Engine Oil Licensing and Certification System

API 1509
TWENTY-FIRST EDITION, FEBRUARY 2022

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Downstream Segment

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Foreword

This publication describes the voluntary API Engine Oil Licensing and Certification System (EOLCS) and is intended to explain to marketers how the API Engine Oil Quality Marks are licensed and displayed for the consumer. The publication describes methods for developing new engine oil performance standards and provides the marketer with a description of the API Marks and their use, licensing requirements, aftermarket conformance, and enforcement procedures. It also explains the interaction and roles of the various independent organizations that are part of the API EOLCS.

Suggested revisions are invited and should be submitted to the Standardization Director, American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Recent changes

1. Extensive reorganization of the Annexes has taken place vs. the 19th and prior editions. However, Annexes A through G remain in their 19th-edition order. The evolution in the organization of the later editions can be summarized as follows:

Annexes prior to 19th edition	20th edition changes (superseded by 21st ed.)	21st edition status
A through G	Order unchanged	Order unchanged
H [Engine Oil Licensing and Certification System (EOLCS) Online Application]	Appeared as an entry in the Glossary (Annex P)	Remains as an entry in the Glossary (Annex Q)
I [Glossary]	Appeared as Annex P	Now appears as Annex Q
J [ACC Petroleum Additives Panel Product Approval Code of Practice]	Appeared as Annex K	Remains as Annex K
K [Physical and Chemical Ranges for Auditing]	Appeared as Annex L	Remains as Annex L
L [Guidelines for Selection of Product and Engine Test Audits]	Subject matter removed	(No longer applicable)
M [API Mark Conformance Audit: Engine Tests]	Subject matter removed	(No longer applicable)
N [Multiple Test Evaluation Procedure]	Incorporated as footnote in Annex O	Incorporated as footnote in Annex O
O [Technical Interpretations of API 1509]	Appeared as Annex M	Remains as Annex M
P [EOLCS Licensing Clarifications]	Appeared as Annex N	Remains as Annex N
Q [ILSAC Minimum Performance Standards for Passenger Car Engine Oils]	Appeared as Annex H	Remains as Annex H
R [API Guidelines for Use of Single Technology Matrix]	Appeared as stabilized Annex O	Remains as stabilized Annex O
S [Performance Requirements for C Category Supplements]	Appeared as Annex J	Remains as Annex J
T [Requirements for API Service Categories CK-4 and FA-4 by Viscosity Grade]	Appeared as part of Annex I	Remains inside Annex I
--	--	A new Annex, Annex P, entitled “API Guidelines for Use of a Single Technology Matrix”, has been added.

2. Annex P, ***API Guidelines for Use of a Single Technology Matrix***, has been added to the text as an outcome of ballot 5573.

3. Figure O-1 has been updated to reflect the current appearance of the EOLCS licensing system, insofar as reporting use of STM.
4. The Tables in Annex I have been modified to reflect some of the changes captured in TMC Information Letter 22-1. Specifically, this edition implements the conclusions of the ASTM D4485 Surveillance Panel regarding high temperature, high-shear requirements for Heavy-Duty Engine Oils.
5. Various errata have been addressed.

Contents

Annexes

Engine Oil Licensing and Certification System

1. SCOPE

This publication describes the API Engine Oil Licensing and Certification System (EOLCS), a voluntary licensing and certification program designed to define, certify, and monitor engine oil performance deemed necessary for satisfactory equipment life and performance by vehicle and engine manufacturers. Engine oil marketers that meet EOLCS requirements may be licensed to display three Marks, the API Service Symbol “Donut” and the API Certification Marks “Shield” or “Starburst” (as applicable).

Sections 2 through 8 of this publication define the current API engine oil service categories and explain the EOLCS licensing requirements, the API Marks and their use, and the EOLCS Aftermarket Audit Program (AMAP). Annexes A through T provide a brief history of engine oil classifications, describe methods for developing new engine oil performance requirements, and explain the interaction and roles of the various independent organizations that are part of the API EOLCS.

2. NORMATIVE REFERENCES

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

American Chemistry Council Petroleum Additives Panel Product Approval Code of Practice

ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup*

ASTM D93, *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*

ASTM D445, *Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)*

ASTM D874, *Standard Test Method for Sulfated Ash from Lubricating Oils and Additives*

ASTM D892, *Standard Test Method for Foaming Characteristics of Lubricating Oils*

ASTM D1552, *Standard Test Method for Sulfur in Petroleum Products (High-Temperature Method)*

ASTM D2007, *Standard Test Method for Characteristic Groups in Rubber Extender and Processing Oils and Other Petroleum Derived Oils by the Clay-Gel Absorption Chromatographic Method*

ASTM D2270, *Standard Practice for Calculating Viscosity Index From Kinematic Viscosity at 40 and 100°C*

ASTM D2622, *Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry*

ASTM D2887, *Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography*

ASTM D3120, *Standard Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry*

ASTM D3244, *Standard Practice for Utilization of Test Data to Determine Conformance with Specifications*

ASTM D4294, *Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectroscopy*

ASTM D4485, *Standard Specification for Performance of Engine Oils*

ASTM D4683, *Standard Test Method for Measuring Viscosity at High Shear Rate and High Temperature by Tapered Bearing Simulator*

ASTM D4684, *Standard Test Method for Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature*

ASTM D4741, *Standard Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered-Plug Viscometer*

ASTM D4927, *Standard Test Method for Elemental Analysis of Lubricant and Additive Components, Barium, Calcium, Phosphorus, Sulfur, and Zinc, by Wavelength-Dispersive X-Ray Fluorescence Spectroscopy*

ASTM D4951, *Standard Test Method for Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry*

ASTM D5119, *Standard Test Method for Evaluation of Automotive Engine Oils in CRC L-38 Spark Ignition Engine*

ASTM D5133, *Standard Test Method for Low Temperature, Low Shear Rate, Viscosity/Temperature Dependence of Lubricating Oils Using a Temperature-Scanning Technique*

ASTM D5185, *Standard Test Method for Determination of Additive Elements, Wear Metals, and Contaminants in Used Lubricating Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)*

ASTM D5293, *Standard Test Method for Apparent Viscosity of Engine Oils Between –5 and –30˚C Using the Cold-Cranking Simulator*

ASTM D5302, *Standard Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation and Wear in a Spark-Ignition Internal Combustion Engine Fueled with Gasoline and Operated Under Low-Temperature Light-Duty Conditions*

ASTM D5480, *Standard Test Method for Motor Oil Volatility by Gas Chromatography*

ASTM D5481, *Standard Test Method for Measuring Apparent Viscosity at High-Temperature and High-Shear Rate by Multicell Capillary Viscometer*

ASTM D5533, *Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIE Spark Ignition Engine*

ASTM D5800, *Standard Test Method for Evaporation Loss of Lubricating Oils by the NOACK Method*

ASTM D5844, *Standard Test Method for Evaluation of Automotive Engine Oils for Inhibition of Rusting (Sequence IID)*

ASTM D5966, *Standard Test Method for Evaluation of Engine Oils for Roller Follower Wear in Light-Duty Diesel Engine*

ASTM D6082, *Standard Test Method for High Temperature Foaming Characteristics of Lubricating Oils*

ASTM D6202, *Standard Test Method for Automotive Engine Oils on the Fuel Economy of Passenger Cars and Light-Duty Trucks in the Sequence VIA Spark Ignition Engine*

ASTM D6278, *Standard Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus*

ASTM D6335, *Standard Test Method for Determination of High Temperature Deposits by Thermo-Oxidation Engine Oil Simulation Test*

ASTM D6417, *Standard Test Method for Estimation of Engine Oil Volatility by Capillary Gas Chromatography*

ASTM D6557, *Standard Test Method For Evaluation of Rust Preventative Characteristics of Automotive Engine Oils*

ASTM D6593, *Standard Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation in a Spark-Ignition Internal Combustion Engine Fueled with Gasoline and Operated Under Low-Temperature Light-Duty Conditions*

ASTM D6594, *Standard Test Method for Evaluation of Corrosiveness of Diesel Engine Oil at 135 °C*

ASTM D6616, *Standard Test Method for Measuring Viscosity at High Shear Rate by Tapered Bearing Simulator Viscometer at 100°C*

ASTM D6709, *Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence VIII Spark-Ignition Engine (CLR Oil Test Engine)*

ASTM D6750, *Standard Test Methods for Evaluation of Engine Oils in a High-Speed, Single-Cylinder Diesel Engine—1K Procedure (0.4 % Fuel Sulfur) and 1N Procedure (0.04 % Fuel Sulfur)*

ASTM D6837, *Standard Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VIB Spark Ignition Engine*

ASTM D6794, *Standard Test Method for Measuring the Effect on Filterability of Engine Oils After Treatment with Various Amounts of Water and a Long (6-h) Heating Time*

ASTM D6795, *Standard Test Method for Measuring the Effect on Filterability of Engine Oils After Treatment with Water and Dry Ice and a Short (30-min) Heating Time*

ASTM D6891, *Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IVA Spark-Ignition Engine*

ASTM D6896, *Standard Test Method for Determination of Yield Stress and Apparent Viscosity of Used Engine Oils at Low Temperature*

ASTM D6922, *Standard Test Method for Determination of Homogeneity and Miscibility in Automotive Engine Oils*

ASTM D7097, *Standard Test Method for Determination of Moderately High Temperature Piston Deposits by Thermo-Oxidation Engine Oil Simulation Test-TEOST MHT*

ASTM D7109, *Standard Test Method for Shear Stability of Polymer-Containing Fluids Using a European Diesel Injector Apparatus at 30 Cycles and 90 Cycles*

ASTM D7156, *Standard Test Method for Evaluation of Diesel Engine Oils in the T-11 Exhaust Gas Recirculation Diesel Engine*

ASTM D7216, *Standard Test Method for Determining Automotive Engine Oil Compatibility with Typical Seal Elastomers*

ASTM D7320, *Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIG, Spark-Ignition Engine*

ASTM D7422, *Standard Test Method for Evaluation of Diesel Engine Oils in T-12 Exhaust Gas Recirculation Diesel Engine*

ASTM D7468, *Standard Test Method for Cummins ISM Test*

ASTM D7484, *Standard Test Method for Evaluation of Automotive Engine Oils for Valve-Train Wear Performance in Cummins ISB Medium-Duty Diesel Engine*

ASTM D7528, *Standard Test Method for Bench Oxidation of Engine Oils by ROBO Apparatus*

ASTM D7549, *Standard Test Method for Evaluation of Heavy-Duty Engine Oils under High Output Conditions—Caterpillar C13 Test Procedure*

ASTM D7563, *Standard Test Method for Evaluation of the Ability of Engine Oil to Emulsify Water and Simulated Ed85 Fuel*

ASTM D7589, *Standard Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VID Spark Ignition Engine*

ASTM D8047, *Standard Test Method for Evaluation of Engine Oil Aeration Resistance in a Caterpillar C13 Direct-Injected Turbocharged Automotive Diesel Engine*

ASTM D8048, *Standard Test Method for Evaluation of Diesel Engine Oils in T-13 Diesel Engine*

ASTM D8111, *Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIH, Spark-Ignition Engine*

ASTM D8114, *Standard Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VIE Spark Ignition Engine*

ASTM D8226, *Standard Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VIF Spark Ignition Engine*

ASTM D8256, *Standard Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation in the Sequence VH Spark-Ignition Engine Fueled with Gasoline and Operated Under Low-Temperature, Light-Duty Conditions*

ASTM D8279, *Standard Test Method for Determination of Timing-Chain Wear in a Turbocharged, Direct-Injection, Spark-Ignition, Four-Cylinder Engine*

ASTM D8291, *Standard Test Method for Evaluation of Performance of Automotive Engine Oils in the Mitigation of Low-Speed, Preignition in the Sequence IX Gasoline Turbocharged Direct-Injection, Spark-Ignition Engine*

ASTM D8350, *Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IVB Spark-Ignition Engine*

ASTM RR:D02:1204, *Fuel Efficient Engine Oil Dynamometer Test Development Activities, Part II (Sequence VI Test)*

CEC L-36-A-90, *High Temperature/High Shear Viscosity*

CEC L-40-A-93, *Evaporative Loss of Lubricating Oils*

DOD CID A-A-52039A, *Lubricating Oil, Automotive Engine, API Service SG*

DOD MIL-L-2104, *Lubricating Oil, Internal Combustion Engine, Tactical Service*

GM 9099P, *Engine Oil Filterability Test (EOFT)*

GM 9099P, *Engine Oil Filterability Test (EOFT) (Modified), May 1980*

JPI 5S-41-93, *Evaporative Loss*

SAE J183, *Engine Oil Performance and Engine Service Classification (Other than "Energy Conserving" or "Resource Conserving")*

SAE J300, *Engine Oil Viscosity Classification*

SAE J357, *Physical and Chemical Properties of Engine Oils*

SAE J1423, *Classification of Energy-Conserving Engine Oil for Passenger Cars, Vans, and Light-Duty Trucks*

3. TERMS AND DEFINITIONS

For the purposes of this document, the terms and definitions in Annex P apply.

4. EOLCS OVERVIEW

4.1. GENERAL

The API EOLCS is designed to define, certify, and monitor engine oil performance that vehicle and engine manufacturers and the oil and additive industries deem necessary for satisfactory equipment life and performance. The system includes a formal license agreement executed by the marketer with API. The program's Marks are intended to help the consumer identify products that have satisfied the requirements for licensing and certification. The system includes an audit process to verify that licensed products in the marketplace comply with the terms of the API Licensing Agreement.

4.1.1 API issues a license to an oil marketer after the marketer confirms it has met all the requirements spelled out in this publication and the EOLCS Online Application (http://engineoil.api.org). The marketer must execute the API Licensing Agreement as a condition of licensure.

4.1.1.1 Note: An oil marketer is defined as the marketing organization responsible for the integrity of the brand name and the representation of the branded product in the marketplace.

4.1.2 A base stock manufacturer is an organization that oversees the production of one or more base stocks by chemical transformation(s) and/or physical separation(s) yielding products defined by that manufacturer's specified physical and/or chemical properties.

4.1.2.1 Some of the chemical transformations commonly involved in producing base stocks used in engine oils include hydrogenation, oligomerization, polymerization, isomerization, and esterification. However, other chemical reactions can be relevant to a manufacturer's process(es).

4.1.2.2 Some of the physical separations commonly invoked in base stock production include extraction, distillation (e.g. to fractionate complex liquid mixtures) and filtration (e.g. in wax removal operations). However, other separation processes may also be used at the base stock manufacturer's discretion.

4.1.2.3 The base stock manufacturer may employ other processes in the production of base stocks in addition to, but not in lieu of, chemical transformations and/or physical separations.

4.1.2.4 Ultimately, base stocks are used as components of finished lubricants, examples of which are gasoline and diesel engine oils formulated to meet performance requirements published in this standard.

4.1.3 Performance requirements, test methods, and limits are cooperatively established by vehicle and/or engine manufacturers [namely, some or all of those represented by the Alliance of Automobile Manufacturers; Japan Automobile Manufacturers Association (JAMA); and Truck and Engine Manufacturers Association (EMA)], technical societies such as ASTM and SAE, and trade associations such as API and the American Chemistry Council (ACC).

4.1.4 API licenses three types of Marks: the API Service Symbol and the API Certification Marks "Shield" and "Starburst". The Service Symbol "Donut" denotes a licensed oil's performance properties through the API Service Categories; the SAE viscosity; and, if applicable, the "Resource Conserving", CI-4 PLUS, and SN PLUS classifications. The API Certification Marks identify oils meeting International Lubricant Specification Advisory Committee (ILSAC) minimum performance standards.

4.1.5 API uses an alphanumeric system known collectively as API Service Categories to define specific engine oil performance standards. These categories are commonly used by vehicle, engine, and equipment manufacturers to identify the engine oil performance standards required by gasoline and diesel engines. The API Service Symbol displays current API Service Categories. The process for developing API "C" categories is explained in Annex D.

4.1.5.1 The API Certification Marks do not change. Annual licenses for the API Certification Marks are issued only for engine oils that meet the current ILSAC performance requirements specified in .Annex H The process for developing new engine oil performance standards for the API Certification Marks is explained in Annex C. At any time during this process, API's Lubricants Standards Group may ask ASTM or other bodies to recommend specifications for passenger car motor oils not addressed by the ILSAC minimum performance specification. This may include the API Lubricants Standards Group itself formulating a standard for a separate engine oil quality category based on deviations/exceptions from the specification being considered during the Annex C process. A Lubricants Standards Group passenger car motor oil standard would be designated as an API S Service Category.

4.1.6 Engine oils licensed to use the API Service Symbol and/or the API Certification Marks must be engine tested using the latest edition of the ACC Petroleum Additives Panel Product Approval Code of Practice (ACC Code of Practice). The ACC Code of Practice requires advance registration of all engine tests along with criteria for handling results from multiple tests on an oil formulation to improve the measurement of the oil's performance (see Annex K for a website reference to this information). Material updates to the ACC Code of Practice will be distributed to ILSAC, EMA, and API sufficiently in advance of formal publication to permit consideration of any comments the three stakeholders may have. Adherence to the ACC Code of Practice as a requirement for the API EOLCS will be periodically reviewed for continued suitability and enhancement.

4.1.7 The ACC Code of Practice currently includes only certain engine tests. For engine oils that use the API S and C Service Categories and/or the "Resource Conserving", CI-4 PLUS, and SN PLUS classifications, the engine tests covered by the ACC Code of Practice shall be conducted in accordance with the ACC Code of Practice.

4.2. PERFORMANCE OF LICENSED OILS

4.2.1 The ultimate assessment of an engine oil's performance includes a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence and bench tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. These specific tests were selected to mimic challenging field conditions and have been judged to be predictive of and applicable to a variety of vehicle tests under similar field conditions. The tests were vetted and agreed to in open forums operated under the auspices of organizations such as API, ASTM, and SAE. The relationships between engine sequence tests and vehicle fleet tests are judged valid based only on the range of base oils and additive technologies investigated — generally those that have proven to have satisfactory performance in service and that are in widespread use at this time. It is the responsibility of licensees introducing base oils or additive technologies that constitute a significant departure from existing practice to ensure that there is no adverse effect to vehicle components or to emission control systems by ensuring that sufficient supporting vehicle fleet testing data has been generated. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in this specification. No marketer can claim to be acting in a reasonable and prudent manner if the marketer knowingly uses a new technology — defined as a significant departure from existing industry practice — based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing that simulates a reasonable range of customer operation.

4.2.1.1 In addition to the requirements for API licensure, marketers should assess all products produced under API licenses using generally accepted quality control measures for adherence to the expected rheological properties submitted in the EOLCS Online Application, their products' specific elemental composition, and other category requirements that may indicate product compliance (Licensed Fingerprint) for such product prior to release for sale. Additionally, the API AMAP program will inspect lubricants in the marketplace for these same properties as further assurance of API license compliance.

4.2.1.2 Marketers are responsible for confirming that adding identification markers to an oil formulation does not impact that oil's performance. Such markers can include dyes, fragrances, isotopic markers, or any other chemical identifier.

4.2.2 The oil marketer of products claiming any API Service Category is responsible for ensuring the oil meets the API category requirements. In addition to the support data available in the ACC Candidate Data Package, the oil marketer shall have sufficient data to ensure that the inclusion of any materials not related to performance into the oil formulation, such as for product identification, maintains the performance of the oil to be licensed consistent with the licensable quality level being sought.

4.3. BOI-VGRA TASK FORCE

4.3.1 The test data that support product claims are the responsibility of the individual marketer. The API Lubricants Standards Group, through its Base Oil Interchange (BOI)/Viscosity Grade Read Across (VGRA) Task Force, develops Base Oil Interchange and SAE Viscosity-Grade Engine Testing Guidelines.

4.3.2 The API Lubricants Standards Group and BOI/VGRA Task Force will determine if additional testing is required per the matrix testing described in Annex C or Annex D for the new engine tests to ensure that sufficient data is available to allow the establishment of appropriate Base Oil Interchangeability and Viscosity-Grade Engine Testing Guidelines simultaneous with the establishment of the category performance criteria. Alternatively, companies may put forth engine test data supporting new read-across or interchange guidelines for adoption through balloting.

4.3.3 Marketers may choose to use the API Base Oil Interchangeability Guidelines, the API Guidelines for SAE Viscosity-Grade Engine Testing, or both in lieu of specified engine testing. However, the decision to use such guidelines does not absolve the marketer of the responsibility to ensure that each licensed engine oil satisfies all engine and bench testing performance requirements.

4.3.4 Previous sections notwithstanding, the oil marketer shall not interchange any base stock within a licensable formulation that could result in compromising the intended performance of that formulation against that license.

4.4. CONFORMANCE AUDIT PROGRAM

4.4.1 All engine oils licensed to use the API Marks are subject to conformance audits. Conformance is determined by comparing measured physical and chemical properties of the oil with licensing data on file at API. In addition, a limited number of products may be randomly selected for engine and bench testing.

4.5. INDUSTRY GROUPS

4.5.1 An Administrative Guidance Panel (AGP) has been established in accordance with the terms of a Memorandum of Understanding between API and Ford, General Motors, and Chrysler for the purpose of providing guidance to the EOLCS.

4.5.2 An Interindustry Advisory Group (IAG; see Annex B) consisting of representatives from organizations such as API, ASTM, ACC, EMA, Independent Lubricant Manufacturers Association (ILMA), Ford, General Motors, Chrysler, SAE, and the U.S. Army has been formed to advise the AGP on enhancements and improvements to the API EOLCS. Recommendations by the IAG will be considered for inclusion in the program.

5. DESCRIPTION OF API MARKS

5.1. GENERAL

5.1.1 API licenses three types of Marks: the API Certification Mark “Starburst” and the API Service Symbol “Donut.” As of May 1, 2020, API has licensed a third mark, the API Certification Mark “Shield.” Certain oils are capable of meeting the technical and licensing requirements of two of the Marks. If properly licensed, these engine oils may be labeled with either or two API Marks. Examples of these three types of Marks are shown in Figure 1 and Figure 2.

5.1.2 API’s licensing of an engine oil does not imply that oils with the API Marks are appropriate for all vehicles or engines in the field. The consumer must refer to the owner’s or operator’s manual for specific vehicle or engine manufacturer’s engine oil recommendations.

5.2. API CERTIFICATION MARKS “STARBURST” AND “SHIELD”

5.2.1 Each API Certification Mark is designed for the identification of engine oils recommended for a general application (for example, gasoline, fuel-flexible, and light-duty diesel). The API Certification Marks “Starburst” and “Shield” may be licensed only if an oil satisfies the requirements of the most recent and applicable ILSAC minimum performance standards specified in Annex O. The API “Starburst” remains the same for a given application even if a new minimum engine oil performance standard is developed for the application (see Annex

C). The viscosity within the API “Shield” may be changed if new viscosities are added to the requirements in Annex O, Table H-7.

Figure 1—API Certification Marks “Starburst” and “Shield”

5.2.2 ILSAC GF-6A and ILSAC GF-6B are the minimum performance standards for passenger cars providing the current bases for issuance of a license to bear the API Certification Marks. As of May 1, 2020, API-licensed oils that meet the criteria for ILSAC GF-6A are eligible to display the API “Starburst” (see Annex O, Table H-6), and API-licensed oils that meet ILSAC GF-6B are eligible to display the API “Shield” (see Annex O, Table H-7.) . See 5.4. for a list of viscosity grades eligible to obtain a license to use the API Certification Mark.

5.3. API SERVICE SYMBOL

5.3.1 General

Service Categories are placed in the upper portion of the API Service Symbol to identify specific engine oil performance standards. The API Service Symbol may be licensed for use with passenger car motor oils, diesel engine oils, or both if the oils meet the performance standards of an appropriate API Service Category or Categories. Currently, the API Service Categories that may be included in the API Service Symbol are SP, SN, SM, SL, SJ, CH-4, CI-4, CJ-4, CK-4, and FA-4 (note that FA-4 cannot appear in the API Service Symbol with any C Service Category). API SP has been allowed for inclusion in the Service Symbol since May 1st, 2020.

5.3.1.1 Oils that meet API CI-4 licensing requirements are also authorized to display CH-4 in the API Service Symbol.

5.3.1.2 Oils that meet API CJ-4 licensing requirements are also authorized to display CI-4 with CI-4 PLUS, CI-4, and CH-4 in the API Service Symbol.

5.3.1.3 Oils that meet API CK-4 licensing requirements are also authorized to display CJ-4, CI-4 with CI-4 PLUS, CI-4, and CH-4 in the API Service Symbol.

5.3.1.4 Since May 1, 2020, SAE 0W-16 and 5W-16 oils may be licensed as API SP.

Figure 2—API Service Symbol

Note: The letters “SI”, “SK”, and “SO” (as of May 1, 2020) have been omitted from the sequence of letter designators for API Service Categories because of their common association with other organizations or systems.

Use of more than one API S Service Category at a time in the API Service Symbol is prohibited. These alphanumeric Service Categories may change as new oil performance standards are developed and approved for use (see Annex D).

For an oil that is formulated for diesel engine applications and meets both C and S Categories, the C Service Category should be put first so that the consumer can recognize that the oil is primarily a diesel engine oil but also meets S Service Category requirements. For an oil that is formulated for passenger car motor oil applications and meets both S and C Service Categories, the S Service Category should be put first so that the consumer can recognize that the oil is primarily a passenger car motor oil but also meets C Category requirements.

5.3.2 Service Categories for Passenger Car Motor Oils

5.3.2.1 SP—2020 Gasoline Engine Warranty Maintenance Service

API Service Category SP was adopted for use in describing engine oils available in 2020. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures. Vehicle owners and operators should follow their vehicle manufacturer's recommendations on engine oil viscosity and performance standard.

Engine oils that meet the API Service Category SP designation (see Annex G, Table G-6 and Table G-7) may be used where API Service Category SN and earlier S categories have been recommended.

Engine oils that meet the API Service Category SP designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing (see Annex E and Annex F).

Engine oils that meet these requirements may display API Service Category SP in the upper portion of the API Service Symbol as of May 1, 2020.

5.3.2.2 SN—2011 Gasoline Engine Warranty Maintenance Service

API Service Category SN was adopted for use in describing engine oils available in 2011. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures. Vehicle owners and operators should follow their vehicle manufacturer's recommendations on engine oil viscosity and performance standard.

Engine oils that meet the API Service Category SN designation (see Annex G, Table G-4 and Table G-5) may be used where API Service Category SM and earlier S categories have been recommended.

Engine oils that meet the API Service Category SN designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing (see Annex E and Annex F).

Engine oils that meet these requirements may display API Service Category SN in the upper portion of the API Service Symbol.

5.3.2.3 SM—2005 Gasoline Engine Warranty Maintenance Service

API Service Category SM was adopted for use in describing engine oils available in 2004. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures.

Engine oils that meet the API Service Category SM designation (see Annex G, Table G-3) may be used where API Service Category SL and earlier S Categories have been recommended.

Engine oils that meet the API Service Category SM designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing (see Annex E and Annex F).

Engine oils that meet these requirements may display API Service Category SM in the upper portion of the API Service Symbol.

5.3.2.4 SL—2001 Gasoline Engine Warranty Maintenance Service

API Service Category SL was adopted for use in describing engine oils available in 2001. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures.

Engine oils that meet the API Service Category SL designation (see Annex G, Table G-2) may be used where API Service Category SJ and earlier S Categories have been recommended.

Engine oils that meet the API Service Category SL designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing (see Annex E and Annex F).

Engine oils that meet these requirements may display API Service Category SL in the upper portion of the API Service Symbol.

5.3.2.5 SJ—1997 Gasoline Engine Warranty Maintenance Service

API Service Category SJ was adopted for use in describing engine oils available in 1996. These oils are for use in service typical of gasoline engines in passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures.

Engine oils that meet the API Service Category SJ designation (see Annex G, Table G-1) may be used where API Service Category SH and earlier S Categories have been recommended.

Engine oils that meet the API Service Category SJ designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing (see Annex E and Annex F).

Engine oils that meet these requirements may display API Service Category SJ in the upper portion of the API Service Symbol.

5.3.3 "Resource Conserving" Oil Classification for Gasoline-Powered Passenger Cars, Sport Utility Vehicles, Vans, and Light-Duty Trucks

5.3.3.1 General

The "Resource Conserving" oil classification for gasoline-powered passenger cars, sport utility vehicles, vans, and light-duty trucks is a supplementary classification for engine oils that have resource conserving properties and is displayed—when used—in the lower portion of the API Service Symbol. The performance requirements for this supplementary classification are described technically in Table A-1 and Table A-2. Testing for conformance to this classification must be in accordance with the ACC Code of Practice. The API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing (see Annex E and Annex F) may be used.

5.3.3.2 "Resource Conserving" in Conjunction with API Service Category SP

API Service SP engine oils designated as "Resource Conserving" are formulated to help improve fuel economy and protect vehicle emission system components in passenger cars, sport utility vehicles, vans, and light-duty trucks powered by gasoline engines. These oils have demonstrated a fuel economy improvement (FEI) in a specific sequence test at the percentages listed in Table A-1 when compared with a baseline oil (BL). Additionally, these oils have demonstrated in other tests listed in Table A-1 that they provide greater emission system and turbocharger

protection and help protect engines when operating on ethanol-containing fuels up to E85. Many previous S Categories made reference to “Energy Conserving,” but this reflected an emphasis on fuel-economy performance alone. “Resource Conserving” in conjunction with API SP focuses on fuel economy, emission system and turbocharger protection, and compatibility with ethanol-containing fuel up to E85.

Since May 1, 2020, oils that have passed the tests at the limits shown in Table A-1 and are properly licensed by API may display “Resource Conserving” in the lower portion of the API Service Symbol in conjunction with API Service SP in the upper portion. The fuel economy and other “Resource Conserving” benefits obtained by individual vehicle operators using engine oils labeled “Resource Conserving” may differ because of many factors, including the type of vehicle and engine, engine manufacturing variables, the mechanical condition and maintenance of the engine, oil that has been previously used, operating conditions, and driving habits.

Table A-1 — ”Resource Conserving” Primary Performance Criteria with API Service Category SP

Performance Test	Performance Criteria	
	FEI SUM	FEI2 minimum after 125 hours aging
Sequence VIE (ASTM D8114[a])		
Viscosity Grade		
XW-20	3.8%	1.8%
XW-30	3.1%	1.5%
10W-30 and all other viscosity grades not listed above	2.8%	1.3%
Sequence VIF (ASTM D8226[a])		
Viscosity Grade		
XW-16	4.1%	1.9%
Sequence IIIHB (ASTM D8111)	81% phosphorus retention min	
Emulsion Retention (ASTM D7563)	No water separation	
High Temperature Deposits, TEOST 33C (ASTM D6335), Total Deposit Weight, mg		
SAE XW-16, 0W-20	Not Required	
All other viscosity grades	30 max	

[a] Viscosity grades are limited to 0W, 5W and 10W multigrade oils.

5.3.3.3 “Resource Conserving” in Conjunction with API Service Category SN

API Service SN engine oils designated as “Resource Conserving” are formulated to help improve fuel economy and protect vehicle emission system components in passenger cars, sport utility vehicles, vans, and light-duty trucks powered by gasoline engines. These oils have demonstrated a fuel economy improvement (FEI) in a specific sequence test at the percentages listed in Table A-2 when compared with a baseline oil (BL). Additionally, these oils have demonstrated in other tests listed in Table A-2 that they provide greater emission system and turbocharger protection and help protect engines when operating on ethanol-containing fuels up to E85.

Many previous S Categories made reference to “Energy Conserving”, but this reflected an emphasis on fuel-economy performance alone. “Resource Conserving” in conjunction with API SN focuses on fuel economy, emission system and turbocharger protection, and compatibility with ethanol-containing fuel up to E85.

Starting October 1, 2010, oils that have passed the tests at the limits shown in Table A-2 and are properly licensed by API may display “Resource Conserving” in the lower portion of the API Service Symbol in conjunction with API Service SN in the upper portion. The fuel economy and other “Resource Conserving” benefits obtained by individual vehicle operators using engine oils labeled “Resource Conserving” may differ because of many factors, including the

type of vehicle and engine, engine manufacturing variables, the mechanical condition and maintenance of the engine, oil that has been previously used, operating conditions, and driving habits.

Table A-2 — "Resource Conserving" Primary Performance Criteria with API Service Category SN

Performance Test	Performance Criteria	
	FEI SUM	FEI2 minimum after 100 hours aging
Sequence VID (ASTM D7589[a])		
Viscosity Grade		
XW-16	2.8%	1.3%
XW-20	2.6%	1.2%
XW-30	1.9%	0.9%
10W-30 and all other viscosity grades not listed above	1.5%	0.6%
Or		
Sequence VIE (ASTM D8114[a])		
Viscosity Grade		
XW-20	3.2%	1.5%
XW-30	2.5%	1.2%
10W-30 and all other viscosity grades not listed above	2.2%	1.0%
Sequence VIF (ASTM D8226[a])		
Viscosity Grade		
XW-16	3.7%	1.8%
Sequence IIIGB (ASTM D7320)	79% phosphorus retention min	
Or		
Sequence IIIHB (ASTM D8111)	81% phosphorus retention min	
Emulsion Retention (ASTM D7563)	No water separation	
High Temperature Deposits, TEOST 33C (ASTM D6335), Total Deposit Weight, mg		
SAE XW-16, 0W-20	Not Required	
All other viscosity grades	30 max	

[a] Viscosity grades are limited to 0W, 5W and 10W multigrade oils.

5.3.3.4 SN PLUS Classification in Conjunction with API Service Category SN and API SN with "Resource Conserving"

API Service Category SN engine oils that also carry the classification SN PLUS are formulated to provide API SN performance and additional protection against low-speed pre-ignition for turbocharged direct injection gasoline-powered vehicles.

Oils that meet the requirements for API SN with SN PLUS or API SN with SN PLUS and "Resource Conserving" at the limit shown in Annex G, Table G-4, and are properly licensed may display "SN PLUS" or ""Resource Conserving SN PLUS" in the lower portion of the API Service Symbol in conjunction with API SN in the upper portion (see Figure 3 and Figure 4).

Oils that satisfy SN PLUS can effectively lubricate engines calling for API SN. Oils that satisfy SN PLUS and "Resource Conserving" can also effectively lubricate engines calling for API SN with "Resource Conserving" or ILSAC GF-5. API SN with SN PLUS and "Resource Conserving" and API SN with SN PLUS are also backward compatible to API Service Categories before API SN.

Figure 3—API SN with SN PLUS

Figure 4—API SN with SN PLUS and "Resource Conserving"

5.3.4 Service Categories for Diesel Engine Oils

5.3.4.1 CK-4—For 2017 Heavy-Duty Diesel Engine Service

API Service Category CK-4 (see Annex I, Table I-4) describes oils for use in high-speed four-stroke cycle diesel engines designed to meet 2017 model year on-highway and Tier 4 non-road exhaust emission standards as well as for previous model year diesel engines. These oils are formulated for use in all applications with diesel fuels ranging in sulfur content up to 500 ppm (0.05% by weight). However, the use of these oils with greater than 15 ppm (0.0015% by weight) sulfur fuel may impact exhaust aftertreatment system durability and/or oil drain interval.

These oils are especially effective at sustaining emission control system durability where particulate filters and other advanced aftertreatment systems are used. API CK-4 oils are designed to provide enhanced protection against oil oxidation, viscosity loss due to shear, and oil aeration as well as protection against catalyst poisoning, particulate filter blocking, engine wear, piston deposits, degradation of low- and high-temperature properties, and soot-related viscosity increase.

Engine oils that meet the API Service Category CK-4 designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines (see Annex E) and the API Guidelines for SAE Viscosity-Grade Read Across (see Annex F).

API CK-4 oils exceed the performance criteria of API CJ-4, CI-4 with CI-4 PLUS, CI-4, and CH-4 and can effectively lubricate engines calling for those API Service Categories. When using CK-4 oil with higher than 15 ppm sulfur fuel, consult the engine manufacturer for service interval recommendations.

Marketers may license products meeting API CK-4 requirements as API CJ-4, CI-4 with CI-4 PLUS, CI-4, and CH-4.

5.3.4.2 FA-4—For 2017 Heavy-Duty Diesel Engine Service

API Service Category FA-4 (see Table I-4) describes certain XW-30 oils specifically formulated for use in select high-speed four-stroke cycle diesel engines designed to meet 2017 model year on-highway greenhouse gas (GHG) emission standards. These oils are formulated for use in on-highway applications with diesel fuel sulfur content up to 15 ppm (0.0015% by weight). Refer to individual engine manufacturer recommendations regarding compatibility with API FA-4 oils.

These oils are blended to a high temperature high shear (HTHS) viscosity range of 2.9cP to 3.2cP to assist in reducing GHG emissions. These oils are especially effective at sustaining emission control system durability where particulate filters and other advanced aftertreatment systems are used. API FA-4 oils are designed to provide enhanced protection against oil oxidation, viscosity loss due to shear, and oil aeration as well as protection against catalyst

poisoning, particulate filter blocking, engine wear, piston deposits, degradation of low- and high-temperature properties, and soot-related viscosity increase.

Engine oils that meet the API Service Category FA-4 designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines (see Annex E) and the API Guidelines for SAE Viscosity-Grade Read Across (see Annex F).

API FA-4 oils are not interchangeable or backward compatible with API CK-4, CJ-4, CI-4 with CI-4 PLUS, CI-4, and CH-4 oils. Refer to engine manufacturer recommendations to determine if API FA-4 oils are suitable for use. API FA-4 oils are not recommended for use with fuels having greater than 15 ppm sulfur. For fuels with sulfur contents greater the 15 ppm, refer to engine manufacturer recommendations.

5.3.4.3 CJ-4—For 2010 Severe-Duty Diesel Engine Service

API Service Category CJ-4 describes oils for use in high-speed four-stroke cycle diesel engines designed to meet 2010 model year on-highway and Tier 4 nonroad exhaust emission standards as well as for previous model year diesel engines. These oils are formulated for use in all applications with diesel fuels ranging in sulfur content up to 500 ppm (0.05% by weight). However, the use of these oils with greater than 15 ppm (0.0015% by weight) sulfur fuel may impact exhaust aftertreatment system durability and/or oil drain interval.

These oils are especially effective at sustaining emission control system durability where particulate filters and other advanced aftertreatment systems are used. Optimum protection is provided for control of catalyst poisoning, particulate filter blocking, engine wear, piston deposits, low- and high-temperature stability, soot handling properties, oxidative thickening, foaming, and viscosity loss due to shear.

Engine oils that meet the API Service Category CJ-4 designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines (see Annex E) and the API Guidelines for SAE Viscosity-Grade Read Across (see Annex F).

API CJ-4 oils exceed the performance criteria of API CI-4 with CI-4 PLUS, CI-4, and CH-4 and can effectively lubricate engines calling for those API Service Categories. When using CJ-4 oil with higher than 15 ppm sulfur fuel, consult the engine manufacturer for service interval recommendations.

Marketers may license products meeting API CJ-4 requirements as API CI-4 with CI-4 PLUS, CI-4, and CH-4.

5.3.4.4 CI-4—For 2004 Severe-Duty Diesel Engine Service

API Service Category CI-4 describes oils for use in high-speed four-stroke cycle diesel engines designed to meet 2004 exhaust emission standards implemented in 2002. These oils are intended for use in all applications with diesel fuels ranging in sulfur content up to 0.5% weight.

These oils are specifically formulated to sustain engine durability where Exhaust Gas Recirculation (EGR) is used and the impact of these oils on other supplemental exhaust emission devices has not been determined. Optimum protection is provided against corrosive and soot-related wear tendencies, piston deposits, degradation of low- and high-temperature viscometric properties due to soot accumulation, oxidative thickening, loss of oil consumption control, foaming, degradation of seal materials, and viscosity loss due to shear.

Engine oils that meet the API Service Category CI-4 designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines (see Annex E) and the API Guidelines for SAE Viscosity-Grade Read Across (see Annex F).

API CI-4 oils are superior in performance to those meeting API CH-4 and may be used in engines calling for that API Service Category. Marketers may license products meeting API CI-4 requirements as API CH-4.

5.3.4.5 CH-4—For 1998 Severe-Duty Diesel Engine Service

API Service Category CH-4 describes oils for use in high-speed four-stroke cycle diesel engines designed to meet 1998 exhaust emissions standards as well as for previous model years. CH-4 oils are specifically compounded for use with diesel fuels ranging in sulfur content up to 0.5% weight.

These oils are especially effective to sustain engine durability even under adverse applications that may stress wear control, high-temperature stability, and soot handling properties. In addition, optimum protection is provided against non-ferrous corrosion, oxidative and insoluble thickening, foaming, and viscosity loss due to shear.

These oils also have the performance capability to afford a more flexible approach to oil drain intervals in accordance with the recommendations of the individual engine builders for their specific engines.

Engine oils that meet the API Service Category CH-4 designation have been tested in accordance with the ACC Code of Practice and may use the API Base Oil Interchangeability Guidelines (see Annex E) and the API Guidelines for SAE Viscosity-Grade Read Across (see Annex F).

CH-4 oils are superior in performance to those meeting API CF-4 and API CG-4 and can effectively lubricate engines calling for those API Service Categories.

5.3.5 CI-4 PLUS Classification in Conjunction with API Service Category CI-4, CJ-4, and CK-4

API Service Category CI-4, CJ-4, and CK-4 engine oils that also carry the classification CI-4 PLUS are formulated to provide a higher level of protection against soot-related viscosity increase and viscosity loss due to shear in vehicles powered by diesel engines.

Oils that meet the requirements for CI-4 PLUS as defined in Annex J and are properly licensed may display “CI-4 PLUS” in the lower portion of the API Service Symbol in conjunction with API CI-4, CJ-4, and/or CK-4 in the upper portion (see Figure 5).

Oils that satisfy CI-4 PLUS are superior in performance to those meeting API CI-4 and CH-4 and can effectively lubricate engines calling for those API Service Categories.

Figure 5—CI-4 PLUS Classification

5.4. SAE VISCOSITY GRADES ELIGIBLE FOR USE WITH API MARKS

The SAE viscosity grades eligible for use with the API Marks are specified in Table A-3. Refer to SAE J300 for the most current SAE Viscosity Classification requirements.

Table A-3 — SAE Viscosity Grades Eligible for Use with API Marks

Low-Temperature Viscosity Grade	High-Temperature Viscosity Grade						
	—	16	20	30	40	50	60
—		Y	Y	Y	Y	Y	Y
0W	Y	YZ	XY	XY	XY	XY	XY
5W	Y	Y	XY	XY	XY	XY	XY
10W	Y	Y	XY	XY	XY	XY	XY
15W	Y	Y	Y	Y	Y	Y	Y
20W	Y	Y	Y	Y	Y	Y	Y
25W	Y	NA	NA	Y	Y	Y	Y

Note:

- X = eligible for the API Certification Mark “Starburst”, provided the oil meets all license requirements outlined in this publication for the API Certification Mark “Starburst”;
- Y = eligible for the API Service Symbol “Donut”, provided the oil meets all license requirements outlined in this publication for the API Service Symbol “Donut”;
- Z = eligible for the API Certification Mark “Shield”, provided the oil meets all license requirements outlined in this publication for the API Certification Mark “Shield”; NA = not applicable.

