17.7 cSt	% BASE OIL	19.1 cSt	% BASE OIL	20.5 cSt	% BASE OIL	21.8 cSt	% BASE OIL
OCP1	150 SN	47.25%	39.88%	39.94%	33.71%	25.57	21.58%	13.51	11.40%	2.52	2.13%		
	500 SN	52.75%	44.52%	60.06%	50.69%	74.43	62.82%	86.49	73.00%	97.48	82.27%		
STAR1	150 SN	82.68%	69.78%	73.9%	62.37%	56.64	47.80%	42.14	35.57%	28.94	24.43%	17.68	14.92%
	500 SN	17.32%	14.62%	26.1%	22.03%	43.36	36.60%	57.86	48.83%	71.06	59.97%	82.32	69.48%
STAR2	150 SN	83.15%	70.18%	74.53%	62.90%	57.59	48.61%	43.36	36.60%	30.41	25.67%	19.35	16.33%
	500 SN	16.85%	14.22%	25.47%	0.22%	42.41	35.79%	56.64	47.80%	69.59	58.73%	80.65	68.07%
STAR3	150 SN	70.01%	59.09%	61.3%	51.74%	44.17	37.28%	29.78	25.13%	16.69	14.09%	5.51	4.65%
	500 SN	29.99%	25.31%	38.7%	32.66%	55.83	47.12%	70.22	59.27%	83.31	70.31%	94.49	79.75%

9%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL
OCP1	150 SN							100%	83.40%	85.7%	71.47%	73.44%	61.25%
	500 SN							0%	0.00%	14.3%	11.93%	26.56%	22.15%
STAR1	150 SN												
	500 SN												
STAR2	150 SN												
	500 SN												
STAR3	150 SN											100%	83.40%
	500 SN												

Appendix VI Calculated base oil ratios (ctd.)

9%VM TYPE	Base oil	15.4 cSt	% BASE OIL	16.2 cSt	% BASE OIL	17.7 cSt	% BASE OIL	19.1 cSt	% BASE OIL	20.5 cSt	% BASE OIL	21.8 cSt	% BASE OIL
OCP1	150 SN	59.74%	49.82%	51.67%	43.09%	35.78%	29.84%	22.43	18.71%	10.29	8.58%		
	500 SN	40.26%	33.58%	48.33%	40.31%	64.22%	53.56%	77.57	64.69%	89.71	74.82%	100	83.40%
STAR1	150 SN	100%	83.40%	92.22%	76.91%	75.17%	62.69%	60.86	50.76%	47.83	39.89%	36.71	30.62%
	500 SN	0%	0.00%	7.78%	6.49%	24.83%	20.71%	39.14	32.64%	52.17	43.51%	63.29	52.78%
STAR2	150 SN	100%	83.40%	91.41%	76.24%	75.66%	63.10%	62.44	52.07%	50.41	42.04%	40.14	33.48%
	500 SN	0%	0.00%	8.59%	7.16%	24.34%	20.30%	37.56	31.33%	49.59	41.36%	59.86	49.92%
STAR3	150 SN	85.81%	71.57%	77.6%	64.72%	61.44%	51.24%	47.88	39.93%	35.53	29.63%	24.99	20.84%
	500 SN	14.19%	11.83%	22.4%	18.68%	38.56%	32.16%	52.12	43.47%	64.47	53.77%	75.01	62.56%

10%VM TYPE	Base oil	10.1 cSt	% BASE OIL	10.9 cSt	% BASE OIL	11.7 cSt	% BASE OIL	12.4 cSt	% BASE OIL	13.5 cSt	% BASE OIL	14.4 cSt	% BASE OIL
OCP1	150 SN									95.39	78.60%	86.54	71.31%
	500 SN									4.61	3.80%	13.46	11.09%
STAR1	150 SN												
	500 SN												
STAR2	150 SN												
	500 SN												
STAR3	150 SN												
	500 SN												

Appendix VI Calculated base oil ratios (ctd.).

10%VM TYPE	Base oil	15.4 cSt	% BASE OIL	16.2 cSt	% BASE OIL	17.7 cSt	% BASE OIL	19.1 cSt	% BASE OIL	20.5 cSt	% BASE OIL	21.8 cSt	% BASE OIL
OCP1	150 SN	77.51	63.87%	70.82	58.36%	59.35	48.90%	49.71	40.96%	40.94	33.73%	33.46	27.57%
	500 SN	22.49	18.53%	29.18	24.04%	40.65	33.50%	50.29	41.44%	59.06	48.67%	66.54	54.83%
STAR1	150 SN					81.29	66.98%	57.5	47.38%	35.85	29.54%	17.38	14.32%
	500 SN					18.71	15.42%	42.5	35.02%	64.15	52.86%	82.62	68.08%
STAR2	150 SN					92.23	76.00%	77.37	63.75%	63.85	52.61%	52.31	43.10%
	500 SN					7.77	6.40%	22.63	18.65%	36.15	29.79%	47.69	39.30%
STAR3	150 SN			93.52	77.06%	76.89	63.36%	62.93	51.85%	50.22	41.38%	39.38	32.45%
	500 SN			6.48	5.34%	23.11	19.04%	37.07	30.55%	49.78	41.02%	60.62	49.95%

Appendix VII Low temperature charateristics of targeted viscosity oil blend.

1%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt
OCP1					
ccs@-10 °C	2,330	2,830	3,360	3,860	4,750
ccs@-20 °C	9,460	11,560	14,320	N/A	N/A
STAR1					
ccs@-10 °C	2,160	2,480	3,070	3,650	4,590
ccs@-20 °C	8,510	10,010	12,890	N/A	N/A
STAR2					
ccs@-10 °C	2,150	2,600	3,250	3,790	4,810
ccs@-20 °C	8,390	10,470	13,540	N/A	N/A
STAR3					
ccs@-10 °C	2,070	2,920	3,020	3,580	4,320
ccs@-20 °C	7,890	8,940	12,310	14,420	N/A

2%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt
OCP1						
ccs@-10 °C	1,760	2,160	2,630	3,060	3,790	4,490
ccs@-20 °C	6,600	8,570	10,620	12,810	N/A	N/A
STAR1						
ccs@-10 °C	1,760	2,000	2,420	2,810	3,500	4,140
ccs@-20 °C	6,770	7,780	9,670	11,480	14,930	N/A
STAR2						
ccs@-10 °C	1,570	1,940	2,310	2,720	3,420	4,080
ccs@-20 °C	5,750	7,300	9,130	10,950	14,440	N/A
STAR3						
ccs@-10 °C	1,800	2,000	2,420	2,850	3,560	4,230
ccs@-20 °C	5,560	7,690	9,590	11,590	N/A	N/A

Appendix VII Low temperature charateristics of targeted viscosity oil blend (ctd.).

3%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt
OCP1								
ccs@-10 °C	1,470	1,850	2,210	2,580	3,270	3,820	4,490	
ccs@-20 °C	5,790	7,220	9,030	10,760	14,300	N/A	N/A	
STAR1								
ccs@-10 °C	1,260	1,570	1,910	2,230	2,810	3,350	4,000	4,570
ccs@-20 °C	4,470	5,710	7,070	8,570	11,270	13,880	N/A	N/A
STAR2								
ccs@-10 °C	1,230	1,460	1,800	2,110	2,660	3,090	3,770	4,370
ccs@-20 °C	4,330	5,410	6,770	8,170	10,690	12,780	N/A	N/A
STAR3								
ccs@-10 °C	1,610	1,930	2,160	2,810	3,220	3,940	4,470	
ccs@-20 °C	4,810	5,890	7,350	8,500	11,260	13,620	N/A	

4%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt	17.7 cSt
OCP1									
ccs@-10 °C	1,400	1,660	1,910	2,230	2,720	3,170	3,770	4,360	
ccs@-20 °C	4,800	6,030	7,600	9,030	11,960	11,460			
STAR1									
ccs@-10 °C	1,150	1,320	1,530	1,750	2,170	2,540	3,140	3,490	4,480
ccs@-20 °C	3,260	4,240	5,420						
STAR2									
ccs@-10 °C	920	1,140	1,390	1,650	2,100	2,500	3,010	3,440	4,350
ccs@-20 °C	3,110	3,940	5,020	6,130	8,120	9,870	12,300	14,440	N/A
STAR3									
ccs@-10 °C	1,010	1,250	1,510	1,770	2,230	2,680	3,200	3,720	
ccs@-20 °C	3,360	4,230	5,410	6,560	8,610	10,650	13,220	N/A	

Appendix VII Low temperature charateristics of targeted viscosity oil blend (ctd.)

