

APPENDIX E—API BASE OIL INTERCHANGEABILITY GUIDELINES FOR PASSENGER CAR MOTOR OILS AND DIESEL ENGINE OILS

E.1 General

E.1.1 INTRODUCTION

Not all base oils have similar physical or chemical properties or provide equivalent engine oil performance in engine testing. During engine oil manufacture, marketers and blenders have legitimate needs for flexibility in base oil usage. The API Base Oil Interchangeability Guidelines (BOI) were developed to ensure that the performance of engine oil products is not adversely affected when different base oils are used interchangeably by engine oil blenders.

The API Base Oil Interchangeability Guidelines define the minimum prudent physical and engine testing necessary to ensure that engine oil performance is not adversely affected by substitution of one base oil for another. The Guidelines are based on actual engine test data, using different base oils, for both gasoline and diesel engine oil performance. The Passenger Car Motor Oil Guidelines were based on the use of API Service Category SG performance level additive technology and updated for API SH, SJ, SL, and SM quality levels. The Diesel Engine Oil Guidelines were based on the use of API Service Categories CD and CD-II performance level additive technologies and updated for CE, CF, CF-2, CF-4, CG-4, CH-4, CI-4, and CJ-4 quality levels. At these relatively high levels of additive formulation, many of the base oil differences are “overwhelmed” by the additive performance package. For this reason, these guidelines should not be used to predict equivalent interchange at additive performance levels lower than API Service Categories SH and CD.

These Guidelines define the minimum acceptable level of testing for interchanging a base oil that every marketer must perform as a condition for obtaining a license.

It is understood that when comparing base stock properties, the precision of the methods listed in Table E-1 is taken into consideration.

Use of these Guidelines does not absolve the marketer of the responsibility for the actual performance of the licensed product sold in the aftermarket. The licensee must still ensure all of the engine and bench test results.

These Guidelines are subject to modifications based on new data, new or revised test methods, and/or new performance specifications. The current Guidelines must always be used.

E.1.2 DEFINITIONS

The definitions in E.1.2.1 through E.1.2.3 apply to these Guidelines.

E.1.2.1 A *base stock* is a lubricant component that is produced by a single manufacturer to the same specifications (independent of feed source or manufacturer’s location); that meets the same manufacturer’s specification; and that is identified by a unique formula, product identification number, or both. Base stocks may be manufactured using a variety of different processes including but not limited to distillation, solvent refining, hydrogen processing, oligomerization, esterification, and rerefining. Rerefined stock shall be substantially free from materials introduced through manufacturing, contamination, or previous use.

E.1.2.2 A *base stock slate* is a product line of base stocks that have different viscosities but are in the same base stock grouping and from the same manufacturer.

E.1.2.3 A *base oil* is the base stock or blend of base stocks used in an API-licensed oil.

E.1.3 BASE STOCK CATEGORIES

All base stocks are divided into five general categories:

a. Group I base stocks contain less than 90 percent saturates and/or greater than 0.03 percent sulfur and have a viscosity index greater than or equal to 80 and less than 120 using the test methods specified in Table E-1.

- b. Group II base stocks contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 80 and less than 120 using the test methods specified in Table E-1.
- c. Group III base stocks contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 120 using the test methods specified in Table E-1.
- d. Group IV base stocks are polyalphaolefins (PAO).
- e. Group V base stocks include all other base stocks not included in Group I, II, III, or IV.

Note: PAOs can be interchanged one for another without engine testing, as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

Table E-1—Analytical Methods for Base Stock

Property	Test Method
Saturates	ASTM D 2007
Viscosity index	ASTM D 2270
Sulfur (use one listed method)	ASTM D 1552 ASTM D 2622 ASTM D 3120 ASTM D 4294 ASTM D 4927

Note: The most recent version of each of the listed standards shall be used.

E.2 Interchange for Passenger Car Motor Oils

E.2.1 GUIDELINES

E.2.1.1 Based on existing engine test data submitted to API, the passing engine tests specified in Tables E-2, E-3, and E-4 are required for interchanging the base stock in an original API-licensed PCMO.

E.2.1.2 In any case where base stocks of more than one group are interchanged simultaneously, the most severe testing requirement applies.

E.2.1.3 Engine testing is not required when a single interchange base stock that meets the definition of Group I, Group II, Group III, or Group IV is used at less than or equal to 10 mass percent of the blended PCMO formulation. In some cases, higher percentages of Group III or Group IV may be substituted without further engine testing as specified in Tables E-2, E-3, and E-4 or in the ACC Code (Appendix I, Guideline 5). The ACC Code should be followed for Group V.

E.2.1.4 The PCMO blended with the interchange base stock shall meet all physical and chemical specifications and bench test requirements for API Service Category SM and/or SL and/or SJ and/or SH and minimum performance standards for ILSAC (where applicable).

E.2.1.5 Base stocks approved under the provisions of these Guidelines may be commingled without further testing, consistent with provisions of Appendix F.

E.2.2 REQUIREMENTS

E.2.2.1 API recognizes the importance of the Multiple Test Evaluation Procedures. Engine testing to support base oil interchangeability shall be in accordance with Appendix N. These Guidelines shall be used in conjunction with the ACC Code.

E.2.2.2 Complete performance documentation is required for the original PCMOs. The detergent inhibitor (DI) and/or viscosity modifier (VM) remain unchanged when interchange base oils are tested, except as provided by the ACC Code. A base oil interchange obtained under these guidelines applies to a single PCMO formulation. In the event of a change in the DI and/or VM outside the ACC Code, these Guidelines shall be reapplied.

Table E-2—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed SH, SJ, SJ/Energy Conserving, and/or ILSAC GF-2 PCMO^a

Base Oil Interchange Requirements for API Service Category SH and API Service Category SJ without Energy Conserving					
Base Stock in Original API Licensed PCMO	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIE, VE ^b	IIIE	≤30% ^c , None >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	≤30% ^c , None >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	All
Group II	IIIE, VE	IIIE, VE ^d	≤30% ^c , None >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	≤30% ^c , None >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	All
Group III	All	All	All	≤30% ^c , VE >30% ^c , All	All
Group IV	All	All	≤30% ^c , VE >30% ^c , All	None ^e	All
Group V	All	All	All	All	All

Base Oil Interchange Requirements for ILSAC GF-2 and for API Service Category SJ with Energy Conserving ^f					
Base Stock in Original API Licensed PCMO	Interchange Base Stock				
	Group I ^g	Group II ^g	Group III	Group IV	Group V
Group I	IIIE, VE ^b	IIIE	≤30% ^c , VIA >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	≤30% ^c , VIA >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	All
Group II	IIIE, VE, VIA	IIIE, VE ^d	≤30% ^c , VIA >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	≤30% ^c , VIA >30 and ≤50% ^c All except VE and L-38 >50% ^c , All except L-38	All
Group III	All	All	All	≤30% ^c , VE, VIA >30% ^c , All	All
Group IV	All	All	≤30% ^c , VE, VIA >30% ^c , All	None ^e	All
Group V	All	All	All	All	All

Note: API SL tests may be substituted for SH and SJ tests: Ball Rust Test (at SL limits) for Sequence IID; Sequence IIIF (at different limits—see ASTM D 4485) for Sequence IIIE; Sequence IVA and VG (at SL limits) for Sequence VE; and Sequence VIB (at different limits—see ASTM D 4485) for Sequence VIA; and Sequence VIII (at SL limits) for L-38.

^aPCMO = passenger car motor oil; IIIE = ASTM Sequence IIIE engine test; VE = ASTM Sequence VE engine test; VIA = ASTM Sequence VIA engine test; L-38 = CRC L-38 engine test; All = full license approval engine test program; None = no engine test required.

^bSequence VE not required provided saturates level in new candidate oil is greater than or equal to saturates level in original candidate oil and sulfur level in new candidate oil is less than or equal to sulfur level in original oil, within the precision of the tests (effective June 5, 2000).

^cRepresents mass percentage of the PCMO formulation.

^dSequence VE not required provided saturates level in new candidate oil is greater than or equal to saturates level in original candidate oil, within the precision of the tests.

^ePAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

^fFor the Sequence VIA test, all oils blended in the interchange stock must have HTHS viscosity the same or lower than the original blend within the repeatability of the measurement method.

