Extending SAE J300 to Viscosity Grades below SAE 20

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ABSTRACT

The SAE Engine Oil Viscosity Classification (EOVC) Task Force has been gathering data in consideration of extending SAE J300 to include engine oils with high temperature, high shear rate (HTHS) viscosity below the current minimum of 2.6 mPa·s for the SAE 20 grade. The driving force for doing so is fuel economy, although it is widely recognized that hardware durability can suffer if HTHS viscosity is too low. Several Japanese OEMs have expressed interest in revising SAE J300 to allow official designation of an engine oil viscosity category with HTHS viscosity below 2.6 mPa·s to enable the development of ultra low friction engines in the future. This paper summarizes the work of the SAE EOVC Low Viscosity Grade Working Group comprising members from OEMs, oil companies, additive companies and instrument manufacturers to explore adoption of one or more new viscosity grades. Past studies relating HTHS viscosity to engine wear will be reviewed, and an analysis of the rheological properties of commercial SAE xW-20 oils will be presented. New data will also be offered to demonstrate the feasibility of formulating engine lubricants to meet HTHS viscosities as low as 1.7 mPa·s while meeting current low temperature oil starting viscosity and ILSAC volatility requirements. Finally, the paper will address the measurement precision of current HTHS methods on prototype low HTHS engine oils.

INTRODUCTION

The Engine Oil Viscosity Classification (EOVC) Task Force is a standing committee of SAE Technical Committee 1 formed in 1975 [1] for the purpose of overseeing SAE J300, the Engine Oil Viscosity Classification Surface Vehicle Standard. The purpose of the Standard is to define engine lubricating oils "in rheological terms only." There are four categories of oil viscosity measurements that affect engine operation:

1. high temperature, high shear rate (HTHS) viscosity that controls oil film thickness in bearings,

2. low temperature, high shear rate viscosity that relates to engine startability,

3. low temperature, low shear rate viscosity that relates to oil pumpability, and

4. high shear rate viscometric effects that influence fuel economy.

Other vitally important properties of the oil such as heat dissipation, deposit/sludge control, resistance to oxidative/ thermal degradation, etc. are outside the scope of J300. As vehicle engines have evolved over the years, so have the technical requirements of engine lubricants changed to address a variety of viscometric issues identified by original equipment manufacturers (OEMs). Some examples of problems addressed by the Task Force include low-temperature engine startability, the need to ensure adequate oil supply throughout the engine in cold weather, and high temperature bearing wear protection.

At various times in its history, SAE convened Open Forums to address OEM requests for improvements in lubricant performance. On April 12, 2005 an Open Forum was held in conjunction with the SAE World Congress, "How Should GF-5 Fuel Economy be Defined?" On October 25, 2005, an SAE Open Forum entitled "The Future of the SAE J300 Engine Oil Viscosity Classification System" was held in San Antonio and included formal presentations by OEMs, base stock manufacturers and additive companies. EOVC chairman Andy Jackson reviewed the current classification system and suggested a number of ways that it might be modified to offer a more rational basis for viscosity ranges. Several presentations anticipated future needs for oils with HTHS values below 2.6 mPa·s, in response to engine designers' continuous quest to improve fuel economy. Several oil companies noted that the advent of new high viscosity index (VI), low volatility base stocks could facilitate the formulation of lower HTHS viscosity fluids in the future, and SAE J300 should not be an obstacle to their use.

Development History of HTHS Viscosity Requirements in SAE J300

High temperature viscosity limits within the SAE J300 classification were for many years defined by kinematic viscosity at a defined temperature - most recently 100°C. However, by the mid-1970's there was growing recognition that a rheological measurement more relevant to engine operation was needed. Following a 1977 request by SAE, ASTM Subcommittee 7 established a task force to develop appropriate high temperature, high shear viscometric techniques and understand their relevance to engine operation. This culminated in a 1985 ASTM publication which summarized the technical literature on HTHS viscosity [2]. During this period, the three commonly used HTHS methods were developed and refined: the Tapered Bearing Simulator (TBS, D4683), Tapered Plug Viscometer (TPV, D4741) and High-Pressure Capillary Viscometers (D4624, later D5481). A technical symposium in 1988 summarized much of the ASTM and industry work in terms of both engine studies and HTHS measurement techniques [3]. While these studies noted the relationship between fuel economy and high shear viscosity (at the appropriate engine operating temperature) [3], the concern from a specification standpoint was oil film thickness and its relation to durability; and much effort was spent to correlate HTHS and minimum oil film thickness (MOFT). In fact, in a preamble to STP 1068 technical papers, Z. Holubec (then ASTM D02.07 Chair) noted that "there are those in the industry who refuse to believe that such [engine] failures are likely to occur in future engine designs if HTHS oil viscosity of lubricants is not defined" [3]. It was these MOFT considerations in the journal bearing areas of the engine that drove the focus on 150°C measuring temperatures at a shear rate of 10^6 sec−1.

An example of some of the MOFT-HTHS correlation work from the engine studies is shown in Figure 1 [4].