5%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt	17.7 cSt	19.1 cSt
OCP1										
ccs@-10 °C	1,200	1,400	1,620	1,880	2,310	2,660	3,140	3,570		
ccs@-20 °C	3,780	4,860	6,120	7,350	9,590	11,650	14,610	N/A		
STAR1										
ccs@-10 °C		1,160	1,320	1,510	1,840	2,130	2,600	2,880	3,850	
ccs@-20 °C		3,310	4,130	5,110	6,800	8,360	10,610	12,180	N/A	
STAR2										
ccs@-10 °C		1,120	1,300	1,460	1,740	2,060	2,400	2,690	3,390	4,180
ccs@-20 °C		3,180	3,980	4,800	6,270	7,850	9,520	11,180	N/A	N/A
STAR3										
ccs@-10 °C		1,190	1,410	1,610	1,960	2,340	2,830	3,280	4,070	
ccs@-20 °C		3,220	4,580	4,840	7,550	9,390	11,990	14,440	N/A	

6%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt	17.7 cSt	19.1 cSt	20.5 cSt
OCP1											
ccs@-10 °C	840	1,070	1,310	1,980	2,000	2,260	2,600	3,220	4,040		
ccs@-20 °C	3,060	3,900	5,180	6,110	7,920	9,670	12,010	14,030	N/A		
STAR1											
ccs@-10 °C				1,520	1,300	1,560	1,930	2,140	2,780	3,470	4,470
ccs@-20 °C				3,350	4,490	5,670	7,110	8,440	11,840	N/A	N/A
STAR2											
ccs@-10 °C				1,060	1,270	1,550	1,850	2,170	2,680	3,360	3,920
ccs@-20 °C				3,560	4,700	5,710	7,130	8,410	10,950	13,990	N/A
STAR3											
ccs@-10 °C			940	1,180	1,400	1,650	2,060	2,300	2,910	3,560	4,280
ccs@-20 °C			3,250	3,850	5,240	6,290	7,640	9,160	12,130	N/A	N/A

Appendix VII Low temperature charateristics of targeted viscosity oil blend (ctd.)

7%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt	17.7 cSt	19.1 cSt	20.5 cSt	21.8 cSt
OCP1												
ccs@-10 °C		900	1,070	1,250	1,610	1,860	2,250	2,560	3,220	3,920		
ccs@-20 °C		3,410	4,170	4,990	6,530	7,980	9,820	11,650	N/A	N/A		
STAR1												
ccs@-10 °C					1,140	1,360	1,570	2,040	2,770	3,630	3,700	
ccs@-20 °C					3,850	4,710	5,890	8,000	10,750	N/A	N/A	
STAR2												
ccs@-10 °C					1,030	1,220	1,490	1,730	2,220	2,650	3,260	3,750
ccs@-20 °C					3,700	4,620	5,750	6,660	8,700	11,090	13,710	N/A
STAR3												
ccs@-10 °C				880	1,120	1,340	1,600	1,800	2,360	2,880	3,600	4,160
ccs@-20 °C				3,060	4,170	4,960	6,090	7,150	9,780	12,450	N/A	N/A

8%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt	17.7 cSt	19.1 cSt	20.5 cSt	21.8 cSt
OCP1												
ccs@-10 °C			960	1,110	1,410	1,680	2,010	2,260	2,860	3,500	4,230	
ccs@-20 °C			3,440	4,060	5,340	6,590	8,110	9,460	12,650	N/A	N/A	
STAR1												
ccs@-10 °C						1,040	1,270	1,530	2,260	2,420	2,980	3,580
ccs@-20 °C						3,440	4,400	5,180	7,350	9,480	12,010	N/A
STAR2												
ccs@-10 °C						1,160	1,230	1,380	1,890	2,270	2,710	3,440
ccs@-20 °C						4,210	4,210	5,020	6,790	8,690	10,750	13,860
STAR3												
ccs@-10 °C					910	1,220	1,420	1,640	2,160	2,740	3,270	3,940
ccs@-20 °C					3,260	4,100	5,240	6,090	8,340	10,920	14,030	N/A

Appendix VII Low temperature charateristics of targeted viscosity oil blend (ctd.).

9%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt	17.7 cSt	19.1 cSt	20.5 cSt	21.8 cSt
OCP1												
ccs@-10				850	1,130	1,300	1,600	1,990	2,340	2,930	3,580	4,320
ccs@-20				3,260	4,230	5,140	6,670	7,440	10,370	13,520	N/A	N/A
STAR1												
ccs@-10 °C							970	1,120	1,610	1,810	2,190	2,620
ccs@-20 °C							3,360	3,850	5,590	6,550	8,320	10,070
STAR2												
ccs@-10 °C								1,110	1,380	1,230	2,040	2,300
ccs@-20 °C								3,740	4,490	4,930	7,600	9,170
STAR3												
ccs@-10 °C						920	1,150	1,280	1,610	1,980	2,440	2,830
ccs@-20 °C						3,090	4,060	4,420	5,830	7,370	9,540	11,880

10%VM TYPE	10.1 cSt	10.9 cSt	11.7 cSt	12.4 cSt	13.5 cSt	14.4 cSt	15.4 cSt	16.2 cSt	17.7 cSt	19.1 cSt	20.5 cSt	21.8 cSt
OCP1												
ccs@-10 °C					940	1,120	1,320	1,430	1,610	1,930	2,150	2,460
ccs@-20 °C					3,650	4,100	4,810	5,450	6,680	8,000	9,420	10,840
STAR1												
ccs@-10 °C									1,340	1,960	2,660	3,650
ccs@-20 °C									4,700	7,190	10,560	N/A
STAR2												
ccs@-10 °C									2,110	1,400	1,700	2,030
ccs@-20 °C									3,770	4,760	6,110	7,430
STAR3												
ccs@-10 °C								1,050	1,350	1,660	2,040	2,210
ccs@-20 °C								3,550	4,840	6,020	7,510	8,940

Appendix VIII Multigrade oil blending formulations.

Formulation	OCP110H	OCP19L	OCP18K	OCP17J	OCP16I	OCP15H	OCP14H	OCP13G	OCP12E	OCP11D
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
OCP1	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%	3.00%	2.00%	1.00%
150 SN	58.36%		2.13%	4.31%	6.14%			1.49%	11.33%	11.65%
500 SN	24.04%	83.40%	82.27%	81.09%	80.26%	87.40%	88.40%	87.91%	79.07%	79.75%

Formulation	STAR110H	STAR19L	STAR18L	STAR17K	STAR16K	STAR15I	STAR14I	STAR13G	STAR12F	STAR11D
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
STAR1	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%	3.00%	2.00%	1.00%
150 SN	14.32%	30.62%	14.92%	12.47%	4.94%			9.75%	7.43%	11.65%
500 SN	68.08%	52.78%	69.48%	72.93%	81.46%	87.40%	88.40%	79.65%	82.97%	79.75%

Formulation	STAR210H	STAR29L	STAR28L	STAR27L	STAR26K	STAR25J	STAR24I	STAR23H	STAR22F	STAR21D
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
STAR2	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%	3.00%	2.00%	1.00%
150 SN	43.10%	33.48%	16.33%	8.86%	7.46%			4.56%	8.39%	12.97%
500 SN	39.30%	49.92%	68.07%	76.54%	78.94%	87.40%	88.40%	84.84%	82.01%	78.43%

Formulatio	STAR310H	STAR39L	STAR38L	STAR37L	STAR36K	STAR35I	STAR34H	STAR33H	STAR32F	STAR31E
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
STAR3	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%	3.00%	2.00%	1.00%
150 SN	32.45%	20.84%	4.65%	1.81%	1.42%			1.73%	5.80%	5.47%
500 SN	49.95%	62.56%	79.75%	83.59%	84.98%	87.40%	88.40%	87.67%	84.60%	85.93%

Appendix VIII Multigrade oil blending formulations (ctd.).