^gThe data set used to establish the Sequence VIA Base Oil Interchange Guidelines had the following range of (Group I and Group II) base oil parameters: Viscosity Index: Min 93–Max 116, Aromatics: Min 0.0%–Max 27%, Saturates: Min 71.5%–Max 100%, Sulfur: Min 0.0%–Max 0.4% wt. This information is for reference. It does not restrict application of the guidelines by the marketer who is responsible for ensuring that each licensed engine oil satisfies all engine and bench test performance requirements.

Table E-3—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed SL, SL/Energy Conserving, and/or ILSAC GF-3 PCMO^a

Base Oil Interchange Requirements for API Service Category SL without Energy Conserving					
Base Stock in Original API Licensed PCMO	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIF ^b , IVA ^b , VG ^{d,e}	IIIF ^b , IVA ^b , (effective date in footnote b)	≤30% ^c , None >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except IVA ^{bi} , VG ⁱ , VIII	≤30% ^c , None >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except VIII	All
Group II	IIIF ^b , IVA ^b , VG	IIIF ^b , IVA ^b , VG ^d	≤30% ^c , None >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except IVA ^{bi} , VG ⁱ , VIII	≤30% ^c , None >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except VIII	All
Group III	All except IVA ^b , VIII	All except IVA ^b , VIII	All except IVA ^{bi} , VG ⁱ , VIII ⁱ	≤30% ^c , IVA ^b , VG >30% ^c , All	All
Group IV	All	All	≤30% ^c , IVA ^b , VG >30% ^c , All	None ^f	All
Group V	All	All	All	All	All

Base Oil Interchange Requirements for ILSAC GF-3 and API Service Category SL with Energy Conserving					
Base Stock in Original API Licensed PCMO	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIF ^b , IVA ^b , VG ^{d,e} , VIB ^{g,h}	IIIF ^b , IVA ^b , VIB ^{g,h}	≤30% ^c , VIB >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except IVA ^{bi} , VG ⁱ , VIII	≤30% ^c , VIB >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except VIII	All
Group II	IIIF ^b , IVA ^b , VG, VIB ^{g,h}	IIIF ^b , IVA ^b , VG ^d , VIB ^{g,h}	≤30% ^c , VIB >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except IVA ^{bi} , VG ⁱ , VIII	≤30% ^c , VIB >30% and ≤50% ^c All except IVA ^b , VG, VIII >50% ^c , All except VIII	All
Group III	All except VIB ^{g,h} , IVA ^b , VIII	All except VIB ^{g,h} , IVA ^b , VIII	All except IVA ^{bi} , VG ⁱ , VIII ⁱ , VIB ^{g,h,i,j}	≤30% ^c , IVA ^b , VG, VIB >30% ^c , All	All
Group IV	All	All	≤30% ^c , IVA ^b , VG, VIB >30% ^c , All	None ^f	All
Group V	All	All	All	All	All

Note: Sequence IIIG may be substituted for Sequence IIIF (see ASTM D 4485).

^aPCMO = passenger car motor oil; IIIF = ASTM Sequence IIIF engine test; IVA = ASTM Sequence IVA engine test; VG = ASTM Sequence VG engine test; VIB = ASTM Sequence VIB engine test; VIII = ASTM Sequence VIII engine test; All = full license approval engine test program; None = no engine test required.

^bTest not required provided the new candidate oil's base oil blend viscosity at 100°C is greater than or equal to the base oil viscosity of the original candidate oil, within the precision of the test. For Group I to Group II base oil interchange without energy conserving, this requirement is effective October 13, 2002.

^cRepresents mass percentage of the PCMO formulation.

^dTest not required provided saturates level in new candidate oil is greater than or equal to saturates level in original candidate oil, within the precision of the test.

^eTest not required provided sulfur content in new candidate oil is less than or equal to sulfur content in original candidate oil, within the precision of the test.

^fPAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

^gTest not required provided the CCS viscosity of the new candidate oil is less than or equal to the CCS viscosity of the original candidate oil, within the precision of the test.

^hTest not required provided the HTHS viscosity of the new candidate oil is less than or equal to the HTHS viscosity of the original candidate oil, within the precision of the test.

ⁱData set used to establish the BOI guidelines is based on a base oil VI range up to 126 VI, within the precision of the test.

^jVI of the base oil blend must be less than or equal to the VI of the base oil blend of the original candidate oil, within the precision of the test.

Table E-4—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed SM, SM/Energy Conserving, and/or ILSAC GF-4 PCMO^a

Base Oil Interchange Requirements for API Service Category SM without Energy Conserving					
Base Stock in Original API Licensed PCMO	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIG, IIIGA ^b , IVA ^c , VG ^{e,f}	IIIG, IIIGA ^b , IVA ^c	≤30% ^d , None >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except IVA ^{cj} , VG ^l , VIII	≤30% ^d , None >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except VIII	All
Group II	IIIG, IIIGA ^b , IVA ^c , VG	IIIG, IIIGA ^b , IVA ^c , VG ^e	≤30% ^d , None >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except IVA ^{cj} , VG ^l , VIII	≤30% ^d , None >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except VIII	All
Group III	All except IVA ^c , VIII	All except IVA ^c , VIII	All except IVA ^{cj} , VG ^l , VIII ^l	≤30% ^d , IVA ^c , VG >30% ^d , All	All
Group IV	All	All	≤30% ^d , IVA ^c , VG >30% ^d , All	None ^g	All
Group V	All	All	All	All	All

Base Oil Interchange Requirements for ILSAC GF-4 and API Service Category SM with Energy Conserving					
Base Stock in Original API Licensed PCMO	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIG, IIIGA ^b , IVA ^c , VG ^{e,f} , VIB ^{h,i}	IIIG, IIIGA ^b , IVA ^c , VIB ^{h,i}	≤30% ^d , VIB >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except IVA ^{cj} , VG ^l , VIII	≤30% ^d , VIB >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except VIII	All
Group II	IIIG, IIIGA ^b , IVA ^c , VG, VIB ^{h,i}	IIIG, IIIGA ^b , IVA ^c , VG ^e , VIB ^{h,i}	≤30% ^d , VIB >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except IVA ^{cj} , VG ^l , VIII	≤30% ^d , VIB >30% and ≤50% ^d All except IVA ^c , VG, VIII >50% ^d , All except VIII	All
Group III	All except VIB ^{h,i} , IVA ^c , VIII	All except VIB ^{h,i} , IVA ^c , VIII	All except IVA ^{cj} , VG ^l , VIII ^l , VIB ^{h,i,j,k}	≤30% ^d , IVA ^c , VG, VIB >30% ^d , All	All
Group IV	All	All	≤30% ^d , IVA ^c , VG, VIB >30% ^d , All	None ^g	All
Group V	All	All	All	All	All

^aPCMO = passenger car motor oil; IIIG = ASTM Sequence IIIG engine test; IIIGA = ASTM Sequence IIIGA engine test; IVA = ASTM Sequence IVA engine test; VG = ASTM Sequence VG engine test; VIB = ASTM Sequence VIB engine test; VIII = ASTM Sequence VIII engine test; All = full license approval engine test program; None = no engine test required.

^bTest only required for BOI in ILSAC GF-4 PCMO and 0W-20, 0W-30, 5W-20, 5W-30, and 10W-30 viscosity grade PCMO.

^cTest not required provided the new candidate oil's base oil blend viscosity at 100°C is greater than or equal to the base oil viscosity of the original candidate oil, within the precision of the test.

^dRepresents mass percentage of the PCMO formulation.

^eTest not required provided saturates level in new candidate oil is greater than or equal to saturates level in original candidate oil, within the precision of the test.

^fTest not required provided sulfur content in new candidate oil is less than or equal to sulfur content in original candidate oil, within the precision of the test.

^gPAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

^hTest not required provided the CCS viscosity of the new candidate oil is less than or equal to the CCS viscosity of the original candidate oil, within the precision of the test.

ⁱTest not required provided the HTHS viscosity of the new candidate oil is less than or equal to the HTHS viscosity of the original candidate oil, within the precision of the test.

^jData set used to establish the BOI guidelines is based on a base oil VI range up to 126 VI, within the precision of the test.

^kVI of the base oil blend must be less than or equal to the VI of the base oil blend of the original candidate oil, within the precision of the test.

E.2.2.3 When a base stock or slate of base stocks is to be changed in a number of different viscosity grades containing a single PCMO formulation, these Guidelines shall be used in conjunction with Appendix F, except when the recommended grade for testing contains less than or equal to 10 mass percent of the interchange base stock in the formulation. In this case, the next higher viscosity grade shall be tested.