6. LICENSE SYSTEM FOR API MARKS

6.1. GENERAL

6.1.1 The API EOLCS is a voluntary licensing and certification program designed to define, certify, and monitor engine oil performance deemed necessary for satisfactory equipment life and performance by vehicle and engine manufacturers. Its purpose is to ensure that engine oils meeting the minimum performance standards of vehicle and engine manufacturers are easily identified by consumers.

6.1.2 To use any of the three API Marks, an engine oil marketer must apply for and obtain a license from API. The application steps the marketer must complete and the information the marketer must submit to API to secure the right to use the API Marks are provided in the EOLCS Online Application at http://engineoil.api.org (see Annex P). A marketer desiring to apply for a license must complete the Online Application. Licenses are valid from the date of license approval until March 31 of the next year as long as all program requirements continue to be met. Annual renewals are issued when all renewal steps are completed.

6.2. LICENSING FEES

6.2.1 Licensees pay API licensing fees to support EOLCS. These fees are reviewed annually. The current fee structure is available on-line at https://www.api.org/products-and-services/engine-oil/application-and-fees.

6.2.2 Applicants pay a non-refundable fee at time of application. The application fee is per license, not per product licensed. The application fee is the same if the applicant applies to license one engine oil or many.

6.2.2.1 Current licensees pay an annual minimum licensing fee and an additional annual licensing fee for each US gallon of packaged and bulk API-licensed oil sold after the first million US gallons.

6.2.2.2 Applicants are only assessed the application fee in their initial year of licensing. The additional fee based on a licensee’s volume of API-licensed oil sold is charged to the licensee at time of license renewal. To renew an API license, the licensee must report the volume of all API-licensed oils (packaged and bulk) sold in the prior year. Volume-of-sales figures will be held in strict confidence by API.

6.3. RESPONSIBILITY OF MARKETERS

6.3.1 Only an engine oil marketer may apply for and be awarded a license to display an API Mark. [See the glossary (Annex P) for a definition of marketer.]

6.3.2 As noted in the licensing agreement, the marketer is solely responsible for ensuring that the performance characteristics of the oil product displaying an API Mark or Marks meet all requirements for the Mark or Marks. If multiple Service Categories are used, the marketer must ensure that the oil meets the minimum performance requirements for each of the Service Categories designated. If, in obtaining a license for use of an API Mark, a marketer chooses to use either the API Base Oil Interchangeability Guidelines or API Guidelines for SAE Viscosity-Grade Read Across, that marketer is also responsible for correctly applying those guidelines, per Annex E and Annex F.

6.4. LICENSING PROCEDURES

6.4.1 A valid API license permits the marketer to use the API Marks on its licensed oils and is that marketer's warranty that its licensed oils comply with licensing requirements. The EOLCS Online Application requires applicants to certify that licensed oils meet EOLCS requirements and to abide by all the requirements of the program and the licensing agreement.

6.4.2 The EOLCS Online Application specifies the certified information applicants must submit to demonstrate that their oil or oils meet specific Service Categories or the current ILSAC specification and are eligible for one or more of the API Marks. The information required is also addressed in Annex P. This includes certification by the marketer that each brand and viscosity grade of the engine oil for which licensing is requested meets the most recent version of prescribed technical criteria as set forth in the following standards:

a. ASTM D4485
b. SAE J300
c. SAE J183

The EOLCS Online Application may include additions, deletions, or other modifications to the standards listed above.

6.4.3 The EOLCS Online Application includes but is not limited to the following certification statements:

a. Any engine tests covered by the ACC Product Approval Code of Practice and in the API licensing program must be conducted in accordance with the latest edition of the ACC Product Approval Code of Practice (see Annex K).
b. Any Base Oil Interchangeability or Viscosity-Grade Read Across Guidelines must be applied in accordance with Annex E and Annex F.

The EOLCS Online Application clearly states that the use of API Base Oil Interchangeability Guidelines and API Guidelines for SAE Viscosity-Grade Read Across does not absolve the marketer of the responsibility to meet minimum performance standards for the licensed oils.

6.4.4 The applicant is required to submit the following information (based on the final engine oil formulation) for each product to be considered for licensing (note that a difference in viscosity grade, Service Category, or brand name denotes a separate engine oil):

a. Elemental analysis data.
b. Finished oil physical properties.
c. Additive and base oil information.
d. Engine test information (stand code from applicable category engine tests, base oil interchange/viscosity grade read across use).
e. Product traceability code information.

The EOLCS Online Application specifies that all licensed oils are subject to monitoring and enforcement procedures, including audits.

6.4.5 After the marketer has completed the application process, paid the fee, and been granted the license, the marketer may display the API Marks on licensed products in accordance with Section 7.

6.4.6 API maintains strict confidentiality of all proprietary data provided by license applicants. Information submitted is used only as specified in the license agreement.

6.5. RENEWALS

A license may be renewed annually by mutual agreement of the parties, provided the licensee reports the volume of licensed product sold the previous year, pays the annual fee, and agrees to comply with any amendments to the license agreement and any modifications or additional specifications of the license requirements.

6.6. SYSTEM MONITORING AND ENFORCEMENT

The integrity of the API EOLCS is maintained by means of a formal monitoring and enforcement program, as defined in Section 8.

6.7. PROVISIONAL LICENSE

6.7.1 On rare occasions, a test or tests specified under API licensing requirements for API S, C, or F Service Categories or ILSAC minimum performance standards may be declared by ASTM Subcommittee D02.B0 to be "out of control" or "unavailable" or determined by API to be "unavailable." Reasons for these declarations or determinations may be due to various factors such as a severity shift in the test results, shortage of test materials, an industry-wide test-related emergency, lack of test availability at independent test labs, or another situation that prevents tests from being run. ASTM D02.B0 may declare a test "out of control" when the test's surveillance panel and classification panel have judged the test to be giving uninterpretable performance. ASTM D02.B0 and its panels may also declare a test to be "unavailable" in accordance with ASTM Subcommittee B Test Availability Guidelines. In a case where ASTM determines that a test is "available" and API determines that the same test is "unavailable," API's determination will stand with regard to enacting provisional licensing. API may make its own determination that a test is "unavailable" for reasons noted above and particularly in situations where independent test labs can no longer run a test or tests. When a test or tests are declared "out of control" or determined to be "unavailable," API may grant a provisional license or licenses to an applicant if the candidate engine oil meets all API licensing requirements except for the test or tests that are "out of control" or "unavailable."

6.7.2 When a test or tests are "out of control" or "unavailable," API will evaluate the impact of their loss on the Engine Oil Licensing and Certification System. The evaluation will include the following:

a. Test performance measurement or parameter affected.
b. Reason the test or tests are "out of control" or "unavailable."
c. Proposed issue resolution and the time necessary to implement the resolution.
d. Test recertification plan.
e. Any alternative test/data options available to provide indication of suitable performance.

API will perform its evaluation and report the results of its evaluation to the Lubricants Standards Group. The result of the API evaluation will be reported to Lubricants Standards Group with recommendations on Provisional Licensing.

6.7.3 When a test or tests are expected to be "out of control" or "unavailable" for an undetermined, indefinite period of time, API will consider alternative tests and seek advice from the AGP, Lubricants Standards Group members, lab personnel, and others who have experience with category test replacement. If API recommends and the Lubricants Standards Group agrees, a task force will be formed, and API will follow the steps included in 6.8. .

6.7.4 Where a test or tests are approaching end of life (on the basis of parts availability), API may institute active monitoring of test availability if the queued requests received at independent labs significantly exceed those labs' capacity of tests. This monitoring may lead to API declaring the test "unavailable."

6.7.5 API will notify all API licensees, the Lubricants Standards Group, the Alliance, EMA, JAMA, and ACC of the date on which any test required for an API license is declared "out of control" or "unavailable" and the date on which the test is declared "no longer out of control" or "no longer unavailable".

6.7.6 All applications for a provisional API license shall include data that support the performance of the candidate engine oil in the test or tests not conducted. Ideally, these data shall conform to Level 2 Support, as described in Tab 1 of the ACC Code of Practice. In the absence of Level 2 Support data, the licensee shall submit technical information that demonstrates that the candidate engine oil would likely pass the "out of control" or "unavailable" test or tests.

6.7.7 A request for provisional licensing of an oil is made by checking the provisional licensing box in the EOLCS Online Application. This box should only be checked if a product or formulation does not have a passing result in the test or tests declared "out of control" or "unavailable" at the time of application. The box must not be checked if an applicant is waiting for test results on available tests.

6.7.8 When the API Base Oil Interchangeability Guidelines are used to "interchange" a base oil in a new formulation or the Guidelines for SAE Viscosity-Grade Engine Testing are used to "read across" from a provisionally licensed engine oil, the licensee must indicate provisional status on the EOLCS Online Application for that engine oil.

6.7.9 After a test is "no longer out of control or unavailable" and API has forwarded this information to each licensee holding a provisional license, the licensee holding the provisional license must obtain a passing result on that test. At minimum, the licensee will be given 6 months to obtain a passing result, but more time may be granted if test length or other factors warrant a longer testing period.

6.7.9.1 Upon passing the test, the licensee will request full licensing of the oil by submitting a revised formulation for the provisionally licensed oil and withdrawing the provisionally licensed formulation. The EOLCS Online Application System requires a brand to have at least one valid formulation to remain a licensed brand. This would also apply to any provisionally licensed "interchange" or "read across" oils arising from 6.7.8 .

6.7.9.2 If a revised formulation for the provisionally licensed oil is not received by API within the allotted timeframe included in the "no longer out of control or unavailable" notification to licensees, API will withdraw the provisionally licensed oil and notify the licensee that the API S, C, or F Service Category in the API Service Symbol and/or the API Certification Marks shall no longer be displayed on the label of that engine oil or any engine oil that was provisionally licensed based on that engine oil (per 6.7.8).

6.7.10 Engine oils granted an API provisional license will be listed in API's directory of licensees on API's website in the same manner as API-licensed oils, without any special designation. The licensee is still responsible for the satisfactory performance of all engine oils granted an API provisional license, per 4.2. .

6.8. FORMATION OF TASK FORCE TO ESTABLISH ALTERNATIVES OR REPLACEMENT TESTS FOR OUT OF CONTROL OR UNAVAILABLE TESTS

6.8.1 When API and the Lubricants Standards Group agree that a task force should be formed to establish alternative tests addressing the loss of a test or tests declared "out of control" or "unavailable," the task force shall be formed as indicated below:

a. For tests necessary to validate an oil's eligibility for a license to display the API Certification Marks or an API S Service Category in the API Service Symbol, a task force shall be formed from API and automotive representatives from API's Administrative Guidance Panel (AGP).
b. For tests necessary to validate an oil's eligibility for a license to display a current API C or F Service Category in the API Service Symbol, a task force shall be formed from API and EMA.
c. For tests necessary to validate an oil's eligibility for a license to display simultaneously the API Certification Marks or current API S, C, or F Service Categories in the API Service Symbol, a task force shall be formed from API, AGP automotive representatives, and EMA.

Each of the above-mentioned groups (API, AGP, and EMA) shall select three members to participate on the task force. The task force may also invite other industry representatives as advisory, non-voting members to ensure the right level of technical expertise is available to understand the potential impact of allowing provisional licensing. In all cases, API staff shall act as facilitators for the task force or task forces.

6.8.2 The task force shall complete a comprehensive review that may include the following:

a. Evaluating reasons for the "out of control" or "unavailable" declaration.
b. Conducting a risk assessment and drawing conclusions.

c. Recommending a course of action.
d. Recommending when to cease provisional licensing.

6.8.3 The appropriate specification-development bodies (AOAP for S Service Categories and DEOAP for C and F Service Categories) are responsible for evaluating and approving plans intended to resolve “out of control” or “unavailable” declarations related to S, C, or F Service Categories under their purview.

6.8.4 The task force or task forces will make best efforts to supplement the activities of any one test’s Surveillance Panel by providing new options and occasionally supporting resolution efforts through funding and/or providing in-kind contributions (for example, test parts, test materials, and oils).

6.9. EMERGENCY PROVISIONAL LICENSING

6.9.1 If a supply of base oil or additives utilized by a number of licensees is disrupted, licensees may apply for short-term Emergency Provisional Licenses. A disruption is defined as a significant industry-wide limitation on the supply of a base oil or additive that makes it impossible for multiple licensees to market sufficient quantities of engine oil without violating the API licensing agreement. The disruption must be caused by an unforeseeable event involving, but not limited to, an explosion, fire, legal action, natural disaster, epidemiological event or act of terrorism that is beyond the control of individual licensees.

6.9.2 The licensee’s application for an Emergency Provisional License must include a detailed description of the event that created the need for the Emergency Provisional License; the steps that have been taken by the licensee to find other sources of licensable materials, including both raw materials and finished products; an estimate of the duration of the shortage; and other supporting information required by API. The licensee must also submit technical information that supports, to the satisfaction of API, that the use of the substitute component will not adversely affect the claimed performance standards of the licensed product.

6.9.3 The initial term of the Emergency Provisional License will be granted for up to 90 days. At the discretion of API, this license period may be extended beyond the 90-day term. The Emergency Provisional License is intended to last only until the licensee obtains alternative supplies of materials, completes additional requirements as defined by API, or the disruption ends, whichever is earlier. The Emergency Provisional License will be conditioned upon the licensee fully complying with requirements and other conditions imposed by API to protect consumers and the integrity of the program.

6.9.4 Relief under this section will rarely be granted by API. The burden is on the licensee to establish clearly that there are exigent circumstances that justify the use of this type of remedy and that the failure of the licensee to obtain supplies of base oil, additives, or finished products was not caused by the licensee’s negligence or failure to utilize good business practices.

7. USE AND LABELING REQUIREMENTS FOR API MARKS

7.1. API ENGINE OIL QUALITY MARKS

7.1.1 API licenses three types of engine oil quality marks: the API Certification Mark “Starburst” (see Figure 6), the API Certification Mark “Shield” since May 1, 2020 (Figure 7), and the API Service Symbol “Donut” (see Figure 8 and Figure 9). The marketer may display an API Mark, as described in this section, only after obtaining a license to use the specific API Mark. Under the terms of the License Agreement, marketers may use the Marks in a number of ways: for example, on containers of licensed products [bottles, cans, jugs, kegs, drums, intermediate bulk containers (IBC), tanks, etc.]; in advertisements of licensed products; and in materials describing licensed products.

7.1.2 API will provide licensed marketers with “camera-ready” quality images or electronic versions (TIF, EPS, JPG, and BMP) of the API Marks, on request, for use in producing final artwork.

7.1.3 The API Certification Mark “Starburst” and API Certification Mark “Shield” may be used with the API Service Symbol “Donut” if the marketer meets all licensing requirements for the API Marks for that viscosity grade of engine oil. Note that a difference in viscosity grade, Service Category, or brand name denotes a separate engine oil. The API Marks shall be located and displayed as described in 7.2. through 7.4. 7.4.

7.2. API CERTIFICATION MARK "STARBURST"

7.2.1 If the API Certification Mark "Starburst" is used, it shall be clearly displayed on the front of the container of those engine oils that have been properly licensed by API. Note that this does not prevent the licensed marketer from displaying the API Certification Mark again on the back of the container.

7.2.2 The outside diameter of the API Certification Mark "Starburst" (measured from the outside tips) shall be at least 2.1 centimeters and shall be 1.5 (±0.1) times the inside diameter. The background of the outer band (containing the words AMERICAN PETROLEUM INSTITUTE and CERTIFIED) shall be a color that contrasts with the label background. (For example, if the label background is white, the outside band could be black with the words in white.)

Figure 6—API Certification Mark "Starburst"

The background of the inner circle shall be a color that contrasts with the outer band. The words AMERICAN PETROLEUM INSTITUTE and CERTIFIED in the outer band of the API Certification Mark and the words FOR GASOLINE ENGINES in the center shall be all capital letters. The relationship of the letter size to the allocated space within the API Certification Mark must be consistent for all users of the API Certification Mark. All lettering used for words in the API Certification Mark must be identical for all licensees.

7.2.3 API has registered the API Certification Mark only in the English language, and it can be displayed only as registered and shown in Figure 6. However, the purpose of the API Certification Mark is to assist consumers, so API encourages licensed marketers to translate the words CERTIFIED and FOR GASOLINE ENGINES into any appropriate language outside of the API Certification Mark. The translation must be literal and provided to API as part of the licensing agreement. The location of the translations can be anywhere on the front of the label but not within a mark or symbol of any kind. AMERICAN PETROLEUM INSTITUTE is also a licensed mark and cannot be translated without permission of API.

7.3. API CERTIFICATION MARK "SHIELD"

7.3.1 If the API Certification Mark "Shield" is used, it shall be clearly displayed on the front of the container of those engine oils that have been properly licensed by API. Note that this does not prevent the licensed marketer from displaying the API Certification Mark "Shield" again on the back of the container.

7.3.2 The length of the API Certification Mark "Shield" (measured from the top to the bottom of the shield shape) shall be at least 2.1 centimeters. The inner shield shape (containing the words AMERICAN PETROLEUM INSTITUTE and CERTIFIED FOR GASOLINE ENGINES) and the line denoting the outer shield shape shall be a matching color that contrasts with the label background. (For example, if the label background is a lighter color such as yellow, the inner and outer shields should be a darker color with the lettering inside the inner shield displayed in a lighter color such as the background yellow or white.)

Figure 7—API Certification Mark "Shield"

The words AMERICAN PETROLEUM INSTITUTE and CERTIFIED FOR GASOLINE ENGINES and the acronym SAE and letter "W" in the SAE viscosity shall be all capital letters. The relationship of the font size to the allocated space within the API Certification Mark "Shield" must be consistent with the design shown in Figure 7. A sans serif font must be used for all lettering.

7.3.3 API has registered the API Certification Mark "Shield" only in the English language, and it can be displayed only as registered and shown in Figure 7. However, the purpose of the API Certification Mark "Shield" is to assist consumers, so API encourages licensed marketers to translate the words CERTIFIED FOR GASOLINE ENGINES into any appropriate language outside of the API Certification Mark "Shield." The location of the translation can be anywhere on the front of the label but not within a mark or symbol of any kind. AMERICAN PETROLEUM INSTITUTE is also a licensed mark and cannot be translated without permission of API.

7.4. API SERVICE SYMBOL "DONUT"

7.4.1 The API Service Symbol "Donut" may be located anywhere on the outside of the container. The outside diameter of the API Service Symbol shall be 1.9 times the inside diameter. The Service Category must be placed in the upper part of the "Donut", the SAE viscosity grade in the center, and the optional "Resource Conserving", CI-4 PLUS, and SN PLUS classifications in the lower part. The API Service Symbol shall be large enough for the lettering to be legible and shall strictly conform to the design (including the required information and its placement) shown in Figure 8.

Figure 8—API Service Symbol "Donut"

7.4.2 Beginning December 1, 2016, when API Service FA-4 is claimed, the upper half of the Service Symbol must be divided by a single vertical line, and the API Service Categories and phrase "API Service" must appear as shown in Figure 9 (Service Categories left and "API Service" right of vertical line). Note that licensed FA-4 oils shall use a Service Symbol that conforms to the divided upper half designs in Figure 9 and Figure 10.

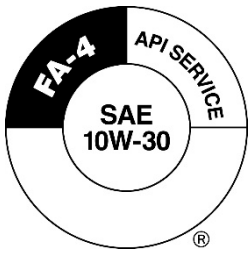

Figure 9—API Service Symbol "Donut" with API FA-4

7.4.3 API Service Symbols may appear as black and white, reversed out, or in color. Examples of acceptable designs are provided in Figure 9 and Figure 10. Any color is acceptable provided the design conforms to the designs shown in Figure 8, Figure 9, or Figure 10.

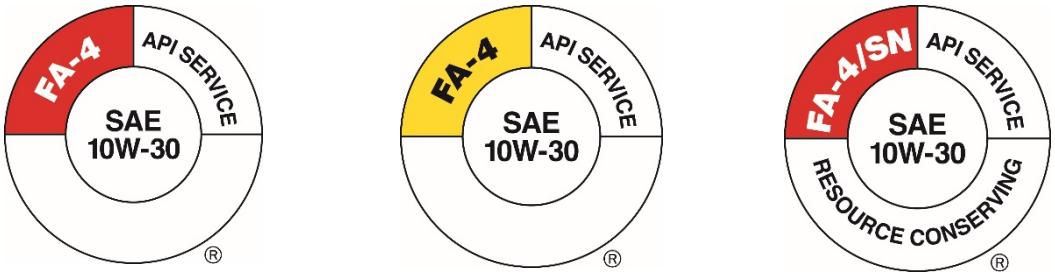

Figure 10—Representative Examples of the API Service Symbol with FA-4

7.4.4 Use of the API Service Symbol is restricted to current API Service Categories [namely, SP, SN; SM; SL; SJ; CH-4; CI-4; CJ-4; CK-4, and FA-4]. Except as prohibited in 5.3.4 , these may appear alone or in combination with other current Service Categories. The API Service Categories must appear in the upper part of the API Service Symbol, but such placement does not preclude their use elsewhere on the container. Use of API Service Categories SA, SB, SC, SD, SE, SF, SG, SH, CA, CB, CC, CD, CD-II, CE, CF, CF-2, CF-4, and CG-4 within the API Service Symbol is prohibited (see Annex A).

7.4.5 During the Mandatory Waiting Period preceding the first-use date of a new Category or Classification, marketers may package licensed product conforming to the corresponding performance and bearing the corresponding Service Symbol ahead of the first-use date. However, such product cannot be sold before the first-use date.

7.4.6 API has registered the API Service Symbol "Donut" only in the English language, and it can be displayed only as registered and illustrated in Figure 8 through Figure 11. However, the purpose of the API Service Symbol "Donut" is to assist consumers, so API encourages licensed marketers to translate the words present in these figures, as relevant, into any appropriate language outside of API Service Symbol "Donut" The location of the translation can be anywhere on the front of the label but not within a mark or symbol of any kind.

7.4.7 Use of more than one API S Service Category in the API Service Symbol is prohibited. SAE 0W-16 and 5W-16 oils may only be licensed as follows:

- API SN
- API SN with "Resource Conserving"
- API SN with SN PLUS
- API SN with SN PLUS and "Resource Conserving"
- API SP
- API SP with "Resource Conserving"
- API SP with SN PLUS
- API SP with SN PLUS and "Resource Conserving"

If API C Service Category oils are licensed for more than one current Service Category, these oils may display the Service Categories in the upper part of the API Service Symbol. Except as specified in 7.4.4 , if the engine oil

marketer chooses to include API C Service Categories with a current API S Category, a virgule (/) must be placed between the API S Service Category and the API C Service Categories, which are separated by commas. Licensees of Service Category C oils may use the C Categories first. Examples of acceptable notations are “API Service SN”; “API Service CK-4”; “API Service CJ-4,CI-4/SM”; “API Service SJ”; “API Service CJ-4/SM”; “API Service CI-4”; and “API Service CH-4.” Figure 11 shows examples of notations for various Service Categories used within the API Service Symbol.

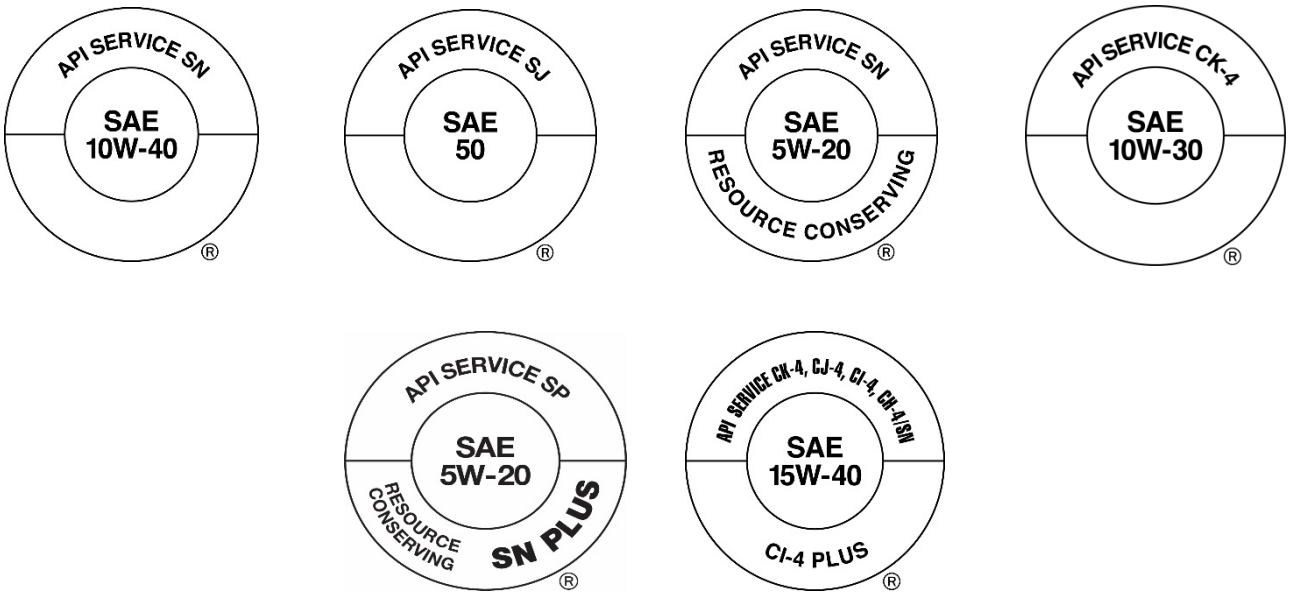

Figure 11—Representative Examples of the API Service Symbol

For an oil that is formulated for diesel engine applications and meets both C and S Categories, the C Category should be put first so that the consumer can recognize that the oil is primarily a diesel engine oil but also meets S Category requirements. Conversely, for an oil that is formulated for passenger car motor oil applications and meets both S and C Categories, the S Category should be put first so that the consumer can recognize that the oil is primarily a passenger car motor oil but also meets C Category requirements. ***Some automobile manufacturers are concerned that engine oils with greater than 800 parts per million (0.08% mass) phosphorus can adversely affect catalytic converters in gasoline-fueled engines.***

7.5. PRODUCT TRACEABILITY CODING

7.5.1 For purposes of conformance audits, the marketer shall ensure that product traceability codes appear on each container and that these codes are legible and durable. Each container shall be coded to permit traceability of samples in the marketplace by formulation, date of packaging, and source of manufacture.

7.5.2 The marketer may use whatever coding system is appropriate or convenient. Disclosure of coding systems to API is required in the EOLCS Online Application (see Annex P). No change in coding is permitted without prior notification of API. Coding information provided to API is considered confidential and will be used only as described in the API license agreement.

8. SYSTEM MONITORING, ENFORCEMENT, AND CONFORMANCE

8.1. GENERAL

8.1.1 API’s Aftermarket Audit Program (AMAP) is a monitoring and enforcement program designed to ensure compliance by marketers (licensees) with the licensing requirements of the API EOLCS at the time of initial licensure as well as in the aftermarket. Monitoring and enforcement efforts are directed to confirm that, for each licensed product:

a. at licensure, the physical and chemical properties of the licensed formulation for such product, as described in the finished oil physical properties and elemental analysis sections of the EOLCS Online Application (the "Licensed Fingerprint"), have met the product qualifications claimed in the formulation information in the Online Application and paragraph 6.4.2 ;
b. each licensed product, as marketed, conforms to the Licensed Fingerprint for that product, and
c. the API marks are properly displayed on licensed product containers and convey accurate information to consumers about the contents.

8.1.2 To ensure continued compliance with API licensing requirements, the Licensed Fingerprint of an engine oil will be used to determine whether the engine oil being marketed complies with the data submitted in the EOLCS Online Application. API may review the information furnished by applicants in the EOLCS Online Application pursuant to paragraph 6.4.4 . This will include, where applicable, API securing and reviewing with the applicant the underlying engine, bench, and analytical testing data from the licensee and program information to confirm that the applicable criteria set forth in API 1509 and in ASTM D4485 have been met.

a. Where the applicable information includes engine and/or bench testing, API shall confirm that the licensee has passing test results for the licensed product, whether full or provisional, that establish that the licensed product met API's standards at initial licensure (or any amended licensure). API shall then determine continued compliance with API's standards for licensure by confirming that the licensed product, as marketed, conforms to the Licensed Fingerprint. As stated in 6.3.2 , the marketer is solely responsible for ensuring that the performance characteristics of the oil product displaying an API Mark or Marks meet all requirements for the Mark or Marks.

b. Where applicable read across guidelines are employed in lieu of engine testing, API shall confirm that the licensee has passing test results for the formulation tested, whether full or provisional, that establish that the licensed product met API's minimum performance standards for licensure at initial licensure (or any amended licensure). API shall then determine continued compliance with API's standards for licensure by confirming that the licensed product, as marketed, conforms to the Licensed Fingerprint and the guidelines have been properly interpreted and applied. In addition, to ensure proper interpretation and application of read across guidelines, prior to and after licensure API may require selected applicants to review in detail with API how such guidelines were interpreted and applied by the applicant. No such review with API shall absolve a marketer of the responsibility for correctly applying read across guidelines.

8.1.3 To ensure that licensed products, as marketed, conform to their respective Licensed Fingerprints, API will annually secure samples of brands and viscosity grades of randomly selected licensed products. Licensees shall be required to use reasonable efforts to ensure that such samples are made available to API. Each of the samples will be analyzed according to a standard audit (see Annex L, Table L-1) that compares the physical and chemical property audit data with the Licensed Fingerprint for the licensed product in question, and may also include tests from Table L-2. Test results must meet the physical and chemical tolerances described in Annex L. API shall consider a sampled oil as in compliance with the API standards for licensure if the oil tested matches the Licensed Fingerprint (see 8.1.2). This includes a complete review of all bench and analytical testing results supporting the licensed product. If API is unable to confirm that the licensed product complies with paragraph 8.1.2 , API shall notify the licensee and take appropriate action as provided in 8.2.1 .

Where the applicable criteria allow the use of read across guidelines in lieu of specified bench and analytical testing, licensees may be required to run bench and analytical tests if the licensed product fails to conform to the Licensed Fingerprint for that product.

8.1.4 API will contract with independent organizations to collect samples from the field and conduct all physical and chemical analyses, bench tests, and engine tests.

8.1.5 Data obtained through the Aftermarket Audit Program are considered confidential, are available only to the appropriate API staff and the licensee, and are used only for the purposes stated in the inquiry. Specific data derived from the Aftermarket Audit Program will not be used for any reason other than the monitoring process

without written permission from the licensee. When summary data are issued by API, they will not be company specific.

8.2. VIOLATIONS

8.2.1 General

Violations of the EOLCS are divided into two categories: (a) noncompliance with technical specifications and (b) improper use of the API Marks.

8.2.1.1 Noncompliance with Technical Specifications

If an API-licensed oil does not meet technical specifications, API will attempt to work directly with the marketer to evaluate the nonconformity and take additional corrective action as appropriate on a voluntary basis. If the matter cannot be satisfactorily resolved, API will take or initiate the actions listed below, singly or in combination, to maintain the credibility of the API Marks and protect the consumer. Enforcement action will be related to the severity of the alleged offense, the period of time that the violating product has been in the marketplace, the efforts made by the marketer to correct the violation, and the possible harmful impact on the consumer. These actions include the following:

a. Temporary suspension of the authority of the licensee to use the API Marks on a product until corrective action has been taken.
b. Termination of the authority of the licensee to use the API Marks on an individual product.
c. Termination of the authority of the licensee to use the API Marks on all API-licensed products marketed by the licensee.
d. Requirement for the licensee to remove noncomplying products that display API Marks from the marketplace.

Note: All monitoring and enforcement actions must be resolved to API's satisfaction before an existing license will be renewed or a new license issued.

8.2.1.2 Improper Use of API Marks

If licensed or unlicensed oils display an improper label or unauthorized labeling data, API will require the marketer to cease and desist from committing the violation and will request verification that the violation has been corrected.

8.2.2 Verification of Compliance with API Enforcement Action

API will take steps to verify that required corrective action has been executed. Actions requested to verify compliance will depend on the seriousness of the violation. The cost of these verification procedures will be borne by the marketer, as specified in the license agreement. Verification procedures include the following:

a. Submission of copies of labels. The marketer will be required to provide a copy of all labels reflecting the correction of the API Mark violation.
b. Attestations. The marketer may be required to furnish an affidavit from a third party (a law firm or an accounting firm) that the specified remedial action has been completed.
c. Retesting. The marketer will agree to undertake any agreed-upon retesting.
d. Other evidence of compliance. API can make other reasonable requests to verify compliance.

8.2.3 Appeals

When API suspends or revokes a license, the former licensee may appeal the decision. Appeals must be submitted in writing to the Director, Global Industry Services. The appeal shall include a statement of the basis for the objection. The appeal must be filed with API within 45 days of the date of notification of the suspension or revocation of the license. The API Director shall investigate the objections raised and respond to them in writing within 45 days of receipt. If the objections cannot be resolved by the Director, a hearing by a designated appeals board shall be convened in accordance with current API policies.

Annex A

Evolution of Engine Oil Classifications

In 1911, SAE developed a system that classified engine oils by viscosity. This engine oil classification system remained in place until 1947, when API designated three types of engine oils: regular, premium, and heavy duty. Generally, the regular oils were straight mineral oils, the premium oils contained oxidation inhibitors, and the heavy-duty oils contained both oxidation inhibitors and detergent-dispersant additives.

Recognizing the inadequacy of this designation system, in 1952 API's Lubricants Committee, in cooperation with ASTM, developed the Engine Service Classification System (ESCS). API and ASTM revised ESCS in 1955 and again in 1960. ESCS separated gasoline and diesel engine performance with Service Categories ML, MM, and MS and DG, DM, and DS, respectively.

In 1969 and 1970, API, ASTM, and SAE established an entirely new classification system that would satisfy the changing warranty, maintenance, and lubrication requirements of the automotive industry. SAE initially determined that there were eight separate Service Categories of passenger car engine oils of current substantial commercial interest to be considered. ASTM established the test methods and performance characteristics and technically described each of the Service Categories. API prepared a user language, including new letter designations for each of the eight Service Categories. These eight engine Service Categories were tied to the ASTM technical description and primary performance criteria. SAE then published results of the entire project and the methodology as SAE J183.

Over the years, API, ASTM, and SAE have established new Service Categories and declared old Service Categories technically obsolete: The three organizations declared Gasoline Engine Service Category SA technically obsolete; Service Categories SB, SC, SD, SE, SF, and SG became technically obsolete when test methods were no longer available to verify performance; and Diesel Engine Service Categories CA, CB, CC, CD, CD-II, CE, CF, CF-2, CF-4, and CG-4 also became technically obsolete when test methods were no longer available to verify performance or the API Lubricants Committee voted by letter ballot to make a category or categories obsolete. Table A-1 lists all technically obsolete Service Categories.

In 1992 and 1993, API, ASTM, and U.S. and Japanese automotive manufacturers introduced improvements in the licensing process for engine oils to ensure the quality of products being marketed and to enhance consumer awareness of the recommended lubricants for new vehicles. This improved process is known today as the API Engine Oil Licensing and Certification System (EOLCS).

Table A-1—Summary of Obsolete Service Categories and Related Military and Industrial Designations

Technically Obsolete API Service Categories	Previous API Service Categories	Related Military and Industrial Designations
Automotive Gasoline Engines (Passenger Car Engine Oils)		
SA	ML	Straight mineral oil
SB	MM	Inhibited oil, minimum duty
SC	MS (1964)	1964 MS warranty approved, M2C101-A
SD	MS (1968)	1968 MS warranty approved, M2C101-B, 6041-M (before July 1970)
SE	None	1972 warranty approved, M2C101-C, 6136-M (previously 6041-M Rev.), MIL-L-46152A
SF	None	1980 warranty approved, M2C153-D, MIL-L-46152B/C, 6048-M, 6049-M
SG	None	1989 warranty approved, MIL-L-46152D/E
SH	None	None
Commercial Diesel Engines (Diesel Engine Oils)		
CA	DG	MIL-L-2104A
CB	DM	Supplement 1
CC	DM	MIL-L-2104B, MIL-L-46152B
CD	DS	MIL-L-45199B, Series 3, MIL-L-2104C/D/E
CD-II	None	MIL-L-2104D/E
CE	None	None
CF	None	None
CF-2	None	None
CF-4	None	None
CG-4	None	None

Annex B

Interindustry Advisory Group to API/Automotive Manufacturers Administrative Guidance Panel on API EOLCS

B.1 SCOPE

The Interindustry Advisory Group (IAG) will provide recommendations to the API/Automotive Manufacturers Administrative Guidance Panel (AGP) on proposed modifications to the API EOLCS.

B.2 FUNCTION

The group will review, evaluate, and make recommendations on EOLCS matters, including tolerance limits, the Aftermarket Audit Program, the ACC Code of Practice, and any other issues relevant to the licensing program.

B.3 ORGANIZATION

Each of the following organizations will be invited to provide one representative to the group: ACC, API, ASTM, Automotive Manufacturers, Truck and Engine Manufacturers Association (EMA), Independent Lubricant Manufacturers Association (ILMA), Japan Automobile Manufacturers Association (JAMA), Petroleum Association of Japan (PAJ), SAE, and the U.S. Army. Representatives from other organizations may be added to the group as deemed necessary by the AGP. A group member serves at the discretion of the sponsoring organization and is charged with addressing improvements and concerns from his or her organization's perspective. Therefore, there will be no fixed term of membership for the group members.

B.4 OFFICERS

The chair of the IAG is the API representative. The chair calls the meetings, sets the agenda, and presides.

The vice chair of the IAG is rotated annually between an Automotive Manufacturer and an EMA representative. The vice chair assists the chair and presides when the chair is absent.

The secretary of the IAG is the API EOLCS Manager. The secretary assists the chair, arranges meetings, drafts minutes, and handles the group's correspondence.

B.5 MEETINGS

The intent is to meet at the call of the chair, not to exceed two meetings per year. Where possible, group meetings will be held in conjunction with other scheduled meetings that are widely attended by industry. Meetings will be held in accordance with API policy.

B.6 DECISION MAKING

The chair will attempt to achieve group consensus on issues before a formal vote. Lacking consensus, standard voting procedures will be followed, with a simple majority of voting members present at the meeting required to carry any motion. Each organization will have a single ballot in each formal vote. The chair will allow dissenting voters to present their views when forwarding the outcome of votes.

Annex C

Developing New Engine Oil Performance Standards for API Certification Marks

C.1 GENERAL

One of the objectives of API's voluntary Engine Oil Licensing and Certification System (EOLCS) is to help consumers identify engine oils recommended by vehicle and engine manufacturers. To accomplish this objective, the International Lubricant Specification Advisory Committee (formerly International Lubricant Standardization and Approval Committee) (ILSAC) and API created in 1993 the API Certification Mark. The API Certification Mark, or "Starburst" for short, is a Registered Mark that clearly identifies passenger car engine oils meeting the latest engine oil performance standard adopted by ILSAC and API. A companion Certification Mark, known as "Shield", has been created to meet the special requirements of engine oils meeting ILSAC GF-6B.

This annex outlines the primary process used to set specifications for certain passenger car engine oils and describes the procedures that API will use to determine whether these specifications become a standard against which engine oil marketers are licensed to use the API Certification Marks.

Vehicle and engine manufacturers, technical societies, trade associations, lubricant and additive marketers, independent testing laboratories, and consumers play essential roles in defining and developing new minimum performance standards for engine oils. To allow balanced input from all interested industry participants, API will give strong preference to accepting engine tests that are under the jurisdiction of ASTM subcommittee D02.B0, monitored by the ASTM test monitoring center, and under the governance of an ASTM surveillance panel.

C.2 AUTO/OIL ADVISORY PANEL

The Auto/Oil Advisory Panel (AOAP) develops the specifications against which engine oil marketers are licensed to use the API Certification Marks. The AOAP guides and facilitates the development and introduction of AOAP performance specifications for passenger car engine oils.

C.2.1 MEMBERSHIP UPDATED WITH API PROPOSAL

AOAP shall consist of voting and liaison members that have a material interest in developing passenger car engine oil specifications. Material interest includes the following:

a. Any gasoline-fueled automotive engine manufacturer that recommends the standard, or
b. Manufacturers of a gasoline-fueled automotive engine that might use an oil meeting the standard, or
c. Manufacturers or marketers of an oil that meets the standard, or
d. Manufacturers of a component used to formulate oil that meets the standard.

Voting members shall represent companies that are members in good standing in the API Lubricants Standards Group, ACC Petroleum Additives Panel, ILMA, Alliance of Automobile Manufacturers, or JAMA; and liaison member representatives of companies that are members in good standing in ASTM, SAE, or STLE. Representatives from the U.S. Army would also be included as liaison members.

A company that wishes to be a voting member of AOAP shall submit a written request to API that includes a brief explanation of the company's material interest in the specification and proof of membership in one of the organizations identified above. API will maintain the list of companies that have requested membership and met membership qualifications.

Companies with a material interest that participate in other trade organizations not listed in this Annex may request liaison membership by writing to API. The written request must explain the organization's interest in engine oil specifications. Representatives of companies who request membership shall be granted membership if a vote for their inclusion, taken by existing AOAP members, leads to a simple majority of affirmative votes. Such a vote can take place during either a meeting or a conference call. An organization's initial request for membership must be made at least 1 month before the initiation of a precision matrix supporting the specification.

Members must demonstrate active participation in the development of the standard by attending meetings and voting or commenting on issued ballots. Failure to attend at least one meeting per year or to vote on two consecutive letter ballots shall result in the removal of the representative from the panel roster.

API and the Alliance shall each designate a co-chair for the panel. The responsibility of the co-chairs is agreed upon by the AOAP. These typically include setting meeting agendas, reviewing actions, and calling for votes when required. API will provide administrative support such as making meeting arrangements and distributing meeting announcements and minutes.

A panel member may send a proxy to participate in the panel, and the proxy's participation counts toward a member's requirement to actively participate in the panel. If a member chooses to send a proxy, the member shall provide the name of the proxy to API in writing before the start of a scheduled AOAP meeting or conference call. Notification may be made by email or letter. Proxies are not necessary for representatives from the same company.

Changes to company voters shall be provided to API in writing.

C.2.2 VOTING

The AOAP shall attempt to reach consensus on issues related to needs and the issuance and finalization of a draft specification. A quorum of two thirds of both industries (auto and oil) is required for AOAP to conduct official business. Consensus is established when substantial agreement has been reached by the panel. Substantial agreement means more than a simple majority but not necessarily unanimity. Consensus requires that all views and objections be considered and that an effort be made toward their resolution. For purposes of these procedures, consensus shall be defined as follows:

a. Voting is balanced or weighted to ensure ratios of 50 percent Auto and 50 percent Oil.
b. Two-thirds of Auto and two-thirds of Oil votes cast, less waives, are affirmative.
c. Fifty percent of all possible votes are affirmative on each side.