Formulation	OCP110A	OCP19D	OCP18C	OCP17B	OCP16A	OCP15A	OCP14A
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
OCP1	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%
150 SN	78.60%	83.40%	81.09%	83.14%	86.40%	58.18%	58.85%
500 SN	3.80%		3.31%	2.26%		29.22%	29.55%

Formulation	STAR110E	STAR19G	STAR18F	STAR17E	STAR16D	STAR15B	STAR14A
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
STAR1	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%
150 SN	66.98%	83.40%	82.35%	77.17%	82.72%	43.45%	54.54%
500 SN	15.42%		2.05%	8.23%	3.68%	43.95%	33.86%

Formulation	STAR210E	STAR29H	STAR28F	STAR27E	STAR26D	STAR25B	STAR24A
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
STAR2	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%
150 SN	76.00%	76.24%	82.51%	77.42%	79.01%	45.33%	56.72%
500 SN	6.40%	7.16%	1.89%	7.98%	7.39%	42.07%	31.68%

Formulation	STAR310D	STAR39F	STAR38E	STAR37D	STAR36C	STAR35B	STAR34A
Additive1	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Additive 2	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%	4.85%
STAR3	10.00%	9.00%	8.00%	7.00%	6.00%	5.00%	4.00%
150 SN	77.06%	83.40%	82.71%	85.40%	82.45%	42.76%	54.10%
500 SN	5.34%		1.69%		3.95%	44.64%	34.30%

Determination of shear stability of polymer-containing oils – Diesel injector rig method

This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations.

FOREWORD This method is technically equivalent to DIN 51382 and it has been adopted by CEC as CEC L-14-T. 74.

1. SCOPE

This method covers procedures for evaluating the shear stability of polymer-containing oils in terms of the permanent viscosity loss resulting when a sample is mechanically stressed under the test conditions.

2. SUMMARY OF METHOD

The test fluid is mechanically stressed by being pumped through a circuit incorporating a diesel injector nozzle and a diesel injection fuel pump. Samples are taken after the fluid has completed a predetermined number of passes [Note 1] through the circuit. Kinematic viscosities of the original sample and of samples taken during the test are determined at 40°C and 100°C. These figures are used to calculate on a percentage basis the extent of oil degradation due to shear forces in this test.

NOTE 1: Up to 30 passes should be sufficient for crankcase oils but hydraulic oils need 250 or even 500 passes.

3. APPARATUS

3.1. *Injector Rig* – as described in Annex X1.

3.2. *Viscometer and Bath* – meeting the requirements of IP Method 71.

4. MATERIALS

4.1. *Calibration Oil* – Reference Oil RL-34/2.[1]

5. SAMPLE

600 ml of sample is required.

6. CALIBRATION

6.1. The apparatus should be checked with the calibration oil after 20 runs or after 3 months, whichever occurs first. The viscosity loss at 100°C after 30 cycles should be between 2.5 and 3.20 mm^2/S (cSt). When greater deviations are found, a fresh setting of the apparatus, perhaps by the exchange of components, such as the nozzle, filter cartridge, pump or parts of the pump may be necessary. With a brand-new nozzle pressure setting, at least a 4 h running-in period with the calibration oil should be followed.

6.2. Calibrate according to the procedures given in 7 and 8.

[1]Reference Oil RL-34/3 may be ordered from Kraft- und Schmierstofftechnik, 6702 Bad Durkheim Bruchstr/24 Germany.

7. PREPARATION OF APPARATUS

7.1. Set up the apparatus, shown schematically in Fig. 2, so that the dead volume between the three-way stopcock (8)[2] and the outlet of the nozzle (1) is 20 ± 5 ml. Adjust the connecting pipe (10) between the lower reservoir (7) and the pump (12) accordingly.

7.2. Ensure that the injector breaking pressure is set at 175 bar (2540 psi).

7.3. Connect the upper glass reservoir (5) to the cooling water supply which should be adjusted to keep the oil in the lower reservoir (7) at 30 to 35°C.

7.4. All the test runs start with a warm supply pump. To achieve this, run the apparatus under test conditions for at least 30 minutes prior to each test. During this period check the flow rate and adjust to 170 ± 5 ml/min. Record the number of pump strokes per 100 ml of fluid.

7.5. Drain the oil used in 7.4 via stopcock (8) and replace the upper glass reservoir (5) with a beaker. Make three flushing runs using 100 ml of the test oil for each run, pass through the injector area and discard. During all flushing runs ensure that the lower outlet from the atomization chamber (2) is open.

7.6. During the final flush stop the pump so that the dead volume between the three-way stopcock (8) and the nozzle outlet (1) remains full of oil. Drain surplus oil remaining in the reservoir (7) from the stopcock (8).

8. PROCEDURE

8.1. The shear test is normally carried out with 170 ml of test oil (150 ml plus the dead volume). Add 200 ml to the lower reservoir (7) and, as the dead volume has been left full from 7.6 run the first 50 ml to waste via outlet pipe (3) leaving a total of 170 ml in the apparatus. Should this be insufficient for the number of samples required for viscosity determinations throughout the test, increase the volume of test oil left in the apparatus accordingly.

8.2. *Single Passes* – charge 200 ml of test fluid to the lower reservoir (7). Close the lower outlet from the atomization chamber (2) and run the first 50 ml to waste. Position the distributor plates in both reservoirs (5, 7) and with both stopcocks open (6, 8)

[2]Figures in brackets refer to items shown in Fig. 2.