E.2.3 EXAMPLES

E.2.3.1 General

The API Base Oil Interchangeability Guidelines must be used in conjunction with the API Guidelines for SAE Viscosity-Grade Engine Testing (see Appendix F). When the original approved grade contains less than or equal to 10 mass percent of the interchange base stock, the higher grade must be tested if it contains greater than 10 percent of the interchange base stock in the formulation.

E.2.3.2 Example 1

In this example, a marketer wants to replace the Group I, 200N base stock in the marketer's SAE 5W-30 and 10W-30 grades with a new Group I, 200N base stock from another manufacturer. The SAE 5W-30 grade is a fully approved API SJ product made with a Group I base oil mix of 10 percent or less 200N and 90 percent or more 100N. The SAE 10W-30 grade is an approved API SJ product by viscosity grade read-across made with a Group I base oil mix of 65 percent 200N and 35 percent 100N. Both grades use the same Group I base stock slate.

The marketer needs to take the following steps:

- a. Check the API Guidelines for SAE Viscosity-Grade Engine Testing. An SAE 5W-30 grade may be read across to an SAE 10W-30 grade when the same base stock slate is used in both grades.
- b. Check the API Base Oil Interchangeability Guidelines. Since the SAE 5W-30 product contains less than or equal to 10 percent 200N base stock in the base oil and the interchange base stock is from the same group, no engine testing is required for the interchange. However, testing is required on the SAE 10W-30 product (the higher viscosity grade with a higher level of 200N). According to the API Base Oil Interchangeability Guidelines, the marketer must obtain a passing Sequence IIIIE to interchange one Group I, 200N base stock with another. The marketer may also need to obtain a passing Sequence VE if the requirements noted in Table E-2 are not met.

E.2.3.3 Example 2

In this example, a marketer wants to replace the Group I, 100N and 200N base stocks in its approved SAE 5W-30 and 10W-30 grades with Group I, 100N and 200N base stocks from another source. The SAE 5W-30 grade is a fully approved API SJ product made with a Group I base oil mix of 10 percent or less 200N and 90 percent or more 100N. The SAE 10W-30 grade is an approved API SJ product by viscosity read-across made with a Group I base oil mix of 65 percent 200N and 35 percent 100N. Both grades use the same base stock slate.

The marketer needs to take the following steps:

- a. Check the API Guidelines for SAE Viscosity-Grade Engine Testing. As in the previous example, an SAE 5W-30 grade may be read across to an SAE 10W-30 grade when the same base stock slate is used.
- b. Check the API Base Oil Interchangeability Guidelines. If the marketer viewed the grades independently, the SAE 5W-30 product would require testing because of the level of 100N base oil, and the 10W-30 product would require testing because of the level of 200N. However, because the API Guidelines for SAE Viscosity-Grade Engine Testing permit read across from the tested SAE 5W-30 grade to the SAE 10W-30 grade when the same base stock slate is used in both grades, only the SAE 5W-30 grade would need to be tested. As in Example 1, the marketer must run a Sequence IIIIE and may have to run a Sequence VE in the new base stocks.

E.2.3.4 Example 3

In this example, a marketer wants to interchange the source (brand) of Group I bright stock in an SAE 30 grade. This interchange involves a fully approved API SJ SAE 5W-30 grade made with a Group I base oil mix of

90 percent 100N and 10 percent 200N. The SAE 30 grade is a fully approved API SJ product by viscosity read-across made with a Group I base oil mix of 90 percent 200N and 10 percent bright stock. Both grades use the same base stock slate.

The marketer needs to take the following steps:

- a. Check the API Guidelines for SAE Viscosity-Grade Engine Testing. An SAE 5W-30 API SJ product may be read across to an SAE 30 grade if the same base stock slate is used.
- b. Check the API Base Oil Interchangeability Guidelines. Base stock slate sources at 10 percent or less of the formulation may be interchanged with other base stock sources without further testing.

E.2.3.5 Example 4

In this example, a marketer wants to interchange the source (brand) of Group I bright stock in an SAE 30 grade. The SAE 30 grade is a fully approved API SJ product by viscosity read-across from an SAE 5W-30 grade. The SAE 30 contains 15 percent bright stock in the finished formulation. Both grades use the same base stock slate.

The marketer needs to check the API Base Oil Interchangeability Guidelines. Since the bright stock is present at greater than 10 percent, the Sequence IIIIE and possibly the Sequence VE must be run in the SAE 30 grade with the new bright stock.

E.2.3.6 Example 5

In this example, a marketer wants to interchange the source (brand) of Group II, 200N base stock used in a fully approved API SJ SAE 10W-30 grade. The product is made with a Group II base oil mix of 80 percent 100N and 20 percent 200N. The base oil mix meets the Group II requirements of less than or equal to 0.03 percent sulfur and greater than or equal to 90 percent saturates.

The marketer needs to check the API Base Oil Interchangeability Guidelines. The 200N oil is present at greater than 10 percent in the original formulation, so testing is required. To make the interchange, the marketer must run a Sequence IIIIE and may have to run a VE.

E.2.3.7 Example 6

In this example, a marketer wants to make an SAE 40 grade from the same base stock slate used in a fully approved API SJ SAE 5W-30 grade. The SAE 5W-30 grade is made with a Group I base oil mix of 90 percent 100N and 10 percent 200N and is formulated with a nondispersant viscosity modifier. The SAE 40 grade contains 80 percent 300N and 20 percent bright stock in the base oil.

The marketer needs to take the following steps:

- a. Check the API Guidelines for SAE Viscosity-Grade Engine Testing. A non-Energy Conserving API SJ SAE 5W-30 product may be read across to an SAE 40 grade without further testing (note that if the SAE 5W-30 were formulated with a dispersant viscosity modifier, a Sequence VE test would be required).
- b. Check the API Base Oil Interchangeability Guidelines. Since the SAE 40 grade has the same source (brand) base oils, no interchange is taking place. No further testing is required.

E.2.3.8 Example 7

In this example, a marketer wants to exchange the Group II, 100N base stock in the base oil mix of a fully approved API SL SAE 5W-30 grade for a Group I, 100N base stock. The SAE 5W-30 grade is made with a base oil mix of 50 percent Group II, 100N and 50 percent Group I, 150N.

The marketer needs to check the API Base Oil Interchangeability Guidelines. To exchange a Group II for a Group I oil, the marketer needs to run the Sequence VG, IIIF (or Sequence IIIG per ASTM D 4485) and IVA tests and, if Energy Conserving is desired for API Service Category SL, the Sequence VIB test. Check Table E-3 for Footnotes that might apply for this interchange.

Note: In E.2.3.8, if both the 100N and 150N base stocks were interchanged for new Group I base stocks, the most severe testing requirements [namely, Sequence VG, IIIF (or Sequence IIIG per ASTM D 4485) and IVA tests and, if Energy Conserving is desired for API Service Category SL, the Sequence VIB test) would apply.

E.2.3.9 Example 8

In this example, a marketer wants to change from a full Group IV and Group V slate of base stocks to a partly Group IV (PAO) slate for a PCMO. The marketer has two products involved in this interchange: a fully approved API SL SAE 10W-30 grade with a Group IV and Group V base oil mix (Group IV/V) that contains PAO and ester fluids and a fully approved SAE 10W-30 grade with a Group I base oil mix that contains 60 percent 100N and 40 percent 250N. Both oils contain the same DI additive treat and VM.

The marketer needs to check the API Base Oil Interchangeability Guidelines. Exchange between a full Group IV/V and Group I requires full approval testing. This has been done for the Group I and the Group IV/V products. Since both the Group I stocks and the full Group IV/V blend are approved, mixtures of the two can be used without further testing.

E.2.3.10 Example 9

In this example, a marketer wants to change one PAO (Group IV) in a PAO-plus-ester SAE 5W-30 grade. The fully-approved API SL/Energy Conserving/ILSAC GF-3 SAE 5W-30 grade is made with a mix of Group IV and Group V base oils consisting of 4-centistoke PAO and ester fluids.

No testing is required for the substitute 4-centistoke PAO, provided it meets the same physical and chemical specifications as the original 4-centistoke PAO.