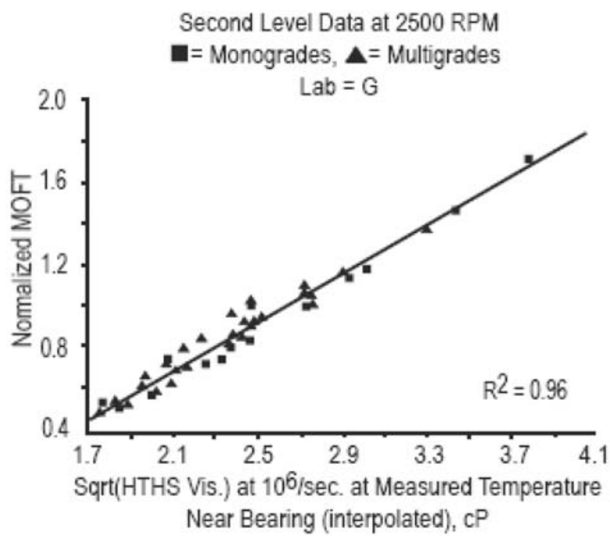


Figure 1. Correlation of normalized minimum oil film thickness to (HTHS viscosity)$^{0.5}$ at measured temperature [4]. Copyright SAE International Reprinted with permission from SAE paper* 902064*.

Other studies utilized a range of engine oils formulated with a single performance additive package and measured the effects of very low HTHS viscosities on main and connecting rod bearing wear in field testing; high wear was observed below some threshold HTHS viscosity (Fig. 2, 3) [5, 6]. Additional work demonstrated that a similar step change in wear can be observed in piston ring and cam face wear [7].

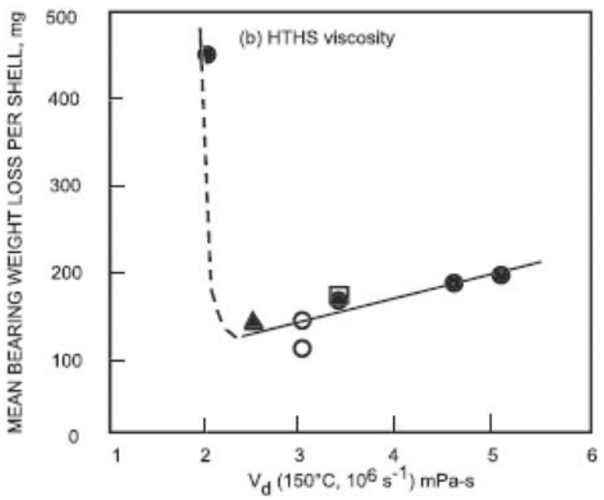


***Figure 2a. Dependence of big-end bearing weight loss on viscosity [5]. Copyright SAE International Reprinted with permission front SAE paper* 892154.**

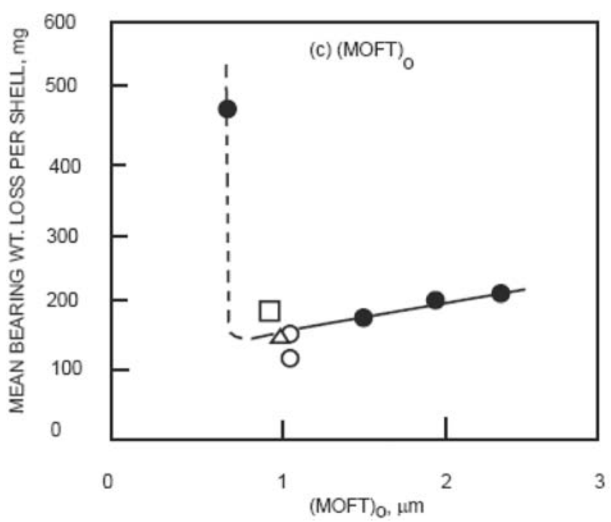


***Figure 2b. Dependence of big-end bearing weight loss on minimum oil film thickness [5]. Copyright SAE International Reprinted with permission from SAE paper* 892154.**

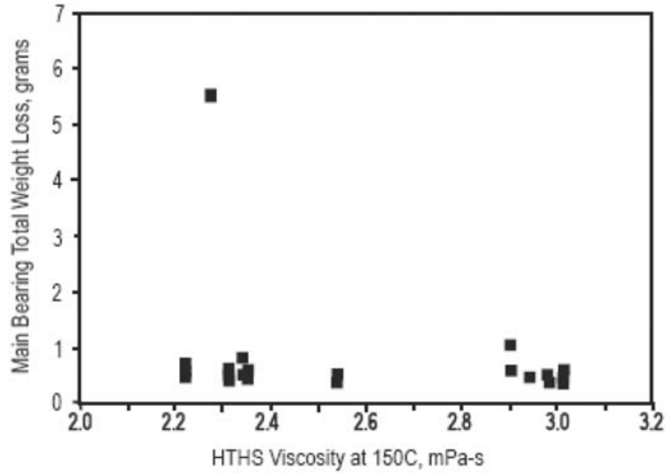


***Figure 3a. Main bearing wear as a function of HTHS viscosity at 150°C from a controlled field test [6]. Copyright SAEInternational. Reprinted with permission front SAE paper* 922342.**