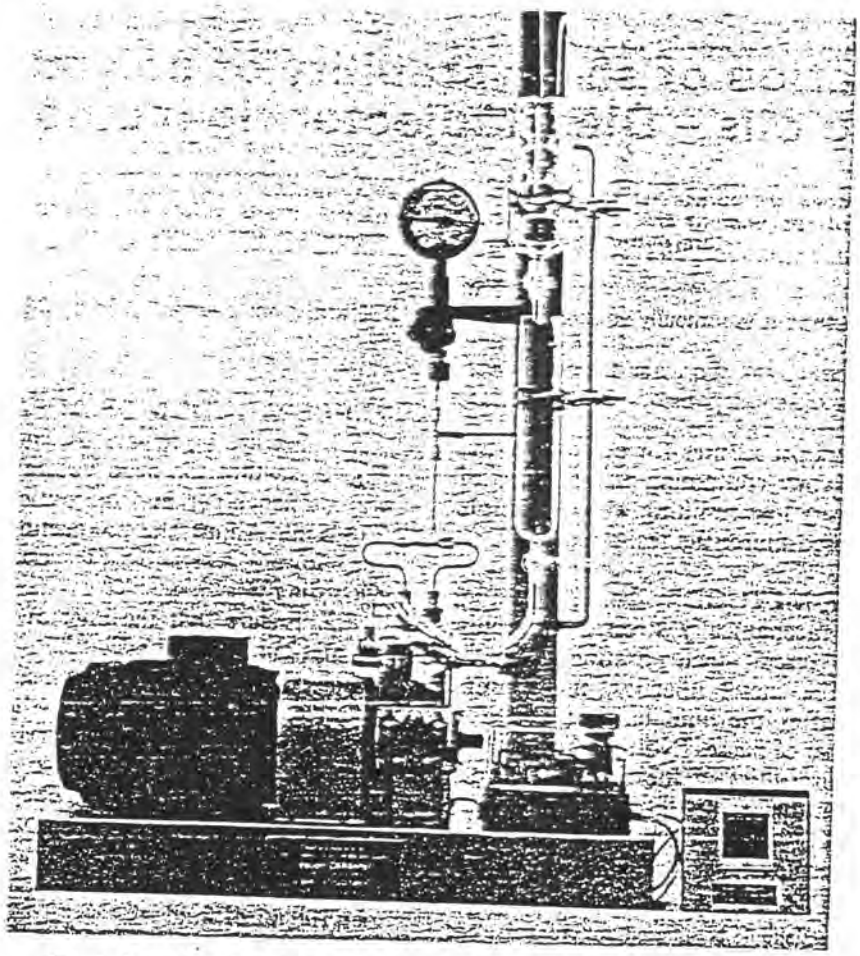

Fig. 1. Diesel injector rig for shear stability test for polymer-containing oils.

set the automatic counter (14) to the number of strokes calculated from 7.4 or, alternatively, run to a calculated time so that all the fluid circulates once only. Take a sample sufficient for the viscosity determination in the middle of the cycle by placing a suitable vessel under the efflux pipe (3), lower the upper reservoir if necessary.

8.3. *Continuous Passes to a Predetermined Number* – charge 200 ml of test fluid to the lower reservoir (7) and with the lower outlet for the atomization chamber (2) closed, run the first 50 ml to waste. Position the distributor plates in both reservoirs (5, 7) and open both stopcocks (6, 8) for continuous circulation. Set the automatic counter (14) where fitted, to the number of strokes calculated from 7.4 to give the required number of passes and run the pump. Alternatively, run to a calculated time. Take a sample from the lower reservoir after circulation has ceased.

8.4. Determine the kinematic viscosity at 40°C and 100°C on the samples taken from 8.2 and 8.3 [Note 2].

NOTE 2: Other temperatures may be employed if required.

8.5. *Shear Stability Curve* – combine the results of 8.2 to 8.4 to obtain a series of viscosity changes against known passes. After each viscosity sample is taken calculate the next sampling point on the quantity remaining in the apparatus. Keep both distributor plates in position throughout.

9. CALCULATION

9.1. Calculate the changes in Kinematic Viscosity at 'T' (temperature) due to breakdown caused by mechanical stress as follows:

9.1.1. Percentage decrease in kin vis @ 'T'

$$= \frac{\text{New Oil Viscosity} - \text{Viscosity after 'X' Passes}}{\text{New Oil Viscosity}} \times 100$$

or

9.1.2. If the viscosity of the finished blend without the polymer is known, Percentage Polymer Breakdown

$$= \frac{\text{Loss in Polymer Contributed Viscosity}}{\text{Original Polymer Contributed Viscosity}} \times 100$$

$$= \frac{\text{New Oil Viscosity} - \text{Viscosity after 'X' Passes}}{\text{New Oil Viscosity} - \text{Blend Viscosity without Polymer}} \times 100$$

For ease of examination the results may be plotted on a graph, using percentage decrease of polymer breakdown as ordinate and the number of passes as abscissa.

Appendix IX Standard test method for diesel injector rig shear stability test (ctd.).

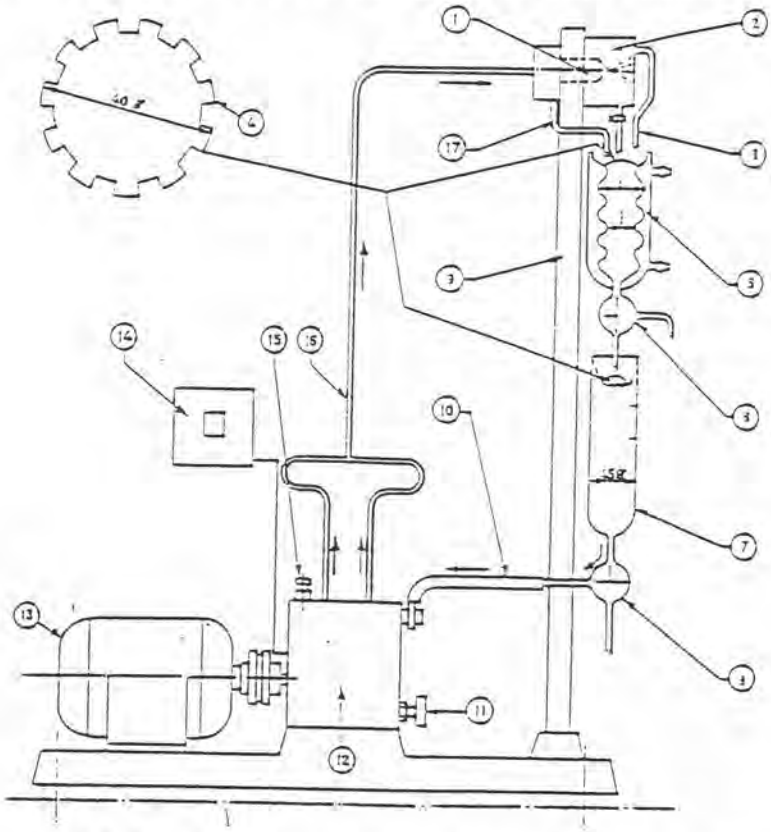

Fig. 2. Apparatus for shear stability test for polymer-containing oils.

1. Spray nozzle set to 172 bar.
2. Atomization chamber.
3. Outlet of the atomized liquid.
4. Distributor plate for 5.
5. Glass container – 250 ml with cooling jacket.
   i = approx 50.
   j = approx 25.
   Length = approx 180.
6. 3-Way cock.
7. Glass container – 250 ml graduated 45 diameter.
8. 3-Way cock.
9. Stand.
10. Connection with pump-suction opening.
11. Pump setting screw.
12. 2-Cylinder injection pump, Bosch Type PE2A 90C 300/3S 2266.
13. E-Motor, 1.1 kW, 900 rpm.
14. Automatic stroke-count measuring and cut-off device.
15. Ventilating screw/pump.
16. Pressure tubing from pump to injector.
17. Return line for overflowing liquid.

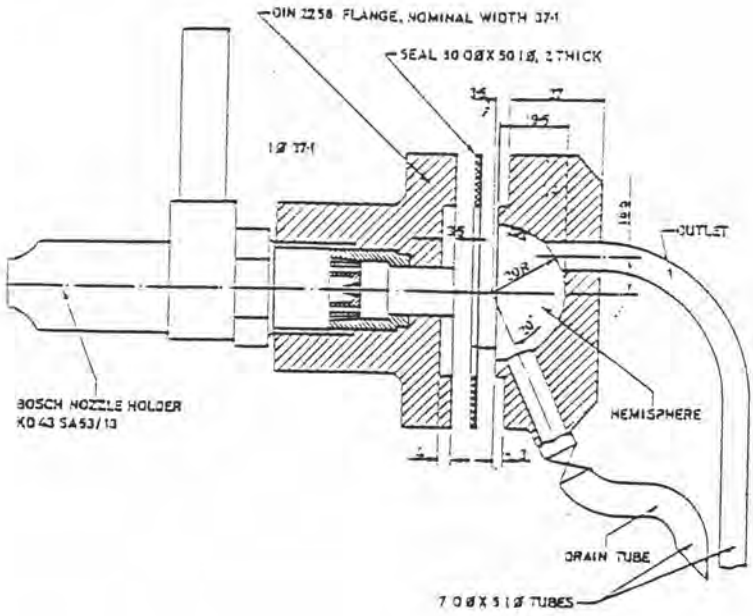

Fig. 3. Atomization chamber with nozzle and nozzle holder.

