ANNEX F—API GUIDELINES FOR SAE VISCOSITY–GRADE ENGINE TESTING

F.1 General

If an oil is eligible for SAE Viscosity-Grade Engine Test Guidelines for passenger car motor oils or diesel engine oils and the sponsoring company desires to waive testing, the sponsoring company shall conform to the registration process, the ACC Code, and the Multiple Test Evaluation Procedure for the required engine tests.

F.1.1 SAE VISCOSITY CRITERIA

The SAE viscosity grades constitute a classification for engine lubricating oils in rheological terms only and are intended for use by engine manufacturers in determining the engine oil viscosity grades to be recommended for use in their engines and by oil marketers in formulating and labeling their products.

Two series of viscosity grades are defined in SAE J300: (a) those that contain the letter W and those that do not contain the letter W. Single-viscosity-grade oils ("single-grades") with the letter W are defined by maximum low-temperature cranking and pumping viscosities and a minimum kinematic viscosity at 100°C. Single grades without the letter W are based on a set of minimum and maximum kinematic viscosities at 100°C and a minimum high-temperature/high-shear measured at 150°C and 1 million reciprocal seconds. Multiple-viscosity-grade oils ("multigrades") are defined by all of the following criteria:

a. Maximum low-temperature cranking and pumping viscosities.
b. A kinematic viscosity at 100°C that falls within the prescribed range of one of the non-W grade classifications.
c. A minimum high-temperature/high-shear viscosity at 150°C and 1 million reciprocal seconds.

F.1.2 VISCOSITY-GRADE READ ACROSS GUIDELINES

In certain situations, data generated from one viscosity grade of a given engine oil formulation may be extrapolated to another viscosity grade that uses the same additive technology by means of a practice commonly referred to as "read-across" (See Tables F-1 through F-17).

These Viscosity-Grade Engine Testing Guidelines can be used to complete a testing program using the most severe viscosity grade for each individual test for the grades being licensed. Engine tests shall be registered using the ACC Code. No read-across or substitute data are permitted for physical and chemical analyses or for bench tests (except as allowed in F.1.3 and F.4); that is, all specified physical and chemical analyses must be run on the final formulation. Proposed changes to the read-across tables or F.1.3 should be sent to the Chair of API's Base Oil Interchange (BOI)/Viscosity Grade Read-Across (VGRA) Task Force or API. The proposal must include a justification and supporting data for such change.

Properties of base oils used in the development of BOI and VGRA guidelines for certain passenger car motor oils and heavy-duty engine oils are given in Annex E, Tables E-3 and E-16, respectively. These values are provided for information only and do not represent any limitation on interpretation of these guidelines.

F.1.3 PRINCIPLES FOR VISCOSITY GRADES NOT COVERED

Tables F-2 through F-16 indicate when a viscosity grade read-across is allowed (X) and not allowed (—). For viscosity grades not included in those tables, read-across is allowed for certain tests if the viscosity grades meet all the applicable technical principles described in Table F-1. Read-across for viscosity grades not covered by Tables F-1 through F-17 is not allowed until API's BOI/VGRA Task Force reviews the justification and data supporting a change to the tables and recommends the change to the API Lubricants Standards Group and the Lubricants Standards Group approves the change. Check marks in Table F-1 indicate which technical principles apply to a specific test. Paragraph F.3 provides examples on applying these technical principles to new viscosity grades.

Table F-1A—Technical Principles for New Viscosity Grades and Read Across

(Applies to oils with $HTHS^{150} \geq 2.6$ mPa•s)

	Passenger Car Motor Oils	IID	L-38/ VIII	IIIE/ IIIF/ IIIG/ IIIH	IIIGA Note 2	IIIGB	IVA	VE	VG	VIA/ VIB/ VID/ VIE
a	Detergent (dispersant)-inhibitor (DI) content of read-across viscosity grade shall be equal to or higher than that of original viscosity grade. Increase in DI is limited to maximum allowed by ACC Code	✓	✓	✓	✓	✓	✓	✓	✓	Note 3
b	Base stock blend kinematic viscosity at 100°C of read-across viscosity grade must be equal to or higher than that of original viscosity grade, considering precision of test method	NA	NA	✓	✓	NA	✓	✓	NA	Note 3
c	Viscosity modifier (VM) content of read-across viscosity grade must be equal to or lower than that of original viscosity grade	NA	NA	Note 4	Note 4	NA	✓	✓ or Note 5	✓ or Note 5	Note 3

Notes:

1. ✓ = principle is applicable; NA = not applicable.
2. Technical principles for the Sequence IIIGA are limited to 0W, 5W, and 10W multigrades.
3. New viscosity grades and associated read-across can only be added after review by the API BOI/VGRA Task Force and approval by the API Lubricants Standards Group.
4. Viscosity modifier content must be no more than 1.5 times higher than the viscosity modifier content in the oil on which the test was run.
5. For dispersant-type VM, the VM content of the read-across viscosity grade must be equal to or higher than the original viscosity grade.
6. Read-across viscosity grades must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend if a Group V base stock is used in the original viscosity grade.