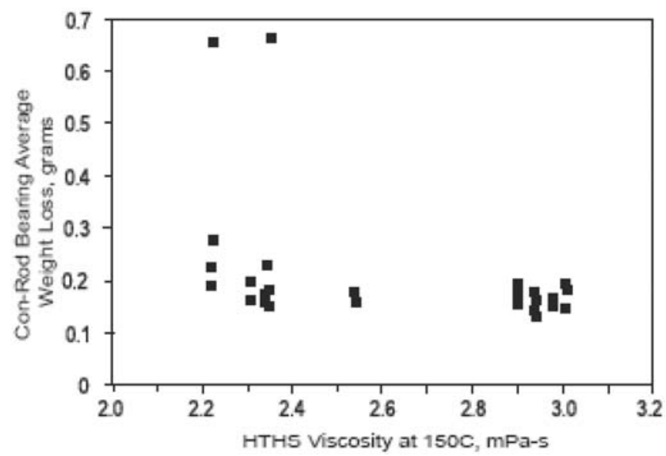


***Figure 3b. Connecting rod bearing wear as a function of HTHS viscosity at 150°C from a controlled field test [6]. Copyright SAEInternational. Reprinted with permission front SAE paper* 922342.**

The first reference to HTHS viscosity in J300 appeared in the June 1987 version and was limited to comments on instrumental methods and OEM limits with a recommendation that formulators consider these during oil development [8]. These comments were further expanded with additional references in the June 1989 version of J300, but it was not until the February, 1992 Standard that HTHS limits were explicitly defined, the initial approach being to associate them with the 'W' grade classification.

Table 1. HTHS Limits Introduced with SAE* J300 *FEB92

SAE Viscosity Grade	Low-Temperature (°C) Cranking Viscosity[1], cP	Low Temperature (°C) Pumping Viscosity[3], cP	Kinematic Viscosity[4] (cSt) at 100°C		High-Temperature High-Shear Viscosity[5,6] (cP) at 150°C and 10^6 s^{-1}
	Max	Max with no Yield Stress	Min	Max	Min
0W	3,250 at -30	30,000 at -35	3.8	---	2.4
5W	3,500 at -25	30,000 at -30	3.8	---	2.9
10W	3,500 at -20	30,000 at -25	4.1	---	2.9
15W	3,500 at -15	30,000 at -20	5.6		3.7
20W	4,500 at -10	30,000 at -15	5.6	---	3.7
25W	6,000 at -5	30,000 at -10	9.3		3.7
20	---	---	5.6	< 9.3	---
30	---	---	9.3	< 12.6	---
40	---	---	12.5	< 16.3	---
50	---	---	16.3	< 21.9	---
60	---	---	21.9	< 26.1	---

These limits would later be revised to associate them to the non-W grade classification (with some consideration for differentiated limits with multigrade 40's depending upon their W grade.

Table 2. HTHS Limits Introduced with SAE* J300 *MAR93

SAE Viscosity Grade	Low-Temperature (°C) Cranking Viscosity[1], cP	Low Temperature (°C) Pumping Viscosity[3], cP	Kinematic Viscosity[4] (cSt) at 100°C		High-Temperature High-Shear Viscosity[5,6] (cP) at 150°C and 10^6 s^{-1}
	Max	Max with no Yield Stress	Min	Max	Min
0W	3,250 at -30	30,000 at -35	3.8	---	---
5W	3,500 at -25	30,000 at -30	3.8	---	---
10W	3,500 at -20	30,000 at -25	4.1	---	---
15W	3,500 at -15	30,000 at -20	5.6		---
20W	4,500 at -10	30,000 at -15	5.6	---	---
25W	6,000 at -5	30,000 at -10	9.3		---
20	---	---	5.6	< 9.3	2.6
30	---	---	9.3	< 12.6	2.9
40	---	---	12.5	< 16.3	2.9 (0W-/ 5W- / 10W-40)
40	---	---	12.5	< 16.3	3.7 (15W- / 20W- / 25W-40, 40)
50	---	---	16.3	< 21.9	3.7
60	---	---	21.9	< 26.1	3.7

These HTHS limits remained unchanged until the J300 NOV2007 version which adjusted the 0W/5W/10W-40 minimum from 2.9 to 3.5 mPa·s.

As mentioned previously, various studies have demonstrated correlations between engine fuel economy and HTHS viscosity of the lubricant [12, 13, 14]. In general, correlation is greatest when the viscosity is measured at a temperature typical of the bulk oil during the fuel economy test cycle (e.g. 70 ~ 100°C). In fact the strong correlation between 100°C HTHS and fuel economy in the new Seq. VID test has led to the adoption of read-across rules based upon the HTHS viscosity of the original oil and the read-across fluid at this temperature [15]. The viscosity at which this correlation breaks down in a particular engine needs to be examined by the respective engine designer to define an optimal HTHS viscosity for fuel economy performance.