E.2.3.11 Example 10

In this example, a marketer wants to add 15 percent more Group IV base stock to a licensed API SJ SAE multi-viscosity grade made with a mix of 15 percent Group IV base stock, 65 percent Group II base stock, and 20 percent DI/VM additive treat. The new formulation contains 30 percent Group IV base stock, 50 percent Group II base stock, and 20 percent DI/VM additive treat.

No engine testing (except for the Sequence VIA if the oil is energy conserving) is required for the new formulation since Table E-2 allows up to 30 percent maximum of Group IV base stock in the finished oil formulation without further testing.

E.2.3.12 Example 11

In this example, a marketer wants to add 30 percent more Group IV base stock to a licensed API SL/Energy Conserving SAE multi-viscosity grade made with a mix of 20 percent Group IV base stock, 60 percent Group II base stock, and 20 percent DI/VM additive treat. The new formulation contains 50 percent Group IV base stock, 30 percent Group II base stock, and 20 percent DI/VM additive treat.

Table E-3 requires Sequence IIIF and VIB engine testing when the total Group IV content is increased to 50 percent. If the total Group IV content were increased to above 50 percent, complete engine testing except for the Sequence VIII would be required for the new formulation.

E.2.3.13 Example 12

In this example, a marketer wants to know how much more Group IV base stock can be added to an API SJ- or SL-licensed SAE multi-viscosity grade made with a mix of 24 percent Group IV base stock, 56 percent Group II base stock, and 20 percent DI/VM additive treat without further engine testing.

Since both Table E-2 and Table E-3 allow up to 30 percent maximum of Group IV base stock in the finished oil formulation without further testing when interchanging Group II with Group IV, the marketer could add 6 percent more Group IV base stock without further engine testing. The new formulation would contain 30 percent Group IV base stock, 50 percent Group II base stock, and 20 percent DI/VM additive treat.

E.2.3.14 Additional Examples

Additional examples on applying Base Oil Interchangeability Guidelines may be noted in Appendix O.

E.3 Interchange for Diesel Engine Oils

E.3.1 GUIDELINES

E.3.1.1 Based on existing engine test data submitted to API, the passing engine tests specified in Tables E-5 through E-17 are required for interchanging the base stock in an original API-licensed diesel engine oil.

E.3.1.2 In any case where base stocks of more than one group are interchanged simultaneously, the most severe testing requirement applies.

E.3.1.3 Engine testing is not required when a single interchange base stock that meets the definition of Group I, Group II, Group III, or Group IV is used at less than or equal to 10 mass percent of the blended diesel engine oil formulation. In some cases, higher percentages of Group III or Group IV may be substituted without further engine testing as specified in Tables E-5 through E-17 or the ACC Code (Appendix I, Guideline 5). The ACC Code should be followed for Group V.

E.3.1.4 The diesel engine oil blended with the interchange base oil shall meet all physical and chemical specifications required for API Service Categories CF, CF-2, CF-4, CG-4, CH-4, CI-4, and CJ-4 as appropriate.

E.3.1.5 Base stocks approved under the provisions of these Guidelines may be commingled without further testing, consistent with Appendix F.

Table E-5—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed CF and CF-2 Diesel Engine Oil

Base Stock in Original API-Licensed CF and CF-2 Oil	Interchange Base Stock ^{a,b,c}				
	Group I	Group II	Group III	Group IV	Group V
Group I	1M-PC and 6V 92TA ^d (CF-2)	1M-PC and 6V 92TA ^d (CF-2)	1M-PC and 6V 92TA (CF-2)	≤30%, None ^e (CF) >30%, 1M-PC and 6V 92TA (CF-2)	All
Group II	6V 92TA ^d (CF-2)	1M-PC and 6V 92TA ^d (CF-2)	1M-PC and 6V 92TA (CF-2)	≤30%, None ^e (CF) >30%, 1M-PC and 6V 92TA (CF-2)	All
Group III	All except VIII	All except VIII	All except VIII	<30%, All except VIII >30%, All	All
Group IV	All	All	<30%, All except VIII >30% All	None ^{b,d}	All
Group V	All	All	All	All	All

^aAll = full license-approval engine testing program; None = No engine test required.

^bPAOs can be interchanged one for another without engine testing, as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

^cIf the lubricant also meets CF-4, CH-4, CI-4 and/or CJ-4 interchange requirements, Cat 1M-PC testing is waived.

^dThe 6V 92TA test is waived only if the base oil viscosity at 100°C is equal to or greater than the base oil viscosity in the originally approved formulation.

^eUp to 30% mass Group IV base oil substitution into an original, fully formulated Group I or Group II API-licensed CF oil is allowed without further engine testing, provided that the original oil also meets SJ.

Table E-6—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed CF-4 Diesel Engine Oil

Base Stock in Original API-Licensed CF-4 Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	None ^b	None ^b	≤30%, None >30%, T-9, 1K	≤30%, None >30%, T-9, 1K	All
Group II	None ^b	None ^b	≤30%, None >30%, T-9, 1K	≤30%, None >30%, T-9, 1K	All
Group III	All except VIII	All except VIII	All except VIII	<30%, All except VIII >30%, All	All
Group IV	All	All	<30%, All except VII >30%, All	None ^c	All
Group V	All	All	All	All	All

^aT-9 = Mack T-9 engine test; 1K = Caterpillar 1K engine test; All = full license-approval engine testing program; None = No engine tests required.

^bThe 1K test has been removed as a requirement for base oil interchange in Group I and Group II base stocks. This change is based on substantial data gathered by API that statistically confirms that no base oil effects exist in the 1K test.

^cPAOs can be interchanged one for another without engine testing, as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

Table E-7—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed CG-4 Diesel Engine Oil

Base Stock in Original API-Licensed CG-4 Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIF, T-8 ^b	IIIF (See Note c)	≤30%, 1N if >30%, IIIF, RFWT, EOAT also required	≤30%, 1N if >30%, IIIF, RFWT, EOAT also required	All
Group II	IIIF, T-8, RFWT ^d (See Note c)	IIIF, T-8 ^b	≤30%, 1N if >30%, IIIF, RFWT, EOAT also required	≤30%, 1N if >30%, IIIF, RFWT, EOAT also required	All
Group III	All except VIII	All except VIII	All except VIII	<30% All ^e except VIII >30% All ^e	All
Group IV	All	All	<30% All ^e except VIII >30% All ^e	None ^f	All
Group V	All	All	All	All	All

^aIIIF = ASTM Sequence IIIF engine test; 1N = Caterpillar 1N engine test; T-8 = Mack T-8 engine test; EOAT = Engine Oil Aeration engine test; RFWT = Roller Follower Wear Test; All = full license-approval engine testing program; None = No engine tests required.

^bIf saturates as measured by the ASTM D 2007 Test Method is greater than or equal to 80 percent in the original API-licensed CG-4 diesel engine oil and if the interchange base oil is greater than or equal in saturates within the precision of the test method, the T-8 test is waived. If saturates as measured by the ASTM D 2007 Test Method is less than 80 percent in the original API-licensed CG-4 diesel engine oil and if the interchange base oil is greater than or equal in saturates at the 95 percent confidence level (see example in E.3.3.5), the T-8 test is waived.

^cThe 1N test has been removed as a requirement for base oil interchange in Group I and Group II base stocks. This change is based on substantial data gathered by API that statistically confirms that no base oil effects exist in the 1N test.

^dNeeds to be run in only one Group I base stock when interchanging from Group II to Group I.

^eIf less than or equal to 30 percent of the base oil, the L-38 and Sequence IIIF tests are waived.

^fPAOs can be interchanged one for another without engine testing, as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

Table E-8—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed CH-4 Diesel Engine Oil

Base Stock in Original API-Licensed CH-4 Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIF, M11 ^{b,c} , T-8E ^d , T-9 ^{b,c}	IIIF, 1P ^e	≤30%, 1P if >30%, 1K, T-9, RFWT, M11, EOAT, IIIF also required	≤30%, 1P if >30%, 1K, T-9, RFWT, M11, EOAT, IIIF also required	All
Group II	IIIF, M11, T-8E, T-9, RFWT ^f	IIIF, M11 ^b , T-8E ^d , T-9 ^b	≤30%, 1P if >30%, 1K, T-9, RFWT, M11, EOAT, IIIF also required	≤30%, 1P if >30%, 1K, T-9, RFWT, M11, EOAT, IIIF also required	All
Group III	All	All	All	All ^g	All
Group IV	All	All	All ^g	None ^h	All
Group V	All	All	All	All	All

^aIIIF = ASTM Sequence IIIF engine test; 1K = Caterpillar 1K engine test; 1P = Caterpillar 1P engine test; M11 = Cummins M11 engine test; T-8E = Mack T-8E engine test; T-9 = Mack T-9 engine test; EOAT = Engine Oil Aeration Test; RFWT = Roller Follower Wear Test; All = full license-approval engine testing program; None = No engine tests required.