Consensus is defined as noted above and each negative vote shall be accompanied by the information below. A letter ballot (electronic ballot) should be used whenever negative votes are cast during AOAP meetings:

a. Specific paragraph, section, or part negative ballot pertains to.
b. Specific substantive reason(s) for negative vote.
c. Proposed wording or action to resolve negative vote.

Additionally, each abstention shall be explained in writing.

Ballots shall be qualified and negatives and comments considered and resolved in accordance with the latest edition of API's *Procedures for Standards Development*.

If AOAP cannot achieve consensus on the draft specification, then ILSAC may issue a draft for industry comment pursuant to C.3.2.4. If AOAP cannot achieve consensus on the final specification, then ILSAC may issue a specification pursuant to C.3.3.2. If AOAP cannot achieve consensus on needs, the Administrative Guidance Panel will convene pursuant to C.4.3.

C.2.3 PROCEDURES

The AOAP shall provide an adequate level of due process by ensuring the following:

a. All meetings of the AOAP where the proposed specifications are discussed, decisions made, or votes taken are open to all interested parties.
b. Interested parties are given a meaningful opportunity to comment on draft specifications. Comments received by the AOAP shall be reviewed and evaluated pursuant to the consensus criteria specified in C.2.2. The AOAP shall document responses to comments received on the draft specifications.

c. Any party having a material interest in the process has the right to bring a timely appeal of an AOAP action or decision. Appeals must be submitted in writing to the Co-Chairs of the AOAP. If the objections cannot be resolved by the Co-Chairs, the appeal will be transmitted to an API appeals board for resolution. Appeals shall be addressed following the process defined in the latest edition of API's *Procedures for Standards Development*.

C.3 AOAP DEVELOPMENT PROCESS

The AOAP specification development process is designed to accomplish the following:

a. Validate the need for a new specification.
b. Achieve stakeholder consensus early in the process.
c. Optimize the process for developing and approving new specifications.

A new specification is developed in steps, some of which are conducted in parallel and provide input to subsequent steps, as summarized in Figure C-1.

C.3.1 DETERMINATION OF NEED

C.3.1.1 Request for a New Specification

Any individual, company, or association may request a new definition of oil performance that may eventually result in a new specification. To invoke the evaluation process, the new specification request must be submitted to the Co-Chairs of the AOAP and to the Chair of the API Lubricants Standards Group.

The request for a new specification must include adequate data and justification for the proposed specification. The request must demonstrate a need for significant oil performance changes to meet requirements not met by existing categories. Justification should include, but is not limited to, one or more of the following:

a. Impending government regulations.
b. Consumer-driven needs.
c. New hardware design or service requirements.
d. Field problems encountered with current oils.

Following the receipt of the new specification request, the Co-Chairs will notify ILSAC and the API Lubricants Standards Group of the proposed specification and request that the associations confirm that AOAP should evaluate the need for the specification.

C.3.1.2 Evaluation Criteria

The AOAP will work to reach a consensus position on the need and timing for the new specification by considering the following questions:

a. What is the proposed change and why is it required?
b. Does data presented support the request?
c. When is it needed in the marketplace?
d. What are the potential impacts on engines?
e. What are the potential impacts on consumers?
f. What are the potential impacts on the environment?
g. How could the change affect existing API categories? Could an existing API category satisfy the need expressed?
h. What performance and field tests are needed to properly evaluate the performance needs requested?
i. Are the tests available now? If not, in what timeframe can the performance and field tests be developed?

The AOAP may solicit additional industry input and data at any time to assist it in reaching a decision. Other industry groups [for example, SAE, API Detroit Advisory Panel (DAP), and EMA] may be asked to provide supplemental information.

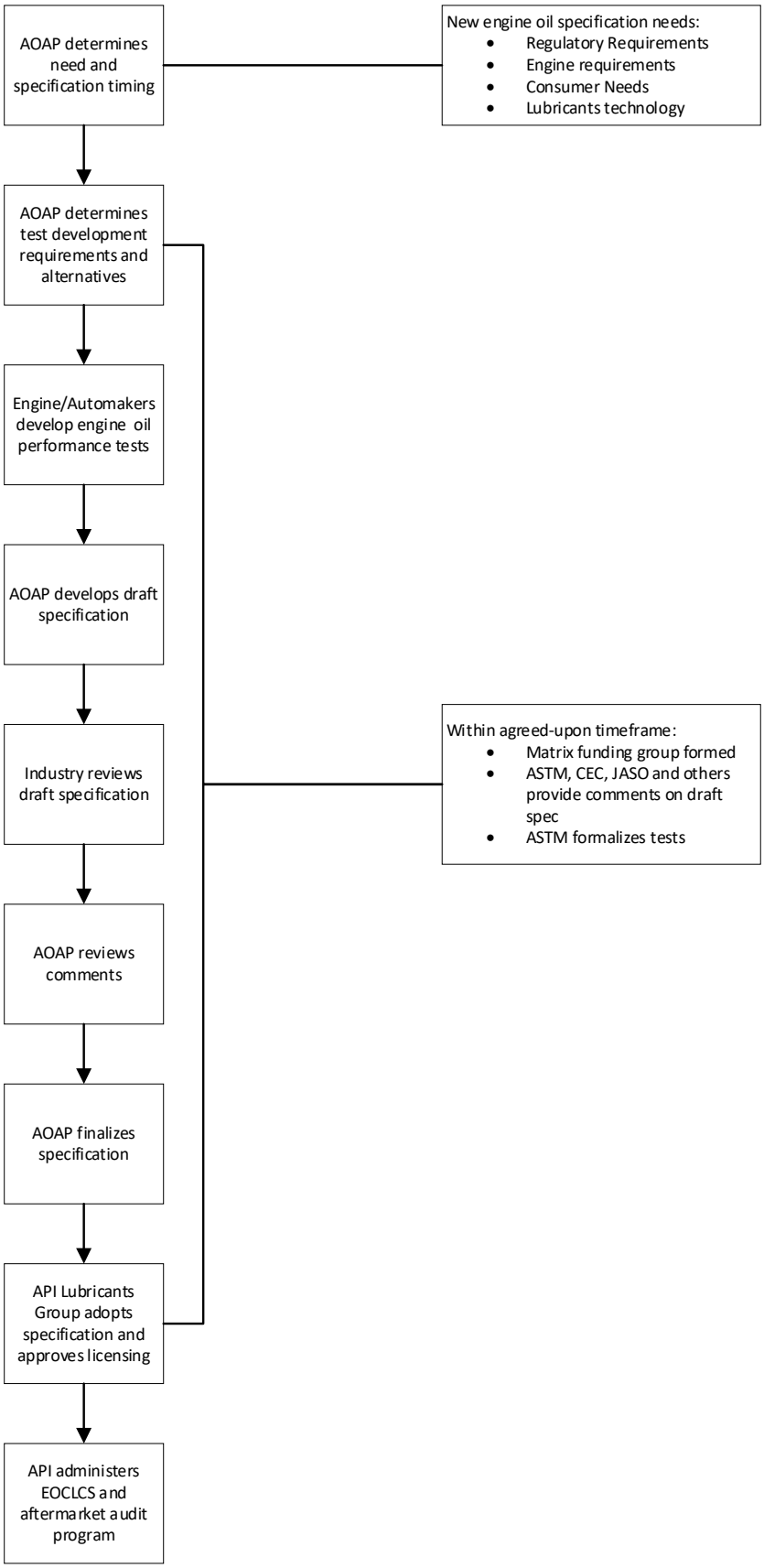

Figure C-1. Process for Developing New Engine Oil Performance Standards for API Certification Marks

C.3.1.3 Decision on Need

The AOAP shall evaluate the request pursuant to the consensus process outlined in C.2.2 and make one of the decisions below:

a. Support the request for the new AOAP specification and proceed with development. This recommendation shall document the basis for determining that there is a need for the new specification.
b. Deny the request.
c. Determine that it cannot reach consensus.

The sponsor has the option of resubmitting the request with additional information if the AOAP denies the request or is unable to reach consensus. If the AOAP cannot achieve consensus on needs after reviewing the additional information, the Administrative Guidance Panel will convene pursuant to C.4.3.

C.3.2 SPECIFICATION DEVELOPMENT

When the AOAP approves the request for the development of a new specification, the AOAP will proceed with development. Parties such as ACC, ASTM, SAE, ILMA, and independent test laboratories may be requested to assist in the development process. Other national, regional, or international bodies—for example, Japanese Automobile Standards Organization (JASO) and CEC – LUBRICANTS Conseil européen de coordination pour le développement des essais de performance des combustibles, lubrifiants et autres fluides utilisés dans les transports [Coordinating European Council (CEC)]—may also be asked for input during this process.

C.3.2.1 Timing

The AOAP will draft a timetable for the development of a new specification to enable the issuance of the AOAP specification and licensing of products with the API “Starburst” or “Shield” at the earliest practicable date. That timetable will indicate the dates at which specific development milestones should be reached and the date first allowable licensing of the “Starburst” or “Shield” should occur for the new specification. The resulting timeline shall be reviewed periodically. In all timetable reviews, the date proposed for first licensing shall allow oil marketers a reasonable opportunity to perform the testing required for licensing prior to the first-license date.

Prior to the start of any precision matrixes, the elements of the timeline should be formally agreed upon by AOAP voting members, recognizing that circumstances could change the timeline and the subsequent changes shall be agreed upon by AOAP voting members before the timeline is considered in agreement by AOAP.

C.3.2.2 Identification of Test Development Needs and Alternatives

If an appropriate test method is not available, a new test method must be developed. Test procedures may be developed or modified by ASTM, CEC, JASO, or other technical societies or trade associations, an OEM, or a third-party contractor. AOAP decides the appropriateness of the tests in the proposed specification per C.2.2.

The AOAP will monitor the specification development process to ensure adherence to the approved timeline. The AOAP will also develop alternative methods of satisfying the specification needs in the specified timeline to ensure that unanticipated problems or situations will not have the potential to unduly delay specification development. If a test or a performance measurement is not ready by the scheduled time, a replacement shall be developed, or the requirement dropped.

Any change in the timeline and/or change in the specification shall require AOAP approval as described in C.2.2.

C.3.2.3 Development of ILSAC Draft

C.3.2.3.1 Review of Proposed ILSAC Draft Specifications

After agreement has been reached on the need, tests and alternatives have been identified, and timing has been established, the AOAP is charged with developing a draft specification. Performance-based rather than composition-based standards should be used to the maximum extent feasible. The AOAP may consider proposed requirements submitted by any stakeholder in the engine oil specification development process (ILSAC, API, ACC, a company, an individual, or another association). After considering these inputs, the AOAP may send its proposed draft to the ASTM

Passenger Car Engine Oil Classification Panel (PCEOCP) for review within a specified timeframe. If appropriate, the AOAP may also send the proposed draft to JASO and/or CEC.

As necessary, the ASTM PCEOCP, JASO, and/or CEC will be asked to review the proposed draft, and within a specified timeframe, prepare an informal report for the AOAP to consider. The following inputs will be requested from the ASTM PCEOCP and, if necessary, JASO and CEC during this review:

a. The groups will evaluate the proposed draft specification and limits and provide comments on whether the proposed test methods will evaluate the needs defined by the AOAP.
b. Each group will be requested to issue a report to the AOAP that contains a summary of comments and data received during the group's proceedings.

While the AOAP may seek input from ASTM, PCEOCP, JASO, and CEC, the AOAP can proceed with specification development if the results of these reviews are not delivered within a specified timeframe. Pursuant to the consensus process specified in C.2.2, the AOAP will issue a draft AOAP specification for review and comment by all interested parties (see C.3.2.4).

C.3.2.3.2 Formalization of Tests

Once a new test becomes available (e.g., shows satisfactory discrimination of oil performance) pursuant to C.3.2.2, the appropriate industry group, for example ASTM, CEC, JASO, or other, will determine test precision.

For example, if an engine test is being developed by ASTM, the AOAP will provide a specified timeframe to ASTM. It is ASTM's responsibility to have a functioning task force or surveillance panel in place to coordinate activities and analyze test data including determining when a test is ready for matrix testing. For bench tests, ASTM must provide a method for referencing and/or calibrating each bench test that does not have an assigned surveillance panel. Based on the AOAP's agreed upon timeline, ASTM will also develop a timetable that contains, among other things, planned dates for reference oil selection, bench and engine test selection, and test method completion. The objective is to formalize the tests and establish criteria to demonstrate that the tests are precise, are reproducible, and have the ability to discriminate. All applicable engine and bench tests shall be monitored by the TMC (or equivalent) prior to incorporation into the final specification (see C.3.3).

If ASTM fails to discharge these responsibilities in a timely manner, the AOAP shall take appropriate actions to ensure that the timing identified in C.3.2.1 for implementing the specification will be met. This may include developing an AOAP specification containing alternative test methods.

C.3.2.3.3 Specification Development Funding

The testing necessary for determining precision as described in C.3.2.3.2 often requires funding. At times, funding might also be required for engine testing to establish base oil interchange (BOI) and viscosity grade read across (VGRA) guidelines, studies, and consumer education. For previous ILSAC specifications, the Alliance for Automobile Manufacturers, JAMA, API, and ACC have provided this funding. When precision and BOI/VGRA testing or other funding is required, the Lubricants Standards Group shall form a task force to evaluate the need and develop a plan for raising the funding. This funding task force will be composed of volunteers from the Lubricants Standards Group, the Alliance, ACC, ILMA, ASTM, and JAMA. For new performance standards, the funding group shall fulfill its role by at least addressing the following points:

a. Calculate the amount of funding necessary for precision and BOI/VGRA matrix testing as recommended by the matrix design task force.
b. Solicit funding for proposed precision and BOI/VGRA matrix testing.
c. If necessary, modify the matrix testing design to match the funding available.
d. Develop a Memorandum of Agreement (MOA) for precision and BOI/VGRA matrix testing.
e. Ensure all companies and organizations that agree to fund the matrix sign the MOA.

C.3.2.4 Industry Review of ILSAC Draft Specification

The draft AOAP specification developed in C.3.2.3 will be circulated to all interested parties for comment. The AOAP will solicit comments in writing and will hold public forums as deemed appropriate. The AOAP will review the comments and data from the industry received in C.3.2.3 before determining the requirements and limits for the final specification. If there are significant changes in the requirements between the draft and the final specification, the AOAP will conduct another comment period on the revised specification. All comment periods will be for a period of

at least 30 days. A longer review period may be allowed for comments on an initial draft. If AOAP cannot achieve consensus on the draft specification, then ILSAC may issue a draft for industry comment as indicated in C.2.2 above.

In parallel with industry review of the draft AOAP specification, API will solicit data on specification demonstration oils (see item b of C.3.3.1) in such a manner as to maintain confidentiality of individual company data.

C.3.3 SPECIFICATION FINALIZATION

C.3.3.1 Review of Development Process

At or near the end of the development of the new specification (e.g., prior to C.3.3.2), the AOAP shall confirm that the following items have been addressed:

a. (1) The tests developed satisfy the needs agreed to by the AOAP, (2) the performance descriptions contained in the proposed consumer language are met by the tests proposed for the specification, (3) the timetable is acceptable, (4) and the test methods chosen to define the new standard represent the best means of establishing the new performance level.

b. Available data on demonstration oils have been reviewed. A demonstration oil shows the technical and commercial viability of the proposed new engine oil specification. This is an oil formulated with base stock and additive components expected to be commercially available when licensing of the new specification begins. Ideally the oils shall have been tested in and passed, at the proposed limits, all engine, chemical, physical, and bench tests required in the draft specification, according to the ACC Code of Practice[1] in effect at the time the tests are run (for engine tests). Registration is not needed, but stand calibration is required.

c. If sufficient information on a demonstration oil is not available, AOAP will re-evaluate the draft specification for technical and commercial viability. While information on a demonstration oil is useful as input to the limit-setting process and may help achieve consensus, the demonstration oil is not required prior to achieving the AOAP consensus pursuant to item a of C.3.3.2.

d. All industry comments on the proposed specification have been reviewed to ensure that they have been considered and addressed by the AOAP in sufficient detail.

C.3.3.2 Approval of the Final AOAP Specification

When AOAP agrees that the original goals and objectives of the specification appear to have been met, AOAP will promptly convene to vote on acceptance of the final AOAP specification. If AOAP approves the final specification in accordance with the procedures in C.2.2, the specification will be forwarded to the API Lubricants Standards Group for consideration for adoption into API 1509.

C.4 API LUBRICANTS STANDARDS GROUP ADOPTION OF AOAP SPECIFICATION

C.4.1 CONVENING OF LUBRICANTS STANDARDS GROUP

A meeting of the API Lubricants Standards Group will be scheduled as soon as possible after API has received the final AOAP specification or the specification has been issued unilaterally by ILSAC. The Lubricants Standards Group will vote whether to accept the AOAP specification or the specification issued unilaterally by ILSAC as the basis for licensing of the API “Starburst” or “Shield” via letter ballot pursuant to API *Procedures for Standards Development*.

The Chair of the Lubricants Standards Group will resolve negative ballots and comments in accordance with the latest edition of API’s standards procedures.

C.4.2 ADHERENCE TO PROCESS

[1] Provided the AOAP has accepted the ACC Code of Practice as a basis for engine testing.

When submitting an AOAP specification that has been approved pursuant to C.3.3.2, AOAP must provide documentation that the following criteria have been satisfied:

a. Complied with due process requirements.
b. Provided justification for overriding any technical objections raised during the AOAP process.
c. Provided data on at least one demonstration oil meeting all of the requirements defined in item b of C.3.3.1 at the time the specification is delivered, provided such data has been made available.
d. Showed that the AOAP specification oil will be reasonably achievable and will likely be widely available to consumers within the specified timeframe (e.g., recommended additional time for compliance).
e. Based on data from items c and d above, showed that the AOAP specification provides significantly more needed benefits to consumers (as identified in C.3.1) than any other specification proposal the AOAP considered.

C.4.3 RESOLUTION BY ADMINISTRATIVE GUIDANCE PANEL (IF REQUIRED)

If the API Lubricants Standards Group does not adopt the AOAP specification or if the AOAP cannot achieve consensus on needs, the Administrative Guidance Panel will either withdraw the request for a new specification or convene to consider dissolution of the Certification system.

Annex D

Developing New Diesel Oil Performance Standards for API C Service Categories

D.1 GENERAL

One of the objectives of API's voluntary Engine Oil Licensing and Certification System (EOLCS) is to help consumers identify lubricants that meet the needs of their vehicles. This is accomplished through the use of category designations within the API Service Symbol. These categories are based on engine oil performance specifications that require close coordination and consensus among the affected parties. Technical societies, trade associations, lubricant and additive marketers, vehicle and engine manufacturers, independent testing laboratories, and consumers play essential roles in defining and developing new minimum lubricant performance standards. This annex outlines the roles and responsibilities of each organization in the heavy-duty diesel oil specification development process for API licensing.

API is responsible for licensing engine oil marketers against and enforcement of lubricant performance standards adopted for use in EOLCS. The API Lubricants Standards Group must grant final approval to any new category and recommend its inclusion in EOLCS.

D.2 API C SERVICE CATEGORIES FOR DIESEL OILS

The C Service Category Development Process for diesel oils is designed to accomplish the following:

a. Justify and validate the need for a new category.
b. Achieve stakeholder consensus early in the process.
c. Establish funding sources for all necessary category components.
d. Optimize the process for developing and approving new categories.

A new C category is developed in three phases, as summarized in Figure D-1.

D.3 CATEGORY DEVELOPMENT PHASES

D.3.1 PHASE 1: CATEGORY REQUEST/EVALUATION

D.3.1.1 Sponsor

A new definition of oil performance that may eventually result in a new category can be requested by any individual, company, or association (see Figure D-2). This party is referred to as the sponsor of the request.

D.3.1.2 Evaluation Process

The purpose of the evaluation process is to determine whether there is a need for the proposed category. To invoke the evaluation process, a sponsor must submit a new category request to the Chairpersons of the Joint API/EMA Diesel Engine Oil Advisory Panel (DEOAP).

The DEOAP is a formally constituted committee composed of representatives from API and EMA member companies who deal with heavy-duty lubricant matters affecting the two trade associations. The DEOAP will guide and facilitate the introduction of proposed heavy-duty performance categories. In addition to DEOAP members, liaison representatives from allied organizations—for example, ACC, SAE, ASTM, ILMA, and the U.S. Army—may also participate.

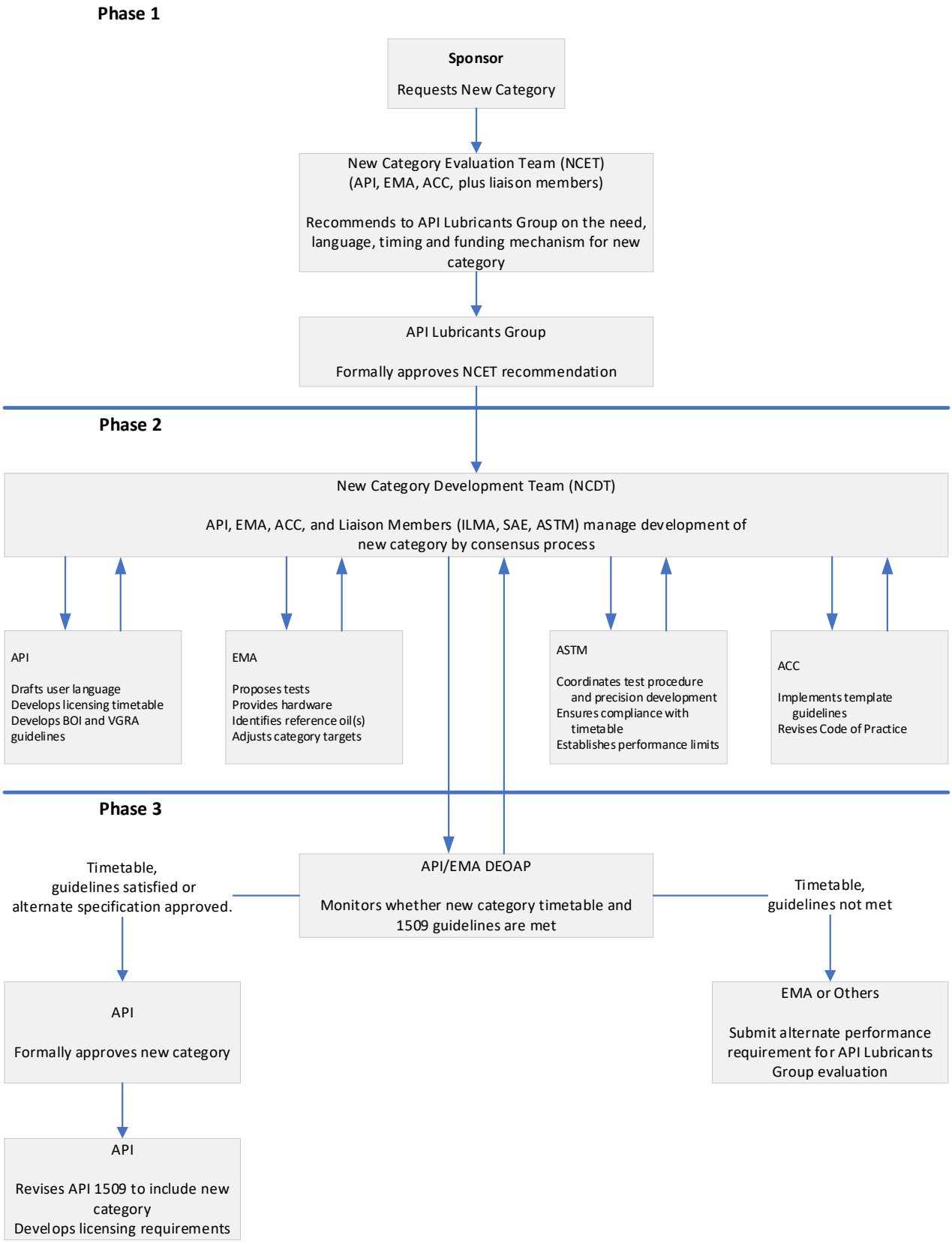

Figure D-1. Heavy Duty Category Request/Approval Process

The Chairpersons of the DEOAP will acknowledge the receipt of the new category request and will work with the category sponsor to furnish the DEOAP with the information necessary to make a decision. The DEOAP has 6 months from the date that all the requested information has been presented to make a decision to either accept or reject the request for a new category. If no decision on the request is made within 6 months, it is automatically forwarded to the API Lubricants Standards Group for its members' information and disposition.

The sponsor must provide adequate data and justification for the proposed category. The request must demonstrate a need for significant oil performance changes to meet requirements not met by existing categories. Justification should include, but is not limited to, one or more of the following:

a. Likely or impending government regulations.
b. Consumer-driven needs.
c. New hardware design or service requirements.

D.3.1.3 New Category Evaluation Team (NCET)

The Chairpersons of the DEOAP will ask API, EMA, and ACC to appoint representatives to serve on an ad hoc review team that will formally evaluate each request for a new category—a New Category Evaluation Team (NCET).

NCET membership will be limited to the minimum number needed to accomplish the work while remaining consistent with full technical representation. This number may vary depending on the requested category. API, EMA, and ACC may each have up to three representatives on the NCET. At the first meeting, the NCET will develop working rules, elect a chairperson, decide who to invite as liaison representatives, and request a meeting with the sponsor. The API, EMA, and ACC representatives are equal participants and decision making by consensus will be strongly encouraged. However, if that is not possible, decision making will be assumed by API and EMA representatives through majority vote. In the case of a tie vote, the request will be addressed by the DEOAP. All NCET meetings will be open to API, EMA, and ACC member company representatives and others.

D.3.1.3.1 NCET Evaluation Responsibilities

The NCET will work to reach consensus positions on the following questions:

a. What is the proposed change and why is it required?
b. Does data presented support the request?
c. When is it needed in the marketplace?
d. What are the potential impacts on engines?
e. What are the potential impacts on consumers?
f. What are the potential impacts on the environment?
g. How could the change affect existing API categories?
h. Are performance tests available that properly evaluate the performance needs requested?
i. Do the perceived benefits outweigh the projected costs?
    1. How much will it cost to develop test procedures and determine precision and define, if necessary, Base Oil Interchange (BOI) and Viscosity-Grade Read Across (VGRA) Guidelines for the proposed category?
    2. What is the estimated total cost to carry out projected work for the new category if the need is approved?

Note: The DEOAP is responsible for calculating an estimated total cost for developing the proposed category and ensuring that an agreement in principle is reached on category development funding before submitting the request to the API Lubricants Standards Group. To that end, the DEOAP Co-Chairpersons will establish an ad hoc Task Force for that specific purpose. This group should include representatives from the principal stakeholders in the process: API, EMA, ACC, independent test laboratories, and other parties deemed appropriate.

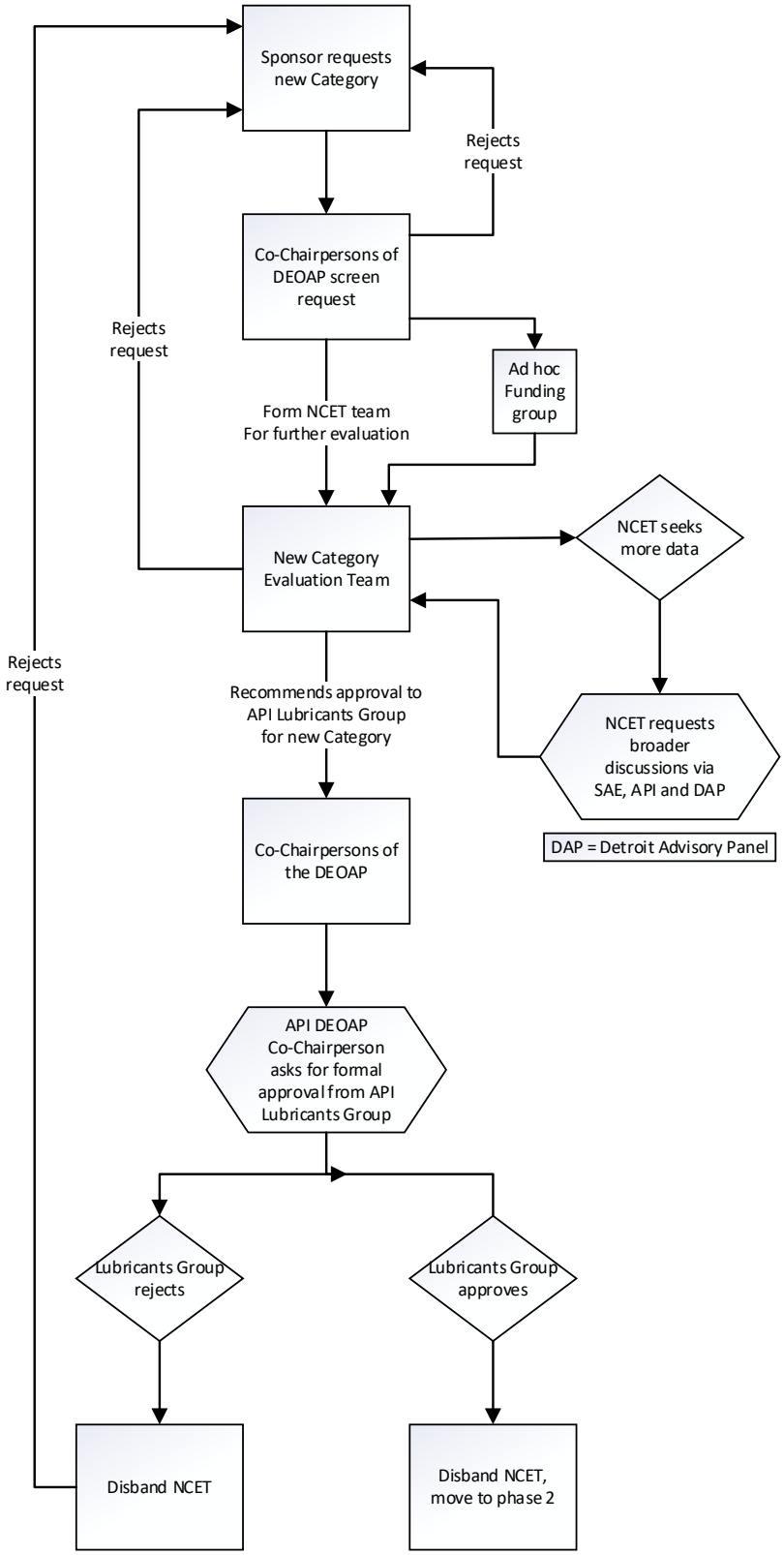

Figure D-2. Phase 1: Category Request/Evaluation

The NCET may solicit additional industry input and data at any time to assist it in reaching a decision. Any industry group [e.g., SAE, API Detroit Advisory Panel (DAP), and EMA] can be asked to provide supplemental information.

The NCET's specific charge is to evaluate the request and to make one of the decisions below:

a. Support the request for the new category and recommend to DEOAP that the request be forwarded to the API Lubricants Standards Group for consideration to proceed with category development. This recommendation shall identify the need for the category, recognize its feasibility, provide a timetable for category development, suggest draft language for the category, and identify the proposed method for funding development of the new category. The API Co-Chairperson of the DEOAP shall present the DEOAP recommendation, along with appropriate documentation, to the API Lubricants Standards Group for consideration at its next meeting.

or

b. Deny the request, explaining to the sponsor in writing the reasons for the denial. The sponsor has the option of resubmitting the request with additional information.

or

c. Not reach consensus. If the NCET cannot reach consensus on the request for a new performance category, the API Co-Chairperson shall provide the API Lubricants Standards Group with the vote outcome and a summary of the reasons for the action.

D.3.1.3.2 API Lubricants Standards Group

The API Lubricants Standards Group must approve or deny the recommendation by formal vote. If denied, the API DEOAP Co-Chairperson will provide the sponsor with a written explanation outlining the Lubricants Standards Group's reasons for disapproval. The sponsor may then make a new request with modifications based on the Lubricants Standards Group actions.

If the API Lubricants Standards Group approves the NCET recommendation for the new category, the API DEOAP Co-Chairpersons will move the process forward, and development of the new category will commence. Independent of whether the Lubricants Standards Group approves or denies the request, the ad hoc NCET disbands at this point in the process.

D.3.2 PHASE 2: CATEGORY DEVELOPMENT

D.3.2.1 New Category Development Team (NCDT) Responsibilities

When the API Lubricants Standards Group approves the request for new category development, the API DEOAP Co-Chairpersons will convene an ad hoc New Category Development Team (NCDT) (see Figure D-3).

The NCDT will function under the same guidelines as the NCET (see D.3.1.3). However, the API, EMA, and ACC representatives need not be the same as those on the NCET. The NCDT will decide on working rules, select a chairperson or facilitator, and, as with the NCET, invite liaison representatives from other groups or affected parties: ASTM, SAE, ILMA, independent test laboratories, or others as required. Other national, regional, or international bodies—for example, JAMA—may also be asked for input during category implementation.

The DEOAP Co-Chairpersons will explain to the NCDT any conditions established by the Lubricants Standards Group, including, but not limited to, the following:

a. The proposed draft language for the category.
b. The proposed timetable.

The DEOAP Co-Chairpersons are responsible for ensuring that funding sources are established to cover the specific costs for all necessary category components. These components, which may include development of new engine and bench tests and precision matrix testing, are identified and confirmed during Phase 2 by the functional work groups: for example, ASTM and the NCDT, respectively. The DEOAP Co-Chairpersons will establish a new ad hoc funding Task Force or reconvene the Task Force used to arrive at the agreement in principle on funding (see D.3.1.3.1). The composition of this Task Force will be constituted in the same manner as the original one and function in a similar way.

The NCDT will manage and coordinate the new process working toward final approval within the timetable and budget. The Co-Chairpersons will monitor the process on behalf of the EMA and API Lubricants Standards Groups and periodically report on progress to them. In addition, the Co-Chairpersons will carry out any other liaison functions that are not covered by the responsibilities of the NCDT.

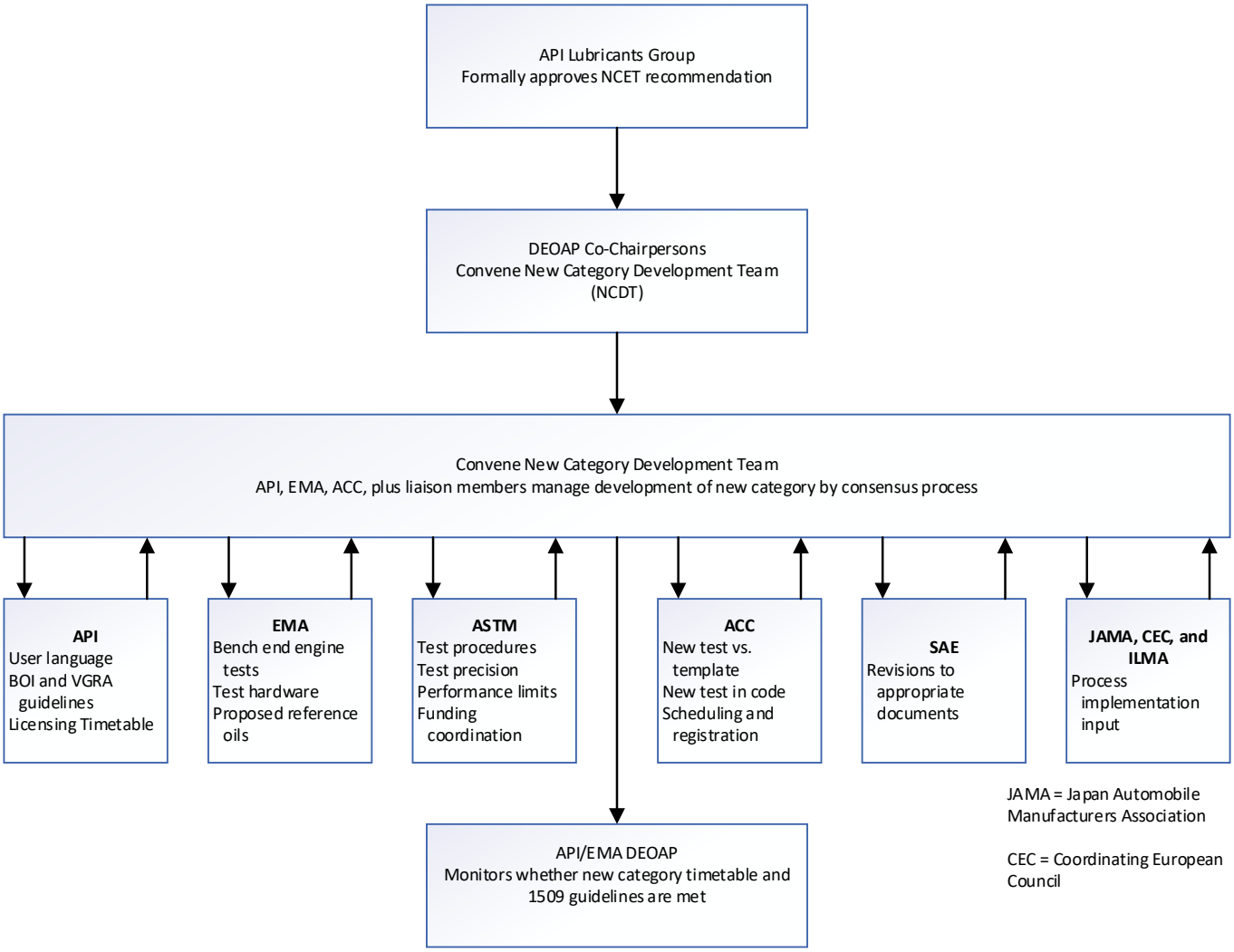

Figure D-3. Phase 2: Category Development

D.3.2.2 Specific Duties of NCDT

The NCDT will manage all phases of category development through four functional work groups chaired by NCDT members: an API member will manage the API function, an EMA member the EMA function, an ACC member the ACC function, and another NCDT member the ASTM and SAE functions.

D.3.2.2.1 API Function

a. Ensure that no conflicts develop between existing categories and the one proposed.

b. Coordinate with the API BOI/VGRA Task Force on its development of base oil interchange and viscosity-grade read-across guidelines based on data (including ASTM matrix testing), engineering judgment, and field experience.

1. Ensure that matrix testing is conducted for the new engine tests in accordance with the plan developed by the NCET (see D.3.1.3.1) so that sufficient data is available to allow the establishment of appropriate BOI and VGRA guidelines simultaneous with the establishment of the category performance criteria.

2. Review proposed BOI/VGRA guidelines with the NCDT before formal approval. These guidelines will be embodied in the new category request when it is forwarded to the API Lubricants Standards Group to consider for inclusion in API 1509.

c. Draft a timetable to enable licensing at the earliest practicable date. That timetable will indicate the dates at which first allowable licensing can occur for the new category. Normally, the first allowable licensing date for a new category is 1 year after ASTM Subcommittee B formally approves the new performance standard used to define the category. This delay allows all oil marketers equal opportunity to meet the category requirements.

d. Develop draft consumer user language. The final version of that language will be approved by the API Lubricants Standards Group and EMA Lubricants Committee.

e. Ensure that emergent marketing or consumer issues that arise during category development are brought to the attention of responsible groups for resolution.

D.3.2.2.2 EMA Function

a. Guide the selection process for appropriate reference oils as well as low and high discrimination oils. At least one reference oil must be identified that meets all the bench and engine tests contained in the new category. The oil shall be used in test development and reformulated as necessary to ensure the best measure of performance. Before any new minimum performance category can be established by ASTM, at least one reference oil must be able to meet all category requirements. This reference oil shall have been engine tested in accordance with the ACC Code of Practice.

   The new category sponsors or their designee will have the primary responsibility for recommending oil selections. The DEOAP will provide feedback and formally approve the selections, and the selections will be reviewed with ASTM.

Note: “Discrimination” oils should be available for each test. It is highly desirable that the minimum performance reference oil represent the performance level of the oil category being superseded and the high performance reference oil meet the expected performance level of the new category.

b. Recommend and/or provide relevant engine tests and hardware, with or without a test procedure.

c. Stay abreast of changes that may occur (government-, industry-, or consumer-generated) and, when necessary, suggest modifications to the new category to ensure that it will meet the predetermined target (see D.3.1.3.1). Coordinate any necessary modifications in language and tests with the NCDT.

D.3.2.2.3 ACC Function

a. Assess the new tests against the criteria of the ACC Code of Practice Template with the objective of optimizing cost-effective engine testing quality. Test precision and discrimination are examples of qualities to be assessed. Provide analysis of these assessments to the DEOAP and NCDT.

b. Incorporate the new engine tests that meet the Template into the ACC Code of Practice together with accompanying test scheduling and registration procedures.

D.3.2.2.4 ASTM and SAE Function

a. Work through ASTM Section D02.B0.02 Heavy-Duty Engine Oil Classification Panel to select or develop test methods that evaluate the needs defined by the NCET.

b. Ensure that the bench and/or engine tests selected for the new category will satisfy the requirements of the draft consumer language approved by the API Lubricants Standards Group. The NCDT and ASTM will also develop a timetable that contains, among other things, planned dates for reference oil selection, bench and engine test selection, and test method completion. Dates must agree with those approved by the Lubricants Standards Group (see D.3.2.1). Tests should correlate with field experience.

c. Provide input, as requested, to the new category sponsors in the selection of appropriate discrimination reference oils for the individual tests in the new proposed category (see D.3.2.2.2).

    1. Coordinate with other appropriate technical societies, such as SAE, to develop and approve written test procedures and limits for tests not within the ASTM system that will be published as standards and specifications.

    2. Once a test shows satisfactory discrimination of oil performance, conduct matrix testing to determine test precision and assess base oil and viscosity-grade effects. If, for example, an engine test is being developed by ASTM, it is ASTM's responsibility to have a functioning task force or surveillance panel in place to coordinate activities and analyze test data. For bench tests, ASTM must provide a method for referencing and/or calibrating each bench test that does not have an assigned surveillance panel.

d. Implement and coordinate through the appropriate ASTM group the funding mechanism recommended by the NCET and approved by the API Lubricants Standards Group for the development of tests, precision, and base oil interchange. Also establish the high reference/"passing" category oil for the Test Monitoring Center.

e. Establish pass/fail limits for each test and the entire category.

f. Update SAE "J" documents as appropriate.

D.3.2.3 Category Completion

At or near the end of the development of the new category, the NCDT must undertake a number of actions to bring the process to a successful conclusion. In general, these actions are to review the output of the four functional groups and advise as necessary to ensure completion as well as harmony among the discrete parts. Specific actions are as follows:

a. For the ASTM functional group, review the appropriateness of the test data developed for discrimination and precision. Agree on the final description for each new performance test and that the optimum test methods and performance limits have been chosen. (At least one "demonstration" reference oil capable of meeting all minimum performance criteria is required.)

b. For the ACC functional group, ensure that the ACC Code of Practice includes each of the new engine performance tests.

c. Obtain from SAE and other cooperating agencies any standards, codes, and publications that are necessary parts of the new category.