Table F-1B—Technical Principles for New Viscosity Grades and Read Across

(Applies to oils with $HTHS^{150} \geq 2.3$ mPa•s)

	Passenger Car Motor Oils	IIIHB	VH	X
A	Detergent (dispersant)-inhibitor (DI) content of read-across viscosity grade shall be equal to or higher than that of original viscosity grade. Increase in DI is limited to maximum allowed by ACC Code	✓	✓	✓
B	Base stock blend kinematic viscosity at 100°C of read-across viscosity grade must be equal to or higher than that of original viscosity grade, considering precision of test method	NA	✓	NA
C	Viscosity modifier (VM) content of read-across viscosity grade must be equal to or lower than that of original viscosity grade	NA	✓ or Note 3	Note 4

Notes:
1. ✓ = principle is applicable; NA = not applicable.
2. New viscosity grades and associated read-across can only be added after review by the API BOI/VGRA Task Force and approval by the API Lubricants Standards Group.
3. For dispersant-type VM, the VM content of the read-across viscosity grade must be equal to or higher than that of the original viscosity grade.
4. Viscosity modifier content must be no more than 2.5 times higher than the viscosity modifier content in the oil on which the test was run because this was the range of VM tested in the BOI/VGRA matrix.
5. Read-across viscosity grades must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend if a Group V base stock is used in the original viscosity grade.

F.2 Requirements for Passenger Car Motor Oils

F.2.1 Blends shall use only base stocks as defined in Annex E.

F.2.2 Base oils introduced from other manufacturers shall be tested in accordance with Annex E.

F.2.3 The same detergent-(dispersant) inhibitor (DI) portion of the total performance additive package shall be used at equal or higher concentrations for alternative viscosity grades. The increase in DI is limited to that allowed in the ACC Code. Viscosity modifier, foam inhibitor, and pour point depressant levels may be adjusted for alternative viscosity grades, in accordance with the ACC Code.

F.2.4 ACC Code and ASTM Multiple Test Evaluation Procedure testing practices shall be followed.

F.3 Examples Using VGRA Tables and Technical Principles for VGRA

F.3.1 GENERAL

Read-across to or from viscosity grades not shown in the tables is allowed if the requirements in F.1.3 are met. If the requirements are not met, read-across is not allowed. Examples of how F.1.3 can be applied are provided below.

F.3.2 EXAMPLE 1

In this example, a Sequence IIIE test is run on an SAE 0W-30 core viscosity grade [i.e., tested viscosity grade]. What other viscosity grades can be covered by read-across from the tested SAE 0W-30? To answer this question, take the following steps:

Step 1: Determine if requirement "a" in Table F-1 is met for all the desired read-across viscosity grades. This requires keeping the DI constant, or if higher, consistent with the ACC Code of Practice. Since an SAE 0W-30 is most likely blended with some or all Group III or Group IV base stocks, many of the higher viscosity grades would probably not be part of this product line. The higher viscosity grades, if marketed, could have a different DI and/or base stock slate.
Step 2: For the read-across viscosity grades (i.e., those you are reading to) of interest in Table F-4, determine if the requirements for both "b" and "c" in Table F-1 can be met concurrently. This involves having equal or higher base stock blend viscosity and a VM content in the "read to" multigrades that is no more than 1.5 times higher than that in the SAE 0W-30. There are some grades that are certain to meet "b" and "c", and some where it will depend on the blending approach. Some trial blends may have to be made. Decide if there are single grades desired or feasible considering the base stocks used in the core formulation.
Step 3: For viscosity grades that you wish to cover by read-across but are not shown in Table F-4, follow the instructions for "b" and "c" described in Step 2.
Step 4: Determine which viscosity grades meet Table F-1 requirements "a," "b", and "c". These grades are covered by viscosity grade read-across. Grades that fail to meet all these requirements are not covered by read-across.

Note: The marketer of a formulation has the final responsibility for assuring that the product meets API requirements.

F.3.3 EXAMPLE 2

In this example, an SAE 5W-30 blended with Group IV base stocks and a nondispersant VM has passed a VE test. A marketer wants to read-across this test to an SAE 5W-40 grade, one not included in Table F-7. Since the SAE 5W-40 is not included in Table F-7, "a," "b", and "c" in Table F-1 must be consulted. It is likely that the DI content of the SAE 5W-40 would be equal to or higher than the SAE 5W-30, so requirement "a" would be met. However, "b" and "c" probably cannot be met. A SAE 5W-40 oil would normally not have a higher base stock blend kinematic viscosity at 100ºC than an SAE 5W-30, and more nondispersant VM would be required in a SAE 5W-40 oil. Therefore, this read-across is not allowed.