^bTest not required if the saturates level of the new candidate oil is greater than or equal to the saturates level of the original candidate oil, within the precision of the test.

^cTest not required if the sulfur level of the new candidate oil is less than or equal to the sulfur level of the original candidate oil, within the precision of the test.

^dIf saturates as measured by the ASTM D 2007 Test Method is greater than or equal to 80 percent in the original API-licensed CH-4 diesel engine oil and if the interchange base oil is greater than or equal in saturates within the precision of the test method, the T-8E test is waived. If saturates as measured by the ASTM D 2007 Test Method is less than 80 percent in the original API-licensed CH-4 diesel engine oil and if the interchange base oil is greater than or equal in saturates at the 95 percent confidence level (see example in E.3.3.5), the T-8E test is waived.

^eTest pass required in one Group II base stock. Other Group II base stocks may then be interchanged without testing.

^fNeeds to be run in only one Group I base stock when interchanging from Group II to Group I.

^gIf less than or equal to 30 percent of the base oil, the Sequence IIIF test is waived.

^hPAOs can be interchanged one for another without engine testing, as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

Table E-9—Passing Engine Tests Required for Interchanging the Base Stock in an Original API-Licensed CI-4 Diesel Engine Oil

Base Stock in Original API-Licensed CI-4 Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	IIIF, M11EGR ^{b,c} , T-8E ^d , T-10 ^{b,c,e}	IIIF, T-10 ^{b,e}	≤30%, 1N ^f , 1R, T-10 ^{b,e} if >30%, 1K ^f , IIIF, M11EGR, T-10, EOAT, RFWT also required	≤30%, 1N ^f , 1R, T-10 ^{b,e} if >30%, 1K ^f , IIIF, M11EGR, T-10, EOAT, RFWT also required	All
Group II	1R, IIIF, M11EGR, T-8E, T-10, RFWT ^g	IIIF, M11EGR ^b , T-8E ^d , T-10 ^{b,e}	≤30%, 1N ^f , 1R, T-10 ^{b,e} if >30%, 1K ^f , IIIF, M11EGR, T-10, EOAT, RFWT also required	≤30%, 1N ^f , 1R, T-10 ^{b,e} if >30%, 1K ^f , IIIF, M11EGR, T-10, EOAT, RFWT also required	All
Group III	All	All	All	All ^h	All
Group IV	All	All	All ^h	None ⁱ	All
Group V	All	All	All	All	All

^aIIIF = ASTM Sequence IIIF engine test; 1K = Caterpillar 1K engine test; 1R = Caterpillar 1R engine test; M11EGR = Cummins M11EGR engine test; T-8E = Mack T-8E engine test; T-10 = Mack T-10 engine test; T-10A = Mack T-10A engine test; EOAT = Engine Oil Aeration Test; RFWT = Roller Follower Wear Test; All = full license-approval engine testing program; None = No engine tests required. Where multiple footnotes are shown for a given test, all requirements must be satisfied. A required test may be waived if the % of stock interchanged is less than a stated amount, and/or other criteria are met as shown in a footnote.

^bTest not required if the saturates level of the new candidate oil is greater than or equal to the saturates level of the original candidate oil, within the precision of the test.

^cTest not required if the sulfur level of the new candidate oil is less than or equal to the sulfur level of the original candidate oil, within the precision of the test.

^dTest not required if note b is met and saturates as measured by the ASTM D 2007 Test Method is greater than or equal to 80 percent in the original API licensed CI-4 diesel engine oil, or if saturates as measured by the ASTM D 2007 Test Method is less than 80 percent in the original API licensed CI-4 diesel engine oil and if the interchange base oil is greater than or equal in saturates at the 95 percent confidence level. (See example in E.3.3.5).

^eTest not required if the base oil blend viscosity at 100°C of the new candidate oil is greater than or equal to the base oil blend viscosity at 100°C of the original candidate oil within the precision of the test.

^fCI-4 requires 1K with the 1N as an alternate, and the guidelines apply to the test chosen.

^gNeeds to be run in only one Group I base stock when interchanging from Group II to Group I.

^hIf less than or equal to 30 percent of the base oil, the Sequence IIIF test is waived.

ⁱPAOs can be interchanged one for another without engine testing, as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

E.3.1.6 The base oil interchange guidelines for API CJ-4 are provided in paragraphs E.3.1.7 through E.3.1.11, Tables E-10 through E-17, and Figure E-1.

Table E-10—Caterpillar 1N Testing Required for Base Oil Interchange

Base Stock in Tested Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	NO	NO	YES	YES	YES
Group II	NO	NO	YES	YES	YES
Group III	YES	YES	YES	YES	YES
Group IV	YES	YES	YES	NO ^b	YES
Group V	YES	YES	YES	YES	YES

^aNO = No 1N required for interchange from original candidate oil. YES = 1N required for interchange from original candidate oil.

^bPAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

E.3.1.7 If more than one passing Cummins ISM or ISB test is available on a given technology, BOI is allowed if the candidate's base oil blend saturates level, sulfur content, and base oil KV@°100C fall within the range of saturates, sulfur, and base oil KV@100°C of the base oil blends in the original passing oils with a minimum of two tested/two passed and the Group III content of the candidate falls within the range of the Group III content covered by the original passing oils. If only one passing Cummins ISM or ISB test is available on a given technology then Table E-11 applies.

Table E-11—Cummins ISM and ISB Testing Required for Base Oil Interchange

Base Stock in Tested Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	YES ^{b,c}	NO	≤30%, NO if >30%, YES	≤30%, NO if >30%, YES	YES
Group II	YES	YES ^b	≤30 % NO if >30 % YES	≤30%, NO if >30%, YES	YES
Group III	YES	YES	YES	YES	YES
Group IV	YES	YES	YES	NO ^d	YES
Group V	YES	YES	YES	YES	YES

^aNO = Neither ISM nor ISB tests required for interchange from original candidate oil. YES = Both ISM and ISB tests required for interchange from original candidate oil.

^bTest not required if the saturates level of the new candidate oil is greater than or equal to the saturates level of the original candidate oil, within the precision of the test.

^cTest not required if the sulfur level of the new candidate oil is less than or equal to the sulfur level of the original candidate oil, within the precision of the test.

^dPAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

E.3.1.8 If more than one passing Mack T-12 test is available on a given technology, BOI is allowed if the proposed interchange oil's base oil blend saturates level, sulfur content, and base oil KV@100°C fall within the range of saturates, sulfur content, and base oil viscosity at 100°C of the base oil blends in the original oils with a minimum of two tested/two passed and the Group III content of the candidate falls within the range of the Group III content covered by the original oils. Alternatively, Table E-12 can be used for base oil interchange if only one passing Mack T-12 test is available on a given technology.

Table E-12—Mack T-12 Testing Required for Base Oil Interchange

Base Stock in Tested Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	YES ^{b,c,d}	YES ^{b,d}	≤30%, YES ^{b,d} if >30%, YES	≤30%, YES ^{b,d} if >30%, YES	YES
Group II	YES	YES ^{b,d}	≤30%, YES ^{b,d} if >30%, YES	≤30%, YES ^{b,d} if >30%, YES	YES
Group III	YES	YES	YES	YES	YES
Group IV	YES	YES	YES	NO ^e	YES
Group V	YES	YES	YES	YES	YES

^aNO = No T-12 test required for interchange from original candidate oil. YES = T-12 test required for interchange from original candidate oil.

^bTest not required if the saturates level of the new candidate oil is greater than or equal to the saturates level of the original candidate oil, within the precision of the test.

^cTest not required if the sulfur level of the new candidate oil is less than or equal to the sulfur level of the original candidate oil, within the precision of the test.

^dTest not required if the base oil blend viscosity at 100°C of the new candidate oil is greater than or equal to the base oil blend viscosity at 100°C of the original candidate oil, within the precision of the test.

^ePAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

E.3.1.9 Base Oil Interchange for all Mack T-11 engine tests associated with API CJ-4 and for Mack T-11 engine tests associated with API CI-4 and CI-4 PLUS started after April 28, 2006 may be determined using the method provided in Tables E-13 or E-14 or Figure E-1. Tables E-13 and E-14 and Figure E-1 all define the minimum saturates content of the candidate oil that can be interchanged from the original test oil.

Table E-13—Mack T-11 BOI Saturates Requirements (within a range)

Tested Oil	Candidate Oil
$X \leq 70.0$	80.0 minimum
$70.0 < X < 95.0$	$(0.6 * X + 38)$ minimum
$X \geq 95.0$	95.0 minimum

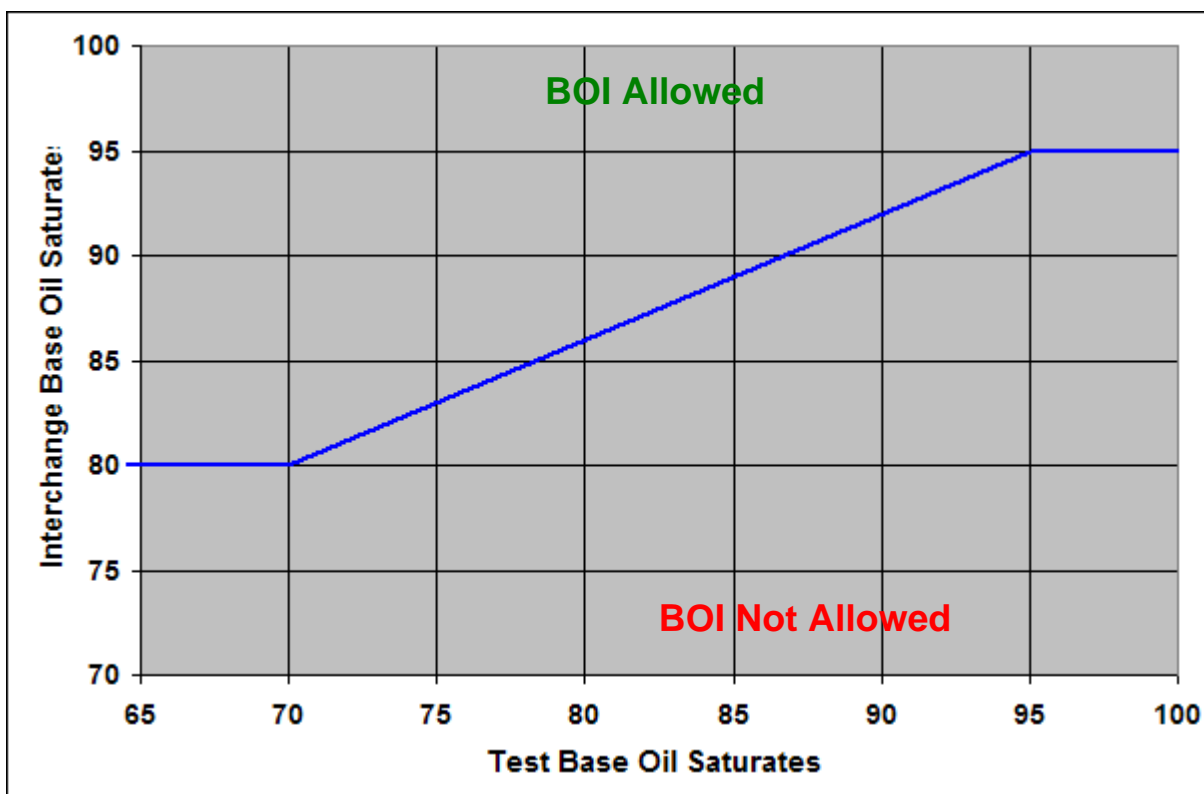


Figure E-1—Mack T-11 BOI Saturates Requirements (according to plot)

Table E-14—Mack T-11 BOI Saturates Requirements (minimum saturates for interchange)

Base Oil Originally Tested for Licensing	Minimum Saturates for Interchange Base Oil
≤70.0	80.0
71.0	80.6
72.0	81.2
73.0	81.8
74.0	82.4
75.0	83.0
76.0	83.6
77.0	84.2
78.0	84.8
79.0	85.4
80.0	86.0
81.0	86.6
82.0	87.2
83.0	87.8
84.0	88.4
85.0	89.0
86.0	89.6
87.0	90.2
88.0	90.8
89.0	91.4
90.0	92.0
91.0	92.6
92.0	93.2
93.0	93.8
94.0	94.4
≥95.0	95.0

Table E-15—Roller Follower Wear Tests (RFWT) Required for Base Oil Interchange

Base Stock in Tested Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	NO	NO	≤30%, NO if >30%, YES	≤30%, NO if >30%, YES	YES
Group II	YES ^b	NO	≤30%, NO if >30%, YES	≤30%, NO if >30%, YES	YES
Group III	YES	YES	YES	YES	YES
Group IV	YES	YES	YES	NO ^c	YES
Group V	YES	YES	YES	YES	YES

^aNO = No RFWT required for interchange from original candidate oil. YES = RFWT is required for interchange from original candidate oil.

Where multiple footnotes are shown for a given test, all requirements must be satisfied. A required test may be waived if the percentage of base stock interchanged is less than a stated amount and/or other criteria are met as shown in a footnote.

^bNeeds to be run in only one Group I base stock when interchanging from Group II to Group I.

^cPAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

Table E-16—Engine Oil Aeration Tests (EOAT) Required for Base Oil Interchange

Base Stock in Tested Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	NO	NO	≤30%, NO if >30%, YES	≤30%, NO if >30%, YES	YES
Group II	NO	NO	≤30%, NO if >30%, YES	≤30%, NO if >30%, YES	YES
Group III	YES	YES	YES	YES	YES
Group IV	YES	YES	YES	NO ^b	YES
Group V	YES	YES	YES	YES	YES

^aNO = No EOAT required for interchange from original candidate oil. YES= EOAT is required for interchange from original candidate oil.

Where multiple footnotes are shown for a given test, all requirements must be satisfied. A required test may be waived if the percentage of stock interchanged is less than a stated amount and/or other criteria are met as shown in a footnote.

^bPAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

Table E-17—Sequence IIIF/IIIG Testing Required for Base Oil Interchange

Base Stock in Tested Oil	Interchange Base Stock ^a				
	Group I	Group II	Group III	Group IV	Group V
Group I	YES	YES	≤30%, NO if >30%, YES	≤30%, NO if >30%, YES	YES
Group II	YES	YES	≤30%, NO >30%, YES	≤30%, NO if >30%, YES	YES
Group III	YES	YES	YES	≤30%, NO >30%, YES	YES
Group IV	YES	YES	≤30%, NO >30%, YES	NO ^b	YES
Group V	YES	YES	YES	YES	YES

^aNO = No Sequence IIIF required for interchange from original candidate oil. YES = Sequence IIIF is required for interchange from original candidate oil. A Sequence IIIG can be substituted for a Sequence IIIF. Where multiple footnotes are shown for a given test, all requirements must be satisfied. A required test may be waived if the percentage of stock interchanged is less than a stated amount and/or other criteria are met as shown in a footnote.

^bPAOs can be interchanged one for another without engine testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.

E.3.1.10 Single Technology Matrix (STM) is an alternate approach to BOI for Sequence IIIF, IIIF HD, IIIG, and IIIGA Tests (see Appendix R).

E.3.1.11 Caterpillar C13 test base oil interchange guidelines within Groups I, II, and III are described in paragraphs E.3.1.11.1 and E.3.1.11.2 (see notes below). Acceptable test methods for base stock and base oil blend properties are listed in Table E-1. It is understood that when comparing properties, the precision of the methods is taken into consideration.

Notes:

- 1) The typical viscosity index of the Group III in the candidate must be no more than 6 units higher than the typical viscosity index of the Group III in the passing C13 oil with no allowance for test precision.
- 2) PAOs (Group IV) can be interchanged one for another without testing as long as the original PAO has had full approval and the interchange PAO meets the original PAO manufacturer's specifications in all physical and chemical properties.
- 3) When Group V base stocks are present, the C13 test must be run.