When the NCDT is in agreement that all of its original goals and objectives have been met, the team will forward all procedures, facts, data, and information that is pertinent to the new category to the DEOAP. The DEOAP will promptly convene and together with the NCDT ensure that (1) the tests developed under NCDT guidance satisfy the need expressed by the original sponsor, (2) the performance targets contained in the proposed consumer language are met by the tests proposed for the category, (3) the timetable is acceptable, (4) and the test methods chosen to define the new standard represent the most cost-effective means of establishing the new performance level. All input is evaluated, including API BOI and VGRA guidelines. The complete package is then presented by the DEOAP Co-Chairpersons, with a recommendation for formal approval, to the API Lubricants Standards Group. API must approve the complete package including the final consumer language.

D.3.3 PHASE 3: CATEGORY IMPLEMENTATION

D.3.3.1 Alternate Category Development Process

As stated in D.3.2.1, the Co-Chairpersons will monitor the category development process to ensure adherence to the timeline as well as other applicable API 1509 new category guidelines (see Figure D-4).

If unanticipated problems or situations arise that cannot be overcome and that unduly delay category development or prevent original plans from meeting expectations, EMA may choose to develop minimum performance requirements or a new category for API consideration through a process of their own choosing outside of the processes herein described. However, before this or any new minimum API performance category is adopted, it must be approved by the API Lubricants Standards Group at which time it may be incorporated into API 1509.

D.3.3.2 Normal Category Development Process

Upon agreement between the NCDT and DEOAP that all parameters of the new category that were approved by the API Lubricants Standards Group during the evaluation phase have been met (see D.3.2.3), the final approval procedure is implemented. However, if for some reason, full, complete approvals have not been obtained, the DEOAP will carry out the necessary negotiations to resolve differences.

When all differences are resolved, the final specification will include its API Category designation, a description of performance parameters, pass/fail limits, BOI and VGRA guidelines, ACC Code of Practice requirements, and consumer language. Timelines for licensing will also be designated by API.

After final approval is obtained, API staff will be responsible for issuing revisions to API 1509 and advising oil marketers and other affected parties of the new licensing standard.

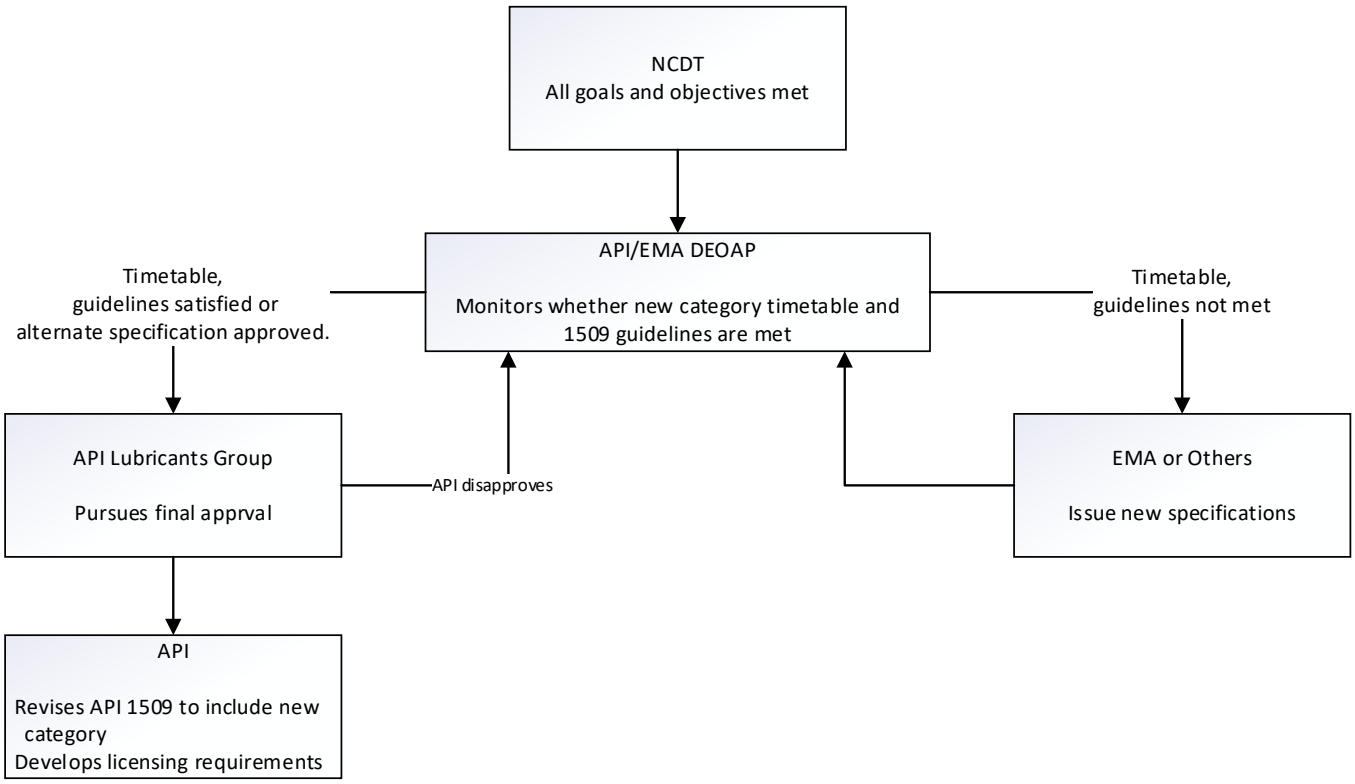

Figure D-4. Phase 3: Category Implementation

D.4 SUPPLEMENT TO EXISTING C CATEGORY

An individual, company, or association may propose to the DEOAP that a Supplement to an existing C Category be developed to meet an urgent field performance need. If developed and approved, this Supplement would be incorporated into API 1509 as a separate, licensable classification in the lower portion of the API Service Symbol "Donut." The Supplement would not replace the existing C Category; however, it would establish additional performance requirements beyond those originally approved for the Category. Oils licensed against the existing C Category specification would remain licensed.

Since the request for the Supplement results from an urgent field performance need, the development process is designed to move more quickly than the traditional C Category development process. This "fast track" process is managed by the DEOAP and is intended to minimize retesting and oil qualification time.

D.4.1 SUPPLEMENT EVALUATION

The DEOAP will formally evaluate each request for a Supplement to an existing C Category. Decision-making by consensus will be strongly encouraged. However, if that is not possible, decision-making will be assumed by API and EMA representatives through majority vote. In the case of a tie vote, DEOAP will continue to work to achieve a consensus but, if unable to do so, will refer the request to the API Lubricants Standards Group for resolution.

For a proposed C Category Supplement to move forward, DEOAP should consider the following items:

a. Tests must be developed and be ASTM-approved or have made significant progress toward ASTM approval.
b. Oils are being marketed that meet the proposed Supplement.
c. Multiple technologies have been shown to meet the proposed Supplement.
d. There is no previous Supplement for this category (one Supplement per Category).

The DEOAP will work to reach consensus positions on the following questions:

a. What is the proposed change and why is it required?
b. What field performance issues support the need for a Supplement?
c. Does data presented support the request?
d. When is it needed in the marketplace?
e. What are the potential impacts on engines and aftertreatment devices?
f. What are the potential impacts on consumers?
g. What are the potential impacts on the environment?
h. Can the tests requested for the Supplement be used for the next full, new C Category?
i. Are the requested performance tests available, or will they be available within the requested time frame, that properly evaluate the requested performance needs?
j. Do the perceived benefits outweigh the projected costs?

Note: Since a Supplement will rely heavily on engine manufacturer tests and/or performance specifications, EMA members will be responsible for determining and justifying the economics for development.

The DEOAP may solicit further industry input and data at any time to assist it in reaching a decision. Any industry group [e.g., SAE, API Detroit Advisory Panel (DAP), ACC and EMA] can be asked to provide additional information.

The DEOAP must decide to:

a. Support the request for the Supplement and forward it to the API Lubricants Standards Group for consideration to proceed with development. This recommendation shall identify the need for the Supplement to an existing Category, recognize its feasibility, provide a timetable for development, suggest draft language for the Supplement, and verify funding of the development. The API Co-Chairperson of the DEOAP shall present the DEOAP recommendation, along with appropriate documentation, to the API Lubricants Standards Group for consideration at its next meeting.

or

b. Deny the request, explaining to the sponsor in writing the reasons for the denial. The sponsor has the option of resubmitting the request with additional information. The API Co-Chairperson of the DEOAP shall report this denial to the API Lubricants Standards Group.

or

c. Not reach consensus. If the DEOAP cannot reach consensus on the request for a Supplement, the API Co-Chairperson shall provide the API Lubricants Standards Group with the vote outcome and a summary of the reasons for the action.

D.4.2 API LUBRICANTS STANDARDS GROUP

The API Lubricants Standards Group must approve or deny the recommendation for a Supplement by formal vote. If denied, the API DEOAP Co-Chairperson will provide the sponsor with a written explanation outlining the API

Lubricants Standards Group's reasons for disapproval. The sponsor may then make a new request to the DEOAP with modifications based on the API Lubricants Standards Group actions.

If the API Lubricants Standards Group approves the DEOAP recommendation for the Supplement, the DEOAP Co-Chairpersons will proceed with development.

D.4.3 SUPPLEMENT DEVELOPMENT

When the API Lubricants Standards Group approves the request for development of a C Category Supplement, the DEOAP will follow the Fast-Track process outlined on Figure D-5. A comparison of the fast track supplement process and the normal C Category process is shown on Table D-1 for guidance.

The DEOAP Co-Chairpersons will explain any conditions established by the Lubricants Standards Group, including, but not limited to, the following:

a. The proposed draft language for the Supplement.

b. The proposed timetable.

Development of a Supplement will be fast-tracked by relying on the following principals:

a. Performance requirements will be based primarily on tests developed by Original Equipment Manufacturer (OEM) sponsors.

b. Oils meeting the Supplement must maintain the performance criteria of the corresponding C Category.

c. Oils licensed by API for the Supplement must also be licensed for the corresponding C Category.

d. The ASTM HDEOCP, or the appropriate Surveillance Panel or Test Development Task Force, must deem engine tests as suitable for use in the Supplement, and the tests must be monitored by TMC.

e. Engine tests must be run in ASTM-calibrated stands and meet performance limits and read-across guidelines established by the OEM test sponsor OR applicable engine test results must be reviewed by the test sponsor and deemed acceptable (see Section D.5 regarding OEM review).

D.4.4 ASSOCIATION FUNCTIONS—CATEGORY SUPPLEMENT

D.4.4.1 OEM Test Sponsor

The OEM sponsoring each individual test shall fulfill the following requirements:

a. Justify the need for the test and performance limits.
b. Provide test hardware.
c. Provide a test procedure.
d. Provide discrimination and precision data.
e. Provide suggested initial BOI and VGRA guidelines.
f. Provide suggested pass/fail limits.

D.4.4.2 API

API shall fulfill the following requirements:

a. Ensure that no conflicts develop between existing Categories and the proposed new Supplement.

b. For the Supplement, ensure that the test sponsor provides sufficient input to allow adoption of appropriate BOI and VGRA Guidelines simultaneous with the establishment of the Supplement performance criteria. Coordinate these activities with the API BOI/VGRA Task Force.

c. Draft a timetable to enable Supplement licensing at the earliest practicable date. This timetable will indicate the dates at which first allowable licensing can occur. Supplement requests will generally be approved based on a more urgent need for enhanced performance in the field. Therefore, every effort will be made to license use of a Supplement classification at the earliest possible date, after the performance tests are accepted for use and limits are defined.

d. Develop draft Consumer User Language. The final version of that language will be approved by the API Lubricants Standards Group and EMA Lubricants Committee.

e. Ensure that emergent marketing or consumer issues that arise during development of a Category Supplement are brought to the attention of responsible groups for resolution.

D.4.4.3 EMA

EMA shall fulfill the following requirements:

a. Recommend the combination of engine and bench tests to define the Supplement.

b. Establish the engine and bench test limits.

c. Guide the selection process for appropriate reference oils as well as low and high discrimination oils.

    1. Since a Supplement incorporates new tests from engine builder specifications, the sponsor of the test must identify reference oils that demonstrate that performance differentiation can be achieved. The sponsor should also provide information illustrating that passing a new test is sufficient to meet the performance criteria of the existing C Category upon which the Supplement is based.

    2. The new Supplement sponsors or their designees will have the primary responsibility for recommending oil selections. The DEOAP will provide feedback and formally approve the selections, and the selections will be reviewed with ASTM.

Note: “Discrimination” oils should be available for each test. It is mandatory that the minimum performance discrimination oil meet the performance level of the oil Category being superseded and the high performance discrimination oil meet the expected performance level of the new Supplement.

d. Recommend and/or provide relevant engine tests and hardware, with or without a test procedure.

Note: Test procedures must be provided for fast-tracking development of a new Supplement.

D.4.4.4 ACC

ACC shall fulfill the following requirements:

a. Assess any new tests against the criteria of the ACC Code of Practice Template with the objective of optimizing cost-effective engine testing quality. Test precision and discrimination are examples of qualities to be assessed. Provide analysis of these assessments to the DEOAP.

b. Consider incorporating the new engine tests that meet the Template into the ACC Code of Practice together with accompanying test scheduling and registration procedures.

D.4.4.5 ASTM and SAE

ASTM and SAE shall fulfill the following requirements:

a. Ensure that the engine and/or bench tests selected for the new Supplement will satisfy the requirements of the draft consumer language approved by the API Lubricants Standards Group. Dates indicated must agree with those approved by the API Lubricants Standards Group (see D.4.2). Tests should correlate with field experience.

b. Provide input, as requested, to the new Supplement sponsors in the selection of appropriate discrimination reference oils for the individual tests in the new proposed Supplement (see D.4.4.3).

    1. ASTM will coordinate with other appropriate technical societies, such as SAE, to develop and approve written test procedures and limits for tests not within the ASTM system that will be published as standards and specifications.

2. It is ASTM's responsibility to have a functioning Development Task Force or Surveillance Panel in place to coordinate activities and analyze test data. For bench tests that do not have an assigned Surveillance Panel, ASTM must provide referencing and/or calibration methods

c. Update SAE "J" documents as appropriate.

D.4.5 SUPPLEMENT COMPLETION

D.4.5.1 Category Supplement

When the DEOAP is in agreement that all of its original goals and objectives have been met, the DEOAP will promptly convene to ensure that (1) the tests involved satisfy the needs expressed by the original sponsor, (2) the performance targets contained in the proposed consumer language are met by the tests proposed for the Supplement, (3) the timetable is acceptable, (4) and the test methods chosen to define the new Supplement represent the most cost-effective means of establishing the new performance level. All input is evaluated, including API BOI and VGRA Guidelines. The DEOAP will carry out the above functions to the extent possible, considering the fast-track process used to develop the Supplement.

D.4.5.2 API Lubricants Standards Group Approval

The complete package describing a new C Category Supplement is then presented by the DEOAP Co-Chairpersons, with a recommendation for formal approval, to the API Lubricants Standards Group. The API Lubricants Standards Group must approve by letter ballot the complete package including the final consumer language. If the API Lubricants Standards Group does not approve the C Category Supplement package, they must send it back to the DEOAP indicating changes necessary for approval or reasons for an outright rejection.

D.4.6 CATEGORY SUPPLEMENT IMPLEMENTATION

Upon agreement between the DEOAP members that all parameters of the new Category Supplement that were approved by the API Lubricants Standards Group during the evaluation phase have been met, the final approval procedure is implemented. However, if for some reason, full, complete approvals have not been obtained, the DEOAP will carry out the necessary negotiations to resolve differences.

When all differences are resolved, the final specification will include its API Category Supplement Classification, a description of performance parameters, pass/fail limits, BOI and VGRA Guidelines, ACC Code of Practice requirements, and consumer language. Timelines for licensing will also be designated by API.

If, during this step, the DEOAP makes any changes to the package approved by the API Lubricants Standards Group, these changes must be presented by the DEOAP API Co-Chairperson to the API Lubricants Standards Group for final approval.

After final approval is obtained, API staff will be responsible for issuing revisions to API 1509 and advising oil marketers and other affected parties of the new licensing standard.

D.5 SUPPLEMENT PERFORMANCE REQUIREMENTS AND DOCUMENTATION

It is expected that the performance tests and limits for a new Supplement will be listed in applicable industry documents, such as ASTM D4485. However, since a Supplement is developed with a fast-track process to meet an urgent technical need and with an expedited time to first license, it is important that the performance needs and limits for an active Supplement are incorporated into API 1509 as soon as possible.

D.5.1 ACTIVE SUPPLEMENT REQUIREMENTS

The performance requirements and test limits for an approved Supplement are outlined in Annex J of API 1509. CI-4 PLUS is the only active C Category Supplement for which an API license can be issued as of September 1, 2004.

D.5.2 SUPPLEMENT PERFORMANCE CERTIFICATION

A marketer that wants to license an oil against the Supplement requirements must attest in the API EOLCS Online Application that the product meets the requirements of the Supplement and its associated C Category. For the C

Category, this means following the traditional process for licensing the oil with API (i.e., the marketer attests that the product has been tested in accordance with and met all applicable requirements for the Category as defined in API 1509, the ACC Code of Practice, SAE J300, and ASTM D4485).

For the Supplement, the marketer must meet the specific performance requirements approved by the DEOAP and the API Lubricants Standards Group. However, the fast-track process also allows marketers to apply technical judgment in lieu of candidate engine test results. If technical judgment is applied, it must be documented in one of two ways in cooperation with the OEM test sponsor:

a. Formal OEM approval (e.g., oil is listed on an OEM approval list or an OEM approval letter has been issued for the oil).

b. Confirmation of OEM review. If this method is used, the marketer must indicate in the EOLCS Online Application that the OEM has reviewed the pertinent data and agreed the product meets the requirements of the Supplement. The marketer must submit a Part F signed by the OEM and marketer confirming the review occurred.

Note: The OEM approval or review process must involve a detailed summary and discussion of results from the specific engine test type in question. These data, which should be on similar and related oil formulations or from a Single Technology Matrix (STM), will be used to support the oil marketer's position that the oil being licensed is capable of meeting the performance requirements.

API may require marketers to provide additional technical data, engine test results, or documentation at any time if API believes that additional data is needed to establish the performance of specific oil formulations. Marketers remain responsible for ensuring and warranting that all products that are licensed and marketed pursuant to the streamlined process will satisfy and meet all of the specified performance criteria. If a marketer has reason to believe that a specific product or formulation does not satisfy all of the performance criteria, the marketer must immediately notify API.

Table D-1 Comparison of Fast Track Supplement and Normal C Category Development Processes

Process/Subprocess	Category	Supplement
Specification		
Establish need	NCET	DEOAP
Tests	EMA	Individual OEMs
Timeline management	NCDT/ASTM	DEOAP
Test Development		
Hardware selection	OEMs	OEMs
Initial procedure	OEMs	OEMs
Final procedure	ASTM	OEMs
Precision data	ASTM	OEMs
Discrimination data	OEMs	OEMs
Research report	ASTM	ASTM
Template evaluation	ACC	ACC
Monitoring	ASTM	ASTM
Reference oils	OEMs	OEMs
Testing protocol	ACC	ASTM approved
Product Approval		
Testing required	ASTM	DEOAP
Limits	EMA/API	OEMs
BOI/VGRA	API	OEM/API
Latest pre-licensed C category		API
Accept test development data		API
Formulation modifications	ACC	ACC
Licensing	API	API
Aftermarket Auditing	API	API

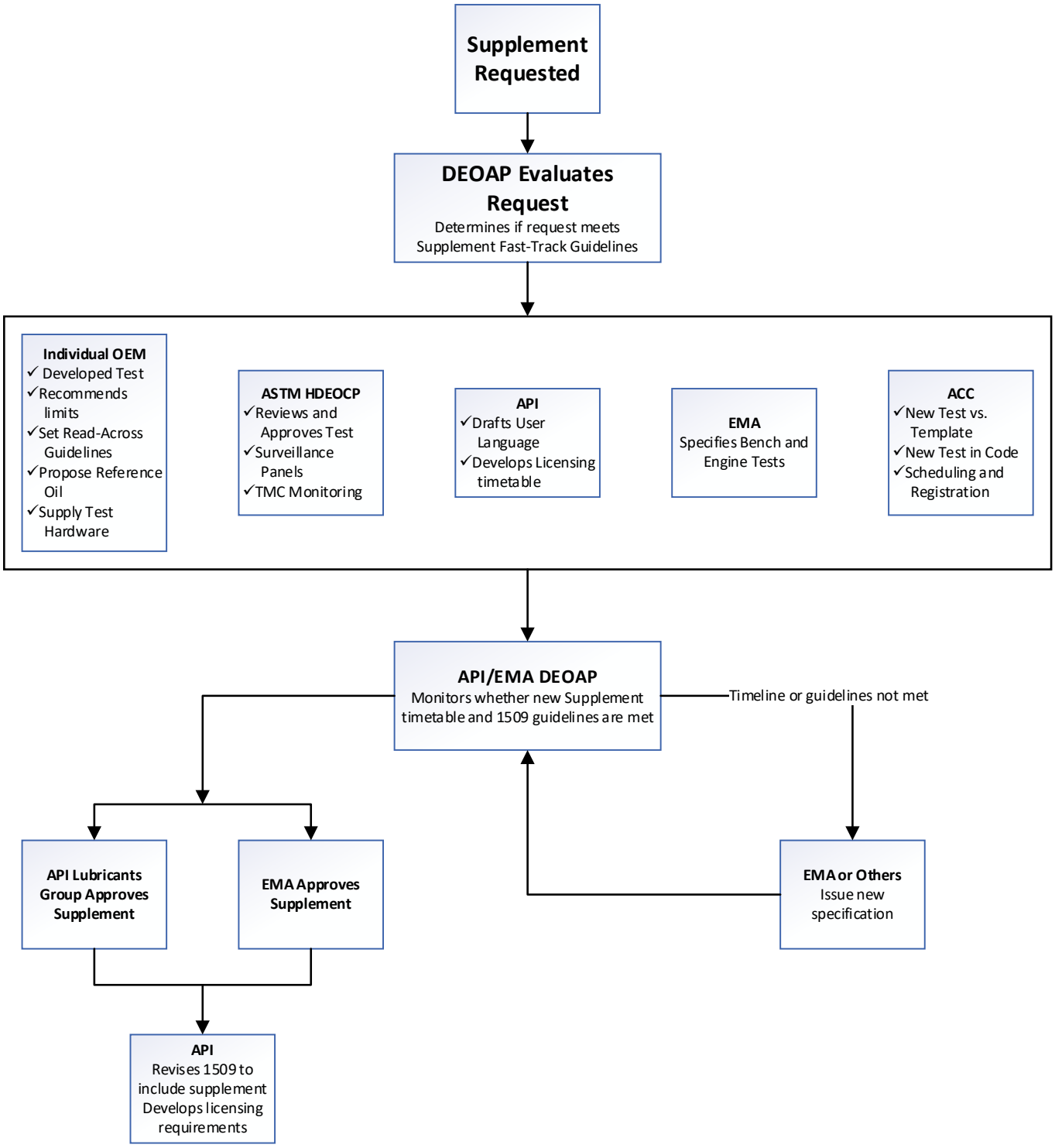

Figure D-5. Heavy Duty Category Supplement Request/Approval Process Fast-Track Approach

Annex E

API Base Oil Interchangeability Guidelines for Passenger Car Engine 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 (PCMO) Guidelines were based on the use of API Service Category SG performance level additive technology and updated for SJ, SL, SM, SN and SP 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, CJ-4, CK-4, and FA-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

E.1.2.1 A *base stock* is a lubricant component that is produced by a single base stock manufacturer to the same specifications (independent of feed source or manufacturer’s location); that meets the same base stock manufacturer specification; and that is identified by a unique formula, product identification number, or both. Base stocks 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 group and from the same base stock manufacturer.

E.1.2.3 A base oil is the base stock or blend of base stocks used in a finished lubricant.

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). PAOs can be interchanged without additional qualification testing as long as the interchange PAO meets the original PAO manufacturer's specifications in physical and chemical properties. The following key properties need to be met in the substituted stock:

    1) Kinematic viscosity at 100°C, 40°C, and -40°C
    2) Viscosity index
    3) NOACK volatility
    4) Pour point
    5) Unsaturates

e. Group V base stocks include all other base stocks not included in Group I, II, III, or IV.

Table E-1—Analytical Methods for Base Stock

Property	Test Method
Saturates[a,b,c] (use one listed method)	ASTM D2007 ASTM D7419
Viscosity index	ASTM D2270
Sulfur (use one listed method)	ASTM D1552 ASTM D2622 ASTM D3120 ASTM D4294 ASTM D4927

[a] The most recent version of each of the listed standards shall be used.
[b] For Saturates below 75.0% ASTM D2007 must be used.
[c] For saturates ≥ 75.0% ASTM D7419 data must be converted to the ASTM D2007 equivalent using the correlation equation outlined in ASTM D7419 to apply read across.

E.1.4 KEY ABBREVIATIONS

- **DI**: Detergent Inhibitor
- **VI**: Viscosity Index
- **VM**: Viscosity Modifier. Although viscosity modifiers are frequently referred to as Viscosity Improvers (and thus abbreviated to "VI"), this Annex will rigorously employ "VM" to avoid ambiguities vs. "Viscosity Index".

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, passing engine tests specified in Section E.2 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 this annex or in the ACC Code of Practice (Appendix I, Guideline 5). The ACC Code of Practice 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 the appropriate API Service Category and/or ILSAC specification.

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

E.2.1.6 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. In the following tables, BOV refers to the Base Oil Blend Viscosity measured by ASTM D445.

E.2.1.7 For engine oils licensed by API against the ILSAC GF-5 standard, the licensee shall ensure that the ROBO or IIIGA data supporting the final formulation was produced in a formulation containing the pour point depressant and base stock(s) used in the licensed formulation.

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 to the information referred to in Annex P, footnote . These Guidelines shall be used in conjunction with the ACC Code of Practice.

E.2.2.2 Complete performance documentation is required for the original Passenger Car Motor Oils (PCMO). The detergent inhibitor (DI) and/or viscosity modifier (VM) remain unchanged when interchange base oils are tested, except as provided by the ACC Code of Practice. 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 of Practice, these Guidelines shall be reapplied.

E.2.2.3 For the passenger car tests listed in , these Guidelines may allow some testing relief. Check the Guidelines for each specific test before establishing the test program requirements for a specific oil formulation.

Table E-2—Tests for API S Category Base Oil Interchange

Test Name	ASTM	Annex E Reference	SJ	SL	SM	SN	SP	Resource Conserving	SN PLUS	GF-5	GF-6A	GF-6B
Sequence IIIE	D5533	E.2.2.4.1	X									
Sequence IIIF	D6984	E.2.2.4.1	X	X								
Sequence IIIG/IIIGA/IIIGB	D7320	E.2.2.4.1	X	X	X	X		X		X		
Sequence IIIH/IIIHA/IIIHB	D8111	E.2.2.4.2			X	X	X	X		X	X	X
Sequence IVA	D6891	E.2.2.4.3	X	X	X	X				X		
Sequence IVB	D8350	E.2.2.4.4					X	X			X	X
Sequence VE	D5302	E.2.2.4.5	X	X								
Sequence VG	D6593	E.2.2.4.5	X	X	X	X				X		
Sequence VH	D8256	E.2.2.4.6	X	X	X	X	X			X	X	X
Sequence VID	D7589	E.2.2.4.7						X		X		
Sequence VIE	D8114	E.2.2.4.8	X	X	X	X	X	X		X	X	
Sequence VIF	D8226	E.2.2.4.9				X	X	X				X
CRC L-38	D5119	E.2.2.4.10	X									
Sequence VIII	D6709	E.2.2.4.10	X	X	X	X	X			X	X	
Sequence IX	D8291	E.2.2.4.11					X		X		X	X
Sequence X	D8279	E.2.2.4.12					X				X	X
Ball Rust Test	D6557	E.4.2.5	X	X	X	X	X			X	X	X
EOFT	D6795	E.4.2.3	X	X	X	X	X			X	X	X
Filterability – EOWTT	D6794	E.4.2.4	X	X	X	X	X			X	X	X
Homogeneity & Miscibility	D6922	E.4.2.3	X	X	X	X	X			X	X	X
TEOST 33/33C	D6335	E.4.2.1	X			X	X	X		X	X	
TEOST MHT	D7097	E.4.2.2		X	X	X				X		
Aged Oil Low Temp. Vis. ROBO	D7528	E.2.1.7				X	X			X	X	X
Elastomer Compatibility Std. Ref. Elastomers	D7216	E.4.2.11				X	X	X		X	X	X

Note: X = Test methods where BOI is defined. Testing requirements can be found in API 1509 Annex G, Annex O and/or ASTM D4485.

E.2.2.4 Passenger car engine tests required for interchanging the base stock are given in E.2.2.4.1 through E.2.2.4.12. The BOI Guidelines vary according to the API base stock group and amount of the base stocks used in the original test oil and the candidate oil formulations. All percentages are mass percent of the total formulation unless otherwise noted.

The testing to support BOI and VGRA guideline development for each sequence test cited by the API Service Categories and ILSAC specifications utilizes base stocks, base oils, and finished fluids with a range of physical properties. The significance of the effect of these physical properties on lubricant performance can vary for each test or test type. Data for base stocks, base oils, and/or finished fluids are included in Table E-3 below. These values are provided for information only and do not represent any limitation on interpretation of these guidelines.

Table E-3—Base Stock, Base Oil, Finished Fluid Data to Support BOI/VGRA Guideline Development for Sequence Tests Cited

Sequence	Base Stock Groups	BOV_{100} Range, $mm^2/_S$	Base Oil VI Range	Base Oil Sats Range (D7419), wt%	Base Oil Sats Range (D2007), wt%	Base Oil Sulfur Range, ppm	Viscosity Grade Range
IIIH	I, II, III[a]	4.5 to 10.7	96 to 139	96.0 to >99.8	93.1 to 98.2	<5 to 371	0W-16 to 20W-50
IVB	II, III	4.2 to 11.2	108 to 140	96.7 to >99.8	93.4 to 99.0	<5	0W-16 to 20W-50
VH	I, II, III, IV	4.2 to 11.1	95 to 130	Group I 86.8 to 87.5 Group II 95.0 to >99.8 Group III >99.8	Group I 82.8 to 83.5 Group II 92.7 to 99.0[b] Group III 97.7 to 98.4	Group I 1301 to 1365 Groups II, III <5	0W-16 to 20W-50
VIE	II, III	4.2 to 5.9	111 to 135	96.9 to >99.8	93.6 to 99.9	<5	0W-20 to 10W-30
VIF	III	4.2 to 4.4	122 to 130	>99.8	98.3 to 99.7	<5	0W-16, 0W-20
IX	II, III, IV	4.2 to 6.2	109 to 136	96.7 to >99.8	93.4 to 99.9	<5	0W-16 to 10W-30
X	II, III, IV	4.2 to 6.2	109 to 140	96.7 to >99.8	93.4 to 98.4	<5	0W-16 to 10W-40, 5W

[a] Group 1 blended with Group III at 36% Group I/64% Group III ratio.

[b] Data not supplied on all Group II base stocks to enable calculation of all base oil saturates levels.

E.2.2.4.1 For Sequence IIIE, IIIF, IIIFHD, IIIG and IIIGA tests required for interchanging the base stock, specific requirements are given in Table E-4.

E.2.2.4.1.1 Single Technology Matrix (STM) is an alternate approach to BOI for Sequence IIIF, IIIFHD, IIIG, and IIIGA (see Annex O).

Additionally, once a combination of five passing Sequence IIIGB and/or Sequence IIIHB tests (Sequence IIIHB at Sequence IIIGB equivalency) has been demonstrated on a unique technology [a unique technology is a single additive package (DI) at a constant treat rate], then no additional Sequence IIIGB or Sequence IIIHB testing is required for that unique technology.

Table E-4—Sequence IIIE, IIIF, IIIFHD, IIIG, IIIGA, and IIIGB Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	≤ 30% Not Required ----- > 30% Required	≤ 30% Not Required ----- > 30% Required	Required
Group II	Required	Required	≤ 30% Not Required ----- > 30% Required	≤ 30% Not Required **-----** > 30% Required	Required
Group III	Required	Required	Required	≤ 30% Not Required ----- > 30% Required	Required
Group IV	Required	Required	≤ 30% Not Required ----- > 30% Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.2.2.4.2 For Sequence IIIH and IIIHB tests required for interchanging the base stock, specific requirements are given in Table E-5.

Additionally, once five passing Sequence IIIHB tests have been demonstrated on a unique technology [a unique technology is a single additive package (DI) at a constant treat rate], then no additional Sequence IIIHB testing is required for that unique technology.

Table E-5—Sequence IIIH and IIIHB Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	≤ 30% Not Required ----- > 30% Required	Required	Required
Group II	Required	Required	≤ 30% Not Required ----- > 30% Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.2.2.4.3 For Sequence IVA tests required for interchanging the base stock, specific requirements are given in Table E-6.

Table E-6—Sequence IVA Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if BOV @ 100°C ≥ original	Not Required if BOV @ 100°C ≥ original	≤30% Not Required ----- > 30% Not Required if BOV @ 100°C ≥ original	≤30% Not Required ----- > 30% and ≤ 50% Not Required if BOV @ 100°C ≥ original ----- > 50% Required	Required
Group II	Not Required if BOV @ 100°C ≥ original	Not Required if BOV @ 100°C ≥ original	≤30% Not Required ----- > 30% Not Required if BOV @ 100°C ≥ original	≤30% Not Required ----- > 30% and ≤ 50% Not Required if BOV @ 100°C ≥ original ----- > 50% Required	Required
Group III	Not Required if BOV @ 100°C ≥ original	Not Required if BOV @ 100°C ≥ original	Not Required if BOV @ 100°C ≥ original	≤ 30% Not Required if BOV @ 100°C ≥ original ----- > 30% Required	Required
Group IV	Required	Required	≤ 30% Not Required ----- > 30%Required	Not Required provided the interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

Note: BOV refers to the base oil blend viscosity measured by ASTM D445.

E.2.2.4.4 For Sequence IVB tests required for interchanging the base stock, specific requirements are given in Table E-7.

Table E-7—Sequence IVB Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required if base oil viscosity @ 100°C ≥ original	Not Required if base oil viscosity @ 100°C ≥ original	Required	Required
Group III	Required	Not Required if base oil viscosity @ 100°C ≥ original	Not Required if base oil viscosity @ 100°C ≥ original	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

Note: The guidelines in this table were developed from data generated on oil with viscosity grades from SAE 0W-16 to SAE 20W-50. These do 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.

E.2.2.4.5 For Sequence VE/VG tests required for interchanging the base stock, specific requirements are given in Table E-8.

Table E-8—Sequence VE/VG Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ and saturates ≥ original	Not Required	Not Required	≤50% Not Required ----- > 50% Required	Required
Group II	Required	Not Required if saturates ≥ original	Not Required	≤50% Not Required ----- > 50% Required	Required
Group III	Required	Required	Not Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.2.2.4.6 For Sequence VH tests required for interchanging the base stock, specific requirements are given in Table E-9.

Table E-9—Sequence VH Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if base oil viscosity at 100°C ≥ original and both original and candidate base oil saturates by ASTM D2007 ≥ 83% and sulfur ≤ 0.13% --- Not Required if base oil viscosity at 100°C ≥ original when original base oil saturates by ASTM D2007 < 83% or sulfur > 0.13% and candidate oil saturates ≥ original and candidate oil sulfur ≤ original	Not Required if base oil viscosity at 100°C ≥ original	Not Required if base oil viscosity at 100°C ≥ original	Required	Required
Group II	Not Required if base oil viscosity at 100°C ≥ original and candidate base oil saturates by ASTM D2007 ≥ 83% and sulfur ≤ 0.13%	Not Required if base oil viscosity at 100°C ≥ original	Not Required if base oil viscosity at 100°C ≥ original	Required	Required
Group III	Not Required if base oil viscosity at 100°C ≥ original and candidate base oil saturates by ASTM D2007 ≥ 83% and sulfur ≤ 0.13%	Not Required if base oil viscosity at 100°C ≥ original	Not Required if base oil viscosity at 100°C ≥ original	Required	Required
Group IV	Required	< 50% Not Required if base oil viscosity at 100°C ≥ original --- ≥ 50% Required	< 50% Not Required if base oil viscosity at 100°C ≥ original --- ≥ 50% Required	Not Required provided the interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.2.2.4.7 For Sequence VID tests required for interchanging the base stock, specific requirements are given in Table E-10.

Table E-10—Sequence VID Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required if HTHS@100°C (D6616) ≤ original. If HTHS@100°C > the original, see equations for Table E-9		Required	Required
Group III	Required			Required	Required
Group IV	Required	Required	Required	Not Required provided interchange Group IV meets original manufacturer's specification in all physical and chemical properties E.1.3.d	Required
Group V	Required	Required	Required	Required	Required

Equations for Table E-10

If the HTHS@100°C of the candidate oil is > the HTHS@100°C of the original passing oil, 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:

$H_{Candidate}$ is the HTHS@100°C of the candidate oil as measured by ASTM D6616
$H_{Original}$ is the HTHS@100°C of the original tested oil as measured by ASTM D6616
$FEIsum_{Limit}$ is the FEI sum passing limit for the original tested viscosity grade
$FEIsum_{Original}$ is the FEIsum ($FEI1_{Orginal}$ + $FEI2_{Orginal}$) result of the original tested oil
-0.485 is the FEIsum coefficient from the Seq. VID industry matrix model
$FEI2_{Limit}$ is the FEI2 passing limit for the original tested viscosity grade
$FEI2_{Original}$ is the FEI2 result of the original tested oil
-0.227 is the FEI2 coefficient from the Sequence VID industry matrix model
R is the reproducibility as reported in the most recent version of ASTM D6616

Note:

R = 0.035 (3.5%) for ASTM D6616-07

The range of HTHS@100°C used to develop the Sequence VID industry matrix model was 5.44 to 7.68 cP.

E.2.2.4.8 For Sequence VIE tests required for interchanging the base stock, specific requirements are given in Table E-11.

Table E-11—Sequence VIE Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required if HTHS@150°C ≤ original. If HTHS@150°C > original, see equation below	Not Required if HTHS@150°C ≤ original. If HTHS@150°C > original, see equation below	Required	Required
Group III	Required	Not Required ifHTHS@150°C ≤ original. If HTHS@150°C > original, see equation below	Not Required if HTHS@150°C ≤ original. If HTHS@150°C > original, see equation below	Required	Required
Group IV	Required	Required	Required	Not Required provided interchange Group IV meets original manufacturer's specification in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

Equation for Table E-11

If the HTHS@150°C of the candidate oil is > the HTHS@150°C of the original passing oil, testing is not required if both 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:

$H_{Candidate}$ is the HTHS@150°C of the candidate oil as measured by ASTM D4683
$H_{Original}$ is the HTHS@150°C of the original tested oil as measured by ASTM D4683
$FEIsum_{Limit}$ is the FEI sum passing limit for the original tested viscosity grade
$FEIsum_{Original}$ is the FEIsum ($FEI1_{Orginal}$ + $FEI2_{Orginal}$) result of the original tested oil
$FEI2_{Limit}$ is the FEI2 passing limit for the original tested viscosity grade
$FEI2_{Original}$ is the FEI2 result of the original tested oil
R is the reproducibility as reported in the most recent version of ASTM D4683; the current $R = 0.03207 \times H_{Original} + 0.0389$ for ASTMD4683-17
-0.733 and -0.246 are coefficients from the Sequence VIE industry matrix model

E.2.2.4.9 For Sequence VIF tests required for interchanging the base stock, specific requirements are given in Table E-12.

Table E-12—Sequence VIF Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Required	Required	Not Required	Required
Group III	Required	Required	Not Required if base oil VI of candidate oil ≥ original test oil	Not Required	Required
Group IV	Required	Required	Required	Not Required provided interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.2.2.4.10 For CRC L-38/Sequence VIII tests required for interchanging the base stock, specific requirements are given in Table E-13.

Note: These BOI Guidelines apply only to bearing weight loss.

Table E-13—CRC L-38/Sequence VIII Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Not Required	Not Required	Required
Group II	Not Required	Not Required	Not Required	Not Required	Required
Group III	Not Required	Not Required	Not Required	≤ 30% Not Required ----- > 30% Required	Required
Group IV	Required	Required	≤ 30% Not Required ----- > 30% Required	Not Required provided interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

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 E-14.

Table E-14—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

E.2.2.4.11 For Sequence IX tests required for interchanging the base stock, specific requirements are given in Table E-15.

Table E-15—Sequence IX Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required	Not Required	Not Required	Required
Group III	Required	Not Required	Not Required	Not Required	Required
Group IV	Required	Not Required	Not Required	Not Required	Required
Group V	Required	Required	Required	Required	Required

Note: The guidelines in this table were developed from data generated on oil with viscosity grades from SAE 0W-16 to SAE 10W-30. These viscosity grades do 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.

E.2.2.4.12 For Sequence X tests required for interchanging the base stock, specific requirements are given in Table E-16.

Table E-16—Sequence X Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required	Not Required	Not Required	Required
Group III	Required	Not Required	Not Required	Not Required	Required
Group IV	Required	Not Required	Not Required	Not Required	Required
Group V	Required	Required	Required	Required	Required

Note: The guidelines in this table were developed from data generated on oil with viscosity grades from SAE 0W-16 to SAE 10W-40. These viscosity grades do 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.

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 Annex 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 IIIE to interchange one Group I, 200N base stock

with another. The marketer may also need to obtain a passing Sequence VE if the requirements of Table E-5 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 IIIE 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 IIIE 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 IIIE 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-6 to see if read-across is allowed.

Note: 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 D4485] 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 the BOI tables allow 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.

According to the tables, Sequence IIIF and VIB engine testing is required 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 the tables 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 Example 13

For Sequence VID BOI (Table and Equation) the following example is applicable:

A passing oil using any combination of API Group II and/or III base stocks is being read to a candidate formulation of equivalent or lower HTHS using different API Group II or III base stocks.

A candidate oil using the same technology (Performance Package and Viscosity Modifier) is formulated to the same viscosity grade using different Group II or Group III base stocks. The candidate oil has an HTHS @100°C of 6.44 cP.

The Base Oil Interchange is allowed to the candidate oil because the HTHS@100°C value of the candidate oil is less than the original tested oil and the base stocks involved are combinations of Group II and Group III.

E.2.3.15 Example 14

For Sequence VID BOI (Table and Equation) the following example is applicable:

A passing oil using any combination of API Group II and/or III base stocks is being read to a candidate formulation of higher HTHS using different API Group II, III base stocks.

The original formulated oil using a Group II or Group III base stock(s) (or mixture) is run in the Sequence VID and achieves a passing FEI_{sum} and FEI2. The oil has an HTHS @100°C of 6.52 cP. The passing result is 0.40 above the passing specification for FEI_{sum} (i.e. $FEI_{sumLimit} – FEI_{sumOriginal} = -0.40$) and 0.16 above the passing specification for FEI2. (i.e. $FEI2_{Limit} – FEI2_{Original} = -0.16$)

A candidate oil using the same technology (Performance Package and Viscosity Modifier) is formulated to the same viscosity grade using different Group II or Group III base stocks. The candidate oil has an HTHS @100°C of 7.40 cP. The reproducibility (R) for D6616-07 is 0.035 (3.5%).