SAE WORKING GROUP MISSION AND MEMBERSHIP

The scope and objectives of the SAE Low Viscosity Grade Working Group were established by the EOVC Task Force as follows: "With OEM guidance, develop options for extending the SAE J300 classification system to oils with HTHS (150°C) viscosities below 2.6 mPa·s. This will require additions/modifications to the kinematic viscosity classifications."

Members of the Working Group are listed in the Appendix.

Straw man Proposal for SAE Viscosity Grades below SAE 20

The Working Group felt that a reasonable starting position for creating new viscosity grades below SAE 20 would be to define HTHS in increments of 0.3 mPa·s without initially imposing kinematic viscosity limits narrower than the current SAE 20 grade. See Table 3 below. This "straw man" proposal was mailed on November 6, 2009 to representatives of the International Lubricants Standardization and Approval Committee ILSA) and the European Automobile Manufacturers Association (ACEA) to solicit feedback from their members.

Table 3. Straw man proposal for new SAE viscosity grades below SAE 20. KV = kinematic viscosity at 100°C.

Proposed SAE Grade	HTHS min	KV min	KV max
20 (existing grade)	2.6	5.6	<9.3
15	2.3	5.6	<9.3
10	2.0	5.6	<9.3
5	1.7	5.6	<9.3

Since the new ranges share the same kinematic viscosity limits, they were meant to be distinguished solely on the basis of HTHS viscosity.

To date, feedback to the proposed straw man has been mixed. Toyota Motor Corp and Honda Motor Corp have indicated support for the proposed limits and the activities of this Working Group. Both companies would like to see a formal system in place to allow common understanding of the HTHS requirements for these low viscosity fluids. Ford Motor Co. has responded that they see no current/near term need for viscosity grades below SAE 20 [9]. They have expressed concerns about the potential to label an oil as meeting more than one viscosity grade, and would prefer to have discrete ranges in both HTHS and kinematic viscosity. Both Ford and Chrysler have commented in Work Group meetings that they want to protect the integrity of the current SAE 20 viscosity grade classification as both manufacturers recommend SAE 5W-20 oils for many of their engines.

ACEA responded that they see no need for changes to SAE J300 [10], and have similar concerns about potential viscosity grade overlap in the system being proposed. ATIEL

(Association Technique de l'Industrie Européenne des Lubrifiants) has also provided some input, indicating that it takes no exception to the current straw man [11]. Their comments: "In general it appears there is room for further refinement of the ultra-low viscosity grades in anticipation of future powertrains capable of utilising such viscosity grades. However ATIEL believe there should be a stronger consensus and input from the global OEMs before any changes are made to J300".

It should be noted that the Low Viscosity Grade Working Group is aware of the issues raised by some of the respondents. Uniquely defining kinematic viscosity ranges as well as HTHS would be difficult because of the existence of a wide range of commercial additive and base oil technologies and would likely impact other areas such as industry shear stability specifications (not part of J300). Regarding the labeling issues, this is expected to be addressed by changes to the text of the J300 standard requiring marketers to label the oil as the highest non-W grade that is met by the HTHS viscosity. Thus an oil with a 2.6 mPa·s viscosity could only be labeled as an SAE 20 although it might meet the requirements of the proposed 5, 10 and 15 grades.

Blend Studies

To explore the feasibility of formulating engine oils to the new proposed viscosity grades, four Working Group members conducted independent blend studies which are summarized in this section, coded BS-1, BS-2, BS-3 and BS-4.

BS-1. Scope: API Group III base oils, GF-4/SM quality performance additive and various viscosity modifiers. The results are summarized in Table 4.

Table 4. Blend Study Data (BS-1)

Oil number	Base Oils	KV100 (mm^2/s)	HTHS (mPa-s)	CCS @ -35C (mPa-s)	Noack (% volatiles)
1	4 cSt	5.82	1.85	3289	
2	4 cSt	7.22	1.97	3489	
3	4 cSt	7.8	2.05	3581	12.7
4	4 cSt	5.67	1.88	3268	12.6
5	4 cSt	6.75	1.97	3585	13.4
6	4 cSt	7.21	2.08	3706	13
7	4 cSt	5.78	1.89	3167	
8	4 cSt	7.11	2.03	3379	
9	4 cSt	7.65	2.32	3463	12.2
10	4 cSt	5.68	1.94	3130	
11	4 cSt	6.75	2.17	3316	
12	4 cSt	6.96	2.21	3340	12.5
13	4 cSt	5.86	1.97	3218	
14	4 cSt	6.92	2.22	3419	
15	4 cSt	7.65	2.37	3638	
16	4 cSt	5.66	1.96	3252	
17	4 cSt	6.59	2.19	3405	
18	4 cSt	6.87	2.27	3494	
19	4 cSt	5.53	1.95	3265	
20	4 cSt	6.37	2.26	3491	
21	4 cSt	6.79	2.23	3602	
22	4 cSt	5.62	1.95	3387	
23	4 cSt	6.58	2.2	3783	
24	4 cSt	6.8	2.26	3897	
25	4 cSt	8.28	2.15	3662	
26	4 cSt	7.44	2.13	3731	
27	4 cSt	7.99	2.29	3543	
28	4 cSt	7.91	2.27	3697	
29	4 cSt	7.19	2.15	3558	
30	4 cSt	7.16	2.17	3719	
31	4 cSt + 6 cSt	9.11	2.48	4886	
32	4 cSt + 6 cSt	8.2	2.42	5030	
33	4 cSt + 6 cSt	8.78	2.56	4596	
34	4 cSt + 6 cSt	8.7	2.57	4816	
35	4 cSt + 6 cSt	8.01	2.47	4744	
36	4 cSt + 6 cSt	8.14	2.56	5657	