E.3.1.11.1 If only one passing C13 test is available on a given technology and only Group II and/or Group III base stocks are present in the passing C13 oil and the candidate, then C13 BOI is allowed if the viscosity index (VI) of the base oil blend for the candidate oil is equal to or less than the VI of the base oil blend of the passing C13 oil (see note below). If Group I base stock is present in either the passing C13 oil or the candidate, then C13 BOI is allowed if the base oil blend of the candidate has the same saturates level, the same or less sulfur, and the same or lower VI than the base oil blend of the passing C13 oil. Additional guidelines apply when Group III base stock is present in the C13 passing oil:

- a. The candidate oil must have Group III content equal to or less than the passing oil.
- b. The typical viscosity index of the Group III in the candidate must be no more than 6 units higher than the typical viscosity index of the Group III in the passing C13 oil with no allowance for test precision.

Worksheets like the ones shown below can be used to determine if a candidate's properties meet the C13 BOI criteria above. Examples follow that show how the worksheets should be used.

Worksheet 1: If only Group II and/or III in both the candidate and passing oils

	Candidate		Passing Oil
Base oil blend VI		< or =	
Group III content, % in oil		< or =	
Group III VI		See b above	

Example w/worksheet 1: If only Group II and/or III in both the candidate and passing oils

	Candidate		Passing Oil
Base oil blend VI	104	< or =	115
Group III content, % in oil	13.5	< or =	40
Group III VI	126	See b above	126

In the example above, the candidate's properties meet the BOI criteria when compared to the passing oil. BOI is allowed for this candidate.

Worksheet 2: If Group I in either the candidate or passing oils

	Candidate		Passing Oil
Base oil blend sats, %		=	
Base oil blend sulfur, ppm		< or =	
Base oil blend VI		< or =	
Group III content, % in oil		< or =	
Group III VI		See b above	

Example w/worksheet 2: If Group I in either the candidate or passing oils

	Candidate		Passing Oil
Base oil blend sats, %	87	=	87
Base oil blend sulfur, ppm	347 ^a	< or =	320
Base oil blend VI	93	< or =	99
Group III content, % in oil	0	< or =	15
Group III VI	---	See b above	128

^aNeed to apply the precision of the method.

The candidate's properties meet the BOI criteria when compared to the passing oil. In this case, the precision of the sulfur method shows the sulfur contents to be the same (D2622, 320 ppm +/- 41 ppm covers 347 ppm). BOI is allowed for this candidate.

E.3.1.11.2 If more than one passing C13 test is available on a given technology, BOI is allowed if the candidate's base oil blend saturates level, sulfur content, and viscosity index fall within the range of saturates level, sulfur, and VI of the base oil blends in the original passing oils (minimum two tested/two passed oils) and the Group III content of the candidate oil falls within the range of Group III content covered by the original passing oils. Additionally, the typical viscosity index of the Group III in the candidate oil must be no more than 6

units higher than the typical viscosity index of the Group III in the passing C13 oil with no allowance for test precision.

A worksheet like the one shown below can be used to determine if a candidate's properties meet the C13 BOI criteria above. Examples follow that show how the worksheets would be used.

Worksheet 3: If more than one passing C13 test is available on a given technology

	Passing Oil 1	Passing Oil 2	Candidate
Base oil blend sats, %			
Base oil blend sulfur, ppm			
Base oil blend VI			
Group III content, % in oil			
Group III VI (See b above)			
Is C-13 required?			Yes or no?
Reason			

Example 1 w/worksheet 3: If more than one passing C13 test is available on a given technology

	Passing Oil 1	Passing Oil 2	Candidate
Base oil blend sats, %	87	96	87
Base oil blend sulfur, ppm	347	0	320
Base oil blend VI	93	115	99
Group III content, % in oil	0	40	15
Group III VI (See b above)	--	126	128
Cat C-13	Pass	Pass	
Is C-13 required?			No
Reason			BOI is allowed. Sats, S, VI, and Group III content fall within matrix ranges. Candidate Group III VI is within the acceptable +6 range.

Example 2 w/worksheet 3: If more than one passing C13 test is available on a given technology

	Passing Oil 1	Passing Oil 2	Candidate
Base oil blend sats, %	87	96	94
Base oil blend sulfur, ppm	347	0	90
Base oil blend VI	93	115	112
Group III content, % in oil	0	40	20
Group III VI (See b above)	--	126	134
Cat C-13	Pass	Pass	
Is C-13 required?			Yes
Reason			BOI is not allowed. Base oil sats, S, and VI fall within matrix ranges, but Candidate Group III VI is outside the acceptable +6 range.

E.3.2 REQUIREMENTS

E.3.2.1 API recognizes the importance of the ACC Code. Engine testing to support base oil interchangeability shall be in accordance with the ACC Code.

E.3.2.2 Complete performance documentation is required for the original diesel engine oils. The detergent inhibitor (DI) and/or viscosity modifier (VM) remain unchanged when interchange base oils are tested, except as provided by the ACC Code. A base oil interchange obtained under these Guidelines applies to a single CF, CF-2,

CF-4, CG-4, CH-4, CI-4, or CJ-4 formulation. In the event of a change in the DI and/or VM additive system, these Guidelines shall be reapplied.

E.3.2.3 When a base stock or slate of base stocks is to be changed in a number of different viscosity grades containing a single diesel engine oil formulation, these Guidelines shall be used in conjunction with Appendix F, except when the recommended grade for testing contains less than or equal to 10 mass percent of the interchange base stock in the formulation. In this case, the next higher viscosity grade shall be tested.

E.3.3 EXAMPLES

E.3.3.1 General

The API Base Oil Interchangeability Guidelines must be used in conjunction with the API Guidelines for SAE Viscosity-Grade Engine Testing (see Appendix F). When the original approved grade contains less than or equal to 10 percent of the interchange base stock, the higher grade must be tested if it contains greater than 10 percent of the interchange base stock in the formulation.

E.3.3.2 Example 1

In this example, a marketer wants to exchange the 600N base stock in a Group I slate of base stocks for API Service Category CF-4 diesel engine oils. The marketer has two products involved in this interchange: an SAE 15W-40 grade containing a Group I base oil mix of 50 percent 100N and 50 percent 250N that has been approved by viscosity read-across and testing and an SAE 30 grade containing a Group I base oil mix of 35 percent 250N and 65 percent 600N that has also been approved by viscosity read-across and testing.

The marketer needs to take the following steps:

- a. Check the API Guidelines for SAE Viscosity-Grade Engine Testing. Some diesel engine tests can be read across from multigrade to single grade. Others can be read across from single grade to multigrade. Approval testing in original stocks was conducted accordingly.
- b. Check the API Base Oil Interchangeability Guidelines. Since the SAE 15W-40 product contains none (that is, less than 10 percent of the formulation) of the Group I 600N interchange stock, no testing is required. Additionally, no testing is required for the SAE 30 product when a 600N Group I base stock from another source is used. Group I for Group I interchanges are permitted for CF-4 oils (see Table E-6).

E.3.3.3 Example 2

In this example, a marketer wants to change from a Group II slate of base stocks used in a fully approved API CF-4 SAE 15W-40 diesel engine oil to a Group I slate and also to a mix of Group I and Group II stocks. The approved SAE 15W-40 grade is made with a Group II base oil mix of 65 percent 100N and 35 percent 240N.

The marketer needs to check the API CF-4 Base Oil Interchangeability Guidelines in Table E-6. No further engine testing is required for either interchange.

E.3.3.4 Additional Examples

Additional examples on applying Base Oil Interchangeability Guidelines may be noted in Appendix O.

E.3.3.5 Saturates Calculation Example for Tables E-7, E-8, and E-9

The following calculation is utilized to determine if a Mack T-8 or T-8E test can be waived when both the originally tested base oil and the intended interchange base oil are below 80 percent saturates. A Mack T-8 or T-8E test is necessary for base oil interchangeability if the new base oil percent saturates level is not greater than or equal to the percent saturates level in the originally tested base oil at the 95 percent confidence level. This calculation is performed as follows:

Difference between two means (Z value calculation, one-sided assuming normal distribution):

$$X_1 - X_2 \geq 1.645 \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

where X = mean of saturate determinations
 σ = standard deviation of laboratory performing analyses
n = number of determinations
subscripts 1 and 2 refer to the interchange base oil and original base oil respectively

ASTM D 2007 saturates determinations must be made in a laboratory that has a standard deviation of 1.5 or less with an internal reference oil of less than 80 percent saturates.