The allowable Base Oil Interchange is assessed using Equations E 1.0 as follows:

A = FEI_{sum} HTHS = 6.52 + (-0.40/-0.485) + 6.52 x 0.035 = 7.57 cP
B = FEI2 HTHS = 6.52 + (-0.16/-0.227) + 6.52 x 0.035 = 7.45 cP

The Base Oil Interchange is limited by the lesser of A and B which is 7.45 cP. The candidate oil HTHS@100 °C is 7.40 and is less than 7.45. Therefore, the Base Oil Interchange is allowed.

No further allowance for precision of HTHS measurement is permitted.

E.2.3.16 Example 15

For Sequence VID BOI (Table and Equation) the following example is applicable:

A passing oil using any combination of API Group II and/or III base stocks is being read to a candidate formulation of higher HTHS using different API Group II, III base stocks.

The original formulated oil using a Group II or Group III base stock(s) (or mixture) is run in the Sequence VID and achieves a passing FEI_{sum} and FEI2.. The oil has an HTHS @100°C of 6.52 cP. The passing result is within the lower rounding of passing specification, i.e. -0.04 below the passing specification for FEI_{sum} (i.e. $FEI_{sumLimit}$ – $FEI_{sumOriginal}$ = +0.04) and 0.10 above the passing specification for FEI2. (i.e. $FEI2_{Limit}$ – $FEI2_{Original}$ = -0.10)

A candidate oil using the same technology (Performance Package and Viscosity Modifier) is formulated to the same viscosity grade using different Group II or Group III base stocks. The candidate oil has an HTHS @100°C of 7.02 cP. The reproducibility (R) for D6616-07 is 0.035 (3.5%).

The allowable Base Oil Interchange is assessed using Equations E 1.0 as follows:

A = FEI_{sum} HTHS = 6.52 + (+0.04/-0.485) + 6.52 x 0.035 = 6.67 cP
B = FEI2 HTHS = 6.52 + (-0.10/-0.227) + 6.52 x 0.035 = 7.19 cP

The Base Oil Interchange is limited to the lesser of A or B, which is an HTHS @100°C of 6.67 Cp. The candidate oil HTHS is 7.02 cP and is greater than 6.67 cP so the Base Oil Interchange is NOT allowed.

No further allowance for precision of HTHS measurement is permitted.

E.2.3.17 Additional Examples

Additional examples on applying Base Oil Interchangeability Guidelines may be noted in Annex M.

E.3 INTERCHANGE FOR HEAVY DUTY ENGINE OILS

E.3.1 GUIDELINES

E.3.1.1 Based on existing engine test data submitted to API, passing engine tests specified in Section E.3 are required for interchanging the base stock in an original API-licensed Heavy Duty Engine Oil (HDEO).

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 HDEO formulation. In some cases, higher percentages of Group III or Group IV may be substituted without further engine testing as specified in this annex or in the ACC Code of Practice (Appendix I, Guideline 5). The ACC Code of Practice should be followed for Group V.

E.3.1.4 The heavy duty engine oil blended with the interchange base oil shall meet all physical and chemical specifications required for the appropriate API Service Category.

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

E.3.1.6 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. In the following tables, BOV refers to the Base Oil Blend Viscosity measured by ASTM D445.

E.3.2 REQUIREMENTS

E.3.2.1 API recognizes the importance of the Multiple Test Evaluation Procedures. Engine testing to support base oil interchangeability shall be in accordance with the information referred to in Annex K. These Guidelines shall be used in conjunction with the ACC Code of Practice.

E.3.2.2 Complete performance documentation is required for the original HDEOs. The detergent inhibitor (DI) and/or viscosity modifier (VM) remain unchanged when interchange base oils are tested, except as provided by the ACC Code of Practice. A base oil interchange obtained under these guidelines applies to a single HDEO formulation. In the event of a change in the DI and/or VM outside the ACC Code of Practice, 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 Heavy Duty engine oil formulation, these Guidelines shall be used in conjunction with Annex 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.3.2.4 For HDEO tests listed in Table E-17, the BOI Guidelines may allow for some testing relief. Check Guidelines for each specific test before establishing the test program requirements for a specific oil formulation.

Table E-17—Tests for API C and F Category Base Oil Interchange

Test Name	ASTM	Annex E Reference	CH-4	CI-4	CI-4 w/CI-4 PLUS	CJ-4	CK-4/ FA-4
Sequence IIIF/IIIFHD	D6984	E.2.2.4.1	X	X	X	X	
Sequence IIIG	D7320	E.2.2.4.1	X	X	X	X	
Caterpillar 1K	D6750 (1K)	E.3.2.5.1	X	X	X		
Caterpillar 1N	D6750 (1N)	E.3.2.5.2		X	X	X	X
Caterpillar 1P	D6681	E.3.2.5.4	X	X	X		
Caterpillar 1R	D6923	E.3.2.5.3		X	X		
Caterpillar Oil Aeration Test	D8047	E.3.2.5.16					X
Engine Oil Aeration Test	D6894	E.3.2.5.9	X	X	X	X	
Cummins ISM	D7468	E.3.2.5.11		X	X	X	X
Cummins ISB	D7484	E.3.2.5.11				X	X
Cummins M11	D6838	E.3.2.5.10	X				
Cummins M11 EGR	D6975	E.3.2.5.10		X	X		
Mack T-8	D5967	E.3.2.5.6					
Mack T-8E	D5967	E.3.2.5.6	X	X	X		
Mack T-9	D6483	E.3.2.5.5	X				
Mack T-10	D6987/ D6987M	E.3.2.5.7	X	X	X		
Mack T-10A	75 hr. used oil in D4684	E.4.2.6		X	X		
Mack T-11	D7156	E.3.2.5.13			X	X	X
Mack T-11A	D6896	E.4.2.8			X	X	X
Mack T-12	D7422	E.3.2.5.12		X	X	X	X
Volvo T-13	D8048	E.3.2.5.15					X
Roller Follower Wear Test	D5966	E.3.2.5.8	X	X	X	X	X
Cummins HTCBT	D6594	E.4.2.9	X	X	X	X	X
Elastomer Compatibility (HD)	D7216	E.4.2.7		X	X		

E.3.2.5 Heavy duty engine tests required for interchanging the base stock are given in E.3.2.5.1 through E.3.2.5.16. The BOI guidelines vary according to the API base stock group and amount of the base stocks used in the original test oil and the candidate oil formulations. All percentages are mass percent of the total formulation unless otherwise noted.

The testing to support BOI and VGRA guideline development for each heavy duty engine test included in the API Service Categories utilizes base stocks, base oils, and finished fluids with a range of physical properties. The significance of the effect of these physical properties on lubricant performance can vary for each test or test type. Data for base stocks, base oils, and/or finished fluids are included in Table E-18 below. These values are provided for information only and do not represent any limitation on interpretation of these guidelines.

Table E-18—Base Stock, Base Oil, Finished Fluid Data to Support BOI/VGRA Guideline Development for Heavy Duty Engine Tests Included in API Service Categories

Engine Test	Base Stock Groups	BOV_{100} Range, $mm^2/_S$	Base Oil VI Range	Base Oil Sats Range (D7419), wt%	Base Oil Sats Range (D2007), wt%	Viscosity Grade Range
T-13	II	5.6 to 7.1	108 to 118	97.4 to >99.8	94.7 to 98.3	10W-30[a], 10W-40, 15W-40
COAT	II	5.5 to 7.3	108 to 115	97.4 to >99.8	94.7 to 98.0	10W-30, 10W-40, 15W-40[a]

[a] Viscosity grade used for BOI guideline development.

E.3.2.5.1 For Caterpillar 1K tests required for interchanging the base stock, specific requirements are given in Table E-19.

Table E-19—Caterpillar 1K Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group II	Not Required	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.2 For Caterpillar 1N tests required for interchanging the base stock, specific requirements are given in Table E-20.

Table E-20—Caterpillar 1N Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Required	Required	Required
Group II	Not Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.3 For Caterpillar 1R tests required for interchanging the base stock, specific requirements are given in Table E-21.

Table E-21—Caterpillar 1R Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Required	Required	Required
Group II	Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.4 For Caterpillar 1P tests required for interchanging the base stock, specific requirements are given in Table E-22

Table E-22—Caterpillar 1P Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Required in only one Group II base stock for CH-4/Not Required for CI-4	Required	Required	Required
Group II	Not Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.5 For Mack T-9 tests required for interchanging the base stock, specific requirements are given in Table E-23.

Table E-23—Mack T-9 Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ and saturates ≥ original	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group II	Required	Not Required if saturates ≥ original	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.6 For Mack T-8 and T-8E tests required for interchanging the base stock, specific requirements are given in Table E-24.

Table E-24—Mack T-8/T-8E Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if either of the following is met: 1. Saturates of original oil is ≥ 80% and interchange base oil saturates is ≥ the original oil 2. Saturates of original oil is <80% and interchange base oil saturates is ≥ the original oil saturates at the 95% confidence level (see example in E.3.3.5)	Not Required	Not Required	Not Required	Required
Group II	Required	Not Required if saturates is ≥ the original oil	Not Required	Not Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.7 For Mack T-10 tests required for interchanging the base stock, specific requirements are given in Table E-25 for Interchanging the Base Stock

Table E-25—Mack T-10 Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if: saturates ≥ original AND sulfur ≤ original AND BOV at 100°C ≥ BOV at 100°C of original	Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	Required
Group II	Required	Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.8 For Roller Follower Wear Test (RFWT) tests required for interchanging the base stock, specific requirements are given in Table E-26.

Table E-26—RFWTs Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group II	Required in only one Group I base stock	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.9 For Engine Oil Aeration Tests (EOAT) required for interchanging the base stock, specific requirements are given in Table E-27.

Table E-27—EOATs Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group II	Not Required	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.10 For Cummins M11 and M11 EGR tests required for interchanging the base stock, specific requirements are given in Table E-28.

Table E-28—Cummins M11/M11 EGR Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if: saturates ≥ original AND sulfur ≤ original	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group II	Required	Not Required if saturates ≥ original	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.11 For Cummins ISM and ISB tests required for interchanging the base stock, specific requirements are given below.

E.3.2.5.11.1 If only one passing Cummins ISM or ISB test is available on a given technology, Table E-29 applies.

Table E-29—Cummins ISM and ISB Tests Required for Base Oil Interchange

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if: saturates ≥ original AND sulfur ≤ original	Not Required	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group II	Required	Not Required if saturates ≥ original	≤30% Not Required ----- >30% Required	≤30% Not Required ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.11.2 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@100°C 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.

E.3.2.5.12 For Mack T-12 tests required for interchanging the base stock, specific requirements are given below.

E.3.2.5.12.1 If only one passing Mack T-12 test is available on a given technology, Table E-30 applies.

Table E-30—Mack T-12 Tests Required for Base Oil Interchange

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if: saturates ≥ original AND sulfur ≤ original AND BOV at 100°C ≥ BOV at 100°C of original	Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	Required
Group II	Required	Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	≤30% Not Required if: saturates ≥ original AND BOV at 100°C ≥ BOV at 100°C of original ----- >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.12.2 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.

E.3.2.5.13 Base Oil Interchange for all Mack T-11 engine tests started after April 28, 2006, may be determined using the method provided in Table E-31 or Table E-32 or Figure E-1. Table E-31, Table E-32, 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-31—Mack T-11 BOI Saturates Requirements (within a range)

Tested Oil	Candidate Oil
X ≤ 70.0	80.0 minimum
70.0 < X < 95.0	(0.6*X + 38) minimum
X ≥ 95.0	95.0 minimum

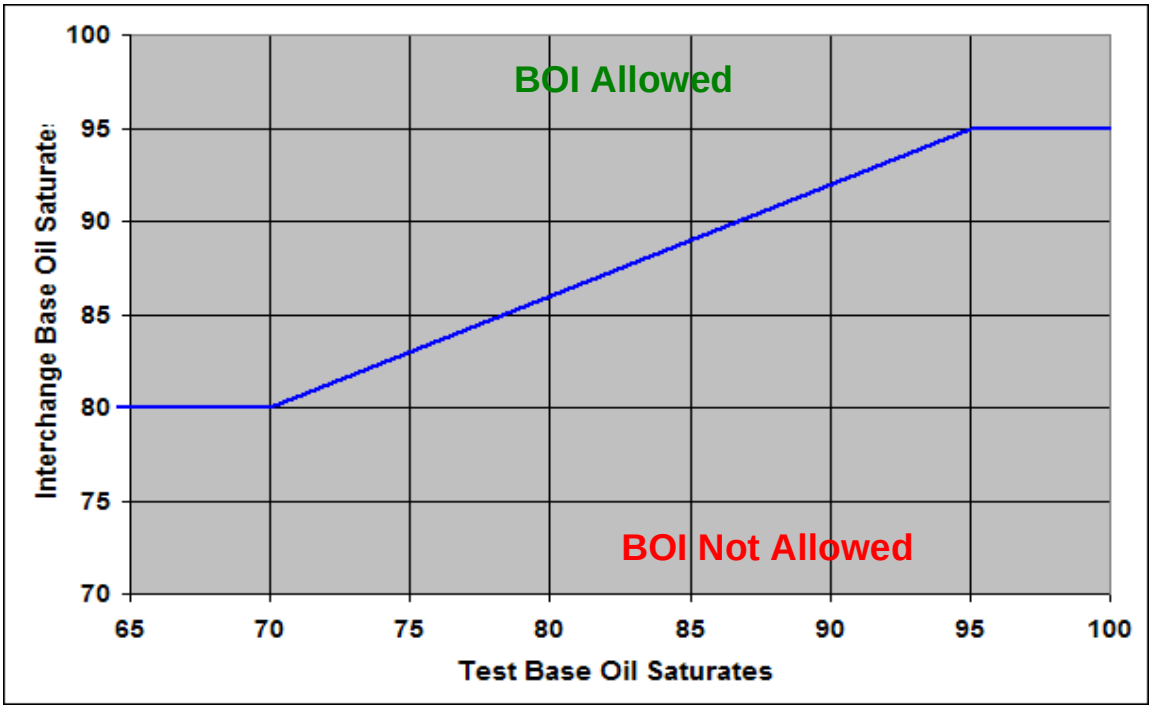

Figure E-1—Mack T-11 BOI Saturates Requirements (according to plot)

Table E-32—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

E.3.2.5.14 Caterpillar C13 test base oil interchange guidelines within Groups I, II, and III are described in paragraphs E.3.2.5.14.1 and E.3.2.5.14.2 (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 in accordance with item d of E.1.3.
3) When Group V base stocks are present, the C13 test must be run.

E.3.2.5.14.1 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

[a]Need 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.3.2.5.14.2 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 C13 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 C13	Pass	Pass	
Is C13 Required?			No
Reason			BOI is allowed. Sats, S, VI, and Group III content fall within matrix ranges. Candidate Group III VI is within 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 acceptable +6 range.

E.3.2.5.15 If only one passing Volvo T-13 test is available on a given technology, Table E-33 applies.

Table E-33—Volvo T-13 Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

E.3.2.5.16 If only one passing Caterpillar Oil Aeration Test (COAT) is available on a given technology, Table E-34 applies.

Table E-34—Caterpillar Oil Aeration Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required provided interchange Group IV meets original manufacturer's specifications in all physical and chemical properties	Required
Group V	Required	Required	Required	Required	Required

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 Annex 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 Heavy Duty 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 Heavy Duty 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.

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 Heavy Duty 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 Base Oil Interchangeability Guidelines. 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 Annex M.

E.3.3.5 Saturates Calculation Example for Table E-20

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 GUIDELINES

E.4.1.1 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 BENCH TESTS WITH ESTABLISHED INTERCHANGE TESTING GUIDELINES

E.4.2.1 TEOST 33C

E.4.2.1.1 Based on existing TEOST 33 (ASTM D 6335) bench test data submitted to API, the passing TEOST 33 tests specified in Table E-35 are required for interchanging the base stock.

Table E-35—Passing TEOST 33 Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock (Applies to SAE 5W-30 and higher viscosity grades only.)				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Required	Required	Required
Group II	Not Required	Not Required	Not Required	Required	Required
Group III	Required	Not Required	Not Required	Required	Required
Group IV	Required	Required	Required	Required	Required
Group V	Required	Required	Required	Required	Required

E.4.2.2 TEOST MHT

E.4.2.2.1 Based on existing TEOST MHT (ASTM D 7097) bench test data submitted to API, the passing TEOST MHT tests specified in Table E-36 are required for interchanging the base stock.

Table E-36—TEOST MHT Tests Required for Interchanging the Base Stock

Base Stock in Original Test Oil	Interchange Base Stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≥ and saturates ≤ original	Required	Required	Required	Required
Group II	Not Required	Not Required	Not Required	Required	Required
Group III	Required	Not Required	Required	Required	Required
Group IV	Required	Required	Required	Required	Required
Group V	Required	Required	Required	Required	Required

E.4.2.3 Homogeneity and Miscibility (H&M) ASTM D 6922 and Engine Oil Filterability (EOFT) ASTM D 6795 [formerly known as GM 9099P Filterability (Standard Method)]

E.4.2.3.1 Homogeneity and Miscibility (H&M) ASTM D 6922 and Engine Oil Filterability (EOFT) ASTM D 6795 [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 of Practice 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.4.2.4 Engine Oil Water Tolerance Test (EOWTT) ASTM D 6794

E.4.2.4.1 The Engine Oil Water Tolerance Test (EOWTT) ASTM D 6794 [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/VM) combination.

E.4.2.5 Ball Rust Test (BRT) ASTM D 6557

E.4.2.5.1 If there is one passing Ball Rust Test (BRT) ASTM D 6557 in the core data set as defined by the ACC Code of Practice, read-across is allowed to all other viscosity grades and base oil slates.

E.4.2.6 Mack T-10A or Mack T-12A

E.4.2.6.1 Neither a Mack T-10A nor a Mack T-12A test is 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 oils (minimum two oils), and fresh oil MRV-TP1 (ASTM D 4684) @ –20ºC of the interchange 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 @ –20ºC for original oil 1
X2 = fresh oil MRV-TP1 @ –20ºC for original oil 2
Y1 = MRV-TP1 @ –20ºC of 75-hour T-10A or T-12A sample for original oil 1
Y2 = MRV-TP1 @ –20ºC of 75-hour T-10A or T-12A sample for original oil 2

An example of this guideline's application is provided in Table E-37.

Table E-37—Example of T-10A or T-12A 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 @ –20ºC, cP	12000	15000	16000	20000	Immaterial
T-10A or T-12A MRV-TP1 @ –20ºC, cP	18000	16000			
T-10A or T-12A 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

[a] T-10A = Mack T-10A engine test; T-12A = Mack T-12A engine test.

E.4.2.7 The Diesel Elastomer Compatibility Test (ASTM D7216 Annex A1)[2]

E.4.2.7.1 The Diesel Elastomer Compatibility Test (ASTM D7216 Annex A1) 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-38.

Table E-38—The Diesel Elastomer Compatibility Test (ASTM D7216 Annex A1) 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.4.2.8 Mack T-11A

E.4.2.8.1 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 cP with no yield stress.

E.4.2.9 High-Temperature Corrosion Bench Test (HTCBT) ASTM D 6594

E.4.2.9.1 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 of Practice, read-across is allowed to all other viscosity grades and base oil slates.

E.4.2.10 Emulsion Retention ASTM D7563

E.4.2.10.1 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/VI combination, testing is required.

E.4.2.11 PCMO Elastomer Compatibility Test (ASTM D7216 Annex A)[2]

E.4.2.12 A passing PCMO Elastomer Compatibility Test (ASTM D7216 Annex A) in the core data set (as defined in the ACC Code) run in Group II or Group III or a mix of Group II and Group III, can be read across to formulations using other Group II or Group III or a mix of Group II and Group III base stocks.

E.4.2.13 Additionally, there is no viscosity grade restriction if the read across is limited to 0W-20, 0W-30, 5W-20, 5W-30, 10W-30 and 10W-40 viscosity grades.

E.4.2.14 When reading to a candidate using Group I base stocks, the PCMO Elastomer Compatibility Test (ASTM D7216 Annex A2) is not required if the base oil saturates and base oil sulfur content (within the precision of the tests) of the interchange base oil fall within the range of the base oil saturates and base oil 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-39**.**

[2] Modified per ballot 5106

Table E-39– Example of PCMO Elastomer Compatibility Test Including API Group I Base Stocks

	Matrix Oil 1	Matrix Oil 2	Candidate Oil A	Candidate Oil B
Base Oil Saturates, mass %	85	99	92	96
Base Oil Sulfur, mass %	0.2	0.0	0.17	0.01
GF-5 Elastomer Compatibility Test	Pass	Pass		
Test Required?			No	No
Reason			Base oil sulfur and Base oil VI falls within matrix ranges	Base oil sulfur and Base oil VI falls within matrix ranges

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 American Chemistry Council Petroleum Additives Product Approval Code of Practice[1], 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 (s^{-1}). 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 (s^{-1}).

F.1.2 KEY ABBREVIATIONS

- **DI**: Detergent Inhibitor
- **VI**: Viscosity Index
- **VM**: Viscosity Modifier. Although viscosity modifiers are frequently referred to as Viscosity Improvers (and thus abbreviated to "VI"), this Annex will rigorously employ "VM" to avoid ambiguities vs. "Viscosity Index".

F.1.3 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 Table F-1 through Table F-21).).

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 of Practice. No read-across or substitute data are permitted for physical and chemical analyses or for bench tests (except as allowed in F.1.4 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.1.4 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, Table E-3 and Table E-18, respectively. These values are provided for information only and do not represent any limitation on interpretation of these guidelines.

F.1.4 PRINCIPLES FOR VISCOSITY GRADES NOT COVERED

Table F-2 through Table F-21 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 (A and B). Read-across for viscosity grades not covered by Table F-1 through Table F-21 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.1.5 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 ≥ 2.6 mPa•s)

	Passenger Car Motor Oils	IID	L-38/ VIII	IIIE/ IIIF/ IIIG	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 of Practice	✓	✓	✓	✓	✓	✓	✓	✓	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 for Table F-1A:

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 ≥ 2.3 mPa•s)

	Passenger Car Motor Oils	IIIH	IIIHB	IVB	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 of Practice	✓	✓	✓	✓	✓
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	NA and Note 3	✓ or Note 4	Note 5

Notes for Table F-1B:

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. Relative viscosity modifier treat level was not found to be a statistically significant factor impacting Sequence IVB performance. The range of relative VM treat levels evaluated in the BOI/VGRA matrix was 1.0x to 1.7x.
4. 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.
5. 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.
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.

F.1.5 EXAMPLES USING VGRA TABLES AND TECHNICAL PRINCIPLES FOR VGRA

F.1.5.1 General

Read-across to or from viscosity grades not shown in the tables is allowed if the requirements in F.1.4 are met. If the requirements are not met, read-across is not allowed. Examples of how F.1.4 can be applied are provided below.

F.1.5.2 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-5, 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-5, 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.1.5.3 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-10. Since the SAE 5W-40 is not included in Table F-10, “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 100°C 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.2 VGRA REQUIREMENTS FOR PASSENGER CAR MOTOR OILS

F.2.1 GENERAL

For Passenger Car Engine Oils, eligibility for Viscosity Grade Read Across requires that the criteria detailed in F.2.1.1 through F.2.1.4 be met.

F.2.1.1 Blends shall use only base stocks as defined in Annex E.

F.2.1.2 Base oils introduced from other manufacturers shall be tested in accordance with Annex E.

F.2.1.3 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 of Practice.

F.2.1.4 ACC Code of Practice and ASTM Multiple Test Evaluation Procedure testing practices shall be followed.

F.2.2 VISCOSITY GRADE ENGINE TESTING READ ACROSS TABLES FOR PCMO.

Note: Engine manufacturers may not recommend all of the viscosity grades shown in Table F-2 through Table F-17 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 for Table F-2:

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.1.4 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.
6. All multigrade oils must meet the requirements of Table F-3.

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 for Table F-4:

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.1.4 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 for Table F-5:

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.1.4 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 IIIH Test

	Can Be "Read-Across" to:															
Test Run On	0W-16	0W-20	0W-30	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	SAE 30	SAE 40	SAE 50
0W-16	NA	--	--	X	--	X	X	--	--	--	X	X	--	X	X	X
0W-20	X	NA	--	X	--	X	X	--	--	--	X	X	X	X	X	X
0W-30	X	X	NA	X	X	X	X	X	X	--	X	X	X	X	X	X
5W-20	--	--	--	NA	--	--	X	--	--	--	X	X	--	X	X	X
5W-30	--	--	--	X	NA	--	X	X	X	--	X	X	X	X	X	X
10W	--	--	--	--	--	NA	--	--	--	--	X	--	--	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	--	--	--	--	--	--	--	--	NA	--	X	X	X	X	X	X
15W-50	--	--	--	--	--	--	--	--	X	NA	X	X	X	X	X	X
20W	--	--	--	--	--	--	--	--	--	--	NA	--	--	X	X	X
20W-40	--	--	--	--	--	--	--	--	--	--	--	NA	--	--	X	X
20W-50	--	--	--	--	--	--	--	--	--	--	--	X	NA	--	X	X
30	--	--	--	--	--	--	--	--	--	--	--	--	--	NA	X	X
40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	NA	X
50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	NA

Notes for Table F-6:

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 should not be higher than that in the oil tested; except for 5W-30 to 10W-40 read the viscosity modifier content must be no more than **1.5x** higher than that in the oil tested.
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-7—Groups I, II, III and IV Viscosity Read-Across: Sequence IIIGA

	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 for Table F-7:

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-8—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 for Table F-8:

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.1.4
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.1.4 are met

Table F-9—Groups I, II, III and IV Viscosity Read-Across: Sequence IVB Test Nondispersant Viscosity Modifier

	Can Be "Read-Across" to:								
Test Run on	0W-16	0W-20	0W-30	5W-20	5W-30	10W-30	10W-40	15W-40	20W-50
0W-16	NA	X	X	X	X	X	X	X	X
0W-20	X	NA	X	X	X	X	X	X	X
0W-30	X	X	NA	X	X	X	X	X	X
5W-20	—	—	—	NA	X	X	X	X	X
5W-30	—	—	—	X	NA	X	X	X	X
10W-30	—	—	—	—	—	NA	X	X	X
10W-40	—	—	—	—	—	X	NA	X	X
15W-40	—	—	—	—	—	—	—	NA	X
20W-50	—	—	—	—	—	—	—	—	NA

Notes for Table F-9:

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. Relative viscosity modifier treat level was not found to be a statistically significant factor impacting Sequence IVB performance. The range of relative VM treat levels evaluated in the BOI/VGRA matrix was 1.0x to 1.7x.
4. New viscosity grades and associated read-across are allowed if the requirements described in F.1.4 are met.
5. 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-10—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 for Table F-10:

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.1.4 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-11—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 for Table F-11:

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.1.4 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-12—Groups I, II, III and IV Viscosity Read-Across: Sequence VH Test Nondispersant Viscosity Modifier

	Can Be "Read-Across" to:															
Test Run on	0W-16	0W-20	0W-30	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
0W-16	NA	—	—	X	—	X	X	—	X	—	X	X	X	X	X	X
0W-20	X	NA	—	X	X	X	X	—	X	—	X	X	X	X	X	X
0W-30	X	X	NA	X	X	X	X	X	X	X	X	X	X	X	X	X
5W-20	—	—	—	NA	—	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	X	X	X
10W-30	—	—	—	—	—	—	NA	—	X	—	X	X	X	X	X	X
10W-40	—	—	—	—	—	—	X	NA	X	—	X	X	X	X	X	X
15W-40	—	—	—	—	—	—	—	—	NA	—	X	X	X	X	X	X
15W-50	—	—	—	—	—	—	—	—	X	NA	X	X	X	X	X	X
20W	—	—	—	—	—	—	—	—	—	—	NA	X	—	X	X	X
20W-40	—	—	—	—	—	—	—	—	—	—	—	NA	—	—	X	X
20W-50	—	—	—	—	—	—	—	—	—	—	—	—	NA	—	X	X
30	—	—	—	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	NA

Notes for Table F-12:

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.1.4 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-13— 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 for Table F-13:

1. 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.
2. 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-13

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@100°C of the candidate oil as measured by ASTM D6616
$H_{Original}$	=	HTHS@100°C 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 range of the HTHS@100°C 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 @100°C 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-14— 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 for Table F-14:

1. A dash (-) means that read across is not permitted; NA = Not applicable.
2. 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.
3. 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 (D4683) of the candidate oil is less than or equal to that of the original tested oil.

Equations for Table F-14

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@150°C of the candidate oil as measured by ASTM D4683
$H_{Original}$	=	HTHS@150°C 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 $R = 0.03207 \times H_{Original} + 0.0389$ for ASTM D4683-17

Table F-15—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-16— 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 for Table F-16:

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.1.4 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.

[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.

F.3 VGRA REQUIREMENTS FOR DIESEL ENGINE OILS

F.3.1 GENERAL

For Heavy Duty Engine Oils, eligibility for Viscosity Grade Read Across requires that the criteria detailed in F.3.1.1 through F.3.1.4 be met.

F.3.1.1 Blends shall use only base stocks as defined in Annex E.

F.3.1.2 Base oils introduced from other manufacturers shall be tested in accordance with Annex E.

F.3.1.3 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 of Practice. Viscosity modifier, foam inhibitor, and pour point depressant levels may be adjusted for alternative viscosity grades, in accordance with the ACC Code of Practice.

F.3.1.4 ACC Code of Practice and ASTM Multiple Test Evaluation Procedure testing practices shall be followed.

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]

Performance Test	From SAE	To SAE
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
(Continued next page)		
EOAT	10W	10W-30, 15W-40, 15W-50
	10W-30	10W, 15W-40, 15W-50
	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 for Table F-17:

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.

[c] 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.

F.4 VGRA FOR BENCH TEST

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 of Practice 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 of Practice, 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 of Practice, read-across is allowed to all other viscosity grades and base oil slates.

F.4.6 TEOST TEST (METHOD 33) (ASTM D6335)

Table F-18—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 for Table F-18:

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. If the viscosity grade of interest is not in the table, then the TEOST Test Method 33 must be run.

F.4.7 TEOST MHT-4 TEST (ASTM D7097)

Table F-19—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 for Table F-19:

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.

F.4.8 PCMO ELASTOMER COMPATIBILITY TEST (ASTM D7216 ANNEX 2A)

Table F-20—Groups II and III Viscosity Read-Across: PCMO Elastomer Compatibility Test[4] (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.

[4] Modified per ballot 5106

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

F.4.9 ROBO TEST (ASTM D7528)

Table F-21—Groups I, II, III and IV Viscosity Read-Across: ROBO Test[5]

	Can be "Read Across" To:								
Test Run on	0W-16	0W-20	0W-30	5W-20	5W-30	5W-40	10W	10W-30	10W-40
0W-16	NA	X	-	X	X	-	-	-	-
0W-20	X	NA	-	X	X	X	-	-	-
0W-30	X	X	NA	X	X	-	-	-	-
5W-20	-	-	-	NA	-	-	X	X	-
5W-30	-	-	-	X	NA	-	X	X	X
5W-40	-	-	-	X	X	NA	-	-	-
10W-30	-	-	-	-	-	-	X	NA	X
10W-40	-	-	-	-	-	-	X	X	NA

Notes for Table F-21:

1. X = read-across is permitted for the viscosity grades identified based on data approved by API BOI/VGRA Task Force and API Lubricants 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

[5] Introduced per Ballot 5108

Annex G

Requirements for API Service Categories SJ, SL, SM, SN, SP by Viscosity Grade[1]

G.1 API SERVICE CATEGORY SJ

Table G-1—Requirements for API Service Category SJ by Viscosity Grade

Engine Test Requirements[a]—All Viscosity Grades	
ASTM D5844 (Sequence IID)	
Average engine rust rating	8.5 (min)
Number stuck lifters	None
Or	
ASTM D6557[b] (Ball Rust Test)	
Average gray value	100 (min)
ASTM D5533 (Sequence IIIE)	
Hours to 375% kinematic viscosity increase at 40°C	64 (min)
Average engine sludge rating	9.2 (min)
Average piston skirt varnish rating	8.9 (min)
Average oil ring land deposit rating	3.5 (min)
Lifter sticking	None
Scuffing and wear	
Cam or lifter scuffing	None
Cam plus lifter wear, mm	
Average	30 (max)
Maximum	64 (max)
Ring sticking (oil-related)	None
Or	
ASTM D6984 (Sequence IIIF)	
Kinematic viscosity, % increase at 40°C	325 (max)
Average piston skirt varnish rating	8.5 (min)
Weighted piston deposit rating	3.2 (min)
Screened average cam-plus-lifter wear, mm	20 (max)
Hot stuck rings	None
Or	
ASTM D7320 (Sequence IIIG)	
Kinematic viscosity, % increase at 40°C	150 (max)
Weighted piston deposit rating	3.5 (min)
Cam-plus-lifter wear average, µm	60 (max)
Hot stuck rings	None
Or	
ASTM D8111 (Sequence IIIH 60/70-Hour Guideline)	
60 kinematic viscosity, % increase at 40°C	307 (max)
70 average weighted piston deposits, merits	2.5 (min)
70 average piston skirt varnish, merits	7.5 (min)

[1]API Category SH was withdrawn from this tabulation on publication of the 18th edition.

ASTM D5302 (Sequence VE)	
Average engine sludge rating	9.0 (min)
Rocker arm cover sludge rating	7.0 (min)
Average piston skirt varnish rating	6.5 (min)
Average engine varnish rating	5.0 (min)
Oil ring clogging, %	Report
Oil screen clogging, %	20.0 (max)
Compression ring sticking (hot stuck)	None
Cam wear, mm	
Average	127 (max)
Maximum	380 (max
ASTM D6891 (Sequence IVA) plus ASTM D6593 (Sequence VG[b])	
Average cam wear, µm	120
Average engine sludge rating	7.8 (min)
Rocker arm cover sludge rating	8.0 (min)
Average piston skirt varnish rating	7.5 (min)
Average engine varnish rating	8.9 (min)
Oil screen clogging, %	20 (max)
Hot stuck compression rings	None
Or	
ASTM D6891 (Sequence IVA) plus ASTM D8256 (Sequence VH)	
Average engine sludge, merits	7.4 (min)
Average rocker cover sludge, merits	7.4 (min)
Average engine varnish, merits	8.6 (min)
Average piston skirt varnish, merits	7.4 (min)
Oil screen clogging, % area	Rate & report
Hot stuck compression rings	None
ASTM D5119 (L-38)	
Bearing weight loss, mg	40 (max)
Shear stability	[c]
Or	
ASTM D6709 (Sequence VIII)	
Bearing weight loss, mg	26.4 (max)
Shear stability	[c]

Bench Test and Measured Parameter[a]	Viscosity Grade Performance Criteria	
	SAE 0W-20, SAE 5W-20, SAE 5W-30, SAE 10W-30	All Others[d]
ASTM D5800 volatility loss, % max[e]	22	20[f]
ASTM D6417 volatility loss at 371°C (700°F),% max[e]	17	25[e]
ASTM D5480 volatility loss at 371°C (700°F), % max[e]	17	15[f]
ASTM D6795, % flow reduction, max	50	50
ASTM D6794, % flow reduction, max	Report	Report
With 0.6% H_2O	Report	Report
With 1.0 % H_2O	Report	Report
With 2.0% H_2O	Report	Report
With 3.0% H_2O	Report	Report
ASTM D4951 or D5185 phosphorus % mass, max	0.10[g]	NR
ASTM D92 flash point, °C min[h]	200	NR
ASTM D93 flash point, °C min[h]	185	NR
ASTM D892 foaming tendency (Option A)		
Sequence I, max, foaming/settling[i]	10/0	10/0
Sequence II, max, foaming/settling[i]	50/0	50/0
Sequence III, max, foaming/settling[i]	10/0	10/0
ASTM D6082 (optional blending required), static foam max, tendency/stability	200/50[j]	200/50[j]
ASTM D6922, homogeneity and miscibility	[k]	[k]
L-38 or Sequence VIII shear stability	[l]	I
ASTM D6335 high temperature deposits (TEOST), deposit wt, mg, max	60	60
ASTM D5133 gelation index, max[b]	12	NR
ASTM D4683, D4741, or D5481, High Temp/High Shear Viscosity @ 150°C, mPa·s, min	NR	2.6

Note: All oils must meet the requirements of the most recent edition of SAE J300; NR = Not required.

[a] Tests and limits are per ASTM D4485

[b] If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the "S" category and there is no API Certification Mark, the Sequence VG (ASTM D6593), Ball Rust (ASTM D6557), and Gelation Index (ASTM D5133) tests are not required

[c] Ten-hour stripped kinematic viscosity (oil shall remain in original viscosity grade).

[d] Does not include SAE 0W-16 and 5W-16.

[e] Volatility requirement shall be met in either Test Method D5800, Test Method D 5480, or Test Method D6417. A passing result in only one of these procedures is required.

[f] Passing volatility loss performance only required for SAE 15W-40 oils.

[g] This is a non-critical specification as described in ASTM D3244.

[h] Either Test Method D92 or Test Method D93 flash point requirement shall be met.

[i] Settling volume determined at 10 min.

[j] Settling volume determined at 1 min.

[k] Homogeneous with SAE Reference Oils.

[l] Ten-hour stripped kinematic viscosity must remain in original SAE viscosity grade except XW-20 which must remain ≥5.6 mm²/s.

G.2 API SERVICE CATEGORY SL

Table G-2—Requirements for API Service Category SL by Viscosity Grade

Engine Test Requirements[a]—All Viscosity Grades	
ASTM D6984 (Sequence IIIF)	
Kinematic viscosity, % increase at 40°C	275 (max)
Average piston skirt varnish rating	9.0 (min)
Weighted piston deposit rating	4.0 (min)
Screened average cam-plus-lifter wear, mm	20 (max)
Hot stuck rings	None
Low temperature viscosity performance	Report
Or	
ASTM D7320 (Sequence IIIG)	
Kinematic viscosity, % increase at 40°C	150 (max)
Weighted piston deposit rating	3.5 (min)
Cam-plus-lifter wear average, µm	60 (max)
Hot stuck rings	None
Low temperature viscosity performance	Report
Or	
ASTM D8111 (Sequence IIIH 70-Hour Guideline)	
70h kinematic viscosity, % increase at 40°C	181 (max)
70h average weighted piston deposits, merits	3.3 (min)
70h average piston skirt varnish, merits	7.9 (min)
ASTM D6891 (Sequence IVA)	
Average cam wear (7 position avg.), µm	120 (max)
ASTM D5302 (Sequence VE)[b]	
Average cam wear, µm	127 (max)
Cam wear, µm	380 (max)
ASTM D6593 (Sequence VG[c])	
Average engine sludge rating	7.8 (min)
Rocker arm cover sludge rating	8.0 (min)
Average piston skirt varnish rating	7.5 (min)
Average engine varnish rating	8.9 (min)
Oil screen clogging, %	20 (max)
Hot stuck compression rings	None
Cold stuck rings	Report
Oil screen debris, %	Report
Oil ring clogging, %	Report
Or	
ASTM D8256 (Sequence VH)	
Average engine sludge, merits	7.4 (min)
Average rocker cover sludge, merits	7.4 (min)
Average engine varnish, merits	8.6 (min)
Average piston skirt varnish, merits	7.4 (min)
Oil screen clogging, % area	Rate & report
Hot stuck compression rings	None

Engine Test Requirements[d] *(continued)*—All Viscosity Grades	
ASTM D6709 (Sequence VIII)	
Bearing weight loss, mg	26.4 (max)
Shear stability	*e*

Bench Test and Measured Parameter[a]	Bench Test and Measured Parameter	
	SAE 0W-20, SAE 5W-20, SAE 0W-30, SAE 5W-30, SAE 10W-30	All Others[e]
ASTM D6557 (Ball Rust Test), avg. gray value, min[e]	100	100
ASTM D5800 volatility loss, % max	15	15
ASTM D6417 volatility loss at 371°C (700°F), % max	10	10
ASTM D6795, % flow reduction, max	50	50
ASTM D6794, % flow reduction, max		
With 0.6% H2O	50	50
With 1.0 % H2O	50	50
With 2.0% H2O	50	50
With 3.0% H2O	50	50
ASTM D4951 or D5185 phosphorus % mass, max[f]	10[g]	NR
ASTM D892 foaming tendency (Option A)		
Sequence I, max, foaming/settling[h]	10/0	10/0
Sequence II, max, foaming/settling[h]	50/0	50/0
Sequence III, max, foaming/settling[h]	10/0	10/0
ASTM D6082 (optional blending required), static foam max, tendency/stability[i]	100/0	100/0
ASTM D6922, homogeneity and miscibility	*j*	j
Sequence VIII shear stability	*k*	k
ASTM D7097, high temperature deposits (TEOST MHT), deposit wt, mg, max	45	45
ASTM D5133 gelation index, max[b]	12[l]	NR
ASTM D4683, D4741, or D5481, High Temp./High Shear Viscosity @ 150°C, mPa·s, min	NR	2.6

a Tests and limits are per ASTM D4485

b Not required for oils containing a minimum of 0.08 % mass phosphorus in the form of ZDDP.

c If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the "S" category and there is no API Certification Mark, the Sequence VG (ASTM D6593), Ball Rust (ASTM D6557), and Gelation Index (ASTM D5133) tests are not required.

d Tests and limits are per ASTM D4485

e Does not include SAE 0W-16 and 5W-16.

f For all viscosity grades: If CH-4, CI-4, and CJ-4 categories precede the "S" category and there is no API Certification Mark, the limit for phosphorus does not apply. However, the CJ-4 limits for phosphorus and sulfur do apply for CJ-4 oils. This footnote cannot be applied if CK-4 or FA-4 is also claimed. Note that these oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.

g This is a non-critical specification as described in ASTM D3244.

h Settling volume determined at 10 min.

i Settling volume determined at 1 min.

j Homogeneous with SAE Reference Oils.

k iTen-hour stripped kinematic viscosity must remain in original SAE viscosity grade except XW-20 which must remain ≥5.6 mm²/s.

l For gelation temperatures at or above the W-grade pumpability temperatures as defined in SAE J300.