TABLE 1.

% Viscosity loss	Repeatability %	Reproducibility %
up to 2	0.5	1.5
2 to 10	1.0	3.5
10 to 25	1.0	4.5
over 25	2.0	6.0

10. REPORT

Report as Shear Stability, IP 294:

(1) Number of passes.
(2) Viscosity Index before and after shearing.
(3) *Either*, per cent decrease in kinematic viscosity at temperature T *or*, per cent polymer breakdown.

11. PRECISION

11.1. The data listed in Table 1 are from DIN 51 382 and are limited to engine oils containing polymers at 100°C.

11.1.1. The precision of other viscosity data at other temperatures is not known.

ANNEX X1

DIESEL INJECTOR RIG FOR SHEAR STABILITY TEST

X1.1. *Injector Rig*[3] – as shown in the photograph (Fig. 1) and diagrammatically in Figs 2 and 3 and comprising:

[3]The injector rig complete with automatic counter may be purchased from: HEA-Hamburger Elektro Apparate Gmbh, Eidelstedter Weg 255, D-2083 Halstenbek (Near Hamburg), West Germany.

X1.1.1. *Injector Nozzle* (1)[4] – type Bosch DN 8 S2.

X1.1.2. *Nozzle Holder* (Fig. 3) – type Bosch KD 43 SA 53/13. The injector breaking pressure should be set at 175 bar (2538.2 psi) with a suitable hand test-set (e.g. the Hartridge Nozzle Testmaster using reference fluid[5]). Other nozzle types and/or breaking pressures may be used if required to correlate with special service conditions.

X1.1.3. *Atomization Chamber* (2) – and detailed in Fig. 3. Ensure that the distance between the end of the nozzle and the impact wall remains constant.

X1.1.4. *Supply Pump* (12) – diesel injection fuel pump, type Bosch PE 2A 90C 300/3S 2266.

X1.1.5. *Electric Motor* (13) – 1.1kW, 950 ± 50 rpm.

X1.1.6. *Two Glass Tap Funnels* (5, 7) – each having a three-way stopcock (6, 8). The upper reservoir (5) possesses a double glass wall through which cooling fluid may pass and is fitted with a distributor plate (4) so that uniform run-off on to the inner glass wall is ensured. The lower reservoir (7) which is graduated, also contains a distributor plate in order to prevent channelling in the oil during the test.

X1.1.7. *Oil-resistant Rubber/PVC Tubing* (10) for joining the lower reservoir (7) to the pump (12). Special tubing materials may be required when using non-mineral oils.

X1.1.8. *Automatic Stroke-counter* (14) optional.

[4]Figures in brackets refer to items shown in Fig. 2.
[5]Approved reference fluids are:

BP	Energol Mineral Colza
Castrol	Castrol Mineral Colza
Esso	IL 1838
Gulf	Calibration Oil 45A
Mobil	Certrex 1102
Shell	Fusis Oil A

Appendix X Viscometric data of multigrade oils.

Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results
	KV@40	230.27		KV@40	209.35		KV@40	152.84		KV@40	170.02		KV@40	185.63
STAR110L	KV@100	25.81	OCP19L	KV@100	21.83	OCP14G	KV@100	16.77	STAR210L	KV@100	21.80	STAR25J	KV@100	19.49
	KVI	143		KVI	126		KVI	110		KVI	153		KVI	120
	CCS@ -10	3650		CCS@ -10	4370		CCS@ -10	4670		CCS@ -10	2040		CCS@ -10	4640
	KV@40	181.43												
				KV@40	193.30		KV@40	190.70		KV@40	174.04		KV@40	167.00
STAR19L	KV@100	22.03	OCP18K	KV@100	20.46	STAR17K	KV@100	21.12	STAR29L	KV@100	21.28	STAR24I	KV@100	18.12
	KVI	146		KVI	124		KVI	131		KVI	145		KVI	120
	CCS@ -10	2690		CCS@ -10	4300		CCS@ -10	3750		CCS@ -10	2390		CCS@ -10	4670
	KV@40	200.71		KV@40	175.45		KV@40	188.93		KV@40	193.69		KV@40	167.71
STAR18L	KV@100	22.67	OCP17J	KV@100	18.98	STAR16K	KV@100	20.52	**STAR28L**	KV@100	21.99	STAR23H	KV@100	16.51
	KVI	138		KVI	123		KVI	127		KVI	137		KVI	103
	CCS@ -10	3630		CCS@ -10	4120		CCS@ -10	4870		CCS@ -10	**3260**		CCS@ -10	**4300**
	KV@40	238.51		KV@40	163.11		KV@40	186.59		KV@40	194.55		KV@40	181.02
STAR38L	KV@100	22.75	OCP16I	KV@100	17.58	STAR15G	KV@100	19.72	**STAR27L**	KV@100	21.37	STAR310L	KV@100	21.52
	KVI	117		KVI	118		KVI	122		KVI	131		KVI	142
	CCS@ -10	4060		CCS@ -10	4620		CCS@ -10	4870		CCS@ -10	**3840**		CCS@ -10	**2370**
	KV@40	277.96		KV@40	160.35		KV@40	173.00		KV@40	188.06		KV@40	191.12
STAR37L	KV@100	23.57	OCP15G	KV@100	17.31	STAR14G	KV@100	18.06	**STAR26K**	KV@100	19.92	STAR39L	KV@100	21.63
	KVI	106		KVI	118		KVI	115		KVI	123		KVI	135
	CCS@ -10	4320		CCS@ -10	4040		CCS@ -10	4870		CCS@ -10	**4020**		CCS@ -10	**2910**

Appendix X Viscometric data of multigrade oils (ctd.).

Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results
	KV@40	178.62		KV@40	140.90		KV@40	195.42		KV@40	95.04		KV@40	94.19
STAR35I	KV@100	17.73	STAR13G	KV@100	15.57	STAR36K	KV@100	15.40	STAR18F	KV@100	14.75	STAR28F	KV@100	14.34
	KVI	108		KVI	114.20		KVI	74.20		KVI	162.00		KVI	157.40
	CCS@ -10	**4490**		CCS@ -10	4020		CCS@ -10	4100		CCS@ -20	**3480**		CCS@ -20	3610
	KV@40	113.83		KV@40	130.59		KV@40	189.06		KV@40	91.30		KV@40	90.52
OCP110H	KV@100	15.95	STAR12F	KV@100	14.70	STAR34H	KV@100	13.91	STAR17E	KV@100	14.06	STAR27E	KV@100	13.66
	KVI	149.50		KVI	113.40		KVI	56.50		KVI	158.30		KVI	153
	CCS@ -10	1470		CCS@ -10	4140		CCS@ -10	4540.00		CCS@ -20	3810		CCS@ -20	3250
	KV@40	141.96		KV@40	113.39		KV@40	151		KV@40	109.80		KV@40	104.68
OCP13G	KV@100	15.33	STAR11D	KV@100	13.76	STAR33H	KV@100	15.77	STAR15B	KV@100	15	STAR25B	KV@100	14.07
	KVI	110.40		KVI	119.90		KVI	107.90		KVI	138		KVI	136
	CCS@ -10	4620		CCS@ -10	3820.00		CCS@ -10	4440.00		CCS@ -20	7980.00		CCS@ -20	7340
	KV@40	117.86		KV@40	130		KV@40	121.19		KV@40	88.34		KV@40	112.32
OCP12E	KV@100	13.77	STAR22F	KV@100	14.97	STAR31E	KV@100	13.62	STAR14A	KV@100	12.56	STAR310H	KV@100	16.29
	KVI	114.80		KVI	117.10		KVI	109.00		KVI	139		KVI	156
	CCS@ -10	3820		CCS@ -10	4020.00		CCS@ -10	**4230**		CCS@ -20	6260		CCS@ -20	3520
	KV@40	110.70		KV@40	115		KV@40	92.48		KV@40	107.41		KV@40	98.93
OCP11D	KV@100	12.79	STAR21D	KV@100	13.75	OCP110E	KV@100	13.54	STAR29H	KV@100	15.63	STAR39F	KV@100	13.31
	KVI	109.00		KVI	118.40		KVI	147.70		KVI	154		KVI	133
	CCS@ -10	3840		CCS@ -10	3680.00		CCS@ -20	3650		CCS@ -20	3790		CCS@ -20	3150

Appendix X Viscometric data of multigrade oils (ctd.).

Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results	Sample	Properties	Results
	KV@40	89.39		KV@40	133.06		KV@40	79.91		KV@40	66.46		KV@40	78.26
STAR38E	KV@100	13.61	STAR32F	KV@100	11.02	OCP18C	KV@100	11.58	OCP16A	KV@100	10.20	OCP14A	KV@100	12.15
	KVI	155		KVI	52.37		KVI	137.00		KVI	139.20		KVI	152.00
	CCS@ -20	3280		CCS@ -10	4140		CCS@ -20	3450		CCS@ -20	3130		CCS@ -20	5790.00
	KV@40	108.00		KV@40	84.97		KV@40	73.52		KV@40	83.00		KV@40	78.83
STAR35B	KV@100	13.72	OCP19D	KV@100	12.28	OCP17B	KV@100	11.09	OCP15A	KV@100	11.20	STAR16D	KV@100	11.85
	KVI	126		KVI	122.50		KVI	141.20		KVI	124.00		KVI	144.50
	CCS@ -20	7620		CCS@ -20	3320		CCS@ -20	3330		CCS@ -20	5790		CCS@ -20	3420
	KV@40	80.53		KV@40	78.85		KV@40	86.73		KV@40	87.76		KV@40	76.05
STAR26D	KV@100	12.29	STAR37D	KV@100	12.13	STAR34A	KV@100	10.91	STAR24A	KV@100	12.12	STAR36C	KV@100	11.53
	KVI	149.30		KVI	149.90		KVI	111.3		KVI	132		KVI	145.00
	CCS@ -20	3500		CCS@ -20	3100		CCS@ -20	6070		CCS@ -20	5830		CCS@ -20	3280

Appendix XI Shear stability results of multigrade oils.

SAE 60 grades

SAMPLE	Property	Viscosity Null	Before	Viscosity 30 cycles	%SSI 30 cycles	Relative Viscosity	Viscosity 60 cycles	%SSI 60 cycles	Relative Viscosity	Viscosity After 90	%SSI 90 cycles	Relative Viscosity	After250 Viscosity	%SSI 250 cycles	Relative Viscosity
11	KV@40		230.27	221.06		0.96									
STAR110L	KV@100	10.23	25.81	24.78	6.63	0.96	24.52	8.28	0.95	24.26	9.94	0.94	24.00	11.60	0.93
	KVI		143	144											
	CCS@ -10		3650	3660											
12	KV@40		181.43	175.93		0.97									
STAR19L	KV@100	10.00	22.03	21.15	7.33	0.96	20.93	9.16	0.95	20.71	10.99	0.94	20.49	12.82	0.93
	KVI		146	144											
	CCS@ -10		2690	2830											
13	KV@40		200.71	189.18		0.94									
STAR18L	KV@100	11.45	22.67	21.99	6.06	0.97	21.54	10.10	0.95	21.31	12.12	0.94	21.09	14.14	0.93
	KVI		138	137											
	CCS@ -10		3630	3660											
33	KV@40		238.51	156.12		0.65									
STAR38L	KV@100	12.52	22.75	17.97	46.70	0.79	17.75	48.92	0.78	17.52	51.14	0.77	17.52	51.14	0.77
	KVI		117	123											
	CCS@ -10		4060	5580											
34	KV@40		277.96	157.85		0.57									
STAR37L	KV@100	12.84	23.57	18.62	46.13	0.79	18.38	48.33	0.78	18.15	50.53	0.77	18.15	50.53	0.77
	KVI		106	102											
	CCS@ -10		4320	4750											

Appendix XI Shear stability results of multigrade oils ctd.)

SAE 50 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
2	KV@40		209.35	168.70		0.81	164.19		0.78						
OCP19L	KV@100	13.05	21.83	19.43	27.35	0.89	19.21	29.84	0.88	18.99	32.33	0.87	18.99	32.33	0.87
	KVI		126	125.8											
	CCS@ -10		4370	4080											
3	KV@40		193.30	145.28		0.75	192.93		1.00						
OCP18K	KV@100	12.8	20.46	18.41	26.72	0.90	18.21	29.39	0.89	18.00	32.06	0.88	18.00	32.06	0.88
	KVI		124	139.6											
	CCS@ -10		4300	4230											
4	KV@40		175.45	140.46		0.80	150.84		0.86						
OCP17J	KV@100	12.56	18.98	17.27	26.60	0.91	17.12	29.06	0.90	16.89	32.51	0.89	16.89	32.51	0.89
	KVI		123	126.2											
	CCS@ -10		4120	4210											
5	KV@40		163.11	158.78		0.97									
OCP16I	KV@100	12.37	17.58	16.18	26.98	0.92	16.00	30.35	0.91	15.83	33.72	0.90	15.83	33.72	0.90
	KVI		118	107											
	CCS@ -10		4620	4700											
6	KV@40		160.35	141.75		0.88									
OCP15G	KV@100	13.05	17.31	16.27	24.40	0.94	15.92	32.53	0.92	15.75	36.60	0.91	15.58	40.66	0.90
	KVI		118	119											
	CCS@ -10		4040	4140											

Appendix XI Shear stability results of multigrade oils(ctd.)

SAE 50 grades

SAMPLE	Property	Viscosity Null	Before	Viscosity 30 cycles	%SSI 30 cycles	Relative Viscosity	Viscosity 60 cycles	%SSI 60 cycles	Relative Viscosity	Viscosity After 90	%SSI 90 cycles	Relative Viscosity	After250 Viscosity	%SSI 250 cycles	Relative Viscosity
7	KV@40		152.84	139.35		0.91									
OCP14G	KV@100	13.05	16.77	15.94	22.52	0.95	15.77	27.02	0.94	15.60	31.52	0.93	15.60	31.52	0.93
	KVI		110	115											
	CCS@ -10		4670	4670											
14	KV@40		190.70	178.85		0.94									
STAR17K	KV@100	11.71	21.12	20.28	8.98	0.96	20.07	11.22	0.95	19.85	13.47	0.94	19.85	13.47	0.94
	KVI		131	136											
	CCS@ -10		3750	4520											
15	KV@40		188.93	183.70		0.97									
STAR16K	KV@100	12.50	20.52	19.91	7.67	0.97	19.70	10.23	0.96	19.50	12.79	0.95	19.50	12.79	0.95
	KVI		127	127											
	CCS@ -10		4870	4540											
16	KV@40		186.59	180.04		0.96									
STAR15G	KV@100	13.05	19.72	19.33	5.91	0.98	19.13	8.87	0.97	18.93	11.82	0.96	18.93	11.82	0.96
	KVI		122	122											
	CCS@ -10		4870	6420											
17	KV@40		173.00	169.63		0.98									
STAR14G	KV@100	13.05	18.06	17.70	7.21	0.98	17.52	10.82	0.97	17.52	10.82	0.97	17.52	10.82	0.97
	KVI		115	116											
	CCS@ -10		4870	8670											

Appendix XI Shear stability results of multigrade oils(ctd.)