BS-2. Scope: API Group III and PAO base oils with API SM/ ILSAC GF-4 performance additive and a 24 SSI OCP viscosity modifier. The results are summarized in Table 5.

Table 5. Blend Study Data (BS-2)

Oil	Base Oils	VM (wt. %)	KV100 (mm^2/s)	HTHS mPa-s 100°C	HTHS mPa-s 150°C	CCS mPa-s -35C
1	PAO4		4.72			1935
2	4 cSt		5.04			2902
3	PAO4 + PAO6		5.66			3113
4	4 cSt + 6 cSt		5.9			5175
5	PAO6		6.88	5.2	2.11	5301
7	4 cSt + 6 cSt	1	6.743	5.09	2.20	4409
9	4 cSt + 6 cSt	2.5	6.807	5.01	2.13	3608
10	PAO6 + PAO8		6.947	5.28	2.31	5465
6	4 cSt + 6 cSt		5.68	4.35	1.93	5926
8	4 cSt + 6 cSt	2	6.404	4.84	2.14	5997
11	4 cSt + 6 cSt	3.3	6.944	4.29	2.29	6200
12	4 cSt + 6 cSt	3.5	6.958	4.28	2.29	6057

BS-3 Scope: API Group III base oils with ILSAC GF-4 performance additive and a 35 SSI OCP viscosity modifier. The results are summarized in Table 6.

Table 6. Blend Study Data (BS-3)

Oil	Base Oil Viscosity mm^2/s 100°C	VM (wt. %)	KV100 (mm^2/s)	HTHS mPa-s 150°C	CCS mPa-s -35°C	Noack (wt % loss)
1	4.75	6.75	8.7	2.62	5259	
2	4.75	5.25	7.9	2.46	4993	
3	4.75	3.75	7.3	2.34	4969	
4	4.75	2.25	6.7	2.21	4616	
5	4.75	0.75	6.1	2.08	4423	
6	4.45	0.75	5.9	2.05	4000	11.4
7	4.43	6.75	8.3	2.53	4585	
8	4.28	6.75	8.1	2.48	4277	
9	4.14	6.75	7.9	2.44	3982	
10	4.13	5.25	7.3	2.36	3850	12.0
11	4.14	2.25	6.1	2.09	3540	11.8
12	4.00	6.75	7.7	2.40	3714	
13	4.00	0.00	5.2	1.88	3050	12.5
14	3.70 *	0.00	4.7	1.70		
15	3.56 *	0.00	4.6	1.68	2280	22.2

**Contains 3 cSt oil manufactured from the same refinery stream as the other Group III oils in this blend study*

BS-4 Scope: API Group III base oils with prototype ILSAC GF-5 performance additive and various viscosity modifiers. The results are summarized in Table 7.

Table 7. Blend Study Data (BS-4)

Oil	KV100 (mm^2/s)	HTHS mPa-s 100°C	HTHS mPa-s 150°C	CCS mPa-s -35C
1	5.70	4.30	1.97	4094
2	8.18	5.60	2.59	4955
3	7.21	5.22	2.36	5212
4	6.35	4.81	2.15	5754
5	9.06	6.21	2.82	6792
6	5.62	4.23	1.93	3137
7	8.04	5.51	2.53	3779
8	7.08	5.14	2.30	3975
9	6.35	4.83	2.14	4381
10	8.91	6.12	2.75	5153
11	5.70	4.31	1.96	4072
12	8.22	5.39	2.50	4738
13	7.20	5.02	2.30	5055
14	6.36	4.80	2.16	5682
15	9.12	5.99	2.72	6440
16	5.68	4.25	1.95	3964
17	8.57	5.28	2.52	4505
18	7.25	4.95	2.31	4933
19	6.34	4.77	2.15	5589
20	9.35	5.80	2.65	5987
21	5.66	4.31	1.92	4017
22	8.18	5.29	2.47	4532
23	7.12	5.05	2.28	4982
24	6.33	4.84	2.14	5660
25	9.06	5.86	2.70	6194
26	5.62	4.24	1.92	3130
27	8.04	5.18	2.43	3587
28	7.01	4.92	2.24	3812
29	6.26	4.75	2.12	4254
30	8.89	5.73	2.64	4769
31	5.68	4.36	1.93	4030
32	8.16	5.48	2.53	4529
33	7.15	5.14	2.30	4959
34	6.32	4.85	2.12	5617
35	9.04	6.07	2.72	6191
36	5.68	4.35	1.93	3982
37	8.22	5.25	2.44	4378
38	7.34	5.05	2.29	5010
39	6.32	4.78	2.11	5607
40	9.11	5.78	2.65	6008
41	5.59	4.16	1.91	3077
42	8.06	5.13	2.37	3383
43	5.95	4.48	2.02	3644
44	7.43	5.15	2.31	4387
45	8.94	5.68	2.63	4568
46	5.74	4.32	1.95	4077
47	8.14	5.51	2.51	4748
48	7.20	5.15	2.29	5191
49	6.35	4.81	2.12	5714
50	9.01	6.15	2.74	6482