G.3 API SERVICE CATEGORY SM

Table G-3—Requirements for API Service Category SM

Engine Test Requirements[a]	Viscosity Grade Performance Requirements	
	SAE 0W-20, SAE 5W-20, SAE 0W-30, SAE 5W-30, SAE 10W-30	All Others[b]
ASTM D7320 (Sequence IIIG)		
Kinematic viscosity increase @ 40°C, %	150 (max)	150 (max)
Average weighted piston deposits, merits	3.5 (min)	3.5 (min)
Hot stuck rings	None	None
Average cam plus lifter wear, µm	60 (max)	60 (max)
Or		
ASTM D8111 (Sequence IIIH)		
Kinematic viscosity increase @ 40°C, %	150 (max)	150 (max)
Average weighted piston deposits, merits	3.2 (min)	3.2 (min)
Hot stuck rings	None	None
ASTM D4684 (Sequence IIIGA), ASTM D8111 (Sequence IIIHA), or ASTM D7528 (ROBO)		
Evaluate EOT oil from ASTM Sequence IIIGA, Sequence IIIHA, or ROBO test with ASTM D4684 (MRV TP-1)	ASTM D4684 viscosity of EOT sample must meet requirements of original grade or next higher grade	NR
ASTM D6891 (Sequence IVA)		
Average cam wear (7 position avg.), µm	90 (max)	90 (max)
ASTM D6593 (Sequence VG)[c]		
Average engine sludge, merits	7.8 (min)	
Average rocker cover sludge, merits	8.0 (min)	
Average engine varnish, merits	8.9 (min)	
Average piston skirt varnish, merits	7.5 (min)	
Oil screen sludge, % area	20 (max)	
Oil screen debris, % area	Rate & report	
Hot-stuck compression rings	None	
Cold stuck rings	Rate & report	
Oil ring clogging, % area	Rate & report	
Follower pin wear, cyl #8, avg, µm	Rate & report[d]	
Ring gap increase, cyl #1 and #8, avg, µm	Rate & report[d]	
Or		
ASTM D8256 (Sequence VH)		
Average engine sludge, merits	7.4	7.4
Average rocker cover sludge, merits	7.4	7.4
Average engine varnish, merits	8.6	8.6
Average piston skirt varnish, merits	7.6	7.6
Oil screen clogging, % area	Rate & report	Rate & report
Hot stuck compression rings	None	None
ASTM D6709 (Sequence VIII)		
Bearing weight loss, mg	26 (max)	26 (max)

Bench Test and Measured Parameter[a]	Viscosity Grade Performance Requirements	
	SAE 0W-20, SAE 5W-20, SAE 0W-30, SAE 5W-30, SAE 10W-30	All Others[b]
ASTM D6557 (Ball Rust Test), avg. gray value, min[c]	100	100
ASTM D5800, evaporation loss, 1 hour at 250°C, % max[e]	15	15
ASTM D6417, simulated distillation at 371°C, % max	10	10
ASTM D6795, EOFT, % flow reduction, max	50	50
ASTM D6794, EOWTT, % flow reduction, max		
with 0.6% H2O	50	50
with 1.0% H2O	50	50
with 2.0% H2O	50	50
with 3.0% H2O	50	50
ASTM D4951 or D5185, phosphorus % mass, max[f]	0.08[f]	NR
ASTM D4951 or D5185, phosphorus % mass, min[f]	0.06[g]	0.06[g]
ASTM D4951, D5185, or D2622, sulfur % mass, max[f]		
SAE 0W-20, 0W-30, 5W-20, and 5W-30	0.5[g]	NR
SAE 10W-30	0.7[g]	NR
ASTM D892 (Option A), foaming tendency		
Sequence I, mL, max, tendency/stability[h]	10/0	10/0
Sequence II, mL, max, tendency/stability[h]	50/0	50/0
Sequence III, mL, max, tendency/stability[h]	10/0	10/0
ASTM D6082 (Option A), high-temperature foaming, mL, max, tendency/stability[i]	100/0	100/0
ASTM D6922, homogeneity and miscibility	[j]	j
ASTM D6709, (Sequence VIII) shear stability	[k]	k
ASTM D7097, TEOST MHT, high temperature deposits, deposit wt, mg, max[f]	35	45
ASTM D5133, gelation index, max[c]	12[l]	NR
ASTM D4683, D4741, or D5481, High Temp./High Shear Viscosity @ 150°C, mPa·s, min	NR	2.6

[a] Tests and limits are per ASTM D4485.

[b] Does not include SAE 0W-16 and 5W-16.

[c] If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the “S” category and there is no API Certification Mark, the Sequence VG (ASTM D6593), Ball Rust (ASTM D6557), and Gelation Index (ASTM D5133) tests are not required.

[d] ASTM Surveillance Panel will review statistics annually.

[e] Calculated conversions specified in ASTM D5800 are allowed.

[f] For all viscosity grades: If CH-4, CI-4 and/or CJ-4 categories precede the "S" category and there is no API Certification Mark, the “S” category limits for phosphorus, sulfur, and the TEOST MHT do not apply. However, the CJ-4 limits for phosphorus and sulfur do apply for CJ-4 oils. This footnote cannot be applied if CK-4 or FA-4 is also claimed. Note that these “C” category oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.

[g] This is a non-critical specification as described in ASTM D3244.

[h] After 10-minute settling period.

[i] After 1-minute settling period.

[j] Shall remain homogenous and, when mixed with ASTM reference oils, shall remain miscible.

[k] Ten-hour stripped kinematic viscosity must remain in original SAE viscosity grade except XW-20 which must remain ≥5.6 mm²/s.

[l] To be evaluated from –5˚C to temperature at which 40,000 cP is attained or –40˚C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.

G.4 API SERVICE CATEGORY SN (AND RELATED CLASSIFICATIONS)

Table G-4—Requirements for API Service Category SN, API SN with "Resource Conserving", and API SN with SN PLUS

	API SN	API SN	API SN with "Resource Conserving"
	SAE 0W-16, SAE 5W-16, SAE 0W-20, SAE 5W-20, SAE 0W-30, SAE 5W-30, SAE 10W-30	Other Viscosity Grades	All Viscosity Grades
Engine Test Requirements[a]			
ASTM D7320 (Sequence IIIG)			
Kinematic viscosity increase @ 40°C, %	150 (max)	150 (max)	150 (max)
Average weighted piston deposits, merits	4.0 (min)	4.0 (min)	4.0 (min)
Hot stuck rings	None	None	None
Average cam plus lifter wear, µm	60 (max)	60 (max)	60 (max)
Or			
ASTM D8111 (Sequence IIIH)			
Kinematic viscosity increase @ 40°C, %	150 (max)	150 (max)	150 (max)
Average weighted piston deposits, merits	3.7 (min)	3.7 (min)	3.7 (min)
Hot stuck rings	None	None	None
ASTM D6891 (Sequence IVA)			
Average cam wear (7 position avg), µm	90 (max)	90 (max)	90 (max)
ASTM D6593 (Sequence VG)[b]			
Average engine sludge, merits	8.0 (min)	8.0 (min)	8.0 (min)
Average rocker cover sludge, merits	8.3 (min)	8.3 (min)	8.3 (min)
Average engine varnish, merits	8.9 (min)	8.9 (min)	8.9 (min)
Average piston skirt varnish, merits	7.5 (min)	7.5 (min)	7.5 (min)
Oil screen sludge, % area	15 (max)	15 (max)	15 (max)
Oil screen debris, % area	Rate & report	Rate & report	Rate & report
Hot-stuck compression rings	None	None	None
Cold stuck rings	Rate & report	Rate & report	Rate & report
Oil ring clogging, % area	Rate & report	Rate & report	Rate & Report
Or			
ASTM D8256 (Sequence VH)			
Average engine sludge, merits	7.6 (min)	7.6 (min)	7.6 (min)
Average rocker cover sludge, merits	7.7 (min)	7.7 (min)	7.7 (min)
Average engine varnish, merits	8.6 (min)	8.6 (min)	8.6 (min)
Average piston skirt varnish, merits	7.6 (min)	7.6 (min)	7.6 (min)
Oil screen clogging, % area	Rate & report	Rate & report	Rate & report
Hot stuck compression rings	None	None	None
ASTM D7589 (Sequence VID)[c]			
SAE XW-16 viscosity grade			
FEI SUM	NR	NR	2.8% min
FEI 2			1.3% min after 100 hours aging

SAE XW-20 viscosity grade			
FEI SUM			2.6% min
FEI 2			1.2% min after 100 hours aging
SAE XW-30 viscosity grade			
FEI SUM			1.9% min
FEI 2			0.9% min after 100 hours aging
SAE 10W-30 and all other viscosity grades not listed above			
FEI SUM			1.5% min
FEI 2			0.6% min after 100 hours aging
Or			
ASTM D8114 (Sequence VIE)[c]			
SAE XW-20 viscosity grade			
FEI SUM			3.2% min
FEI 2			1.5% min after 125 hours aging
SAE XW-30 viscosity grade			
FEI SUM			2.5% min
FEI 2			1.2% min after 125 hours aging
SAE 10W-30 and all other viscosity grades not listed above			
FEI SUM			2.2% min
FEI 2			1.0% min after 125 hours aging
ASTM D8226 (Sequence VIF)			
SAE XW-16 viscosity grade			
FEI SUM			3.7% min
FEI 2			1.8% min after 100 hours aging
ASTM D6709 (Sequence VIII)			
Bearing weight loss, mg	26 (max)	26 (max)	26 (max)
ASTM D8291 (Sequence IX)[d]			
Average number of events	5 (max)[d]	5 (max)[d]	5 (max)[d]

Bench Test and Measured Parameter[a]			
Aged oil low-temperature viscosity			
ASTM D7320, (Sequence IIIGA), aged oil low-temperature viscosity[e]	a) If CCS viscosity measured is less than or equal to maximum CCS viscosity specified for original viscosity grade, run ASTM D4684 (MRV TP-1) at MRV temperature specified in SAE J300 for original viscosity grade. b) If CCS viscosity measured is higher than maximum viscosity specified for original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for next higher viscosity grade). c) EOT IIIGA sample must show no yield stress in D4684 test and its D4684 viscosity must be below maximum specified in SAE J300 for original viscosity grade or next higher viscosity grade, depending on CCS viscosity grade, as outlined in a) or b) above.		
Or			
ASTM D7528, (ROBO Test), aged oil low-temperature viscosity[e]	d) If CCS viscosity measured is less than or equal to maximum CCS viscosity specified for original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for original viscosity grade. e) If CCS viscosity measured is higher than maximum viscosity specified for original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for next higher viscosity grade). f) EOT ROBO sample must show no yield stress in D4684 test and its D4684 viscosity must be below maximum specified in SAE J300 for original viscosity grade or next higher viscosity grade, depending on CCS viscosity grade, as outlined in a) or b) above.		
ASTM D7320, (Sequence IIIGB) phosphorus retention, % min		NR	NR	79
Or				
ASTM D8111, (Sequence IIIHB) phosphorus retention, % min		NR	NR	81
ASTM D4683, D4741, or D5481, High Temp./High Shear Viscosity @ 150°C, mPa·s, min		2.3	2.6	2.3
ASTM D6557 (Ball Rust Test), avg. gray value, min[b]		100	100	100
ASTM D5800, evaporation loss, 1 hour at 250°C, % max[f]		15	15	15
ASTM D6417, simulated distillation at 371°C, % max		10	10	10
ASTM D6795, EOFT, % flow reduction, max		50	50	50
ASTM D6794, EOWTT, % flow reduction, max				
with 0.6% H_2O		50	50	50
with 1.0% H_2O		50	50	50
with 2.0% H_2O		50	50	50
with 3.0% H_2O		50	50	50
ASTM D4951 or D5185, phosphorus % mass, max[g]		0.08[g]	NR	0.08[h]
ASTM D4951 or D5185, phosphorus % mass, min[g]		0.06[h]	0.06[h]	0.06[h]
ASTM D4951, D5185, or D2622, sulfur % mass, max[g]				
SAE 0W-16, 5W-16, 0W-20, 0W-30, 5W-20,and 5W-30		0.5[g]	NR	0.5[g]
SAE 10W-30		0.6[g]	NR	0.6[g]
All other viscosity grades		NR	NR	0.6[g]
ASTM D892 (Option A), foaming tendency				
Sequence I, mL, max, tendency/stability		10/0[i]	10/0[j]	10/0[i]
Sequence II, mL, max, tendency/stability		50/0[i]	50/0[j]	50/0[i]

Sequence III, mL, max, tendency/stability	10/0[i]	10/0[j]	10/0[i]
ASTM D6082 (Option A), high-temperature foaming mL, max, tendency/stability[i]	100/0	100/0	100/0
ASTM D6922, homogeneity and miscibility	*k*	k	k
ASTM D6709, (Sequence VIII) shear stability	*l*	l	l
ASTM D7097, TEOST MHT, high-temperature deposits, deposit wt, mg, max[g]	35	45	35
ASTM D5133, gelation index, max[b]	12*m*	NR	12[m]
ASTM D6335, TEOST 33C, high-temperature deposits, total deposit weight, mg, max			
SAE XW-16	NR	NR	NR
SAE 0W-20	NR	NR	NR
All other viscosity grades	NR	NR	30
ASTM D7563, emulsion retention	NR	NR	No water separation
ASTM D7216 Annex A2, elastomer compatibility	Table G-5	Table G-5	Table G-5

a Tests are per ASTM requirements.

b If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the “S” category and there is no API Certification Mark, the Sequence VG (ASTM D6593) or Sequence VH (ASTM D8256), Ball Rust (ASTM D6557), and Gelation Index (ASTM D5133) tests are not required.

c Viscosity grades are limited to 0W, 5W and 10W multigrade oils.

d Required only for oils claiming to meet API SN with SN PLUS or API SN with SN PLUS and “Resource Conserving”.

e Not required for monograde and 15W, 20W, and 25W multigrade oils.

f Calculated conversions specified in ASTM D5800 are allowed.

g For all viscosity grades: If CH-4, CI-4 and/or CJ-4 categories precede the "S" category and there is no API Certification Mark, the “S” category limits for phosphorus, sulfur, and the TEOST MHT do not apply. However, the CJ-4 limits for phosphorus and sulfur do apply for CJ-4 oils. This footnote cannot be applied if CK-4 or FA-4 is also claimed. Note that these “C” category oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.

h This is a non-critical specification as described in ASTM D3244.

i After 1-minute settling period.

j After 10-minute settling period.

k Shall remain homogenous and, when mixed with ASTM reference oils, shall remain miscible.

l Ten-hour stripped kinematic viscosity must remain in original SAE viscosity grade.

m To be evaluated from –5˚C to temperature at which 40,000 cP is attained or –40˚C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.

Table G-5—Elastomer Compatibility

Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2, The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed herein				
Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	% Δ	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	% Δ	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	% Δ	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	% Δ	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	% Δ	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	% Δ	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	% Δ	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	% Δ	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	% Δ	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	% Δ	-30, 30

G.5 API SERVICE CATEGORY SP (AND RELATED CLASSIFICATIONS)

Table G-6—Requirements for API Service Category SP and API SP with "Resource Conserving"

	API SP	API SP	API SP with "Resource Conserving"
	SAE 0W-16, SAE 5W-16, SAE 0W-20, SAE 5W-20, SAE 0W-30, SAE 5W-30, SAE 10W-30	Other Viscosity Grades	All Viscosity Grades
Engine Test Requirements[a]			
ASTM D8111 (Sequence IIIH)			
Kinematic viscosity increase @ 40°C, %, max	100	100	100
Average weighted piston deposits, merits, min	4.2	4.2	4.2
Hot stuck rings	None	None	None
ASTM D8350 (Sequence IVB)			
Average intake lifter volume loss (8 position avg), mm^3, max	2.7	2.7	2.7
End of test iron, ppm, max	400	400	400
ASTM D8256 (Sequence VH)[b]			
Average engine sludge, merits, min	7.6	7.6	7.6
Average rocker cover sludge, merits, min	7.7	7.7	7.7
Average engine varnish, merits, min	8.6	8.6	8.6
Average piston skirt varnish, merits, min	7.6	7.6	7.6
Oil screen sludge, % area	Rate & report	Rate & report	Rate & report
Oil screen debris, % area	Rate & report	Rate & report	Rate & report
Hot-stuck compression rings	None	None	None
Cold stuck rings	Rate & report	Rate & report	Rate & report
Oil screen clogging, % area	Rate & report	Rate & report	Rate & report
ASTM D8256 (Sequence VH)	7.6	7.6	7.6
ASTM D8114 (Sequence VIE)[c]			
SAE XW-20 viscosity grade			
FEI SUM, % min			3.8
FEI 2, % min after 125 hours aging			1.8
SAE XW-30 viscosity grade			
FEI SUM, % min			3.1
FEI 2, % min after 125 hours aging			1.5
SAE 10W-30 and all other viscosity grades not listed above			
FEI SUM, % min			2.8
FEI 2, % min after 125 hours aging			1.3
ASTM D8226 (Sequence VIF)			
SAE XW-16 viscosity grade			
FEI SUM, % min			4.1
FEI 2, % min after 125 hours aging			1.9
ASTM D6709 (Sequence VIII)			
Bearing weight loss, mg, max			
SAE XW-16	NR	NR	NR
All other viscosity grades	26	26	26

ASTM D8291 (Sequence IX)			
Average number of events for four iterations, max	5	5	5
Number of events per iteration, max	8	8	8
ASTM D8279 (Sequence X)			
% increase, max	0.085	0.085	0.085

Bench Test and Measured Parameter[a]		
Aged oil low-temperature viscosity		
ASTM D8111, (Sequence IIIHA), aged oil low-temperature viscosity[d]		
Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either IIIHA or ROBO Measure CCS viscosity of EOT IIIHA or ROBO sample at CCS temperature corresponding to original viscosity grade	a)If CCS viscosity measured is less than or equal to maximum CCS viscosity specified for original viscosity grade, run ASTM D4684 (MRV TP-1) at MRV temperature specified in SAE J300 for original viscosity grade. b)If CCS viscosity measured is higher than maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for next higher viscosity grade). c)EOT ROBO sample must show no yield stress in D4684 test and its D4684 viscosity must be below maximum specified in SAE J300 for original viscosity grade or next higher viscosity grade, depending on CCS viscosity grade, as outlined in a) or b) above.	
Or		
ASTM D7528, (ROBO Test), aged oil low-temperature viscosity[d]		
Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either IIIHA or ROBO Measure CCS viscosity of EOT IIIHA or ROBO sample at CCS temperature corresponding to original viscosity grade	d)If CCS viscosity measured is less than or equal to maximum CCS viscosity specified for original viscosity grade, run ASTM D4684 (MRV TP-1) at MRV temperature specified in SAE J300 for original viscosity grade. e)If CCS viscosity measured is higher than maximum viscosity specified for original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for next higher viscosity grade). f)EOT ROBO sample must show no yield stress in D4684 test and its D4684 viscosity must be below maximum specified in SAE J300 for original viscosity grade or next higher viscosity grade, depending on CCS viscosity grade, as outlined in d) or e) above.	
ASTM D8111, (Sequence IIIHB) phosphorus retention, % min	NR	NR 81

ASTM D4683, D4741, or D5481, High Temp./High Shear Viscosity @ 150°C, mPa·s, min	2.3	2.3	2.3
ASTM D6557 (Ball Rust Test), avg. gray value, min[b]	100	100	100
ASTM D5800, evaporation loss, 1 hour at 250°C,% max[e]	15.0	15.0	15.0
ASTM D6795, EOFT, % flow reduction, max	50	50	50
ASTM D6794, EOWTT, % flow reduction, max			
with 0.6% H_2O	50	50	50
with 1.0% H_2O	50	50	50
with 2.0% H_2O	50	50	50
with 3.0% H_2O	50	50	50
ASTM D4951 or D5185, phosphorus % mass, max[f]	0.08[g]	NR	0.08[g]
ASTM D4951 or D5185, phosphorus % mass, min[f]	0.06[g]	0.06[g]	0.06[g]
ASTM D4951, D5185, or D2622, sulfur % mass, max[f]			
SAE 0W-16, 5W-16, 0W-20, 0W-30, 5W-20, and 5W-30	0.5[f]	NR	0.5[f]
10W-30	0.6[f]	NR	0.6[f]
All other viscosity grades	NR	NR	0.6[f]
ASTM D892 (Option A and excluding paragraph 11), foaming tendency			
Sequence I, mL, max, tendency/stability	10/0[h]	10/0[i]	10/0[h]
Sequence II, mL, max, tendency/stability	50/0[h]	50/0[i]	50/0[h]
Sequence III, mL, max, tendency/stability	10/0[h]	10/0[i]	10/0[h]
ASTM D6082 (Option A), high-temperature foaming mL, max, tendency/stability[h]	100/0	100/0	100/0
ASTM D6922, homogeneity and miscibility	[j]	j	j
ASTM D6709, (Sequence VIII) shear stability			
XW-16	NR	NR	NR
All other viscosity grades	Stay in grade[k]	Stay in grade[k]	Stay in grade[k]
ASTM D6278, (Diesel Injector) shear stability, KV@100°C after 30 passes, min			
XW-16	5.8	5.8	5.8
All other viscosity grades	NR	NR	NR
ASTM D5133, gelation index, max[b]	12[l]	NR	12[l]
ASTM D6335, TEOST 33C, high-temperature deposits, total deposit weight, mg, max			
SAE XW-16	NR	NR	NR
SAE 0W-20	NR	NR	NR
All other viscosity grades	NR	NR	30
ASTM D7563, emulsion retention	NR	NR	No water separation
ASTM D7216 Annex A2, elastomer compatibility	Table G-7	Table G-7	Table G-7

[a] Tests are per ASTM requirements.

[b] If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the “S” category and there is no API Certification Mark, the Sequence VH (ASTM D8256), Ball Rust (ASTM D6557), and Gelation Index (ASTM D5133) tests are not required.

[c] Viscosity grades are limited to 0W, 5W and 10W multigrade oils.

[d] Not required for monograde and 15W, 20W, and 25W multigrade oils.

[e] Calculated conversions specified in ASTM D5800 are allowed.

[f] For all viscosity grades: If CH-4, CI-4 and/or CJ-4 categories precede the "S" category and there is no API Certification Mark, the “S” category limits for phosphorus and sulfur do not apply. However, the CJ-4 limits for phosphorus and sulfur do apply for CJ-4 oils, and the phosphorus

limit in the “SP with “Resource Conserving”” column (0.08% mass maximum) applies when CK-4 with SP or FA-4 with SP is claimed. Note that these “C” category oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.

[g] This is a non-critical specification as described in ASTM D3244.

[h] After 1-minute settling period.

[i] After 10-minute settling period.

[j] Shall remain homogenous and, when mixed with ASTM reference oils, shall remain miscible.

[k] Ten-hour stripped kinematic viscosity must remain in original SAE viscosity grade.

[l] To be evaluated from –5˚C to temperature at which 40,000 cP is attained or –40˚C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.

Table G-7—Elastomer Compatibility

Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2, The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed herein				
Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	% Δ	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	% Δ	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	% Δ	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	% Δ	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	% Δ	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	% Δ	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	% Δ	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	% Δ	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	% Δ	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	% Δ	-30, 30

Annex H

ILSAC Minimum Performance Standards for Passenger Car Engine Oils

H.1 ILSAC GF-1 MINIMUM PERFORMANCE STANDARD FOR PASSENGER CAR ENGINE OILS (OBSOLETE AUGUST 1, 1997)

H.1.1 INTRODUCTION

The American Automobile Manufacturers Association, Inc. (AAMA) and the Japan Automobile Manufacturers Association, Inc. (JAMA), through an organization called the International Lubricant Standardization and Approval Committee (ILSAC), jointly developed and approved the GF-1 minimum performance standard for gasoline-fueled passenger car motor oils.

This standard includes only the performance requirements and chemical and physical properties of those engine oils that vehicle manufacturers may deem necessary for satisfactory equipment life and performance. It is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information and to conduct its business in a manner that represents minimum risk to consumers and the environment.

This ILSAC minimum performance standard, including all of the additional requirements outlined in Section 4, comprises the first ILSAC standard for passenger car engine oils. Diesel engine oils are not covered in this specification but may be the topic of future discussions between ILSAC and groups representing diesel engine builders.

H.1.2 SUMMARY

The ILSAC GF-1 standard is composed of five parts. The first section on viscosity uses the Society of Automotive Engineers (SAE) Engine Oil Viscosity Classification, SAE J300. The second section encompasses the American Petroleum Institute (API) SH performance requirements. The third section contains specifications for bench test performance parameters, such as volatility, foaming tendency, high-temperature/high-shear rate viscosity, and filterability. The fourth section contains additional requirements including fuel efficiency, catalyst compatibility, and low-temperature viscosity. Key reference documents are listed in the final section.

The truest evaluation of an engine oil product is satisfactory performance in a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been correlated to a variety of vehicle tests.

The correlation between engine sequence tests and fleet tests is judged valid based only on the range of base oils, refining processes and additive technologies that have demonstrated satisfactory performance in widespread use at the time this standard was first issued October 22, 1990, and revised October 12, 1992. The introduction of base oils, refining processes or additive technologies that constitute a significant departure from existing practice would require supporting fleet test data and appropriate ASTM engine tests to validate the correlation between the fleet tests and engine sequence tests for that different base oil, refining process, or additive technology. This fleet testing would be in addition to the other requirements listed in this specification.

It is the responsibility of any individual or organization introducing a new technology that they claim will provide equivalent or better performance to ensure their engine test results still correlate with customer field service. Also, the marketer must ensure there is no adverse effect to vehicle components or emission control systems. No marketer can claim to be acting in a reasonable and prudent manner if the marketer knowingly uses a new technology based only on the results of engine sequence testing without verifying suitability in vehicle fleet testing that simulates the full range of customer operation.

H.1.3 MINIMUM PERFORMANCE STANDARD

The ILSAC GF-1 minimum performance standard is shown in Table H-1.

H.1.3.1 Section 1

The first section of the standard deals with viscosity. It utilizes the most widely accepted definition of viscosity, SAE J300. Table Q-1 specifies the latest revision of this document, in order to keep the ILSAC standard current.

H.1.3.2 Section 2

The second section of the standard defines ASTM engine tests and corresponding requirements used to define API SH Category engine oil performance (see 2.3.2.3[1] and ASTM D4485). The American Society for Testing and Materials (ASTM) Sequence IID test is used to define the low-temperature rust and corrosion protection provided by engine oils. High-temperature valve train wear, oil thickening, and deposits are evaluated in the ASTM Sequence IIIE test. Low- to medium-temperature sludge and wear are determined in the ASTM Sequence VE test. The L-38 test method defines the bearing corrosion protection provided by engine oils. The 1H2 or 1G2 test that defined piston cleanliness was dropped from the October 22, 1990, version of this standard because of concern over interpretation of test results. A replacement test is being sought to evaluate high-temperature deposit formation.

H.1.3.3 Section 3

The bench test requirements are outlined in Section 3. High-temperature, high-shear-rate viscosity provides an estimate of bearing oil film thickness and, thus, relates to bearing life [1]. A value of 2.9 mPa•S at 150°C and 1 million seconds^{-1} is considered by AAMA and JAMA members to provide adequate assurance of bearing durability in passenger car engines.

Volatility, as measured by either the NOACK or ASTM simulated distillation method, is included in the standard because volatility has been shown to correlate with oil consumption in the field [2, 3]. The values were selected to provide acceptable oil economy in the field. The higher allowable volatility values specified for the lighter viscosity grade oils are an acknowledgment of the difficulties encountered with existing refining equipment and/or processes when manufacturing the lighter base stocks necessary for such oils. There is a real need to improve this limit over time, and base oil manufacturers should make plans to modify equipment and/or processes to satisfy future requirements that will likely be more stringent.

A filterability test is incorporated in the standard to ensure the water tolerance of oils under low-temperature conditions. The limits in the General Motors Engine Oil Filterability Test (GM 9099P) correspond to GM's and Ford's initial fill requirements. ASTM has been requested to standardize this test and to consider having the ASTM Test Monitoring Center handle distribution of reference oils and filter paper. This would provide worldwide availability of the test method and test materials.

ASTM Foam Test (D892) limits similar to Ford and General Motors' initial fill and U.S. military specifications are incorporated in the ILSAC standard to ensure that foaming will not be a problem in current and future engines, which tend to run at higher speeds and sometimes incorporate balance shafts, both of which can promote foaming. The Sequence IV portion of this test, although not formally part of the ASTM procedure yet, is believed to correlate better with foaming under high-speed engine operating conditions. The intent of including the Sequence IV portion of this test as a report-only item is to gather data on this procedure so that, after it has become an ASTM standard, it can be added to the ILSAC standard with an appropriate maximum acceptable limit.

Two alternative flash point methods are also included in the standard, primarily to cover safety and materials handling concerns.

A shear stability requirement for the 10-hour oil sample from the L-38 test to remain within the original SAE viscosity grade is also included. An investigation into alternative shear stability methods will be conducted for possible use in future standards.

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[1] Because API SH has been obsoleted, this reference to section 2.3.2.3 is no longer valid. It is maintained to preserve the historic text of ILSAC GF-1.

Requirements for homogeneity and miscibility are included in the standard primarily as quality control checks, to ensure that the oil is blended properly (i.e., that the additives have not settled out).

Table H-1—ILSAC GF-1 Passenger Car Engine Oil Minimum Performance Standard (Obsolete August 1, 1997)

Requirement	Criterion
Viscosity Requirements	As defined by the most recent revision of SAE Standard J300
Engine Test Requirements	As defined by the most recent revision of ASTM D4485
Engine rusting	ASTM D5844 Sequence IID test
Average rust rating	8.5 (min)
Stuck lifters	None
Wear and oil thickening	ASTM D5533 Test Method Sequence IIIE
Increase in viscosity at 40°C	375% (max)
Piston skirt varnish	8.9 (min)
Ring land deposits	3.5 (min)
Average engine sludge	9.2 (min)
Stuck piston rings	No oil related
Cam and lifter wear	
Average, mm	30 (max)
Maximum, mm	64 (max)
Oil consumption, l	5.1 (max)
Sludge and wear	ASTM D5302 Test Method Sequence VE
Average engine sludge	9.0 (min)
Rocker cover sludge	7.0 (min)
Average engine varnish	5.0 (min)
Piston skirt varnish	6.5 (min)
Cam wear	
Average, mm	130 (max)
Maximum, mm	380 (max)
Oil ring clogging[a]	15% (max)
Oil screen clogging	20% (max)
Hot-stuck rings	None
Bearing corrosion	ASTM D5119 Test Method L-38
Bearing weight loss, mg	40 (max)
Piston skirt varnish	9.0 (min)

Table H-1—ILSAC GF-1 Passenger Car Engine Oil Minimum Performance Standard (continued) (Obsolete August 1, 1997)

Requirement	Criterion
Bench Test Requirements	
HTHS viscosity at 150°C and 10^6 s^{-1}	ASTM D4683, ASTM D4741, or CEC L-36-A-90
For all viscosity grades, mPa • S	2.9 (min)
Volatility	Sim. dis. (ASTM D2887) or evaporative loss (CEC L-40-A-93)
ASTM D2887	20% (max) at 371°C (0W, 5W multigrades)
	17% (max) at 371°C (all other multigrades)
CEC L-40-A-93	25% (max) 1 hr at 250°C (0W, 5W multigrades)
	20% (max) 1 hr at 250°C (all other multigrades)
Filterability	
GM 9099P EOFT	50% (max) flow reduction
Foaming tendency	ASTM D892 (Option A)
Foaming, ml	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Sequence IV	Report
Settling[b], ml	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
Sequence IV	Report
Flash point	ASTM D93 or D92
ASTM D93	185°C (min)
ASTM D92	200°C (min)
Shear stability	
L-38 test 10-hour stripped viscosity	Must remain in original SAE viscosity grade
Homogeneity and miscibility	
Federal Test Method 791B, Method 3470	Shall remain homogenous and, when mixed with SAE reference oils, shall remain miscible

Table H-1—ILSAC GF-1 Passenger Car Engine Oil Minimum Performance Standard (continued) (Obsolete August 1, 1997)

Additional Requirements			
Fuel efficiency			
ASTM RR-D:2-1204 Sequence VI Test improvement (EFEI)	2.7% (min)		
Catalyst compatibility			
Phosphorus content	0.12 mass % (max)		
SAE J300 low-temperature viscosity, mPa•S	0W	5W	10W
Cranking	3,250 at -30°C (max)	3,500 at -25°C (max)	3,500 at -20°C (max)
Pumping	30,000 at -35°C (max)	30,000 at -30°C (max)	30,000 at -25°C (max)

Notes:

[a] Effective October 8, 1993, the Oil Ring Clogging parameter has been suspended as a requirement for the Sequence VE test. Therefore, it has been removed as a requirement for licensing. For any programs that include more than one Sequence VE test and the test completion dates include dates both before and after October 8, 1993, Oil Ring Clogging should be ignored for these tests. ASTM re-evaluated this issue in June 1994 and decided to suspend this parameter indefinitely.

[b] Settling determined after 5 minutes, except Sequence IV, in which settling is determined after 5 seconds. Sequence IV test conditions are the same as those in Sequence I, except that the temperature is 150°C and the minimum flow rate is 200 milliliters

H.1.3.4 Section 4

Section 4 of the ILSAC standard incorporates additional requirements. All three of the additional requirements listed in Section 4 must be met in order for an oil to satisfy the licensing requirements of the API Certification Mark in the API Engine Oil Licensing and Certification System (EOLCS). The fuel efficiency requirement is important since widespread use of engine oils providing at least a 2.7 percent fuel economy improvement in the ASTM Sequence VI test could provide fuel savings in the country as a whole as compared to what the situation would be if other oils were used, although the fuel economy obtained by individual vehicle operators may differ because of many factors.

No currently acceptable standard test exists for determining the catalyst poisoning effect of engine oils. In the absence of such a test, and since it has been shown that engine-oil-derived phosphorus poisons emission control devices [4], it is believed prudent to limit the phosphorus content of the engine oil to 0.12 mass percent maximum.

The last portion of Section 4 of the standard deals with the low-temperature viscosity of engine oils, as defined by SAE J300. The low-temperature viscometric properties of multiviscosity grade engine oils are important as they relate to cold starting performance in gasoline-fueled passenger cars.

H.1.3.5 Section 5

Section 5 of the standard references procedures for conducting the tests included in the standard.

References

1. Spearot, J. A.; Murphy, C. K.; and Deysarkar, A. K.; “Interpreting Experimental Bearing Oil Film Thickness Data” (Paper No. 892151), Society of Automotive Engineers, Warrendale, Pennsylvania.

2. Didot, F. E.; Green, E.; and Johnson, R. H.; “Volatility and Oil Consumption of SAE 5W-30 Engine Oil” (Paper No. 872126), Society of Automotive Engineers, Warrendale, Pennsylvania.

3. Carey, L. R.; Roberts, D. C.; and Shaub, H.; “Factors Influencing Engine Oil Consumption in Today’s Automotive Engines” (Paper No. 892159), Society of Automotive Engineers, Warrendale, Pennsylvania.

4. SAE Fuels and Lubricants Technical Committee 1, *Engine Oil/Catalyst and Oxygen Sensor Compatibility Task Force Status Report*, Society of Automotive Engineers, Warrendale, Pennsylvania, October 1985.

H.2 ILSAC GF-2 MINIMUM PERFORMANCE STANDARD FOR PASSENGER CAR ENGINE OILS (OBSOLETE MARCH 31, 2002)

The American Automobile Manufacturers Association of the United States, Inc. (AAMA) and the Japan Automobile Manufacturers Association, Inc. (JAMA), through an organization called the International Lubricants Standardization and Approval Committee (ILSAC), jointly developed and approved an ILSAC GF-2 minimum performance standard for gasoline-fueled passenger car engine oils.

This standard specifies the minimum performance requirements (both engine sequence and bench tests) and chemical and physical properties for those engine oils that vehicle manufacturers deem necessary for satisfactory equipment performance and life.

In addition to meeting the requirements of the standard as shown in Table H-2, it is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information when marketing products meeting the GF-2 standard. It is also the marketer's responsibility to conduct its business in a manner that represents minimum risk to consumers and the environment.

The ultimate assessment of an engine oil's performance must include a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been correlated to a variety of vehicle tests.

The correlation between engine sequence tests and vehicle fleet tests is judged valid based only on the range of base oils and additive technologies that have proven to have satisfactory performance in service and that are in widespread use at this time. The introduction of base oils or additive technologies that constitute a significant departure from existing practice requires sufficient supporting vehicle fleet testing data to validate the correlation between vehicle and ASTM sequence test performance and to ensure there is no adverse effect to vehicle components or to emission control systems. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in this specification.

It is the responsibility of any individual or organization introducing a new technology to perform this vehicle fleet testing, and the responsibility of the oil marketer to ensure the above testing of new technology was satisfactorily completed. No marketer can claim to be acting in a reasonable and prudent manner if the marketer knowingly uses a new technology based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing that simulates the full range of customer operation.

The ILSAC GF-2 Minimum Performance Standard includes the new Sequence VIA test. Viscosity Grade Read Across and Base Oil Interchange Guidelines have been developed specifically for the Sequence VIA test. These guidelines will be reviewed and, if appropriate, updated by API with the approval of AAMA. The current guidelines can be applied for viscosity grade read across and base oil interchange in the Sequence IID, IIIE, and VE and L-38 tests. API has been requested to continue to solicit and review data confirming the applicability of these guidelines to GF-2 oils. Oil marketers use the above guidelines at their own judgment and at their own risk. The use of these guidelines does not absolve the marketer of the responsibility for meeting all specified requirements for any products the marketer sells in the marketplace that are licensed as ILSAC GF-2 with API.

Note: This paragraph has been updated since the ILSAC GF-2 Minimum Performance Standard was issued November 6, 1995.

Table H-2—ILSAC GF-2 Passenger Car Engine Oil Minimum Performance Standard (Obsolete March 31, 2002)

Requirement	Criterion	
Viscosity Requirements	Viscosity, mPa•S, at Temperature, °C	
	Cranking	Pumping
	ASTM D5293	ASTM D4684
	3500 (max) at -20°C	60,000 cP (max) at -30°C
	Gelation Index ASTM D5133:	
	12.0 (max)	
	To be evaluated from -5°C to temperature at which 40,000 cP is attained or -40°C, whichever occurs first	
Engine Test Requirements		
Engine rusting	ASTM D5844 Sequence IID test	
Average rust rating	8.5 (min)	
Stuck lifters	None	
Wear and oil thickening	ASTM D5533 Test Method Sequence IIIE	
Hours to 375% increase in viscosity @ 40°C	64 (min)	
Piston skirt varnish	8.9 (min)	
Ring land deposits	3.5 (min)	
Average engine sludge	9.2 (min)	
Stuck piston rings	No oil related	
Cam and lifter wear		
Average, mm	30 (max)	
Maximum, mm	64 (max)	
Oil consumption, l	5.1 (max)	
Sludge and wear	ASTM D5302 Test Method Sequence VE	
Average engine sludge	9.0 (min)	
Rocker cover sludge	7.0 (min)	
Average engine varnish	5.0 (min)	
Piston skirt varnish	6.5 (min)	
Cam wear		
Average, mm	127 (max)	
Maximum, mm	380 (max)	
Oil screen clogging	20% (max)	
Hot-stuck rings	None	
Piston undercrown deposits	Rate and report	
Ring land deposits	Rate and report	
Cylinder bore wear	Rate and report	
Oil ring clogging	Rate and report	

Table H-2—ILSAC GF-2 Passenger Car Engine Oil Minimum Performance Standard (Obsolete March 31, 2002)

Requirement	Criterion
Engine Test Requirements (cont'd)	
Bearing corrosion	ASTM D5119 Test Method L-38
Bearing weight loss, mg	40 (max)
Fuel economy improvement (FEI)	ASTM D6202 Sequence VIA Test • For SAE 0W-20 and 5W-20 viscosity grades: 1.4% (min) vs. ASTM BC-2 • For other SAE 0W and 5W multi-viscosity grades: 1.1% (min) vs. ASTM BC-2 • For all SAE 10W multi-viscosity grades: 0.5% (min) vs. ASTM BC-2
Bench Test Requirements	
Volatility	Simulated distillation (ASTM D2887 extended) or (ASTM D5480): 17% (max) at 371°C - or - Evaporative loss (CEC L-40-A-93) or JPI 5S-41-93 (Method B) 22% (max), 1 h at 250°C
Filterability	GM 9099P EOFT 50% (max) flow reduction allowable GM EOFT with following modifications (Rate and Report only): 1. Dry ice is not to be used during sample preparation. 2. Sample is to be placed in oven at 70°C for 6.0 hours (±0.25 hours). 3. Tests to be run at 0.6, 1.0, 2.0, and 3.0% water. 4. Test formulation with the highest additive (DI/VI) combination. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different (DI/VI) combination must be tested.
Foaming tendency	ASTM D892 (Option A)
Foaming, ml	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Settling[a] ml	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
High temperature foaming[b]	
Static foam max, tendency/stability	200/50[c]
Flash point	ASTM D93 (ISO 2719) or ASTM D92
ASTM D93 (ISO 2719)	185°C (min)
ASTM D92	200°C (min)

Table H-2—ILSAC GF-2 Passenger Car Engine Oil Minimum Performance Standard (Obsolete March 31, 2002)

Requirement	Criterion
Bench Test Requirements (continued)	
Shear stability	
L-38 test 10-hour stripped viscosity	Must remain in original SAE viscosity grade
Homogeneity and miscibility	
Federal Test Method 791B, Method 3470	Shall remain homogenous and, when mixed with SAE reference oils, shall remain miscible
Additional Requirements:	
High temperature deposits	
Chrysler TEOST Test (Method 33)	60 mg deposit (max)
Catalyst Compatibility	ASTM D4951 or ASTM D5185
Phosphorus Content, mass %	0.10 (max)

[a] Settling determined after 10 minutes.

[b].Follow High Temperature Foam Test in ASTM D6082.

[c] Settling determined after 1 minute.

H.3 ILSAC GF-3 MINIMUM PERFORMANCE STANDARD FOR PASSENGER CAR ENGINE OILS (OBSOLETE APRIL 30, 2004)

The Japan Automobile Manufacturers Association, Inc. and representatives from DaimlerChrysler Corporation, Ford Motor Company and General Motors Corporation, through an organization called the International Lubricant Standardization and Approval Committee (ILSAC), jointly developed and approved an ILSAC GF-3 minimum performance standard for gasoline-fueled passenger car engine oils.

This standard specifies the minimum performance requirements (both engine sequence and bench tests) and chemical and physical properties for those engine oils that vehicle manufacturers deem necessary for satisfactory equipment performance and life.

In addition to meeting the requirements of the standard as shown in Table H-3, it is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information when marketing products meeting the GF-3 standard. It is also the marketer's responsibility to conduct its business in a manner which represents minimum risk to consumers and the environment.

The ultimate assessment of an engine oil's performance must include a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been correlated to a variety of vehicle tests.

The correlation between engine sequence tests and vehicle fleet tests is judged valid based only on the range of base oils and additive technologies that have proven to have satisfactory performance in service and that are in widespread use at this time. The introduction of base oils or additive technologies which constitute a significant departure from existing practice requires sufficient supporting vehicle fleet testing data to validate the correlation between vehicle and ASTM sequence test performance and to ensure there is no adverse effect to vehicle

components or to emission control systems. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in this specification.

Engine oil compatibility with sealing materials and gaskets is not controlled by performance tests in this specification. However, an SAE Committee on Automotive Rubber Specifications (CARS) has established a slate of reference elastomers that may be used for testing of different base oils and additive technologies that constitute a significant departure from existing materials. The CARS committee has also established an ASTM reference oil (TMC1006) that should be considered as an aggressive oil and could also be used as a reference. ILSAC recommends that additive or base oil technologies that exceed the aggression of this reference oil be revised or adequately field tested to ensure no chance of customer seal failures when placed in commercial service.