SAE 50 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
21	KV@40		170.02	157.31		0.93	154.05		0.91						
STAR210L	KV@100	8.99	21.80	19.18	20.42	0.88	18.96	22.13	0.87	18.75	23.83	0.86	18.75	23.83	0.86
	KVI		153	149											
	CCS@ -10		2040	2140											
22	KV@40		174.04	163.17		0.94	156.81		0.90						
STAR29L	KV@100	9.77	21.28	18.94	20.34	0.89	18.51	24.04	0.87	18.30	25.89	0.86	18.30	25.89	0.86
	KVI		145	142											
	CCS@ -10		2390	2200											
23	KV@40		193.69	173.40		0.90	170.86		0.88						
STAR28L	KV@100	11.31	21.99	20.01	18.54	0.91	19.79	20.59	0.9	19.57	22.65	0.89	18.91	28.83	0.86
	KVI		137	135											
	CCS@ -10		**3260**	3390											
24	KV@40		194.55	175.70		0.90	172.53		0.89						
STAR27L	KV@100	12.08	21.37	19.66	18.40	0.92	19.24	23.00	0.9	19.02	25.30	0.89	19.02	25.30	0.89
	KVI		131	128											
	CCS@ -10		**3840**	4000											
25	KV@40		188.06	165.51		0.88	156.81		0.83						
STAR26K	KV@100	12.23	19.92	18.52	18.14	0.93	18.12	23.32	0.91	17.93	25.91	0.90	17.93	25.91	0.90
	KVI		123	126											
	CCS@ -10		**4020**	4040											

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 50 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
26	KV@40		185.63	165.40		0.89									
STAR25J	KV@100	13.05	19.49	18.32	18.15	0.94	17.93	24.20	0.92	17.74	27.23	0.91	17.74	27.23	0.91
	KVI		120	119											
	CCS@ -10		4640	4700											
27	KV@40		167.00	154.03		0.92									
STAR24I	KV@100	13.05	18.12	17.22	17.86	0.95	16.85	25.01	0.93	16.85	25.01	0.93	16.85	25.01	0.93
	KVI		120	117											
	CCS@ -10		4670	4720											
28	KV@40		167.71	138.11		0.82									
STAR23H	KV@100	12.56	16.51	15.85	16.73	0.96	15.52	25.10	0.94	15.52	25.10	0.94	15.52	25.10	0.94
	KVI		103	113											
	CCS@ -10		**4300**	4370											
31	KV@40		181.02	139.58		0.77									
STAR310L	KV@100	10.23	21.52	16.57	43.83	0.77	16.79	41.93	0.78	16.57	43.83	0.77	16.57	43.83	0.77
	KVI		142	134											
	CCS@ -10		**2370**	7790											
32	KV@40		191.12	142.83		0.75									
STAR39L	KV@100	10.86	21.63	17.08	42.18	0.79	16.87	44.19	0.78	16.65	46.20	0.77	16.65	46.20	0.77
	KVI		135	127											
	CCS@ -10		**2910**	7110											

Appendix XI Shear stability results of multigrade oils(ctd.)

SAE 50 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
36	KV@40		178.62	144.17		0.81									
STAR35I	KV@100	13.05	17.73	15.78	41.65	0.89	15.61	45.43	0.88	15.61	45.43	0.88	15.43	49.22	0.87
	KVI		108	100											
	CCS@ -10		**4490**	4640											

Appendix XI Shear stability results of multigrade oils(ctd.)

SAE 40 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
1	KV@40		113.83	92.74		0.81	94.50		0.83						
OCP110H	KV@100	7.96	15.95	14.04	23.95	0.88	13.88	25.95	0.87	13.72	27.94	0.86	13.72	27.94	0.86
	KVI		149.50	147.1											
	CCS@ -10		1470	1490											
8	KV@40		141.96	133.01		0.94									
OCP13G	KV@100	12.89	15.33	14.71	25.17	0.96	14.56	31.46	0.95	14.41	37.75	0.94	14.41	37.75	0.94
	KVI		110.40	109.90											
	CCS@ -10		4620	4640											
9	KV@40		117.86	111.01		0.94	114.65		0.97						
OCP12E	KV@100	11.89	13.77	13.36	21.96	0.97	13.22	29.28	0.96	13.08	36.60	0.95	13.08	36.60	0.95
	KVI		114.80	115.80											
	CCS@ -10		3820	3860											
10	KV@40		110.70	106.27		0.96									
OCP11D	KV@100	11.87	12.79	12.66	13.86	0.99	12.54	27.73	0.98	12.41	41.59	0.97	12.41	41.59	0.97
	KVI		109.00	106.10											
	CCS@ -10		3840	3770											
18	KV@40		140.90	136.11		0.97	137.71		0.98						
STAR13G	KV@100	12.03	15.57	15.42	4.40	0.99	15.26	8.79	0.98	15.11	13.19	0.97	15.11	13.19	0.97
	KVI		114.20	117.50											
	CCS@ -10		4020	9320											

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 40 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
19	KV@40		130.59	127.52		0.98									
STAR12F	KV@100	12.27	14.70	14.56	6.04	0.99	14.41	12.08	0.98	14.26	18.12	0.97	14.26	18.12	0.97
	KVI		113.40	114.80											
	CCS@ -10		4140	4370											
20	KV@40		113.39	112.50		0.99									
STAR11D	KV@100	11.60	13.76	13.62	6.37	0.99	13.49	12.74	0.98	13.35	19.11	0.97	13.35	19.11	0.97
	KVI		119.90	110.40											
	CCS@ -10		3820.00	7560.00											
29	KV@40		130	123		1									
STAR22F	KV@100	12.18	14.97	14.67	10.74	0.98	14.52	16.11	0.97	14.37	21.47	0.96	14.37	21.47	0.96
	KVI		117.10	110.40											
	CCS@ -10		4020.00	4080.00											
30	KV@40		115	110		1									
STAR21D	KV@100	11.75	13.75	13.61	6.89	0.99	13.47	13.78	0.98	13.33	20.66	0.97	13.33	20.66	0.97
	KVI		118.40	113.40											
	CCS@ -10		3680.00	3750.00											
35	KV@40		195.42	146.98		0.75									
STAR36K	KV@100	12.89	15.40	14.17	49.08	0.92	14.01	55.22	0.91	13.86	61.36	0.90	13.86	61.36	0.90
	KVI		74.20	58.10											
	CCS@ -10		4100	3960											

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 40 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
37	KV@40		189.06	137.82		0.73									
STAR34H	KV@100	13.05	13.91	12.94	113.06	0.93	12.80	129.21	0.92	12.66	145.36	0.91	12.66	145.36	0.91
	KVI		56.50	48.90											
	CCS@ -10		4540.00	4700.00											
38	KV@40		151	126		1									
STAR33H	KV@100	12.86	15.77	14.35	48.77	0.91	14.19	54.19	0.90	14.04	59.60	0.89	14.04	59.60	0.89
	KVI		107.90	102.90											
	CCS@ -10		4440.00	7030.00											
40	KV@40		121.19	114.38		0.94									
STAR31E	KV@100	12.48	13.62	13.08	47.69	0.96	12.94	59.62	0.95	12.81	71.54	0.94	12.81	71.54	0.94
	KVI		109.00	104.00											
	CCS@ -10		**4230**	too high											
41	KV@40		92.48	78.26		0.85									
OCP110E	KV@100	6.82	13.54	11.65	28.20	0.86	11.51	30.21	0.85	11.38	32.23	0.84	11.38	32.23	0.84
	KVI		147.70	148.10											
	CCS@ -20		3650	too high											
49	KV@40		101.58	98.65		0.97	97.05		0.96						
STAR19G	KV@100	6.63	15.41	14.64	8.77	0.95	14.49	10.53	0.94	14.33	12.28	0.93	14.33	12.28	0.93
	KVI		160.60	158.20											
	CCS@ -20		**3360**	3500											