If the ASTM D 2007 standard deviation for the laboratory in which both the original 70.0 percent saturates base oil and interchange base oil determinations were run is 1.5 and single saturates determinations were made, the Mack T-8 or Mack T-8E test would be waived for all API Group I Base Oils at least 3.48 percent higher in saturates (73.48 percent saturates minimum).

$$X_1 - X_2 \geq 1.645 \sqrt{\frac{(1.5)^2}{1} + \frac{(1.5)^2}{1}}$$

$$X_1 - X_2 \geq (1.645)(1.5)\sqrt{2}$$

$$X_1 - X_2 \geq 3.48$$

If in the above calculation, the ASTM D 2007 laboratory standard deviations were both 0.7 rather than 1.5 and single determinations were made, waiving the Mack T-8 or Mack T-8E Test for all API Group I Base Oils at least 1.63 percent higher (71.63 percent saturates minimum) would be permissible.

E.4 Interchange for Bench Tests

E.4.1 Complete bench testing is required for interchanging a base stock in an API-licensed oil except where noted in the guidelines below.

E.4.2 Based on existing TEOST 33 (ASTM D 6335) bench test data submitted to API, the passing TEOST 33 tests specified in Table E-18 are required for interchanging the base stock in an original API SJ-licensed PCMO.

Table E-18—Passing TEOST 33 Tests Required for Interchanging the Base Stock in an Original API-Licensed SJ, SJ/Energy Conserving, and/or ILSAC GF-2 PCMO

Base Stock in Original API-Licensed PCMO ^{a,b}	Interchange Base Stock ^{a,b}				
	Group I	Group II	Group III	Group IV	Group V
Group I	NO	NO	YES	YES	YES
Group II	NO	NO	YES	YES	YES
Group III	YES	YES	YES	YES	YES
Group IV	YES	YES	YES	YES	YES
Group V	YES	YES	YES	YES	YES

^aNO = TEOST 33 test not required; YES = TEOST 33 test required; PCMO = passenger car motor oil.

^bApplies to SAE 5W-30 and higher viscosity grades only.

E.4.3 Based on existing TEOST MHT-4 bench test data submitted to API, the passing TEOST MHT-4 tests specified in Table E-19 are required for interchanging the base stock in an original API SL-licensed PCMO.

Table E-19—Passing TEOST MHT-4 Tests Required for Interchanging the Base Stock in an Original API-Licensed SL and/or ILSAC GF-3 PCMO

Base Stock in Original API-Licensed PCMO ^{a,b}	Interchange Base Stock ^{a,b}				
	Group I	Group II	Group III	Group IV	Group V
Group I	NO ^c	YES	YES	YES	YES
Group II	NO	YES	YES	YES	YES
Group III	YES	YES	YES	YES	YES
Group IV	YES	YES	YES	YES	YES
Group V	YES	YES	YES	YES	YES

^aNO = TEOST MHT-4 test not required; YES = TEOST MHT-4 test required; PCMO = passenger car motor oil.

^bApplies to SAE 5W-30 and higher viscosity grades only.

^cTEOST MHT-4 not required provided saturates level in new candidate oil is less than or equal to saturates level in original candidate oil and sulfur level in new candidate oil is greater than or equal to sulfur level in original oil, within the precision of the tests.

E.4.4 Homogeneity and Miscibility (H&M) and Engine Oil Filterability (EOFT) [formerly known as GM 9099P Filterability (Standard Method)] tests are required in one viscosity grade represented in the core data set. Each base oil interchange requires only one H&M and one EOFT test. (See ACC Code for definition of core data set.) Core data sets are typically developed in SAE 5W-30, 10W-30, 10W-40 or 15W-40 viscosity grades.

E.4.5 The Engine Oil Water Tolerance Test (EOWTT) [formerly GM 9099P Filterability (Modified Method for ILSAC GF-2/GF-3)] for each base oil interchange is required only in the viscosity grade with the highest additive (DI/VI) combination.

E.4.6 The Ball Rust Test (BRT) (ASTM D 6557) is not required for Group I to Group I, Group I to Group II, Group II to Group I, and Group II to Group II base oil interchanges. The BRT is also not required where up to 30% Group III or Group IV is substituted for Group I or Group II. However, the BRT is required for all other interchanges. VGRA guidelines for the BRT are outlined in Table F-3.

E.4.7 A T-10A test is not required for base oil interchange if the saturates and sulfur content (within the precision of the two analytical tests) of the interchange base oil fall within the range of the saturates and sulfur content of the base oils in the original candidate oils (minimum two candidate oils), and fresh oil MRV-TP1 (ASTM D 4684) @ -20°C of the interchange candidate is equal to or less than the BOI matrix limit.

The BOI matrix limit is defined as:

$$BOI\ matrix\ limit = 25000 - margin\ of\ safety$$

Margin of safety is defined as:

$$margin\ of\ safety = largest\ of\ Y1 - X1, Y2 - X2, or\ 0$$

where X1 = fresh oil MRV-TP1 @ -20°C for original candidate oil 1
 X2 = fresh oil MRV-TP1 @ -20°C for original candidate oil 2
 Y1 = MRV-TP1 @ -20°C of 75-hour T-10A sample for original candidate oil 1
 Y2 = MRV-TP1 @ -20°C of 75-hour T-10A sample for original candidate oil 2

An example of this guideline's application is provided in Table E-20.

Table E-20—Example of T-10A BOI Guideline Application^a

	Matrix Oil 1	Matrix Oil 2	Candidate Oil A	Candidate Oil B	Candidate Oil C
Base Oil Saturates, mass%	99	65	70	80	75
Base Oil Sulfur, mass%	<0.002	0.7	0.5	0.3	0.8
Is base oil saturates within the matrix range (within the precision of the test)?			Yes	Yes	Yes
Is base oil sulfur within the matrix range (within the precision of the test)?			Yes	Yes	No
Fresh Oil MRV-TP1 @ -20°C, cP	12000	15000	16000	20000	Immaterial
T-10A MRV-TP1 @ -20°C, cP	18000	16000			
Yield stress, Pa	0	0			
Margin of safety	Largest of (18000-12000) or (16000-15000) or 0 = 6000				
BOI matrix limit	25000-6000 = 19000		19000	19000	19000
Test Required?			No	Yes	Yes
Reason			Fresh oil MRV-TP1 less than BOI matrix limit	Fresh oil MRV-TP1 greater than BOI matrix limit	Base oil sulfur not in matrix range

^aT-10A = Mack T-10A engine test.

E.4.8 The CI-4 Elastomer Compatibility Test is not required if the saturates and sulfur content (within the precision of the tests) of the interchange base oil fall within the range of the saturates and sulfur content of the base oils in the original candidate oils (minimum two candidate oils) and the DI package is unchanged. An example of this guideline's application is provided in Table E-21.

Table E-21—Example of CI-4 Elastomer Compatibility BOI Guideline Application

	Matrix Oil 1	Matrix Oil 2	Candidate Oil A	Candidate Oil B
Base Oil Saturates, mass %	99	65	70	80
Base Oil Sulfur, mass %	<0.002	0.7	0.5	0.3
CI-4 Elastomer Compatibility Test	Pass	Pass		
Test Required?			No	No
Reason			Base oil saturates and sulfur fall within matrix ranges	Base oil saturates and sulfur fall within matrix ranges

E.4.9 The CJ-4 Elastomer Compatibility Test is not required if the saturates and sulfur content (within the precision of the tests) of the interchange base oil fall within the range of the saturates and sulfur content of the base oils in the original candidate oils (minimum two candidate oils) and the DI package is unchanged. An example of this guideline's application is provided in Table E-22.

Table E-22—Example of CJ-4 Elastomer Compatibility BOI Guideline Application

	Matrix Oil 1	Matrix Oil 2	Candidate Oil A	Candidate Oil B
Base Oil Saturates, mass %	99	65	70	80
Base Oil Sulfur, mass %	<0.002	0.7	0.5	0.3
CJ-4 Elastomer Compatibility Test	Pass	Pass		
Test Required?			No	No
Reason			Base oil saturates and sulfur fall within matrix ranges	Base oil saturates and sulfur fall within matrix ranges

E.4.10 In addition to the Mack T-11 BOI guidelines being met, for Base Oil Interchange in the Mack T-11A the fresh oil MRV-TP1 (ASTM D 4684) @ -20°C of the interchange candidate must be less than or equal to 20000 cPs with no yield stress.

E.4.11 If there is one passing High-Temperature Corrosion Bench Test (HTCBT) (ASTM D 6594) in the core data set as defined by the ACC Code, read-across is allowed to all other viscosity grades and base oil slates.