It is the responsibility of any individual or organization introducing a new technology to perform this vehicle fleet testing, and the responsibility of the oil marketer to ensure the above testing of new technology was satisfactorily completed. No marketer can claim to be acting in a reasonable and prudent manner if the marketer knowingly uses a new technology based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing that simulates the full range of customer operation.

The ILSAC GF-3 Minimum Performance Standard includes the new Ball Rust Test, the new Sequence IIIF test, the new Sequence IVA test, the new Sequence VG test, the new Sequence VIB test, the new Sequence VIII test, and the new TEOST MHT test. Viscosity grade read across and base oil interchange for these tests may be applicable after VGRA and BOI Guidelines for them are supported by test data and developed by the appropriate groups. It should be pointed out, however, that when oil marketers use the guidelines, they do so based on their own judgment and at their own risk. The use of these guidelines does not absolve the marketer of the responsibility for meeting all specified requirements for any products the marketer sells in the marketplace that are licensed as ILSAC GF-3 with API.

Table H-3—ILSAC GF-3 Passenger Car Engine Oil Minimum Performance Standard (Obsolete April 30, 2004)

Requirement	Criterion
Viscosity Requirements	Oils shall meet all requirements of SAE J300 and low temperature requirements of either SAE 0W, 5W or 10W viscosity grades
	Gelation Index ASTM D5133: 12.0 (max) To be evaluated from -5°C to temperature at which 40,000 cP is attained or -40°C, whichever occurs first
Engine Test Requirements	
Engine rusting	ASTM D6557 Ball Rust Test
Average rust rating	100 (min)
Wear and oil thickening	ASTM D6984 Test Method Sequence IIIF
Viscosity increase (kV 40°C)	275% (max)
Low temp viscosity	Report[a]
Average piston skirt varnish rating	9.0 (min)
Weighted piston deposit rating	4.0 (min)
Hot stuck piston rings	None allowed
Cam plus lifter wear, average, mm	20 (max)
Oil consumption, l	5.2 (max)

Table H-3—ILSAC GF-3 Passenger Car Engine Oil Minimum Performance Standard (continued) (Obsolete April 30, 2004)

Requirement	Criterion
Engine Test Requirements (continued)	
Cam wear	ASTM D5302 Test Method Sequence VE[b]
Average, mm	127 (max)
Maximum, mm	380 (max)
Sludge and varnish	ASTM D6593 Test Method Sequence VG Test
Average engine sludge rating	7.8 (min)
Rocker cover sludge rating	8.0 (min)
Average engine varnish rating	8.9 (min)
Average piston skirt varnish rating	7.5 (min)
Oil screen clogging,%	20 (max)
Hot-stuck compression rings	None
Cold stuck rings	Rate and report
Oil screen debris,%	Rate and report
Oil ring clogging	Rate and report
Valvetrain Wear	ASTM D6891 Test Method Sequence IVA Test
Average cam wear (7 position avg.), mm	120 (max)
Bearing Corrosion	ASTM D6709 Test Method Sequence VIII Test
Bearing weight loss, mg	26.4 (max)
Fuel Economy Improvement	ASTM D6837 Test Method Sequence VIB Test[c] For SAE 0W-20 and 5W-20 viscosity grades: 2.0% FEI 1 (min) after 16 hours aging 1.7% FEI 2 (min) after 96 hours aging For SAE 0W-30 and 5W-30 viscosity grades: 1.6% FEI 1 (min) after 16 hours aging 1.3% FEI 2 (min) after 96 hours aging Sum of FEI 1 and FEI 2 must be 3.0% (min) For SAE 10W-30 and all other viscosity grades not listed above: 0.9% FEI 1 (min) after 16 hours aging 0.6% FEI 2 (min) after 96 hours aging Sum of FEI 1 and FEI 2 must be 1.6% (min)
Bench Test Requirements	
Volatility	
Evaporation loss	ASTM D5800 15% (max), 1 hour at 250°C
Simulated distillation	ASTM D6417 10% (max) at 371°C

Table H-3—ILSAC GF-3 Passenger Car Engine Oil Minimum Performance Standard (continued) (Obsolete April 30, 2004)

Requirement	Criterion
Bench Test Requirements (continued)	
High temperature deposits	ASTM D7097 (TEOST MHT-4)
Deposit Weight, mg	45 (max)
Filterability	
GM 9099P EOFT	50% (max) flow reduction allowable
GM EOFT (modified)	GM EOFT with following modifications (Rate and Report only): 1. Dry ice is not to be used during sample preparation. 2. Sample is to be placed in oven at 70°C for 6.0 hours (±0.25 hours). 3. Tests to be run at 0.6, 1.0, 2.0, and 3.0% water. 4. Test formulation with the highest additive (DI/VI) combination. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different (DI/VI) combination must be tested.
Foaming tendency	ASTM D892 (Option A)
Foaming, ml	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Settling[d] ml	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
High temperature foaming	ASTM D6082 (optional blending required)
Foaming, ml	100 (max)
After settling[e], ml	0 (max)
Shear stability	ASTM D6709 Test Method Sequence VIII Test
10-hour stripped 100°C kinematic viscosity	Must remain in original SAE viscosity grade
Homogeneity and miscibility	ASTM D6922, Method 3470.1 Shall remain homogeneous and, when mixed with SAE reference oils, shall remain miscible
Catalyst compatibility	ASTM D4951 or D5185
Phosphorus content	0.10 mass % (max)

[a] 80-hour test oil sample shall be evaluated by ASTM Test Method D 4684 (MRV TP-1) at the temperature indicated by the low-temperature grade of oil as determined on the 80-hour sample by ASTM Test Method D 5293 (CCS viscosity).

[b] Not required for oils containing a minimum of 0.08% phosphorus in the form of zinc dialkyldithiophosphates (ZDDP).

[c] All FEI 1 and FEI 2 values determined relative to ASTM Reference Oil BC.

[d] Settling determined after 10 minutes.

[e] Settling determined after 1 minute.

H.4 ILSAC GF-4 MINIMUM PERFORMANCE STANDARD FOR PASSENGER CAR ENGINE OILS (OBSOLETE SEPTEMBER 30, 2011)

The Japan Automobile Manufacturers Association, Inc. and representatives from DaimlerChrysler Corporation, Ford Motor Company and General Motors Corporation, through an organization called the International Lubricants Standardization and Approval Committee (ILSAC), jointly developed and approved an ILSAC GF-4 minimum performance standard for gasoline-fueled passenger car engine oils.

This standard specifies the minimum performance requirements (both engine sequence and bench tests) and chemical and physical properties for those engine oils that vehicle manufacturers deem necessary for satisfactory equipment performance and life.

In addition to meeting the requirements of the standard, it is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information when marketing products meeting the GF-4 standard. It is also the marketer's responsibility to conduct its business in a manner which represents minimum risk to consumers and the environment.

The ultimate assessment of an engine oil's performance must include a variety of vehicle fleet tests which simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been judged to be predictive of a variety of vehicle tests.

The relationships between engine sequence tests and vehicle fleet tests are judged valid based only on the range of base oils and additive technologies investigated—generally those which have proven to have satisfactory performance in service, and which are in widespread use at this time. The introduction of base oils or additive technologies which constitute a significant departure from existing practice requires sufficient supporting vehicle fleet testing data to ensure there is no adverse effect to vehicle components or to emission control systems. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in this specification.

Engine oil compatibility with sealing materials and gaskets is not controlled by performance tests in this specification. However, an SAE Committee on Automotive Rubber Specifications (CARS) has established a slate of reference elastomers (see SAE J2643) which may be used for testing of different base oils and additive technologies which constitute a significant departure from existing materials. The CARS committee has also established an ASTM reference oil (Service Oil 105) which should be considered as an aggressive oil and could also be used as a reference. ILSAC recommends that additive or base oil technologies that exceed the aggression of this reference oil be revised or adequately field tested to ensure no chance of customer seal failures when placed in commercial service.

It is the responsibility of any individual or organization introducing a new technology to perform this vehicle fleet testing, and the responsibility of the oil marketer to ensure the above testing of new technology was satisfactorily completed. No marketer can claim to be acting in a reasonable and prudent manner if the marketer knowingly uses a new technology based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing which simulates the full range of customer operation.

The ILSAC GF-4 Minimum Performance Standard includes tests for which Viscosity Grade Read Across and Base Oil Interchange Guidelines have been developed by the appropriate groups. It should be pointed out, however, that when oil marketers use the Guidelines, they do so based on their own judgment and at their own risk. The use of any guidelines does not absolve the marketer of the responsibility for meeting all specified requirements for any products the marketer sells in the marketplace that are licensed as ILSAC GF-4 with API.

Table H-4—ILSAC GF-4 Passenger Car Engine Oil Minimum Performance Standard (Obsolete September 30, 2011)

Requirement	Criterion
Viscosity Requirements	Oils shall meet all requirements of SAE J300. Viscosity grades are limited to SAE 0W, 5W, and 10W multigrade oils.
	Gelation Index ASTM D5133: 12 (max) To be evaluated from -5˚C to temperature at which 40,000 cP is attained or -40˚C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.
Engine Test Requirements	
Wear and oil thickening	ASTM D7320 Test Method Sequence IIIG
Kinematic viscosity increase @ 40°C, %	150 (max)
Average weighted piston deposits, merits	3.5 (min)
Hot stuck rings	None
Average cam plus lifter wear, µm	60 (max)
Aged oil low-temperature viscosity	ASTM Sequence IIIGA
Evaluate the EOT oil from the ASTM Sequence IIIGA test with ASTM D4684 (MRV TP-1)	The ASTM D4684 viscosity of the EOT sample must meet the requirements of the original grade or the next higher grade
Wear, sludge, and varnish	
Average engine sludge, merits	ASTM Sequence VG (ASTM D6593)
Average rocker cover sludge, merits	7.8 (min)
Average engine varnish, merits	8.0 (min)
Average piston skirt varnish, merits	8.9 (min)
Oil screen sludge, % area	7.5 (min)
Oil screen debris, % area	20 (max)
Hot-stuck compression rings	Rate and report
Cold stuck rings	None
Oil ring clogging, % area	Rate and report
Follower pin wear, cyl #8, avg, µm	Rate and report
Ring gap increase, cyl #1 and #8, avg, µm	Rate and report[a]
Wear, sludge, and varnish	Rate and report[a]

Table H-4—ILSAC GF-4 Passenger Car Engine Oil Minimum Performance Standard (continued) (Obsolete September 30, 2011)

Requirement	Criterion
Engine Test Requirements (continued)	
Valvetrain wear	ASTM Sequence IVA (ASTM D6891)
Average cam wear (7 position avg.), µm	90 (max)
Bearing corrosion	ASTM Sequence VIII (ASTM D6709)
Bearing weight loss, mg	26 (max)
Fuel Efficiency	ASTM Sequence VIB[b] (ASTM D6837) SAE 0W-20 and 5W-20 viscosity grades: 2.3% FEI 1 (min) after 16 hours aging 2.0% FEI 2 (min) after 96 hours aging SAE 0W-30 and 5W-30 viscosity grades: 1.8% FEI 1 (min) after 16 hours aging 1.5% FEI 2 (min) after 96 hours aging SAE 10W-30 and all other viscosity grades not listed above: 1.1% FEI 1 (min) after 16 hours aging 0.8% FEI 2 (min) after 96 hours aging
Bench Test Requirements	
Catalyst compatibility	
Phosphorus content, % (mass)	ASTM D4951 0.08 (max)
Sulfur content	ASTM D4951 or D 2622
SAE 0W and 5W multigrades, % (mass)	0.5 (max)
SAE 10W multigrades, % (mass)	0.7 (max)
Wear	
Phosphorus Content, % (mass)	ASTM D4951 0.06 (min)
Volatility	
Evaporation loss, %	ASTM D5800, 1 hour at 250°C 15 (max) (Note: Calculated conversions specified in D 5800 are allowed.)
Simulated distillation, %	ASTM D6417 10 (max) at 371°C
High temperature deposits	ASTM D7097 (TEOST MHT)
Deposit Weight, mg	35 max

Table H-4—ILSAC GF-4 Passenger Car Engine Oil Minimum Performance Standard (continued) (Obsolete September 30, 2011)

Requirement	Criterion
Bench Test Requirements (continued)	
Filterability	
EOWTT, %	ASTM D6794
with 0.6% H_2O	50 (max) flow reduction
with 1.0% H_2O	50 (max) flow reduction
with 2.0% H_2O	50 (max) flow reduction
with 3.0% H_2O	50 (max) flow reduction
	(Note: Test formulation with highest additive (DI/VI) concentration. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different DI/VI combination must be tested.)
EOFT	ASTM D6795
	50 (max) flow reduction
Foaming characteristics	ASTM D892 (Option A)
Tendency, mL	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Stability[c], mL	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
High temperature foaming characteristics	ASTM D6082 (Option A)
Tendency, mL	100 (max)
Stability[d], mL	0 (max)
Shear stability	ASTM Sequence VIII (ASTM D6709)
10-hour stripped KV @ 100°C	Kinematic viscosity must remain in original SAE viscosity grade.
Homogeneity and miscibility	ASTM D6922
	Shall remain homogeneous and, when mixed with ASTM reference oils, shall remain miscible.
Engine rusting	Ball Rust Test (ASTM D6557)
Average gray value	100 (min)

[a] ASTM Surveillance Panel will review statistics annually.

[b] All Fuel Economy Improvement (FEI) 1 and FEI 2 values determined relative to ASTM Reference Oil BC.

[c] After 10-minute settling period.

[d] After 1-minute settling period.

Applicable Documents:

1. SAE Standard, Engine Oil Viscosity Classification—SAE J300, *SAE Handbook*.
2. SAE Standard, Standard Reference Elastomers (SRE) for Characterizing the Effects on Vulcanized Rubbers, Proposed Draft 2003-5—SAE J2643, *SAE Handbook*.
3. ASTM Annual Book of Standards, Volume 5, Petroleum Products and Lubricants, current edition.
4. ASTM Sequence IIIG Test Research Report.
5. M. Batko and D. F. Florkowski, “Low Temperature Rheological Properties of Aged Crankcase Oils,” SAE Paper 2000-01-2943.
6. M. Batko and D. F. Florkowski, “Lubricant Requirements of an Advanced Designed High Performance, Fuel Efficient Low Emissions V-6 Engine,” SAE Paper 01FL-265

H.5 ILSAC GF-5 STANDARD FOR PASSENGER CAR ENGINE OILS (OBSOLETE APRIL 30, 2021)

The Japan Automobile Manufacturers Association, Inc. and representatives from Chrysler Group LLC, Ford Motor Company and General Motors LLC, through an organization called the International Lubricants Standardization and Approval Committee (ILSAC), jointly developed and approved an ILSAC GF-5 minimum performance standard for engine oils for spark-ignited internal combustion engines.

This standard specifies the minimum performance requirements (both engine sequence and bench tests) and chemical and physical properties for engine oils for spark-ignited internal combustion engines. It is expected that many engine manufacturers will recommend ILSAC GF-5 oil. However, performance parameters other than those covered by the tests included or more stringent limits on those tests included in this standard may be required by individual OEMs.

In addition to meeting the requirements of the standard, it is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information when marketing products meeting the ILSAC GF-5 standard. It is also the marketer's responsibility to conduct its business in a manner that represents minimum risk to consumers and the environment.

The ultimate assessment of an engine oil's performance must include a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been judged to be predictive of a variety of vehicle tests.

The relationships between engine sequence tests and vehicle fleet tests are judged valid based only on the range of base oils and additive technologies investigated — generally those that have proven to have satisfactory performance in service and that are in widespread use at this time. The introduction of base oils or additive technologies that constitute a significant departure from existing practice requires sufficient supporting vehicle fleet testing data to ensure there is no adverse effect to vehicle components or to emission control systems. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in this specification.

It is the responsibility of any individual or organization introducing a new technology to perform this vehicle fleet testing, and the responsibility of the oil marketer to ensure the testing of new technology was satisfactorily completed. No marketer can claim to be acting in a reasonable and prudent manner if they knowingly use a new technology based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing that simulates the full range of customer operation.

The ILSAC GF-5 Minimum Performance Standard includes tests for which Viscosity Grade Read Across and Base Oil Interchange Guidelines have been developed by the appropriate groups. It should be pointed out, however, that when oil marketers use the guidelines, they do so based on their own judgment and at their own risk. The use of any guidelines does not absolve the marketer of the responsibility for meeting all specified requirements for any products the marketer sells in the marketplace that are licensed as ILSAC GF-5 with API.

Table H-5—ILSAC GF-5 Passenger Car Engine Oil Standard (Obsolete April 30, 2021)

Requirement	Criterion
Viscosity Requirements	
SAE J300	Oils shall meet all requirements of SAE J300. Viscosity grades are limited to SAE 0W, 5W, and 10W multigrade oils.
Gelation Index	ASTM D5133: 12 (max) To be evaluated from -5˚C to temperature at which 40,000 cP is attained or -40˚C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.
High Temperature/High Shear Viscosity @ 150°C, mPa·s	ASTM D4683, D4741, or D5481 2.6 (min)
Engine Test Requirements	
Wear and oil thickening	ASTM Sequence IIIG (ASTM D7320)
Kinematic viscosity increase @ 40°C, %	150 (max)
Average weighted piston deposits, merits	4.0 (min)
Hot stuck rings	None
Average cam plus lifter wear, µm	60 (max)
Or	
Deposit and oil thickening[1]	ASTM Sequence IIIH (ASTM D8111)
Kinematic viscosity increase @ 40°C, %	150 (max)
Average weighted piston deposits, merits	3.7 (min)
Hot stuck rings	None
Aged oil low-temperature viscosity Evaluate the EOT oil from the ASTM Sequence IIIGA test with ASTM D4684 (MRV TP-1)	ASTM Sequence IIIGA The ASTM D4684 viscosity of the EOT sample must meet the requirements of the original grade or the next higher grade
Wear, sludge, and varnish	ASTM Sequence VG (ASTM D6593)
Average engine sludge, merits	8.0 (min)
Average rocker cover sludge, merits	8.3 (min)
Average engine varnish, merits	8.9 (min)
Average piston skirt varnish, merits	7.5 (min)
Oil screen sludge, % area	7.5 (min)
Oil screen debris, % area	15 (max)
Hot-stuck compression rings	None
Cold stuck rings	Rate and report
Oil ring clogging, % area	Rate and report
Or	
Wear, sludge, and varnish	ASTM Sequence VH (ASTM D8256)
Average engine sludge, merits	7.6 (min)
Average rocker cover sludge, merits	7.7 (min)
Average engine varnish, merits	8.6 (min)
Average piston skirt varnish, merits	7.6 (min)
Oil screen clogging, % area	Rate & report
Hot stuck compression rings	None

[1] Per ballot 4131

Table H-5—ILSAC GF-5 Passenger Car Engine Oil Standard (continued) (Obsolete April 30, 2021)

Requirement	Criterion
Engine Test Requirements (continued)	
Valvetrain wear	ASTM Sequence IVA (ASTM D6891)
Average cam wear (7 position avg), µm	90 (max)
Bearing corrosion	ASTM Sequence VIII (ASTM D6709)
Bearing weight loss, mg	26 (max)
Fuel efficiency	ASTM Sequence VID (ASTM D7589)
SAE XW-20 viscosity grade	
FEI SUM	2.6% min
FEI 2	1.2% min after 100 hours aging
SAE XW-30 viscosity grade	
FEI SUM	1.9% min
FEI 2	0.9% min after 100 hours aging
SAE 10W-30 and all other viscosity grades not listed above	
FEI SUM	1.5% min
FEI 2	0.6% min after 100 hours aging
Or	
Fuel efficiency	ASTM Sequence VIE (ASTM D8114)
SAE XW-20 viscosity grade	
FEI SUM	3.2% min
FEI 2	1.5% min after 125 hours aging
SAE XW-30 viscosity grade	
FEI SUM	2.5% min
FEI 2	1.2% min after 125 hours aging
SAE 10W-30 and all other viscosity grades not listed above	
FEI SUM	2.2% min
FEI 2	1.0% min after 125 hours aging
Bench Test Requirements	
Catalyst compatibility	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.08 (max)
Phosphorus volatility (Sequence IIIGB, phosphorus retention)	ASTM D7320 79% (min)
OR	
Phosphorus volatility (Sequence IIIHB, phosphorus retention)	ASTM D8111 81% (min)
Sulfur content	ASTM D4951, D5185, or D2622
SAE 0W and 5W multigrades, % (mass)	0.5 (max)
SAE 10W-30, % (mass)	0.6 (max)
Wear	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.06 (min)

Table H-5—ILSAC GF-5 Passenger Car Engine Oil Standard (continued)
(Obsolete April 30, 2021)

Requirement	Criterion
Bench Test Requirements (continued)	
Volatility	ASTM D5800
Evaporation loss, %	15 (max), 1 hour at 250°C (Note: Calculated conversions specified in D5800 are allowed.)
Simulated distillation, %	ASTM D6417 10 (max) at 371°C
High temperature deposits	TEOST MHT (ASTM D7097)
Deposit weight, mg	35 (max)
High temperature deposits	TEOST 33C (ASTM D6335)
Total deposit weight, mg	30 (max) Note: No TEOST 33C limit for SAE 0W-20.
Filterability	ASTM D6794
EOWTT, %	
with 0.6% H_2O	50 (max) flow reduction
with 1.0% H_2O	50 (max) flow reduction
with 2.0% H_2O	50 (max) flow reduction
with 3.0% H_2O	50 (max) flow reduction Note: Test formulation with highest additive (DI/VI) concentration. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different DI/VI combination must be tested.
EOFT, %	ASTM D6795 50 (max) flow reduction
Fresh oil foaming characteristics	ASTM D892 (Option A and excluding paragraph 11)
Tendency, mL	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Stability, mL, after 1-minute settling	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
Fresh oil high temperature foaming characteristics	ASTM D6082 (Option A)
Tendency, mL	100 (max)
Stability, mL, after 1-minute settling	0 (max)
Aged oil low temperature viscosity	ROBO (ASTM D7528)
Measure CCS viscosity of EOT ROBO sample at CCS temperature corresponding to original viscosity grade	a) If CCS viscosity measured is less than or equal to maximum CCS viscosity specified for original viscosity grade, run ASTM D4684 (MRV TP-1) at MRV temperature specified in SAE J300 for original viscosity grade. b) If CCS viscosity measured is higher than maximum viscosity specified for original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for next higher viscosity grade).

Table H-5—ILSAC GF-5 Passenger Car Engine Oil Standard (continued)
(Obsolete April 30, 2021)

Requirement	Criterion
Bench Test Requirements (continued)	
	c) EOT ROBO sample must show no yield stress in D4684 test and its D4684 viscosity must be below maximum specified in SAE J300 for the original viscosity grade or next higher viscosity grade, depending on CCS viscosity grade, as outlined in a) or b) above.
	Or
	ASTM Sequence IIIGA (ASTM D7320) (continued)
Aged oil low temperature viscosity (continued)	ASTM Sequence IIIGA (ASTM D7320) (continued)
Measure CCS viscosity of EOT ROBO sample at CCS temperature corresponding to original viscosity grade	i. If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. ii. If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). iii. EOT IIIGA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above.
Shear stability	ASTM Sequence VIII (ASTM D6709)
10-hour stripped KV @ 100°C	Kinematic viscosity must remain in original SAE viscosity grade except XW-20 which must remain ≥ 5.6 mm^2/s
Homogeneity and miscibility	ASTM D6922 Shall remain homogeneous and, when mixed with ASTM Test Monitoring Center (TMC) reference oils, shall remain miscible.
Engine rusting	Ball Rust Test (ASTM D6557)
Average gray value	100 (min)
Emulsion retention	ASTM D7563
0°C, 24 hours	No water separation
25°C, 24 hours	No water separation
Elastomer compatibility	ASTM D7216 Annex A2 Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2. The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed below:

Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	% Δ	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	% Δ	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	% Δ	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	% Δ	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	% Δ	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	% Δ	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	% Δ	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	% Δ	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	% Δ	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	% Δ	-30, 30

Applicable Documents:

1. SAE Standard, Engine Oil Viscosity Classification—SAE J300, *SAE Handbook*.
2. SAE Standard, Standard Reference Elastomers (SRE) for Characterizing the Effects on Vulcanized Rubbers, Proposed Draft 2003-5—SAE J2643, *SAE Handbook*.
3. ASTM Annual Book of Standards, Volume 5, Petroleum Products and Lubricants, current edition.
5. M. Batko and D. F. Florkowski, “Low Temperature Rheological Properties of Aged Crankcase Oils,” SAE Paper 2000-01-2943.
6. M. Batko and D. F. Florkowski, “Lubricant Requirements of an Advanced Designed High Performance, Fuel Efficient Low Emissions V-6 Engine,” SAE Paper 01FL-265

H.6 ILSAC GF-6A AND GF-6B STANDARDS FOR PASSENGER CAR ENGINE OILS (EFFECTIVE MAY 1, 2020)

The Japan Automobile Manufacturers Association, Inc. and representatives from Fiat Chrysler Automobiles, Ford Motor Company, and General Motors LLC, through an organization called the International Lubricants Standardization Advisory Committee (ILSAC), jointly developed and approved the ILSAC GF-6A and GF-6B minimum performance standards for engine oils for spark-ignited internal combustion engines (see Tables Q-6 and Q-7).

This standard specifies the minimum performance requirements (both engine sequence and bench tests) and chemical and physical properties for engine oils for spark-ignited internal combustion engines. It is expected that many engine manufacturers will recommend ILSAC GF-6A and/or GF-6B oils. However, performance parameters other than those covered by the tests included or more stringent limits on those tests included in these standards may be required by individual OEMs.

In addition to meeting the requirements of the standards, it is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information when marketing products meeting the ILSAC GF-6A and GF-6B standards. It is also the marketer's responsibility to conduct its business in a manner that represents minimum risk to consumers and the environment.

The ultimate assessment of an engine oil's performance must include a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been judged to be predictive of a variety of vehicle tests.

The relationships between engine sequence tests and vehicle fleet tests are judged valid based only on the range of base oils and additive technologies investigated — generally those that have proven to have satisfactory performance in service and that are in widespread use at this time. The introduction of base oils or additive technologies that constitute a significant departure from existing practice requires sufficient supporting vehicle fleet testing data to ensure there is no adverse effect to vehicle components or to emission control systems. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in these standards.

It is the responsibility of any individual or organization introducing a new technology to perform this vehicle fleet testing, and the responsibility of the oil marketer to ensure the testing of new technology was satisfactorily completed. No marketer can claim to be acting in a reasonable and prudent manner if they knowingly use a new technology based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing that simulates the full range of customer operation.

The ILSAC GF-6A and GF-6B Minimum Performance Standards include tests for which Viscosity Grade Read Across and Base Oil Interchange Guidelines have been developed by the appropriate groups. It should be pointed out, however, that when oil marketers use the guidelines, they do so based on their own judgment and at their own risk. The use of any guidelines does not absolve the marketer of the responsibility for meeting all specified requirements for any products the marketer sells in the marketplace that are licensed as ILSAC GF-6A or GF-6B with API.

Table H-6—ILSAC GF-6A Passenger Car Engine Oil Standard

Requirement	Criterion
Viscosity Requirements	
SAE J300	Oils shall meet all requirements of SAE J300. Viscosity grades are limited to SAE 0W, 5W, and 10W multigrade oils.
Gelation Index	ASTM D5133: 12 (max) To be evaluated from -5˚C to temperature at which 40,000 cP is attained or -40˚C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.
High Temperature/High Shear	ASTM D4683, D4741, or D5481
Viscosity @ 150°C, mPa·s	2.6 (min)
Engine Test Requirements	
Wear and oil thickening	ASTM Sequence IIIH (ASTM D8111)
Kinematic viscosity increase @ 40°C, %	100 (max)
Average weighted piston deposits, merits	4.2 (min)
Hot stuck rings	None
Wear, sludge, and varnish	ASTM Sequence VH (ASTM D8256)
Average engine sludge, merits	7.6 (min)
Average rocker cover sludge, merits	7.7 (min)
Average engine varnish, merits	8.6 (min)
Average piston skirt varnish, merits	7.6 (min)
Oil screen sludge, % area	Rate & report
Oil screen debris, % area	Rate & report
Hot stuck compression rings	None
Cold stuck rings	Rate and report
Oil ring clogging, % area	Rate and report
Valvetrain wear	ASTM Sequence IVB (ASTM D8350)
Average intake lifter volume loss (8 position avg), mm^3	2.7 (max)
End of test iron, ppm	400 (max)
Bearing corrosion	ASTM Sequence VIII (ASTM D6709)
Bearing weight loss, mg	26 (max)
Fuel efficiency	ASTM Sequence VIE (ASTM D8114)
SAE XW-20 viscosity grade	
FEI SUM	3.8% min
FEI 2	1.8% min after 125 hours aging
SAE XW-30 viscosity grade	
FEI SUM	3.1% min
FEI 2	1.5% min after 125 hours aging
SAE 10W-30 viscosity grade	
FEI SUM	2.8% min
FEI 2	1.3% min after 125 hours aging
Low-speed preignition prevention	ASTM Sequence IX (ASTM D8291)
Average number of events for four iterations	5 (max)
Number of events per iteration	8 (max)
Chain wear	ASTM Sequence X (ASTM D8279)
Percent increase	0.085 (max)

Table H-6—ILSAC GF-6A Passenger Car Engine Oil Standard (continued)

Requirement	Criterion
Bench Test Requirements	
Catalyst compatibility	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.08 (max)
Phosphorus volatility (Sequence IIIHB, phosphorus retention)	ASTM D7320 81% (min)
Sulfur content	ASTM D4951, D5185, or D2622
SAE 0W and 5W multigrades, % (mass)	0.5 (max)
SAE 10W-30, % (mass)	0.6 (max)
Wear	ASTM D4951 or D5185
Phosphorus content,% (mass)	0.06 (min)
Volatility	ASTM D5800 (B&D)
Evaporation loss, %	15.0 (max), 1 hour at 250°C
High temperature deposits	TEOST 33C (ASTM D6335)
Total deposit weight, mg	30 (max) Note: No TEOST 33C limit for SAE 0W-20.
Filterability	ASTM D6794
EOWTT, %	
with 0.6% H_2O	50 (max) flow reduction
with 1.0% H_2O	50 (max) flow reduction
with 2.0% H_2O	50 (max) flow reduction
with 3.0% H_2O	50 (max) flow reduction Note: Test formulation with highest additive (DI/VI) concentration. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different DI/VI combination must be tested.
EOFT, %	ASTM D6795 50 (max) flow reduction
Fresh oil foaming characteristics	ASTM D892 (Option A and excluding Section 11 Alternative Procedure)
Tendency, mL	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Stability, mL, after 1-minute settling	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
Fresh oil high temperature foaming characteristics	ASTM D6082 (Option A)
Tendency, mL	100 (max)
Stability, mL, after 1-minute settling	0 (max)

Table H-6—ILSAC GF-6A Passenger Car Engine Oil Standard (continued)

Requirement	Criterion
Bench Test Requirements (continued)	
Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	ROBO (ASTM D7528) a) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). c) EOT ROBO sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above. Or
Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	d) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. e) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). f) EOT IIIHA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above.
Shear stability 10-hour stripped KV @ 100°C XW-20 XW-30	ASTM Sequence VIII (ASTM D6709) Stay in grade Stay in grade
Homogeneity and miscibility	ASTM D6922 Shall remain homogeneous and, when mixed with ASTM Test Monitoring Center (TMC) reference oils, shall remain miscible.
Engine rusting Average gray value	Ball Rust Test (ASTM D6557) 100 (min)
Emulsion retention 0°C, 24 hours 25°C, 24 hours	ASTM D7563 No water separation No water separation

Table H-6—ILSAC GF-6A Passenger Car Engine Oil Standard (continued)

Requirement	Criterion
Bench Test Requirements (continued)	
Elastomer compatibility	ASTM D7216 Annex A2 Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2. The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed below:

Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	% Δ	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	% Δ	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	% Δ	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	% Δ	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	% Δ	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	% Δ	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	% Δ	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	% Δ	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	% Δ	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	% Δ	-30, 30

Table H-7—ILSAC GF-6B Passenger Car Engine Oil Standard

Requirement	Criterion
Viscosity Requirements	
SAE J300	Oils shall meet all requirements of SAE J300. Viscosity grades are limited to SAE 0W-16 oils.
Gelation Index	ASTM D5133: 12 (max) To be evaluated from -5˚C to temperature at which 40,000 cP is attained or -40˚C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.
Engine Test Requirements	
Wear and oil thickening	ASTM Sequence IIIH (ASTM D8111)
Kinematic viscosity increase @ 40°C, %	100 (max)
Average weighted piston deposits, merits	4.2 (min)
Hot stuck rings	None
Wear, sludge, and varnish	ASTM Sequence VH (ASTM D8256)
Average engine sludge, merits	7.6 (min)
Average rocker cover sludge, merits	7.7 (min)
Average engine varnish, merits	8.6 (min)
Average piston skirt varnish, merits	7.6 (min)
Oil screen sludge, % area	Rate & report
Oil screen debris, % area	Rate & report
Hot stuck compression rings	None
Cold stuck rings	Rate and report
Oil ring clogging, % area	Rate and report
Valvetrain wear	ASTM Sequence IVB (ASTM D8350)
Average intake lifter volume loss (8 position avg), mm^3	2.7 (max)
End of test iron, ppm	400 (max)
Fuel efficiency	ASTM Sequence VIF (ASTM D8226)
SAE 0W-16 viscosity grade	
FEI SUM	4.1% min
FEI 2	1.9% min after 125 hours aging
Low-speed preignition prevention	ASTM Sequence IX (ASTM D8291)
Average number of events for four iterations	5 (max)
Number of events per iteration	8 (max)
Chain wear	ASTM Sequence X (ASTM D8279)
Percent increase	0.085 (max)

Table H-7—ILSAC GF-6B Passenger Car Engine Oil Standard (cont'd)

Requirement	Criterion
Bench Test Requirements	
Catalyst compatibility	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.08 (max)
Phosphorus volatility (Sequence IIIHB, phosphorus retention)	ASTM D7320 81% (min)
Sulfur content	ASTM D4951, D5185, or D2622
SAE 0W and 5W multigrades, % (mass)	0.5 (max)
Wear	ASTM D4951 or D5185
Phosphorus content,% (mass)	0.06 (min)
Volatility	ASTM D5800 (B&D)
Evaporation loss, %	15.0 (max), 1 hour at 250°C
Filterability	ASTM D6794
EOWTT, %	
with 0.6% H_2O	50 (max) flow reduction
with 1.0% H_2O	50 (max) flow reduction
with 2.0% H_2O	50 (max) flow reduction
with 3.0% H_2O	50 (max) flow reduction Note: Test formulation with highest additive (DI/VI) concentration. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different DI/VI combination must be tested.
EOFT, %	ASTM D6795 50 (max) flow reduction
Fresh oil foaming characteristics	ASTM D892 (Option A and excluding Section 11 Alternative Procedure)
Tendency, mL	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Stability, mL, after 1-minute settling	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
Fresh oil high temperature foaming characteristics	ASTM D6082 (Option A)
Tendency, mL	100 (max)
Stability, mL, after 1-minute settling	0 (max)

Table H-7—ILSAC GF-6B Passenger Car Engine Oil Standard (continued)

Requirement	Criterion
Bench Test Requirements (continued)	
Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	ROBO (ASTM D7528) g) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. h) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). i) EOT ROBO sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above.
	Or
Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	j) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. k) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). l) EOT IIIHA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above.
Shear stability KV @ 100°C after 30 passes, cSt	Diesel Injector (ASTM D6278) 5.8 (min)
Homogeneity and miscibility	ASTM D6922 Shall remain homogeneous and, when mixed with ASTM Test Monitoring Center (TMC) reference oils, shall remain miscible.
Engine rusting Average gray value	Ball Rust Test (ASTM D6557) 100 (min)
Emulsion retention 0°C, 24 hours 25°C, 24 hours	ASTM D7563 No water separation No water separation

Table H-7—ILSAC GF-6B Passenger Car Engine Oil Standard (continued)

Requirement	Criterion
Bench Test Requirements (continued)	
Elastomer compatibility	ASTM D7216 Annex A2 Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2. The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed below:

Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	% Δ	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	% Δ	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	% Δ	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	% Δ	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	% Δ	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	% Δ	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	% Δ	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	% Δ	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	% Δ	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	% Δ	-30, 30

Applicable Documents:

1. SAE Standard, Engine Oil Viscosity Classification—SAE J300, SAE Handbook.
2. SAE Standard, Standard Reference Elastomers (SRE) for Characterizing the Effects on Vulcanized Rubbers, Proposed Draft 2003-5—SAE J2643, SAE Handbook.
3. ASTM Annual Book of Standards, Volume 5, Petroleum Products and Lubricants, current edition.

4. M. Batko and D. F. Florkowski, “Low Temperature Rheological Properties of Aged Crankcase Oils,” SAE Paper 2000-01-2943.
5. M. Batko and D. F. Florkowski, “Lubricant Requirements of an Advanced Designed High Performance, Fuel Efficient Low Emissions V-6 Engine,” SAE Paper 01FL-265

Annex I

Requirements for API Heavy Duty Service Categories by Viscosity Grade

I.1 API SERVICE CATEGORY CH-4

Table I-1—Requirements for API Service Category CH-4

CH-4 Engine Tests					
Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
			One-test	Two-test[a]	Three-test[a]
CH-4	D6681	Weighted demerits (WDP), max	350	378	390
	(1P)[b]	Top groove carbon (TGC), demerits, max	36	39	41
		Top land carbon (TLC), demerits, max	40	46	49
		Average oil consumption, g/h (0 h – 360 h), max	12.4	12.4	12.4
		Final oil consumption, (312 h – 360 h), g/h, max	14.6	14.6	14.6
		Piston, ring, and liner scuffing	none	none	none[c]
	D6750	Weighted demerits (WDK), %, max	332	347	353
	(1K)[d]	Top groove fill (TGF), %, max	24	27	29
		Top land heavy carbon (TLHC), %, max	4	5	5
		Average oil consumption,			
		g/kWh (0 h – 252 h), max	0.54	0.54	0.54
		g/MJ (0 h – 252 h), max	0.15	0.15	0.15
		Piston, ring, and liner scuffing	none	none	none[c]
	D6483	Average Liner Wear, normalized to 1.75% soot, µm, max	25.4	26.6	27.1
	(T-9)	Average Top Ring Mass Loss, mg, max[e]	120	136	144
	Or	EOT Used Oil Lead Content less New Oil Lead Content, mg/kg, max	25	32	36
	D6987/D6987M	Liner wear, µm, max	32	34	35
	(T10)	Ring wear, mg, max	150	159	163
	Or	Lead content at EOT, mg/kg, max	50	56	59
	D7422	Liner wear, µm, max	30.0	30.8	31.1
	(T-12)	Top Ring Mass Loss, mg, max	120	132	137
		Lead content at EOT, mg/kg, max	65	75	79
	D5966	Average pin wear,			
	(RFWT)	mils, max	0.30	0.33	0.36
		(µm) max	(7.6)	(8.4)	(9.1)
	D6838	Rocker Pad Average Mass Loss, normalized to 4.5 % soot, mg, max	6.5	7.5	8.0
	(M11)[f]	Oil Filter Differential Pressure at EOT, kPa, max	79	93	100
	Or	Average Engine Sludge, CRC Merits at EOT, min	8.7	8.6	8.5
	D7468	Crosshead wear, mg, max	7.5	7.8	7.9
	(ISM)	Oil filter delta pressure, at 150 h, kPa, max	79	95	103
		Sludge rating, CRC merits, min	8.1	8.0	8.0
	D5967	Relative Viscosity at 4.8% Soot by TGA, max	2.1	2.2	2.3
	(Extended T-8E)[g]	Viscosity increase at 3.8 % Soot by TGA, mm^2/s, max	11.5	12.5	13.0
CH-4		*(continued from previous page)*			

CH-4 Engine Tests					
	D6984 (Seq. IIIF)	60h Viscosity at 40°C, increase from 10 min sample, % max	295	295 (MTAC)[h]	295 MTAC[h]
	Or				
	D7320 (Seq. IIIG)[i]	Kinematic viscosity, % increase at 40°C, max	150	150 (MTAC)	150 (MTAC)
	Or				
	D8111 (Seq. IIIH) using IIIH60 (Appendix X4)	60h Kinematic viscosity, % increase at 40°C max	249	249 (MTAC)	249 (MTAC)
	D6894 (EOAT)[j]	Aeration volume, % max	8.0	8.0 (MTAC)[h]	8.0 (MTAC)[h]

CH-4 Bench Tests					
Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
			One-test	Two-test	Three-test
CH-4	D6594	Used Oil Elemental Concentration			
	(HTCBT at 135°C)	Copper, mg/kg increase, max	20	N/A	N/A
		Lead, mg/kg increase, max	120	--	--
		Tin, mg/kg increase	Report	--	--
		Copper strip rating,[k] max	3	--	--
	D892	Foaming/Settling[l]	One-test	Two-test[a]	Three-test[a]
	Option A not allowed	Sequence I	10/0	N/A	N/A
		Sequence II	20/0	N/A	N/A
		Sequence III	10/0	N/A	N/A
		SAE Grade:	10W-30		15W-40
	D5800 (NOACK)	Percent volatility loss at 250 °C, max	20		18
	Or				
	D6417	Percent volatility loss at 371 °C, max	17		15
	D6278	*SAE Grade*:	XW-30		XW-40
		Kinematic Viscosity after shearing, mm^2/s, at 100°C, min	9.3		12.5

[a] See ASTM D4485, Annex A3 for additional information.

[b] See ASTM Research Report RR:02-1441

[c] If three or more operationally valid tests have been run, the majority of these tests shall not have scuffing. The scuffed tests are considered uninterpretable, and all data from these tests are eliminated from averaging.

[d] Refer to ASTM Research Report RR:D02-1273.

[e] Refer to ASTM Research Report RR:D02-1440.

[f] Refer to ASTM Research Report RR:D02-1439.

[g] A passing T-11 (TGA % soot at 12.0 mm^2/s increase, at 100 °C, min)—6.00 (first test), 5.89 (second test), and 5.85 (third test)—can be used in place of a T-8E in the applicable categories. This is not intended to indicate equivalence.

[h] See ASTM D4485, Annex A2; use method without transformations.

[i] The Sequence IIIG limits shown are more restrictive than the corresponding limits in Sequence IIIF, and are not intended to indicate equivalence. Results meeting the Sequence IIIG criteria stated can be used in lieu of Sequence IIIF.

[j] Refer to ASTM Research Report RR:D02-1379.

[k] The rating system in Test Method D130 is used to rate the copper coupon in Test Method D6594.

[l] Ten minutes for Sequence I, II, and III.