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 40 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
50	KV@40		95.04	93.37		0.98									
STAR18F	KV@100	6.73	14.75	14.02	9.19	0.95	13.87	11.03	0.94	13.72	12.87	0.93	13.72	12.87	0.93
	KVI		162.00	155.00											
	CCS@ -20		3480	3450											
51	KV@40		91.30	90.02		0.99									
STAR17E	KV@100	7.03	14.06	13.49	8.00	0.96	13.35	10.00	0.95	13.21	12.00	0.94	13.21	12.00	0.94
	KVI		158.30	157.70											
	CCS@ -20		3810	3810											
53	KV@40		109.80	107.64		0.98									
STAR15B	KV@100	9	15	14	8	1	14	11	1	14	13	1	14	13	1
	KVI		138	140											
	CCS@ -20		7980.00	7800.00											
54	KV@40		88.34	87.94		1.00									
STAR14A	KV@100	8.45	12.56	12.31	6.11	0.98	12.18	9.17	0.97	12.06	12.23	0.96	12.06	12.23	0.96
	KVI		139	132											
	CCS@ -20		6260	6410											
56	KV@40		107.41	98.35		0.92									
STAR29H	KV@100	6.99	15.63	13.91	19.90	0.89	13.75	21.71	0.88	13.60	23.52	0.87	13.60	23.52	0.87
	KVI		154	158											
	CCS@ -20		3790	3580											

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 40 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
57	KV@40		94.19	90.80		0.96									
STAR28F	KV@100	6.72	14.34	12.77	20.70	0.89	12.62	22.58	0.88	12.48	24.46	0.87	12.48	24.46	0.87
	KVI		157.40	153.90											
	CCS@ -20		3610	3360											
58	KV@40		90.52	87.19		0.96	84.93		0.94						
STAR27E	KV@100	7.02	13.66	12.16	22.63	0.89	12.02	24.69	0.88	11.88	26.74	0.87	11.88	26.74	0.87
	KVI		153	148											
	CCS@ -20		3250	3740											
60	KV@40		104.68	100.22		0.96									
STAR25B	KV@100	9.02	14.07	12.95	22.28	0.92	12.81	25.07	0.91	12.66	27.85	0.90	12.66	27.85	0.90
	KVI		136	133											
	CCS@ -20		7340	7290											
62	KV@40		112.32	97.65		0.87	87.50		0.78						
STAR310H	KV@100	6.90	16.29	12.22	43.36	0.75	12.06	45.10	0.74	11.89	46.83	0.73	11.89	46.83	0.73
	KVI		156	151											
	CCS@ -20		3520	3720											
63	KV@40		98.93	85.66		0.87									
STAR39F	KV@100	6.63	13.31	10.38	43.84	0.78	10.25	45.83	0.77	10.11	47.83	0.76	10.11	47.83	0.76
	KVI		133	154											
	CCS@ -20		3150	3280											

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 40 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
64	KV@40		89.39	77.17		0.86									
STAR38E	KV@100	6.71	13.61	10.62	43.38	0.78	10.48	45.35	0.77	10.35	47.33	0.76	10.35	47.33	0.76
	KVI		155	150											
	CCS@ -20		3280	3250											
67	KV@40		108.00	89.23		0.83									
STAR35B	KV@100	9.20	13.72	11.66	45.55	0.85	11.52	48.59	0.84	11.38	51.63	0.83	11.38	51.63	0.83
	KVI		126	113											
	CCS@ -20		7620	2860											

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 30 grades

SAMPLE	Viscosity		Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
39	KV@40		133.06	120.69		0.91									
STAR32F	KV@100	9.44	11.02	10.80	13.91	0.98	10.69	20.87	0.97	10.58	27.82	0.96	10.58	27.82	0.96
	KVI		52.37	42.30		0.81									
	CCS@ -10		4140	too high											
42	KV@40		84.97	71.10		0.84									
OCP19D	KV@100	6.63	12.28	11.55	13.04	0.94	11.42	15.21	0.93	11.30	17.38	0.92	11.30	17.38	0.92
	KVI		122.50	162.70		1.33									
	CCS@ -20		3320	3290		1									
43	KV@40		79.91	70.34		0.88									
OCP18C	KV@100	6.79	11.58	10.89	14.50	0.94	10.77	16.91	0.93	10.66	19.33	0.92	10.66	19.33	0.92
	KVI		137.00	137.30		1.00									
	CCS@ -20		3450	3470		1									
44	KV@40		73.52	64.75		0.88									
OCP17B	KV@100	6.74	11.09	10.54	12.74	0.95	10.43	15.29	0.94	10.32	17.84	0.93	10.32	17.84	0.93
	KVI		141.20	136.00		0.96									
	CCS@ -20		3330	3390		1									
45	KV@40		66.46	59.77		0.90	59.67		0.90						
OCP16A	KV@100	6.63	10.20	9.69	14.29	0.95	9.59	17.15	0.94	9.48	20.01	0.93	9.48	20.01	0.93
	KVI		139.20	146.10		1.05									
	CCS@ -20		3130	3190		1									

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 30 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
46	KV@40		83.00	74.24		0.89									
OCP15A	KV@100	8.18	11.20	10.75	14.83	0.96	10.64	18.54	0.95	10.53	22.25	0.94	10.53	22.25	0.94
	KVI		124.00	133.00		1.07									
	CCS@ -20		5790	5670		1									
47	KV@40		78.26	71.56		0.91									
OCP14A	KV@100	8.18	12.15	11.79	9.18	0.97	11.67	12.23	0.96	11.55	15.29	0.95	11.55	15.29	0.95
	KVI		152.00	137.00		0.90									
	CCS@ -20		5790.00	5670.00		0.98									
52	KV@40		78.83	77.38		0.98									
STAR16D	KV@100	6.80	11.85	11.50	7.04	0.97	11.38	9.39	0.96	11.26	11.73	0.95	11.26	11.73	0.95
	KVI		144.50	142.60		0.99									
	CCS@ -20		3420	3440		1									
59	KV@40		80.53	77.72		0.97									
STAR26D	KV@100	6.99	12.29	11.55	13.91	0.94	11.43	16.23	0.93	11.31	18.55	0.92	11.31	18.55	0.92
	KVI		149.30	145.00		0.97									
	CCS@ -20		3500	3630		1									
61	KV@40		87.76	90.54		1.03									
STAR24A	KV@100	8.31	12.12	11.51	15.92	0.95	11.39	19.10	0.94	11.27	22.29	0.93	11.27	22.29	0.93
	KVI		132	102		1									
	CCS@ -20		5830	5940		1									

Appendix XI Shear stability results of multigrade oils(ctd.).

SAE 30 grades

SAMPLE	Property	Viscosity	Before	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	Viscosity	%SSI	Relative	After250	%SSI	Relative
		Null		30 cycles	30 cycles	Viscosity	60 cycles	60 cycles	Viscosity	After 90	90 cycles	Viscosity	Viscosity	250 cycles	Viscosity
65	KV@40		78.85	69.65		0.88	66.14		0.84						
STAR37D	KV@100	6.63	12.13	11.04	19.85	0.91	10.92	22.05	0.90	10.80	24.26	0.89	10.80	24.26	0.89
	KVI		149.90	153.20		1.02									
	CCS@ -20		3100	3100											
66	KV@40		76.05	68.01		0.89									
STAR36C	KV@100	6.82	11.53	10.72	17.14	0.93	10.61	19.59	0.92	10.49	22.04	0.91	10.49	22.04	0.91
	KVI		145.00	154.00		1.06									
	CCS@ -20		3280	3300		1									
68	KV@40		86.73	75.39		0.87									
STAR34A	KV@100	8.48	10.91	10.58	13.49	0.97	10.47	17.99	0.96	10.36	22.48	0.95	10.36	22.48	0.95
	KVI		111.3	130.9		1.18									
	CCS@ -20		6070	6090		1									

VITA

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