F.4 VGRA for Bench Tests

F.4.1 HOMOGENEITY AND MISCIBILITY (H&M) (ASTM D6922) AND EOFT (ASTM D6795)

Homogeneity and Miscibility (H&M) (ASTM D6922) and Engine Oil Filterability [EOFT (ASTM D6795)] tests are required in the core data set (see ACC Code for definition of core data set), and then read-across is allowed to all other viscosity grades within the same base stock slate.

F.4.2 EOWTT (ASTM D6794)

The Engine Oil Water Tolerance Test [EOWTT (ASTM D6794)] must be run on the formulation with the highest additive (DI/VM) combination. Results are then read-across to all other base oil/viscosity grade formulations using the same or lower concentration of the identical additive (DI/VM) combination. Each different (DI/VM) combination must be tested.

F.4.3 BALL RUST TEST (ASTM D6557)

If there is one passing Ball Rust Test (BRT) (ASTM D6557) in the core data set as defined by the ACC Code, read-across is allowed to all other viscosity grades and base oil slates.

F.4.4 EMULSION RETENTION (ASTM D7563)

For oils formulated with Group II and/or Group III base stocks, the Emulsion Retention ASTM D7563 is required only for the highest additive (DI/VM) concentration. Read across is allowed to all other Group II, Group III and combinations of Group II and Group III base oil/viscosity grade formulations using the same or lower concentration of the identical additive (DI/VM) combination. If the PPD type is changed for the DI/VM combination, testing is required.

F.4.5 HIGH TEMPERATURE CORROSION BENCH TEST (ASTM D6594)

If there is one passing High Temperature Corrosion Bench Test (HTCBT) (ASTM D6594) in the core data set as defined by the ACC Code, read-across is allowed to all other viscosity grades and base oil slates.

F.5 Requirements for Diesel Engine Oils

F.5.1 Blends shall use only base stocks as defined in Annex E.

F.5.2 Base oils introduced from other manufacturers shall be tested in accordance with Annex E.

F.5.3 The same detergent-(dispersant) inhibitor (DI) portion of the total performance additive package shall be used at equal or higher concentrations for alternative viscosity grades. The increase in DI is limited to that allowed in the ACC Code. Viscosity modifier, foam inhibitor, and pour point depressant levels may be adjusted for alternative viscosity grades, in accordance with the ACC Code.

F.5.4 ACC Code and ASTM Multiple Test Evaluation Procedure testing practices shall be followed.

Note: Engine manufacturers may not recommend all of the viscosity grades shown in Tables F-2 through F-15 for a particular engine type.

Table F-2—Groups I, II, III and IV Viscosity Read-Across: L-38/Sequence VIII Tests

Test Run on	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	X	X	X	X	X	X	X	X	X	X	X	X
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	X
10W	—	—	NA	—	—	—	—	X	—	—	X	X	X
10W-30	—	—	X	NA	X	X	X	X	X	X	X	X	X
10W-40	—	—	X	X	NA	X	X	X	X	X	X	X	X
15W-40	—	—	—	X	X	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	X	X	NA	X	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	X	X	X	NA	X	X	X	X
20W-50	—	—	—	—	—	—	X	X	X	NA	X	X	X
30	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

Notes:

1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
4. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.
5. The read-across in Table F-2 applies only to bearing weight loss and piston varnish~~. All multigrade oils must stay-in-grade for 10 hours in the L-38/Seq. VIII tests (see ILSAC GF-1, GF-2, GF-3, GF-4 and GF-5). Data to support stay-in-grade "read-across" shall be provided by the licensee for API Service Categories SN, SM, SL, SJ, SH, and CG-4 and ILSAC GF-1, GF-2, GF-3, GF-4, and GF-5 oils (0W-XX, 5W-XX, 10W-XX).~~
6. ~~The guidelines in this table apply only to bearing weight loss.~~ All multigrade oils must meet the requirements of Table F-3 ~~stay in grade for 10 hours. Data to support stay-in-grade read across shall be provided by the licensee for active API Service Categories and ILSAC Standards. ASTM D 6278 (30 passes) may be used to support stay-in-grade requirements, where the following limits must be met at 100 °C: SAE XW-20 5.6 cSt minimum, XW-30 8.5 cSt minimum, XW-40 11.5 cSt minimum, and XW-50 15.0 cSt minimum.~~

Data to support stay-in-grade performance shall be maintained by the licensee for active API Service Categories and ILSAC specifications. Either CRC L-38/Sequence VIII or ASTM D6278 (30 passes) may be used to support stay-in-grade requirements where the limits are listed in Table F-3.