The kinematic viscosity and HTHS data from the four blend studies are compared in Figure 4. These results demonstrate that it is feasible to meet the rheological limits for the proposed SAE 10 and 15 viscosity grades, but the minimum kinematic viscosity limit for the proposed SAE 5 grade might have to be set to be lower than 5.6 mm^2/s. It should be noted that while there is a general trend to lower HTHS with decreasing kinematic viscosity, the spread in the data make the assignment of specific kinematic viscosity ranges for each proposed grade difficult.

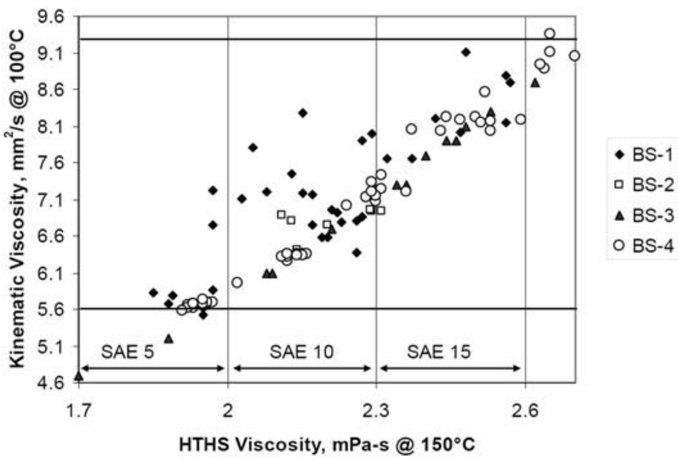


Figure 4. Viscosity data front four independent blend studies compared to proposed HTHS and KV100 limits for viscosity grades below SAE 20.

Precision of HTHS Methods

As previously mentioned, as a consequence of the close relationship of engine oil viscosity and fuel efficiency under operating conditions and the rapidly growing need to improve such efficiency, significant interest has developed within the automotive industry to have engine oils of lower operating viscosity available for use with modern engines. There are three ASTM HTHS methods presently referenced in SAE J300. Each method quotes precision values of repeatability and reproducibility derived from round robin studies on oils varying in HTHS viscosity, but none of the oils had HTHS values below 2.4 mPa·s. This fact has led the SAE Engine Oil Viscosity Classification Task Force to request ASTM Committee D02, Subcommittee 07 and its Section B on High Shear Rate Viscometry to develop this precision information for all three viscometers for oils with HTHS viscosity as low as 1.7 mPa·s.

Preliminary Precision Data - An initial set of eleven oils covering the desired HTHS viscosity range at 150°C were blended by one of the members of the SAE Low Viscosity Grade Working Group. These reference oils were subjected to HTHS evaluation using the Tapered Bearing Simulator (TBS) viscometer at this temperature as well as at 100°C using ASTM Methods D4683 and D6616 respectively. Results at both temperatures are shown in Figure 5.

The average difference in replicate HTHS analyses at 150°C was 0.0104 mPa·s (0.479% of the average viscosity of the 11 oils, that is, 2.17±0.0104 mPa·s). At 100°C and the consequent higher viscosities of the eleven oils, the average difference in replicate analyses was 0.022 mPa·s (in this case, 0.46% of the average viscosity of the eleven oils, that is, 4.74±0.022 mPa·s). These preliminary results were considered encouraging in regard to an adequate level of precision that could be expected with engine oil viscosities from 2.6 down to 1.8 mPa·s.

Further Viscometric Precision Studies

A second set of oils similar to the first was blended in larger quantities in anticipation of ASTM inter-laboratory studies to be conducted on all three types of HTHS viscometers. These oils were made available for appraisal at 150°C by ASTM Method D4683 (TBS), D4741 (Tapered Plug Viscometer) and D5481 (MultiCell High Pressure Capillary Viscometer). Again, ASTM Method D6616 (TBS @ 100°C) was also included.