Table F-3—CRC L-38/Sequence VIII Tests Stay-in-Grade Requirements

Viscosity Grade	L-38/Sequence VIII 10 hr Stripped Kinematic Viscosity@100°C (mm^2/s), min	ASTM D6278 (30 Passes) Kinematic Viscosity@100°C (mm^2/s), min
XW-16	6.1	5.8
XW-20	6.9	6.5
XW-30	9.3	8.5
XW-40	12.5	11.5
XW-50	16.3	15.0
XW-60	21.9	19.8

Table F-4—Groups I, II, III and IV Viscosity Read-Across: Sequence IID Test

	Can Be "Read-Across" to:												
Test Run on	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	X	X	X	X	X	X	X	X	X	X	X	—
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	—
10W	—	—	NA	—	—	—	—	X	—	—	X	X	—
10W-30	—	—	X	NA	X	X	X	X	X	X	X	X	—
10W-40	—	—	X	X	NA	X	X	X	X	X	X	X	—
15W-40	—	—	—	X	X	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	X	X	NA	X	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	X	X	X	X	NA	X	X	X	X
20W-50	—	—	—	—	—	X	X	X	X	NA	X	X	X
30	—	—	—	—	—	—	—	X	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	X	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

Notes:
1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
4. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

Table F-5—Groups I, II, III and IV Viscosity Read-Across: Sequence IIIE/IIIF/IIIG/IIIGB Tests

	Can Be "Read-Across" to:												
Test Run on	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	—	X	X	—	—	—	X	X	X	X	X	X
5W-30	X[a]	NA	X	X	X	X	X	X	X	X	X	X	X
10W	—	—	NA	—	—	—	—	X	—	—	X	X	X
10W-30	—	—	X	NA	X	X	X	X	X	X	X	X	X
10W-40	—	—	X	X	NA	X	X	X	X	X	X	X	X
15W-40	—	—	—	X	X	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	—	X	NA	—	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	—	—	X	NA	X	X	X	X
20W-50	—	—	—	—	—	—	—	—	X	NA	X	X	X
30	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

Notes:
1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group. Viscosity modifier content must be no more than 1.5 times higher than the viscosity modifier content in the oil on which the test was run.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
4. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

[a]The read from 5W-30 to 5W-20 applies to Sequence IIIF/IIIG/IIIGB only.

Table F-6—Groups I, II, III and IV Viscosity Read-Across: Sequence IIIGA and ROBO Test

	Can Be "Read-Across" to:				
Test Run on	5W-20	5W-30	10W	10W-30	10W-40
5W-20	NA	—	X	X	—
5W-30	X	NA	X	X	X
10W-30	—	—	X	NA	X
10W-40	—	—	X	X	NA

Notes:
1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group. Viscosity modifier content must be no more than 1.5 times higher than the viscosity modifier content in the oil on which the test was run.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

Table F-7—Groups I, II, III and IV Viscosity Read-Across: Sequence IVA Test

	Can Be "Read-Across" to:												
Test Run on	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	—	X	X	—	—	—	X	X[a]	X[a]	X	X	X
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	X
10W	—	—	NA	—	—	—	—	X	—	—	X	X	X
10W-30	—	—	—	NA	—	X	—	X	X	X	X	X	X
10W-40	—	—	—	X	NA	X	X	X	X	X	X	X	X
15W-40	—	—	—	X	—	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	—	—	NA	—	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	X	—	—	NA	X	X	X	X
20W-50	—	—	—	—	—	—	—	—	—	NA	X	X	X
30	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

Notes:
1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
4. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

[a]Read-across permitted if requirements in F.1.3 are met.

Table F-8—Groups I, II, III and IV Viscosity Read-Across: Sequence VE/VG Test Nondispersant Viscosity Modifier

	Can Be "Read-Across" to:												
Test Run on	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	—	X	X	—	—	—	X	—	—	X	X	—
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	—
10W	—	—	NA	—	—	—	—	X	—	—	X	X	—
10W-30	—	—	—	NA	—	X	—	X	X	X	X	X	—
10W-40	—	—	—	X	NA	X	X	X	X	X	X	X	—
15W-40	—	—	—	X	—	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	—	—	NA	—	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	X	—	—	NA	X	X	X	X
20W-50	—	—	—	—	—	—	—	—	—	NA	X	X	X
30	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

Notes:
1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
4. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

Table F-9—Groups I, II, III and IV Viscosity Read Across: Sequence VE/VG Test Dispersant Viscosity Modifier[a]

	Can Be "Read-Across" to:												
Test Run on	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	X	—	X	X	X	X	—	X	X	—	—	—
5W-30	—	NA	—	X[b]	X	X	X	—	X	X	—	—	—
10W	—	—	NA	—	—	—	—	X	—	—	X	X	—
10W-30	—	—	—	NA	X	X	X	—	X	X	—	—	—
10W-40	—	—	—	X	NA	X	X	—	X	X	—	—	—
15W-40	—	—	—	X	X	NA	X	—	X	X	—	—	—
15W-50	—	—	—	—	—	—	NA	—	X	X	—	—	—
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	X	X	—	NA	X	—	—	—
20W-50	—	—	—	—	—	—	X	—	—	NA	—	—	—
30	—	—	—	—	—	X	X	—	X	X	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

Notes:
1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
4. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

[a]Read-across is allowed to formulations with an equal or higher concentration of dispersant viscosity modifier.

[b]10W-30 read-across is permitted at a lower concentration of dispersant viscosity modifier than the 5W-30 provided that a passing SAE 30 is also obtained on the formulation where the DI treat remains unchanged.

Table F-10 Groups I, II, III, and IV Viscosity Grade Read-Across: Sequence VID Test

	Can Be "Read-Across" to:							
Test Run on	0W-20	5W-20	0W-30	5W-30	10W-30	0W-40	5W-40	10W-40
0W-20	NA	X1	-	-	-	-	-	-
5W-20	X1	NA	-	-	-	-	-	-
0W-30	X2	X2	NA	X1	X1	-	-	-
5W-30	X2	X2	X1	NA	X1	-	-	-
10W-30	X2	X2	X2	X2	NA	X1	X1	X1
0W-40	-	-	-	-	X1	NA	X1	X1
5W-40	-	-	-	-	X1	X1	NA	X1
10W-40	-	-	-	-	X1	X1	X1	NA

Notes:

X1= VGRA is allowed if HTHS@100°C (D6616) of the candidate oil is less than or equal to the original tested oil OR if HTHS@100°C (D6616) of the candidate oil meets the conditions of equations shown below.

X2 = VGRA is allowed if the original tested oil meets the FEI Sum and FEI2 limit requirements for the read-across viscosity grade and the HTHS@100°C (D6616) of the candidate oil is less than or equal to the original tested oil.

Equations for Table F-10

Testing is not required if both equations are true:

$$H_{Candidate} \leq H_{Original} + \{(FEIsum_{Limit} - FEIsum_{Original}) / -0.485\} + (H_{Original} * R)$$

$$H_{Candidate} \leq H_{Original} + \{(FEI2_{Limit} - FEI2_{Original}) / -0.227\} + (H_{Original} * R)$$

Where:

$H_{Candidate}$	=	HTHS@100ºC of the candidate oil as measured by ASTM D6616
$H_{Original}$	=	HTHS@100ºC of the original tested oil as measured by ASTM D6616
$FEIsum_{Limit}$	=	FEI sum passing limit for the original tested viscosity grade
$FEIsum_{Original}$	=	FEI sum ($FEI1_{Original}$ + $FEI2_{Original}$) result of the original tested oil
-0.485	=	FEI sum coefficient from the Sequence VID industry matrix model
$FEI2_{Limit}$	=	FEI2 passing limit for the original tested viscosity grade
$FEI2_{Original}$	=	FEI2 result of the original tested oil
-0.227	=	FEI2 coefficient from the Sequence VID industry matrix model

Notes:

R	=	reproducibility as reported in the most recent version of ASTM D6616. The current *R* = 0.035 (3.5%) for ASTM D6616-07.

The range of the HTHS@100ºC used to develop the Sequence VID industry matrix model was 5.44 to 7.68 cP (5.25 to 7.95 cP when allowance is made for D6616 reproducibility). This information is for reference. It does not restrict application of the guidelines by the marketer that is responsible for ensuring that each licensed engine oil satisfies all engine and bench test performance requirements.

Example 1: (This example illustrates the application of footnote X1 - Reading to another viscosity grade at the same Sequence VID limits where the HTHS@100 C of the candidate is less than or equal to the HTHS @100C of the original tested oil.)

One has a passing 0W-20 oil with HTHS@100°C of 5.71 cP. Can one read that oil to a 5W-20 oil with a HTHS@100°C of 5.71 cP? The answer is yes because the HTHS@100°C values are equal.

Example 2: (This example illustrates the application of footnote X1 - Reading to another viscosity grade at the same Sequence VID limits but where the HTHS@100 C of the candidate oil is greater than the original tested oil.)

One has a passing 0W-20 oil with HTHS@100°C of 5.71 cP. Can one read that oil to a 5W-20 oil with a HTHS@100°C of 6.08 cP? In order to determine if this read is possible, the conditions of Equation F.1.0 must be met. The 0W-20 original result is FEIsum and FEI2 of 2.69 and 1.51 respectively. The 5W-20 candidate's HTHS@100°C must be equal to or less than the values from the equations:

A = FEIsum HTHS = 5.71 + {(2.6-2.69)/ -0.485} + (5.71 * 0.035) = 6.10 cP
B = FEI2 HTHS = 5.71 + {(1.2-1.51)/ -0.227} + (5.71 * 0.035) = 7.28 cP

The candidate 5W-20 oil has an HTHS@100°C of 6.08 cP which is less than either calculated value A or B so VGRA is allowed from this 0W-20 to this 5W-20.

Example 3: (This example illustrates the application of footnote X2 – Reading a heavier viscosity grade to a lighter viscosity grade when the Seq. VID result on the heavier grade meets the lighter grade's Sequence VID limits.)