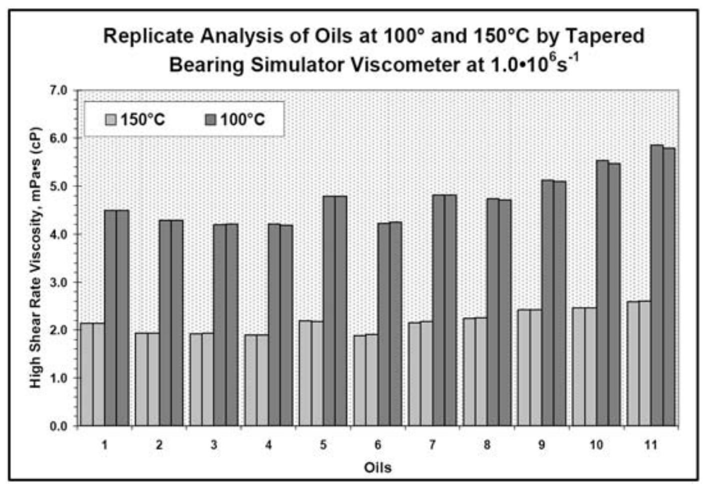


Figure 5. Repeatability of HTHS measurements at 150°C and 100°C for 11 oils.

Replicate results on the second set of twelve blends (re-blends of the previous eleven oils plus one more) are shown at 150°C for the TPV, MCC and TBS in Figure 6. Replicate TPV measurements were run on two instruments by two operators in one laboratory. Replicate MCC tests were run in another laboratory on the same instrument by the same operator. The latter procedure was also followed for replicate TBS measurements. It is evident that as a first and admittedly limited study, the viscometers are in reasonable agreement with one another, with viscosity values generally within 0.02 mPa·s of each other.

It is worth noting that a representative of ASTM Subcommittee 7 recently reported to the SAE EOVC Task Force that a statistical analysis of recent industry round robin data from the ASTM Inter-Laboratory Cross-Check Program, including all three HTHS methods at 150°C, concluded that there is a small but definite bias of 0.03 mPa·s between the capillary and the two rotational methods, with the former being slightly higher than the other two. The limited method comparison reported in this paper, however, does not find that the MCC method has a positive bias relative to the rotational methods. However, further ASTM inter-laboratory studies are planned to verify if a bias exists.

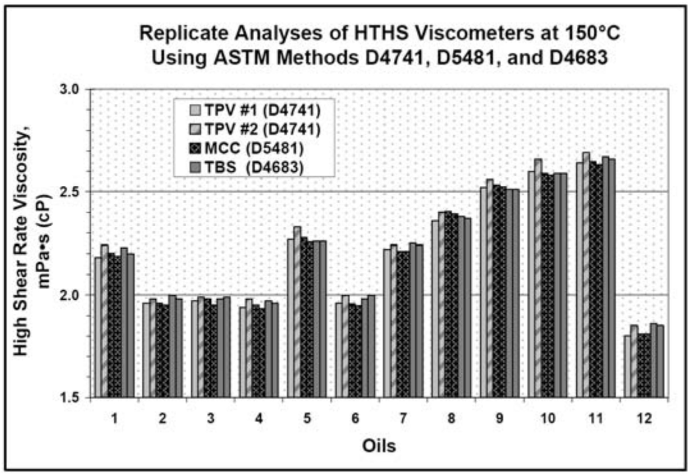


Figure 6. Measurement repeatability and comparison of HTHS results from all three viscometers at 150°C and $1.0 \cdot 10^6 s^{-1}$ shear rate

Figure 7 shows TBS viscometer analyses of the 12 oils at 100°C using Method D6616. Interestingly, these data indicate that TBS precision is generally within 0.02 mPa·s even at this lower temperature of analysis.

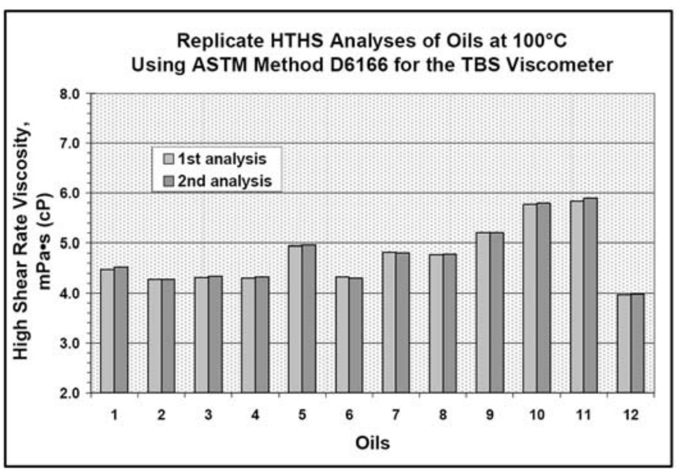


Figure 7. Repeatability of HTHS measurements at 100°C for 12 oils: Tapered Bearing Simulator Viscometer.

As mentioned, ASTM was requested to organize a multi-instrument round robin to establish the precision of the three methods of HTHS viscometry for low HTHS viscosity engine oils. In response, ASTM subcommittee D02 set up a Work Item to cover this ongoing effort for an ASTM multi-instrument round robin whose work is planned for completion by December 2010.