One has a 10W-30 Seq. VID result of FEIsum of 2.62 and FEI2 of 1.34; this 10W-30 oil has an HTHS@100°C of 7.48 cP. These Seq. VID results meet the 0W-20 and 5W-20 Seq. VID limits (FEIsum 2.6 min, FEI2 1.2 min.) and surpass the 0W-30 and 5W-30 Seq. VID limits (FEIsum 1.9 min, FEI2 0.9 min.). This 10W-30 can now be read to a 0W-20, 5W-20, 0W-30, and 5W-30 formulated with the same technology provided that the HTHS@100°C for any of these

other viscosity grades is less than 7.48 cP, the HTHS@100°C of the tested 10W-30.

Example 4: (This example illustrates the application of footnote X1 - Reading a 5W-30 to a 10W-30.)

One has a 5W-30 oil with an HTHS@100°C viscosity of 6.66 cP. This 5W-30 oil has passed the Seq. VID with a result of FEIsum of 2.06 and FEI2 of 0.96. These values meet the 5W-30 Seq. VID limits of FEIsum 1.9 min. and FEI2 0.9 min. A 10W-30 candidate oil has an HTHS@100°C of 7.22 cP. Using equations in F.1.0 the read to this 10W-30 can now be assessed.

A = FEIsum HTHS = 6.66 + {(1.9-2.06)/ -0.485} + (6.66 * 0.035) = 7.22 cP
B = FEI2 HTHS = 6.66 + {(0.90-0.96)/ -0.227} + (6.66 * 0.035) = 7.16 cP

In order for the 5W-30 to read to the 10W-30, the HTHS@100°C for the 10W-30 must be less than or equal to A and B. The candidate 10W-30 has a HTHS@100°C of 7.22 cP, equal to A (7.22 cP) from FEIsum equation, but it is greater than B (7.16 cP) derived from FEI2 equation. Since there is no further allowance for test reproducibility, this read is not permitted. If, however, the 10W-30 was reformulated to a HTHS@100°C of less than or equal to 7.16 cP, the read from the 5W-30 would be allowed.

Table F-11 Groups I, II, III, and IV Viscosity Grade Read-Across: Sequence VIE Test

	Can Be "Read-Across" to:							
Test Run on	0W-20	5W-20	0W-30	5W-30	10W-30	0W-40	5W-40	10W-40
0W-20	NA	X1	-	-	-	-	-	-
5W-20	X1	NA	-	-	-	-	-	-
0W-30	X2	X2	NA	X1	X1	-	-	-
5W-30	X2	X2	X1	NA	X1	-	-	-
10W-30	X2	X2	X2	X2	NA	X1	X1	X1
0W-40	-	-	-	-	X1	NA	X1	X1
5W-40	-	-	-	-	X1	X1	NA	X1
10W-40	-	-	-	-	X1	X1	X1	NA

Notes:
A dash (-) means that read across is not permitted; NA = Not applicable.
X1= VGRA is allowed if HTHS@150°C (D4683) of the candidate oil is less than or equal to the original tested oil OR if HTHS@150°C (D4683) of the candidate oil meets the conditions of equations shown below.
X2 = VGRA is allowed if the original tested oil meets the FEIsum and FEI2 limit requirements for the read-across viscosity grade and the HTHS@150°C (D683) of the candidate oil is less than or equal to that of the original tested oil.

Equations for Table F11.
If the HTHS at 150°C of the candidate oil is greater than the HTHS at 150°C of the original passing oil, testing is not required if both of the following equations are true:

$$H_{Candidate} \leq H_{Original} + \{(FEIsum_{Limit} - FEIsum_{Original}) / -0.733\} + R$$

$$H_{Candidate} \leq H_{Original} + \{(FEI2_{Limit} - FEI2_{Original}) / -0.246\} + R$$

Where:

$H_{Candidate}$	=	HTHS@150ºC of the candidate oil as measured by ASTM D4683
$H_{Original}$	=	HTHS@150ºC of the original tested oil as measured by ASTM D4683
$FEIsum_{Limit}$	=	FEIsum passing limit for the original tested viscosity grade
$FEIsum_{Original}$	=	FEIsum ($FEI1_{Original}$ + $FEI2_{Original}$) result of the original tested oil
$FEI2_{Limit}$	=	FEI2 passing limit for the original tested viscosity grade
$FEI2_{Original}$	=	FEI2 result of the original tested oil
R	=	Reproducibility as reported in the most recent version of ASTM D4683, the current R = 0.03207 x H____ + 0.0389 for ASTM D4683-17

Table F-12—Groups II, III and IV Viscosity Read-Across: Sequence IX Test

	Can Be "Read-Across" to:					
Test Run on	0W-16	0W-20	0W-30	5W-20	5W-30	10W-30
0W-16	NA	X	X	X	X	X
0W-20	X	NA	X	X	X	X
0W-30	X	X	NA	X	X	X
5W-20	X	X	X	NA	X	X
5W-30	X	X	X	X	NA	X
10W-30	X	X	X	X	X	NA

Bracketing two passing formulations for a given technology may be used to waive additional viscosity grade testing. VGRA is allowed if the candidate's base oil viscosity at 100°C falls within the range of the base oil viscosity at 100°C of the two passing formulations. Additionally, the viscosity modifier content must be no more than 1.5 times higher than the highest viscosity modifier content in the oils used to support the VGRA bracket. This approach applies to formulations with base stock Group II, Group III, and Group IV. Oils containing Group I and/or Group V base stocks must contain an equal amount of the same base stock in the finished oil blend for application of viscosity grade read-across.

Example:

	Matrix Oil 1	Matrix Oil 2	Candidate Oil A	Candidate Oil B
Base Oil Viscosity @ 100°C, cSt	4.6	10.9	9.0	12.4
Sequence IX	Pass	Pass		
Test Required?			No	Yes
Reason			Formulation falls within base oil viscosity range	Formulation does not fall within base oil viscosity range

Table F-13 Groups I, II, III, and IV Viscosity Grade Read-Across: Sequence X Test

	Can Be Read- Across to:						
Test Run on	0W-16	0W-20	5W-20	5W-30	5W-40	10W-30	10W-40
0W-16	NA	X	X	X	X	X	X
0W-20	X	NA	X	X	X	X	X
5W-20	X	X	NA	X	X	X	X
5W-30	X	X	X	NA	X	X	X
5W-40	X	X	X	X	NA	X	X
10W-30	X	X	X	X	X	NA	X
10W-40	X	X	X	X	X	X	NA

Notes:

1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
4. BOI/VGRA matrix testing was conducted with oils containing a wide range of viscosity modifier. Oils with zero viscosity modifier were also tested. Oils tested with 2.5 times the amount of viscosity modifier included in the formulation or no viscosity modifier were shown to be statistically no different from the original oil.
5. Tested formulations containing Group I and /or Group V stocks must contain an equal amount of the same base stock in the finished oil blend for application of viscosity grade read-across.

Table F-14—Groups I, II, III and IV Viscosity Read-Across: TEOST Test (Method 33)

	Can Be "Read-Across" to:							
Test Run on	5W-20	5W-30	10W-30	10W-40	15W-40	20W-40	20W-50	Mono-Grade
5W-20	NA	X						
5W-30	X	NA	X	X	X	X	X	X
10W-30	—	—	NA	X	X	X	X	X
10W-40	—	—	X	NA	X	X	X	X
15W-40	—	—	—	—	NA	X	X	X
20W-40	—	—	—	—	—	NA	X	X
20W-50	—	—	—	—	—	X	NA	X

Notes:

1. X = read-across is permitted for viscosity grades identified based on data and some application of technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. Monogrades are defined as SAE 10W, SAE 20W, SAE 30, SAE 40, and SAE 50.
3. A dash (—) means that read-across is not permitted; NA = not applicable.
4. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.
5. New viscosity grades and associated read-across are allowed if requirements described in F.1.3 are met.

Table F-15—Groups I, II, III and IV Viscosity Read-Across: TEOST MHT-4

	Can Be "Read-Across" to:												
Test Run on	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	X	—	X	X	—	—	—	—	—	—	—	—
5W-30	X	NA	—	X	X	—	—	—	—	—	—	—	—
10W	—	—	NA	—	—	—	—	—	—	—	—	—	—
10W-30	X	X	—	NA	X	X	X	—	—	—	—	—	—
10W-40	X	X	—	X	NA	X	X	—	—	—	—	—	—
15W-40	—	—	—	X	X	NA	X	—	—	—	—	—	—
15W-50	—	—	—	X	X	X	NA	—	—	—	—	—	—
20W	—	—	X	—	—	—	—	NA	—	—	—	—	—
20W-40	—	—	—	X	X	X	X	—	NA	X	—	—	—
20W-50	—	—	—	X	X	X	X	—	X	NA	—	—	—
30	—	—	X	—	—	—	—	X	—	—	NA	—	—
40	—	—	X	—	—	—	—	X	—	—	X	NA	—
50	—	—	X	—	—	—	—	X	—	—	X	X	NA

Notes:

1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Standards Group.
2. A dash (—) means that read-across is not permitted; NA = not applicable.
3. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.
4. If the viscosity grade of interest is not in the table, then the TEOST MHT-4 must be run.
5. The principles behind this table are that higher base oil viscosity tends to give poorer performance and that VM level is not necessarily detrimental.

Table F-16—Groups II and III Viscosity Read-Across: GF-5 Elastomer Compatibility Test (ASTM D 7216 Annex 2A)

	Can Be "Read-Across" to:					
Test Run on	0W-20	0W-30	5W-20	5W-30	10W-30	10W-40
0W-20	NA	X	X	X	X	X
0W-30	X	NA	X	X	X	X
5W-20	X	X	NA	X	X	X
5W-30	X	X	X	NA	X	X
10W-30	X	X	X	X	NA	X
10W-40	X	X	X	X	X	NA

For viscosity grades not listed in the table above, bracketing two passing formulations for a given technology may be used to waive additional testing. VGRA is allowed if the candidate's base oil viscosity at100°C falls within the range of the base oil viscosity at 100°C of the 2 passing formulations.