Kinematic Viscosity Considerations

The current SAE Engine Oil Viscosity Classification Standard J300 defines the 100°C kinematic viscosity of SAE 20 grade engine oils to span the range of 5.6 mm^2/s (cSt) to less than 9.3 mm^2/s. The Low Viscosity Grade Working Group questioned whether the lower half of this range is used in practice and chose to conduct several analyses of the Institute of Materials Engine Oil Database covering commercial SAE 20 and XW-20 engine oils, as shown in Figures 8 and 9. It is evident that the kinematic viscosities of more than 90% of the oils were above 8 mm^2/s (cSt) at 100°C. Therefore, the bottom two-thirds of the allowable SAE 20 kinematic viscosity grade is essentially unpopulated. The factor limiting the creation of SAE 20 oils with kinematic viscosity less than about 8 mm^2/s is thought to be the HTHS minimum value of 2.6 mPa·s. By establishing new SAE viscosity grades below this value, lower viscosity oils will be able to be formulated, as was demonstrated in the blend studies reported in this paper.

SUMMARY

The SAE Engine Oil Viscosity Classification Task Force, in consideration of the development of low viscosity engine oils for highly fuel efficient vehicles of the future, is considering a proposal to adopt up to three new viscosity grades below SAE 20. Blend studies with currently available base oils, performance additives and viscosity modifiers confirm that the proposed rheological targets can be met, although adjustment of the minimum kinematic viscosity limit for the proposed SAE 5 grade would be warranted. The introduction of lower viscosity grades in SAE J300 would provide a formal framework to assess the advantages and disadvantages of these oils with respect to fuel economy, wear and other performance characteristics in modern and future engines. Initial studies also show that today's HTHS instruments and test methods have the potential to be sufficiently precise to serve as the basis for the new lower viscosity limits; and ASTM is planning to generate new precision statements for these methods by the end of 2010.

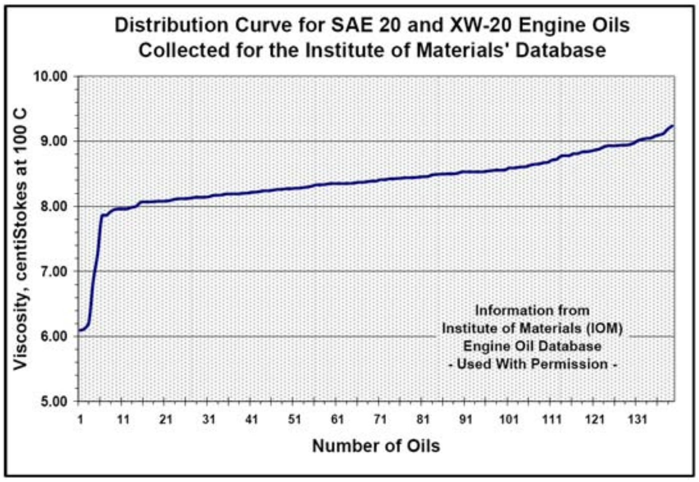
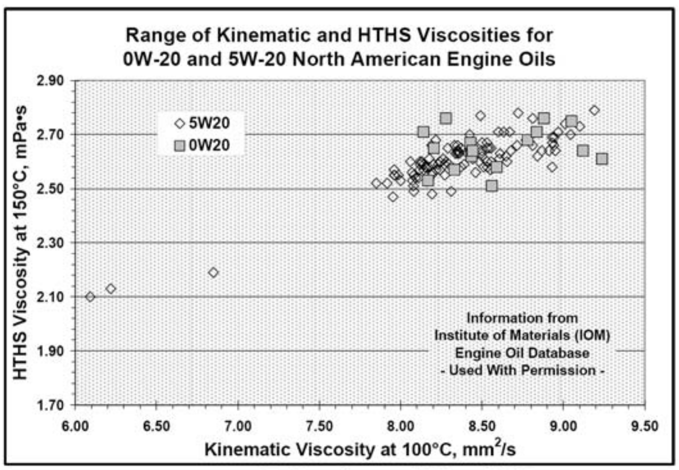


Figure 8. Kinematic viscosity (100°C) of commercial SAE 20 and XW-20 engine oils collected over 30 years (with permission of the Institute of Materials)



the Institute of Materials)

Figure 9. Kinematic and HTHS viscosities of only the SAE OW-20 and 5W-20 engine oils collected for the Institute of Materials Engine Oil Database.

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The Task Force is also grateful to the representatives of the OEM community who have and continue to provide valuable feedback to the ongoing process of proposing new viscosity grades within SAE J300.

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DEFINITIONS/ABBREVIATIONS

API
: American Petroleum Institute

EOVC
: Engine oil viscosity classification task force

HTHS
: High temperature, high shear rate viscosity

J300
: SAE engine oil viscosity classification standard

KV
: Kinematic viscosity

MCC
: Multi-cell high pressure capillary HTHS viscometer

MOFT
: Minimum oil film thickness

OEM
: Original equipment manufacturer

TBS
: Tapered bearing simulator HTHS viscometer

TPV
: Tapered plug HTHS viscometer

VI
: Viscosity index

APPENDIX

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