Example:

	Matrix Oil 1	Matrix Oil 2	Candidate Oil A	Candidate Oil B
Base Oil Viscosity @ 100°C, cSt	4.6	10.9	9.0	12.4
D7216 A2 Result	Pass	Pass		
Test Required?			No	Yes
Reason			Formulation falls within base oil viscosity range	Formulation does not fall within base oil viscosity range

Table F-17—Groups I, II, III and IV Viscosity-Grade Read Across for Diesel Engine Oils

Read-across for viscosity grades not covered explicitly by this table are not allowed unless permitted by table F-1.

Performance Test	From SAE	To SAE
1K	10W-40	10W-30, 15W-40, 15W-50
	15W-40	10W-30, 20W-40, 20W-50
	30	10W, 20W, 40, 10W-30, 15W-40, 20W-50
	40	10W, 20W, 30, 10W-30, 15W-40, 20W-50
1N	15W-40	10W-30, 20W-40, 20W-50
	20W-20[a]	10W
	30	10W, 20W-20[a]
	40	10W, 20W-20[a], 30
	50	10W, 20W-20[a], 30, 40
1P	10W-30	15W-40, 20W-40, 20W-50
	10W-40	10W-30, 15W-40, 15W-50, 20W-40, 20W-50
	15W-40	20W-40, 20W-50
	15W-50	15W-40, 20W-40, 20W-50
1R	10W-30	15W-40
	10W-40	10W-30, 15W-40, 15W-50
C13	10W-30	15W-40
	10W-40	10W-30, 15W-40
	15W-50	15W-40
CBT	10W-30	15W-40
COAT	15W-40	10W-30, 10W-40
	10W-40	10W-30
Elastomer Compatibility	10W-30	15W-40
	15W-40	10W-30
HTCBT	See F.4.5	
M11HST	10W-30	10W-40, 15W-40, 15W-50
	15W-40	10W-40, 15W-50
M11EGR	10W-30	10W-40, 15W-40, 15W-50
	15W-40	10W-40, 15W-50
ISB	10W-30	10W-40, 15W-40, 15W-50
	15W-40	10W-40, 15W-50
ISM	10W-30	10W-40, 15W-40, 15W-50
	15W-40	10W-40, 15W-50
T-8, T-8A and T-8E[b]	15W-40	10W-30, 10W-40, 15W-50
T-9[c]	10W-30	10W-40, 15W-40, 15W-50, 20W-40[d], 20W-50[d]
	15W-40	15W-50, 20W-40[d], 20W-50[d]
T-10	10W-30	10W-40, 15W-40, 15W-50, 20W-40[d], 20W-50[d]
	15W-40	15W-50, 20W-40[d], 20W-50[d]
T-10A	15W-40	0W-XX, 5W-XX, 10W-XX
T-11[e]	10W-30	10W-40
	10W-40	10W-30
	15W-40	10W-30, 10W-40, 15W-50
	15W-50	10W-30, 10W-40, 15W-40
	20W-40	10W-30, 10W-40, 15W-40, 15W-50, 20W-50
	20W-50	10W-30, 10W-40, 15W-40, 15W-50, 20W-40
T-11A	15W-40	0W-XX, 5W-XX, 10W-XX
T-12	10W-30	10W-40, 15W-40, 15W-50, 20W-40[d], 20W-50[d]
	15W-40	15W-50, 20W-40[d], 20W-50[d]
T-12A	15W-40	0W-XX, 5W-XX, 10W-XX
T-13	10W-30	10W-40, 15W-40
	10W-40	10W-30, 15W-40
	15W-40	10W-30, 10W-40
EOAT	10W	10W-30, 15W-40, 15W-50
	10W-30	10W, 15W-40, 15W-50

Performance Test	From SAE	To SAE
	15W-40	10W, 10W-30, 15W-50
	15W-50	10W, 10W-30, 15W-40
	40	10W, 30, 10W-30, 15W-40, 15W-50
RFWT	10W-30	10W-40, 15W-40, 15W-50, 20W-40, 20W-50, 30, 40, 50
	15W-40	15W-50, 20W-40, 20W-50, 40, 50

Notes:

1. This table originally became effective January 1, 1992. Engine manufacturers may not recommend all of the viscosity grades shown in the table for a particular engine type.
2. Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

[a]These read across also apply to SAE 20 and SAE 20W monograde oils.

[b]A CF-4 test program with T-8A or T-8E data to validate soot handling performance must use the T-7 viscosity grade read across guidelines.

[e]A CF-4 test program with T-9 data to validate engine wear performance must use the T-6 viscosity grade read across guidelines.

[d]Provided the saturates level in the new candidate oil is equal to or greater than the original candidate oil and the sulfur level is equal to or less than that of the original candidate oil within the precision of the tests.

[e]Base oil saturates in the test and final formulations must comply with the guidelines in Annex E, and in cases where a dispersant viscosity modifier (DVM) is used, the DVM level in the final formulation must be equal to or greater than the level in the test oil.