I.2 API SERVICE CATEGORY CI-4

Table I-2—Requirements for API Service Category CI-4

CI-4 Engine Tests					
Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
CI-4			One-test	Two-test[a]	Three-test[a]
	D6750[b]	Weighted demerits (WDK)	332	347	353
	(1K)	Top groove fill (TGF), %, max	24	27	29
		Top land heavy carbon (TLHC), %, max	4	5	5
		Average oil consumption,			
		g/kWh (0 h – 252 h), max	0.54	0.54	0.54
		g/MJ (0 h – 252 h), max	0.15	0.15	0.15
		Piston, ring, and liner scuffing	none	none	none
	D6681	Weighted demerits (WDP), max	350	378	390
	(1P)	Top groove carbon (TGC), demerits, max	36	39	41
		Top land carbon (TLC), demerits, max	40	46	49
		Average oil consumption, g/h (0 h – 360 h), max	12.4	12.4	12.4
		Final oil consumption, (312 h – 360 h), g/h, max	14.6	14.6	14.6
		Piston, ring, and liner scuffing	none	none	none
	Or				
	D6923	Weighted demerits (WDR)	382	396	402
	(1R)	Top groove carbon (TGC), demerits, max	52	57	59
		Top land carbon (TLC), demerits, max	31	35	36
		Initial oil consumption (IOC), (0 h – 252 h), g/h, average	13.1	13.1	13.1
		Final oil consumption (432 h – 504 h), g/h, average, max	IOC + 1.8	IOC + 1.8	IOC + 1.8
		Piston, ring and liner distress	none	none	none
		Ring sticking	none	none	none
	D5967 (Extended T-8E)[c]	Relative Viscosity at 4.8% soot[d]	1.8	1.9	2.0
	D6987/D6987M (T10)	Merit rating, min[a]	1000	1000	1000
	Or				
	D7422 (T-12)	Merit rating, min[a]	1000	1000	1000
	D5966	Average pin wear,			
	(RFWT)	mils, max	0.30	0.33	0.36
		(µm) max	7.6	8.4	9.1
	D6975	Average crosshead mass. loss, mg, max	20.0	21.8	22.6
	(M11 EGR)	Average top ring mass loss, mg	report	report	report
		Oil filter differential pressure at 250 h, kPa, max	275	320	341
	Or	Average engine sludge, CRC merits at EOT, min	7.8	7.6	7.5
	D7468	Crosshead wear, mg, max	7.5	7.8	7.9
	(ISM)	Oil filter Δ pressure, at 150 h, kPa, max	55	67	74
		Sludge rating, CRC merits, min	8.1	8.0	8.0

(continued next page)

CI-4 Engine Tests

Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
CI-4			One-test	Two-test[a]	Three-test[a]
	D6984 (Seq. IIIF)[e]	Kinematic viscosity (at 40 °C), percent increase, max	275	275 (MTAC)	275 MTAC
	Or				
	D7320 (Seq. IIIG)[f]	Kinematic viscosity, percent increase at 40 °C max	150	150 (MTAC)	150 (MTAC)
	Or				
	D8111 (Seq. IIIH)	60 h – 80 h[g] Kinematic viscosity, % increase at 40 °C max	370	370 (MTAC)	370 MTAC
	Or				
	D8111 (Seq. IIIH using IIIH70 Appendix X5 guideline)	70 h Kinematic viscosity, % increase at 40 °C max	181	181 (MTAC)	181 (MTAC)
	D6894 (EOAT)[h]	Aeration, volume percent, max	8.0	8.0 (MTAC)[i]	8.0 (MTAC)[i]

CI-4 Bench Tests

Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
CI-4	D6594				
	(HTCBT at 135°C)	Copper, mg/kg increase, max	20	--	--
		Lead, mg/kg increase, max	120	--	--
		Tin, mg/kg increase	Report	--	--
		Copper strip rating,[j] max	3	--	--
	D892	Foaming/Settling[k]			
	Option A not allowed	Sequence I	10/0	--	--
		Sequence II	20/0	--	--
		Sequence III	10/0	--	--
	D5800 (NOACK)	Percent volatility loss at 250 °C, max	15	--	--
	D6278	*SAE Grade*:	XW-30		XW-40
		Kinematic Viscosity after shearing, mm^2/s at 100°C, min	9.3		12.5
	D4683 *or* D4741 *or* D5481[l]	High temperature/high shear viscosity at 150 °C[m], mPa·s		3.5	
	D4684 (MRV TP-1)	The following limits are applied to SAE viscosity grades 0W, 5W, 10W, and 15W: Viscosity of 75 h used oil sample from T-10 test (or T-10A[n] test), *Or* 100 h used oil sample from T-12 test (or T-12A[o] test, tested at –20 °C, mPa·s, max		25 000	
		If yield stress is detected, use modified D4684[p] (external preheat), then mPa·s, max		25 000	
		And yield stress, Pa		<35	

[a] See ASTM D4485, Annex A4 for additional information.

[b] Refer to ASTM Research Report RR:D02-1273. Alternatively, Test Method D6750 (1N) can be used; if this test method is used, the measured parameters and primary performance criteria are the same as those shown for Test Method D6750 (1N) in the CJ-4 category.

[c] A passing T-11 (TGA % soot at 12.0 mm^2/s increase, at 100 °C, min)—6.00 (first test), 5.89 (second test), and 5.85 (third test)—can be used in place of a T-8E in the applicable categories. This is not intended to indicate equivalence.

[d] Relative Viscosity (RV) = viscosity at 4.8 % soot/viscosity of new oil sheared in Test Method D6278.

[e] Refer to ASTM Research Report RR:D02-1391.

[f] The Sequence IIIG limits shown are more restrictive than the corresponding limits in Sequence IIIF, and are not intended to indicate equivalence. Results meeting the Sequence IIIG criteria stated can be used in lieu of Sequence IIIF.

[g] 60 – 80 h value is interpolated according to the equation PVIS@(60 – 80) h = $\left(\frac{\sqrt{PVIS@60\ h}+\sqrt{PVIS@80\ h}}{2}\right)^2$ where PVIS@60 h is percent viscosity increase at 60 hand PVIS@80 h is percent viscosity increase at 80 h.

[h] Refer to ASTM Research Report RR:D02-1379.

[i] See ASTM D4485, Annex A2; use method without transformations.

[j] The rating system in Test Method D130 is used to rate the copper coupon in Test Method D6594.

[k] Ten minutes for Sequence I, II, and III.

[l] Tests as allowed in SAE J300.

[m] Noncritical specification as defined by Practice D3244; may be superseded only by applicable higher limits set by SAE J300.

[n] The T-10A test is the name given to a T-10 test run for 75 h to generate the sample for measurement by Test Method D4684.

[o] The T-12A test is the name given to a T-12 test run for 100 h to generate the sample for measurement by Test Method D4684.

[p] Refer to ASTM Research Report RR:D02-1517.

CI-4 Unadjusted Specification Limits for Elastomer Compatibility[a]

ASTM Bench Test	Elastomer	CI-4
D7216 (Seal compatibility)	Nitrile (NBR)	
	Volume change, %	(+5, -3)
	Hardness change, points	(+7, -5)
	Tensile strength change, %	(+10, -TMC 1006[b])
	Elongation at break change, %	(+10, -TMC 1006)
	Silicone (VMQ)	
	Volume change, %	(+TMC 1006, -3)
	Hardness change, points	(+5, -TMC 1006)
	Tensile strength change, %	(+10, -45)
	Elongation at break change, %	(+20, -30)
	Polyacrylate (ACM)	
	Volume change, %	(+5, -3)
	Hardness change, points	(+8, -5)
	Tensile strength change, %	(+18, -15)
	Elongation at break change, %	(+10, -35)
	Fluoroelastomer (FKM)	
	Volume change, %	(+5, -2)
	Hardness change, points	(+7, -5)
	Tensile strength change, %	(+10, -TMC 1006)
	Elongation at break change, %	(+10, -TMC 1006)

[a] These are the unadjusted specification limits for elastomer compatibility. Candidate oils shall, however, conform to the adjusted specification limits, the calculation of which is described in ASTM D4485, Annex A5.

[b] TMC 1006 is the designation for the reference oil used in this test method. This designation represents the original blend or subsequent approved re-blends of TMC 1006.

I.3 API SERVICE CATEGORY CJ-4

Table I-3—Requirements for API Service Category CJ-4

CJ-4 Engine Tests					
Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
CJ-4			One-test	Two-test	Three-test
	D6750	Weighted demerits (WDN), max	286.2	311.7	323.0
	(1N)	Top groove fill (TGF), %, max	20	23	25
		Top land heavy carbon (TLHC), %, max	3	4	5
		Average oil consumption,			
		g/kWh (0 h – 252 h), max	0.54	0.54	0.54
		g/MJ (0 h – 252 h), max	0.15	0.15	0.15
		Piston, ring, and liner scuffing	none	none	none
		Piston ring sticking	none	none	none
	D7549	Merit Rating,[a] min	1000	1000	1000
	(C13)	Hot-stuck piston ring	none	none	none
	D7484	Slider tappet mass loss, mg, average, max	100	108	112
	(ISB)	Cam lobe wear, µm, average, max	55	59	61
		Crosshead mass loss, mg, average	report	report	report
	D7468	Merit Rating,[a] min	1000	1000	1000
	(ISM)	Top ring mass loss, mg, max	100	100	100
	D5966	Average pin wear			
	(RFWT)	mils, max	0.30	0.33	0.36
		µm, max	(7.6)	(8.4)	(9.1)
	D6894	Aeration, volume, %, max	8.0	8.0	8.0
	(EOAT)			(MTAC)	(MTAC)
	D7156	TGA % Soot at 4.0 mm^2/s increase, at 100 °C, min	3.5	3.4	3.3
	(T-11)	TGA % Soot at 12.0 mm^2/s increase, at 100 °C, min	6.0	5.9	5.9
		TGA % Soot at 15.0 mm^2/s increase, at 100 °C, min	6.7	6.6	6.5
	D7422	Merit Rating,[a] min	1000	1000	1000
	(T-12)				
	D6984 (Seq. IIIF)	Kinematic viscosity (at 40 °C), percent increase, max	275	275 (MTAC)	275 MTAC
	Or				
	D7320 (Seq. IIIG)[b]	Kinematic viscosity (at 40 °C), percent increase, max	150	150 (MTAC)	150 (MTAC)
	Or				
	D8111 (Seq. IIIH)	60 h – 80 h[c] Kinematic viscosity, % increase at 40 °C max	370	370 (MTAC)	370 MTAC
	Or				
	D8111 (Seq. IIIH using IIIH70 Appendix X5 guideline)	70 h Kinematic viscosity, % increase at 40 °C max	181	181 (MTAC)	181 (MTAC)

CJ-4 Bench Tests					
Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
CJ-4	D6594	Copper, mg/kg increase, max	20	--	--
	(HTCBT at 135°C)	Lead, mg/kg increase, max	120	--	--
		Copper strip rating,[d] max	3	--	--
	D892	Foaming/Settling[e]			
	(Foam)	Sequence I	10/0	--	--
		Sequence II	20/0	--	--
		Sequence III	10/0	--	--
	D5800	Evaporative loss at 250 °C, %, max	10W-30		Other grades
	(NOACK)		15		13
	D7109	SAE Grade:	XW-30		XW-40
		Kinematic Viscosity after 90 pass shearing, mm^2/s at 100 °C, min	9.3		12.5
	D4683 *or* D4741 *or* D5481 High temperature /High shear	High temperature/high shear viscosity at 150 °C, min		3.5	
	D6896 (MRV TP-1)	Viscosity of the 180 h used oil drain sample from a T-11 test, tested at –20 °C, mPa·s, max		25 000	
		If yield stress is detected, use the modified test method (external preheat), then measure the viscosity, mPa·s, max		25 000	
		Measure the yield stress, Pa		<35	

CJ-4 Chemical Limits			
Category	Test Method	Measured Parameter	
CJ-4	D874	Mass fraction sulfated ash, %, max	1.0
	D4951	Mass fraction phosphorus, %, max	0.12
		Mass fraction sulfur, %, max	0.4

[a] Refer to ASTM D4485, Annex A6 for more information

[b] The Sequence IIIG limits shown are more restrictive than the corresponding limits in Sequence IIIF, and are not intended to indicate equivalence. Results meeting the Sequence IIIG criteria stated can be used in lieu of Sequence IIIF.

[c] 60 – 80 h value is interpolated according to the equation PVIS@(60 – 80) h = $\left(\frac{\sqrt{PVIS@60\ h}+\sqrt{PVIS@80\ h}}{2}\right)^2$ where PVIS@60 h is percent viscosity increase at 60 hand PVIS@80 h is percent viscosity increase at 80 h.

[d] The rating system in Test Method D130 is used to rate the copper coupon in Test Method D6594.

[e] Ten minutes for Sequence I, II, and III.

CJ-4 Unadjusted Specification Limits for Elastomer Compatibility[a]		
ASTM Bench Test	Elastomer	CI-4
D7216 (Seal compatibility)	Nitrile (NBR)	
	Volume change, %	(+5, -3)
	Hardness change, points	(+7, -5)
	Tensile strength change, %	(+10, -TMC 1006[b])
	Elongation at break change, %	(+10, -TMC 1006)
	Silicone (VMQ)	
	Volume change, %	(+TMC 1006, -3)
	Hardness change, points	(+5, -TMC 1006)
	Tensile strength change, %	(+10, -45)
	Elongation at break change, %	(+20, -30)
	Polyacrylate (ACM)	
	Volume change, %	(+5, -3)
	Hardness change, points	(+8, -5)
	Tensile strength change, %	(+18, -15)
	Elongation at break change, %	(+10, -35)
	Fluoroelastomer (FKM)	
	Volume change, %	(+5, -2)
	Hardness change, points	(+7, -5)
	Tensile strength change, %	(+10, -TMC 1006)
	Elongation at break change, %	(+10, -TMC 1006)
	Vamac G	
	Volume change, %	(+TMC 1006, -3)
	Hardness change, points	(+5, -TMC 1006)
	Tensile strength change, %	(+10, -TMC 1006)
	Elongation at break change, %	(+10, -TMC 1006)

[a] These are the unadjusted specification limits for elastomer compatibility. Candidate oils shall, however, conform to the adjusted specification limits, the calculation of which is described in ASTM D4485, Annex A5.

[b] TMC 1006 is the designation for the reference oil used in this test method. This designation represents the original blend or subsequent approved re-blends of TMC 1006.

I.4 API SERVICE CATEGORIES CK-4 AND FA-4

Table I-4—Requirements for API Service Categories CK-4 and FA-4

CK-4 and FA-4 Engine Tests					
Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
			One-test	Two-test[a]	Three-test[a]
CK-4 or FA-4	D7422 (T-12)	Top ring mass Loss, mg, max	105	105	105
		Cylinder Liner Wear, µm, max	24.0	24.0	24.0
	D8048 (T-13)	IR peak at EOT, Abs., cm^{-1}	125	130	133
		Kinematic viscosity increase at 40°C, % max	75	85	90
		Avg. oil consumption, 48 h to 192 h, g/h, max	Report	Report	Report
	D7156 (T-11)[b]	TGA % soot at 4.0 mm^2/s increase, at 100°C, min	3.5	3.4	3.3
		TGA % soot at 12.0 mm^2/s increase, at 100°C, min	6.0	5.9	5.9
		TGA % soot at 15.0 mm^2/s increase, at 100°C, min	6.7	6.6	6.5
	D7549 (C13)	Merit rating[a], min	1000	1000	1000
	D8047 (COAT)	Average aeration[a], 40 h to 50 h, %	11.8	11.8	11.8
	D7484 (ISB)	Slider tappet mass loss, mg, average, max	100	108	112
		Cam lobe wear, µm, average, max	55	59	61
		Crosshead mass loss, mg, average	Report	Report	Report
	D7468 (ISM)	Top ring mass Loss, mg, max	100	100	100
		Merit rating[a]	1000	1000	1000
	D6750 (1N)	Weighted demerits (WDN), max	286.2	311.7	323.0
		Top groove fill (TGF), %, max	20	23	25
		Top land heavy carbon (TLHC), %, max	3	4	5
		Oil consumption,			
		g/kWh, (0 h – 252 h), max	0.54	0.54	0.54
		g/MJ (0 h – 252 h), max	0.15	0.15	0.15
		Piston, ring, and liner scuffing	none	none	none
		Piston ring sticking	none	none	none
	D5966 (RFWT)	Average pin wear, mils, max	0.30	0.33	0.36
		(µm) max	(7.6)	(8.4)	(9.1)

CK-4 and FA-4 Bench Tests			
		Primary Performance Criteria	
ASTM Bench Test	Measured Parameter	CK-4 SAE J300 viscosity xW-30, xW-40	FA-4 SAE J300 viscosity xW-30
D4683	High temperature/high shear viscosity at 150 °C, mPa·s		
(High temperature/high	xW-30 grades, min	3.5	2.9
Shear)	xW-30 grades, max	N/A	3.2
Or D4741 or D5481	xW-40 grades	Meet SAE J300	N/A
D6594 (135°C HTCBT)	Copper, mg/kg increase, max	20	20
	Lead, mg/kg increase, max	120	120
	Copper strip rating, max	3	3
D7109	Kinematic viscosity after 90 pass shearing, mm^2/s at 100°C, min		
	xW-30	9.3	9.3
	0W-40	12.5	N/A
	Other xW-40	12.8	N/A
	HTHS viscosity (see above methods) at 150°C, min xW-30 grades	3.4	2.8
D5800 (NOACK)	Evaporative loss at 250°C, %, max	13	13
D892	Foaming/settling, mL, max		
	Sequence I	10/0	10/0
	Sequence II	20/0	20/0
	Sequence III	10/0	10/0
D6896 (Sooted oil MRV TP-1) (D7156 engine test requirement)	Viscosity, 180 h used oil sample from T-11/T-11a test, tested at -20°C, mPa-s, max	25000	25000
	Yield stress of 180 h used oil sample above, Pa, max	<35	<35

CK-4 and FA-4 Chemical Limits			
		Primary Performance Criteria	
ASTM Bench Test	Measured Parameter	CK-4 SAE J300 viscosity xW-30, xW-40	FA-4 SAE J300 viscosity xW-30
D874	Mass fraction sulfated ash, %, max	1.0	1.0
D4951 or D5185	Mass fraction phosphorus, %, max	0.12	0.12
D4951 or D5185	Mass fraction sulfur, %, max	0.4	0.4

[a] See ASTM D4485 Annex A6 for additional information.

[b] MRV requirement listed as a bench test.

CK-4 and FA-4 Unadjusted Specification Limits for Elastomer Compatibility			
ASTM Bench Test	Elastomer	CK-4	FA-4
D7216 (Seal compatibility)	Nitrile (NBR)		
	Volume change, %	(+5, -3)	(+5, -3)
	Hardness change, points	(+7, -5)	(+7, -5)
	Tensile strength change, %	(+10, -TMC 1006)	(+10, -TMC 1006)
	Elongation at break change, %	(+10, -TMC 1006)	(+10, -TMC 1006)
	Silicone (VMQ)		
	Volume change, %	(+TMC 1006, -3)	(+TMC 1006, -3)
	Hardness change, points	(+5, -TMC 1006)	(+5, -TMC 1006)
	Tensile strength change, %	(+10, -45)	(+10, -45)
	Elongation at break change, %	(+20, -30)	(+20, -30)
	Polyacrylate (ACM)		
	Volume change, %	(+5, -3)	(+5, -3)
	Hardness change, points	(+8, -5)	(+8, -5)
	Tensile strength change, %	(+18, -15)	(+18, -15)
	Elongation at break change, %	(+10, -35)	(+10, -35)
	Fluoroelastomer (FKM)		
	Volume change, %	(+5, -2)	(+5, -2)
	Hardness change, points	(+7, -5)	(+7, -5)
	Tensile strength change, %	(+10, -TMC 1006)	(+10, -TMC 1006)
	Elongation at break change, %	(+10, -TMC 1006)	(+10, -TMC 1006)
	Vamac G		
	Volume change, %	(+TMC 1006, -3)	(+TMC 1006, -3)
	Hardness change, points	(+5, -TMC 1006)	(+5, -TMC 1006)
	Tensile strength change, %	(+10, -TMC 1006)	(+10, -TMC 1006)
	Elongation at break change, %	(+10, -TMC 1006)	(+10, -TMC 1006)

Notes:

1. These are the *unadjusted specification limits* for elastomer compatibility. Candidate oils shall, however, conform to the adjusted specification limits described in ASTM D4485 Annex A4.
2. TMC 1006 is the designation for the reference oil used in ASTM D7216. This designation represents the original blend or subsequent approved re-blends of TMC 1006.

Annex J

Performance Requirements for C Category Supplements

J.1 SCOPE

This annex describes the supplemental bench and engine test requirements adopted by the API Lubricants Standards Group for an existing C Category. Oils that meet the requirements for a supplement as defined in this annex and are properly licensed by API may display the supplement's classification in the lower portion of the API Service Symbol in conjunction with the associated C Category in the upper portion.

J.2 BENCH AND ENGINE TEST REQUIREMENTS FOR CI-4 PLUS AND CJ-4

Oils that meet the engine and bench requirements for CI-4 PLUS as defined below and are properly licensed by API may display CI-4 PLUS in the lower portion of the API Service Symbol in conjunction with API Service CI-4, CJ-4 and/or CK-4 in the upper portion. FA-4 performance cannot be claimed with CI-4 PLUS. The requirements in this annex include initial base oil interchange and viscosity grade read-across guidelines for the Mack T-11 test. Marketers must also refer to API 1509 for additional guidelines for licensing CI-4 PLUS.

J.2.1 90-PASS SHEAR STABILITY BENCH TEST[a]

The final formulation must meet the following shear stability requirement: The 100°C kinematic viscosity of the oil must stay within its SAE grade after 90 passes in the injector shear bench test.[b]

J.2.2 MACK T-11 ENGINE TEST[a]

All candidate tests must be conducted in an ASTM-calibrated stand. The limits for the Mack T-11 are noted below:

TGA % Soot @ 12.0 cSt increase @ 100°C Linear Interpolation–from 2 data points [New viscosity–after 90 passes (method as per S.2.1)]	6.00 min[c,d]

J.2.2.1 Base Oil Interchange

This section summarizes the methods for comparing the base oil saturates of the formulation being licensed to that in the test oil. The saturate level of the test oil refers to a value for the base oil blend as determined by ASTM D2007. Additive adjustments from the test oil to the final formulation are limited to the Minor Formulation Guidelines contained in the current edition of the ACC Code of Practice.

The methods in Table J-1, Table J-2 and Figure J-1 for determining Base Oil Interchange apply to all Mack T-11 engine tests associated with API CJ-4 and to Mack T-11 engine tests associated with API CI-4 with CI-4 PLUS that were started after April 28, 2006. Base oil interchange for Mack T-11 engine tests associated with API CI-4 and CI-4 PLUS started on or before April 28, 2006, should be determined according to Table J-3.

For the Mack T-11 test, base oil interchange is allowed per Table J-1:

Table J-1—Base Oil Interchange for the Mack T-11 in Conjunction with CJ-4 and CI-4 with CI-4 PLUS

Tested Oil	Candidate Oil
X ≤ 70.0	80.0 minimum
70.0 < X < 95.0	(0.6*X + 38) minimum
X ≥ 95.0	95.0 minimum

In addition to using Table J-1, the limits can be defined by graphical means (see Figure J-1) or the use of tabulated limits (see Table J-2).

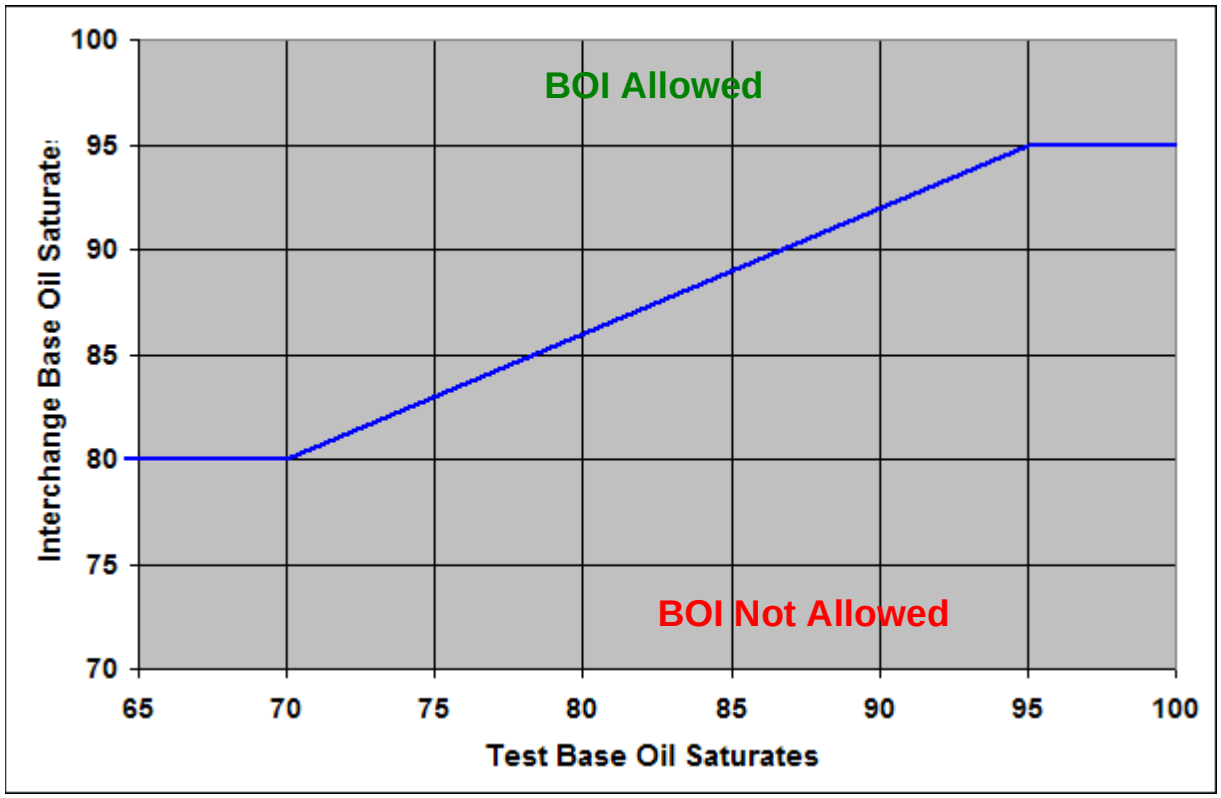

Figure J-1—Plot of Saturates for the Test and Interchange Base Oils

Table J-2—Base Oil Saturates Requirements for BOI

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 J-3—Base Oil Interchange for the Mack T-11 in Conjunction with CI-4 with CI-4 PLUS

% Saturates for Final Formulation	Max % Saturates for Test Oil
X < 80.0	No Read across
80.0 ≤ X < 85.0	X-10
85.0 ≤ X < 90.0	X-5
90.0 ≤ X < 95.0	X
X ≥ 95.0	100

J.2.2.2 Viscosity Grade Read Across

Table J-4 contains the VGRA read-across matrix for the Mack T-11 test. When applying the viscosity grade reads allowed by this matrix, two additional conditions must also be met: (1) Base oil saturates in the test and final formulations must comply with the guidelines in J.2.2.1, and (2) 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.

Table J-4—Viscosity Grade Read across for the Mack T-11

	Read-Across Grades					
Vis Grade Tested	10W-30	10W-40	15W-40	15W-50	20W-40	20W-50
10W-30	NA	X	—	—	—	—
10W-40	X	NA	—	—	—	—
15W-40	X	X	NA	X	—	—
15W-50	X	X	X	NA	—	—
20W-40	X	X	X	X	NA	X
20W-50	X	X	X	X	X	NA

[a] 90-Pass Shear Stability Test (ASTM D7109); Mack T-11 Test (ASTM D7156).
[b] As defined in the most recent edition of SAE J300.
[c] If technical judgment is used to support Mack T-11 performance, please refer to Annex D, paragraph D.5.2, to determine the appropriate licensing procedure.
[d] For situations where multiple tests are run on the same formulation, the following tiered limits can be applied:

Number of Tests	1	2	3 or More
Minimum %TGA Soot @12.0 cSt increase @100°C	6.00	5.89	5.85

Annex K

ACC Petroleum Additives Panel Product Approval Code of Practice

The American Chemistry Council (ACC) Petroleum Additives Panel has developed a Product Approval Code of Practice (the ACC Code of Practice) for passenger car motor oils (PCMOs) and diesel engine oils. The ACC Code of Practice defines practices to help ensure that a particular engine lubricant meets its performance specifications. This is accomplished through the use of specified engine tests, procedures, and record keeping. The ACC Code of Practice went into effect on March 30, 1992. ACC has contracted with the ASTM Test Monitoring Center, Pittsburgh, PA, to serve as the monitoring agency for administration of the ACC Code of Practice as related to scheduling and registering engine oil tests.

Compliance with the ACC Code of Practice is mandatory to obtain a license to use the API Certification Marks or to use API Service Categories SP, SN, SM, SL, SJ, SH, CH-4, CI-4, CJ-4, CK-4, and FA-4 in the API Service Symbol. Oil marketers licensed against the API SP standard have been permitted to display SP in the API Service Symbol since May 1, 2020.

Adherence to the ACC Code of Practice as a requirement for the EOLCS will be periodically reviewed for continued suitability and enhancement.

A copy of the ACC Code of Practice is not included in this publication. Since ACC has committed to continuous updates, a copy of the most recent edition of the ACC Code of Practice may be downloaded from the American Chemistry Council's website at https://www.americanchemistry.com/ProductsTechnology/PAPTG/PAPTG-Code-of-Practice-Resources/Petroleum-Additives-Product-Approval-Code-of-Practice.pdf

The American Chemistry Council is located at 700 Second Street, NE, Washington, DC 20002, USA [telephone (202) 249-7000].

Annex L

Physical and Chemical Ranges for Auditing

Table L-1—API Aftermarket Audit Ranges—Standard Audit

Parameter	Range[a]
Viscosity at 100°C (ASTM D445)	As defined in SAE J300
Cranking viscosity (ASTM D5293)	
All oils	As defined in SAE J300
"Resource Conserving" oils	+10%[b]
Pumping viscosity (ASTM D4684)	As defined in SAE J300
Pumping yield stress (ASTM D4684)	As defined in SAE J300
HTHS viscosity (ASTM D4683)	
API "S" 1st/ILSAC oils[c]	As defined in SAE J300
"Resource Conserving" oils	-15%, +10%[d]
API CI-4, CI-4 with CI-4 PLUS, CJ-4, CK-4 and FA-4 oils	As defined in ASTM D4485 or API 1509, as applicable
NOACK volatility (ASTM D5800)	
API "S" 1st/ILSAC oils[c]	As defined in API 1509
"Resource Conserving" oils	+10%[e]
API CH-4, CI-4, CI-4 with CI-4 PLUS, CJ-4, CK-4 and FA-4 oils	As defined in ASTM D4485 or API 1509, as applicable
Elements with published specification [ICP-(ASTM D4951 or D5185)][f]	
Phosphorus	As defined in ASTM D4485 or API 1509, as applicable
Sulfur	As defined in ASTM D4485 or API 1509, as applicable
Elements with no published specification [ICP (ASTM D4951 or D5185 + D5762)][f]	
Values ≥100 parts per million	–10%, +15%
Values <100 parts per million	–15%, +20%
Total Base Number (ASTM D2896)	–10%, +15%

Note: HTHS = high temperature/high shear; ICP = inductively coupled plasma; ASTM D5762 measures Nitrogen.

[a] ASTM analytical test method precision will be accounted for when applying the acceptance range.

[b] Maximum = Online Application reported value x 1.10 (+10% tolerance) x 1.073 (7.3% Reproducibility) or J300 adjusted for Reproducibility, if lower.

[c] Applies to specifications for API SJ, API SL, API SM, API SN, API SP, ILSAC GF-4, ILSAC GF-5, or ILSAC GF-6A/B, as applicable.

[d] Maximum = Online Application reported value x 1.10 (+10% tolerance) x 1.036 (3.6% Reproducibility)/Minimum = Online Application reported value x 0.85 (-15% tolerance) x 0.964 (-3.6% Reproducibility) or J300 minimum adjusted for reproducibility, if higher.

[e] Maximum = Online Application reported value x 1.10 (+10% tolerance) + 1.0 (Reproducibility) or API 1509 Max + 1.0 Reproducibility, if lower.

[f] The elements to be reported and audited are those included in the EOLCS Online Application.

Table L-2—API Aftermarket Audit Ranges—Expanded Audit

Parameter	Range[a]
Foaming (ASTM D892, all sequences)[b]	Max +10 ml[c]
High temperature foaming (ASTM D6082)	Max +10 ml[c]
Shear stability (ASTM D6278)	
SL, SM & SN oils	*d, e*
CH-4 & CI-4 oils	*f*
Shear stability (ASTM D7109)	
CI-4 with CI-4 PLUS, CJ-4, CK-4, and FA-4 Oils	*g*
Ball rust test (D6557)	*h*
HTCBT (ASTM D6594)	*i*
ROBO (ASTM D7528)—MRV Only	*j, k*

[a] ASTM analytical test method precision will be accounted for when applying the tolerance limits.

[b] Use Option A for API SJ, API SL, API SM, API SN, ILSAC GF-4, and ILSAC GF-5. Settling time = 1 minute for API SN/ILSAC GF-5 or API SP/ILSAC GF-6A/B oils and 10 minutes for all other oils. No Option A for API CH-4, CI-4, CI-4 with CI-4 PLUS, CK-4, or FA-4. Option A may be used for API CJ-4.

[c] Added to API SJ, API SL, API SM, API SN, API SP, ILSAC GF-4, ILSAC GF-5 or ILSAC GF-6A/B specification limits, as applicable

[d] Apply limits outlined in API 1509, Annex F, Table F-3.

[e] Non-conformance to limits outlined in API 1509, Annex F, Table F-3 leads to a request for licensee to confirm Sequence VIII Stay-in-Grade support.

[f] Refer to API CH-4 or CI-4, as applicable.

[g] Refer to API CI-4 with CI-4 PLUS, CJ-4, CK-4, or FA-4, as applicable.

[h] Refer to API SJ, API SL, API SM, API SN, API SP, ILSAC GF-4, ILSAC GF-5 or ILSAC GF-6A/B specifications, as applicable.

[i] Refer to API CH-4, CI-4, CI-4 with CI-4 PLUS, CJ-4, CK-4 or FA-4 as applicable.

[j] Refer to API SM, API SN, SP, ILSAC GF-4, ILSAC GF-5 or ILSAC GF-6A/B specifications, as applicable.

[k] Frequency increased in lieu of running engine tests.

Annex M

Technical Interpretations of API 1509

API 1509 is an API Standard. API Policy and Procedure Number 104, Subject: Standardization, provides general guidance for API Standards activities. Policy Number 104 allows API to provide written "interpretations . . . on the meaning of a standard."

Note that the EOLCS License Agreement (Part C), Section 3, states in part "Licensee agrees to comply with . . . any interpretations of API 1509."

No. 1

Question: What is a definition of "complete engine testing" as found on the EOLCS application form?

Answer: "Complete engine testing" means that the oil has passed each engine test required for licensing of that oil (see Annex G). Where applicable, (for all "S" Category oils) the oil must have been registered with the American Chemistry Council (ACC) monitoring agency (Registration Systems, Inc.) and have passed each test in full compliance with the ACC Product Approval Code of Practice. When a complete engine test program has been successfully completed on an oil, API Guidelines for SAE Viscosity-Grade Engine Testing, Annex F, can be applied for licensing. The intent of "complete engine testing" is to distinguish between oils which have been fully tested and those that are licensed by reference to "read across."

No. 2

Question: On the EOLCS application Product Traceability Code, is the day and time of manufacture actually required to be submitted as part of the EOLCS application for licensure?

Answer: The Introduction to Part D—Product Traceability Code states in part " . . . API is mandating, as a requirement of licensing, that each container of licensed oil marketed be legibly date stamped (bolding added) and that sufficient information be provided in licensing documents to allow API to interpret the date stamp and match the audited oil with the licensing data for that oil."

No. 3

Question: Is the API ILSAC mark design in Figure M-1acceptable for display on containers?

Figure M-1—Incorrect API ILSAC Mark Design

Figure M-2—Correct API Mark Design

Answer: No. Figure 6 (reprinted in Figure M-2) of API 1509 shows how the mark must appear on labels; Section 7.2. specifies design requirements for the mark. Paragraph 7.2.2 states in part, "The background of the outer band (bold added) . . . shall be a color that contrasts with the label background." The specific error in Figure M-1 is that the outer band has been separated into two bands of different colors.

No. 4

Question: A marketer of motor oil, for example a car manufacturer, sells oil under its own name. The marketer purchases its branded oil from several different oil companies, each of which use a completely different format for its product traceability code. How should this be handled under EOLCS?

Answer: Each separate formulation supplied to the marketer must be filed with and accepted by API on a Part B form Product Data Sheet. Each Part B has space for four (4) separate formulations. If a marketer has more than 5 formulations an additional Part B form must be submitted in the licensing document.

API must be able to compare data obtained from oils analyzed under the aftermarket audit program with the data for that oil submitted to API as part of the licensing program. Therefore, an interpretation of the Formulation Code identifier required on Part B for each oil must be available to API. The marketer should submit a separate Part D form, Product Traceability Code, for each formulation and link the information in Part D with Part B.

Please refer to the Introduction to Part D—Product Traceability Code which states in part " . . . API is mandating, as a requirement of licensing, that each container of licensed oil marketed be **legibly date stamped** (bolding added) and that sufficient information be provided in the licensing documents to allow API to interpret the date stamp and match the audited oil with the licensing data for that oil."

No. 5

Question: With regard to the administration fee, does one fee cover the various oils listed on the Application Form? With regard to the volume fee, is this based on the total sales of the various oils on the Application Form? (It is assumed that the volume of each grade is not separately assessed.)

Answer: There are two fees as described in 3.2 of API 1509. The Administration fee is a flat fee payable by all licensees. It covers all licensed oils. The volume of sales fee covers the total sales of licensed oils, that is, the "oils listed on the Application Form." The volume of sales fee is not separately assessed.

No. 6

Question: On the EOLCS application Part D—Product Traceability Code, does the "date stamp" requirement refer to (a) the date of manufacture or packaging, and (b) is the actual day (italics added) of either manufacture or packaging required?

Answer: (a) You must use date of packaging for the date stamp and (b) the day of packaging is required.

No. 7, amended

Question: Assume there are two Group I base oils from different manufacturers, both of which have passed engine and bench tests with given (bolding added) additive and VI packages and both individual base oil/additive blends are licensed "SH."

Could a packager purchase these two different sourced base oils, mix them together (bolding added) with the given additive/VI package and have an API licensed motor oil? This assumes 1) the SAE viscosity grade of the theoretical blend was one licensed for each base oil, and 2) the additive/VI packages and treat levels of the two licensed formulations were consistent.

Answer: Refer to Section E.2.1.5: "Base stocks approved under the provisions of these guidelines may be commingled without further testing."

No. 8

Question: Annex E, Section E.2.2.2 is as follows:

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 of Practice** (bolding added). 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 of the ACC Code of Practice, these guidelines shall be **reapplied** (bolding added).

What part of **the ACC Code of Practice** is referred to?

How should the guidelines (BOIG) be **reapplied**?

Answer: In the ACC Code of Practice, proposed changes in the "core data set" are accomplished by applying Annex H, Guidelines for Minor Formulation Modifications. Proposed changes in a "program" are accomplished by applying Annex I, Program Guidelines.

The BOIG should be reapplied as follows. If the VM/DI concentration in the interchange base oil differs from the original PCMO oil by more than the variation authorized under the ACC Code of Practice (Annex H or I), then complete performance documentation is required for the new PCMO with the interchange basestock.

No. 9Anne

Question: On the EOLCS application Part D—*Product Traceability Code*, is it adequate to indicate only the month and year of manufacture?

Answer: No. The day of manufacture is also required. This response assumes that the date of "manufacture" and "packaging" is the same day.

The Introduction to Part D—Product Traceability Code states in part ". . . API is mandating, as a requirement of licensing, that each container of licensed oil marketed be **legibly date stamped** (bolding added) and that sufficient information be provided in the licensing documents to allow API to interpret the date stamp and match the audited oil with the licensing data for that oil."

The date that appears on the container that is selected for aftermarket auditing must be the date of packaging.

No. 10

Question: Part B of the EOLCS Application for Licensure specifies a test method for measuring sulfur and nitrogen which is not addressed in the text of API 1509. Are licensees bound by requirements specified in the Application for Licensure?

Answer: Yes, the API License Agreement requires licensees to comply with all requirements specified in API 1509 and the Application for Licensure.

Question: If test methods for measuring Physical and Chemical Properties are specified in API 1509, may marketers utilize alternate (but equivalent) test methods to measure these properties?

Answer: No. The properties must be measured by the methods specified in API 1509.

No. 11

Question: In Annex G—Requirements for API Service Categories SH, SJ and SL by Viscosity Grade, the last column in Table G-1 titled "All Other Grades" has an NR for all Bench Tests and the L-38 shear stability test. NR means No Requirement. Following is a review of NR.

Answer: The technical language which describes API Service Category SH specifically mandates the application of specified parts of ILSAC GF-1 or DOD CID A-A-52039 specifications for all viscosity grades covered by these specifications. This includes the three oils specifically noted in Annex G (SAE 5W-30, 10W-30 and 15W-40) and any other oils which are requested to be licensed under ILSAC GF-1. Also, the most recent edition of SAE J300 contains high temperature/high shear requirements for SH.

Annex G, Table G-1, as it appears in API 1509, is correct with the addition of the SAE J300 requirements as noted above. If ASTM subsequently adopts requirements for SH, these requirements will be presented to the appropriate committees for consideration as an amendment to API 1509.

No. 12

Question: If an oil company sells its oil to another company and that company resells the oil under its own brand name does the reseller have to be licensed?

Answer: Yes. Section 4.1.1 of API 1509 includes the following statements. EOLCS is "…a licensing system that includes a formal license agreement executed by the marketer with API." In Section 4.1.1.1 , An oil marketer " is defined as the marketing organization responsible for the integrity of the brand name and the representation of the branded product in the marketplace."

Section 9 of the EOLCS License Agreement is as follows:

> 9. Licensee agrees that it is the marketing organization responsible for the integrity of the brand name and the product's representation in the marketplace **and agrees to use the marks only on products bearing the Licensee's name** (bolding added).

The Licensee's name on the product is the key element. If the owner company's name appears on the container it may license the oil. If the subsidiary's name appears on the container, the subsidiary must be separately licensed.

No. 13

Question: Can a result of 2.69 on a Sequence VI candidate oil test be rounded to 2.70 so as to claim an EFEI of ECII on an EOLCS Application for Licensure?

Answer: Yes. Rounding of Sequence VI candidate test values is done in accord with ASTM E 29–89, Section 2.3 and 4. *Rounding-Off Method*.

References:

ASTM E 29–89 *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.

> 2.3 Rounding Off Method—In other fields, specification limits of (for example), 2.5 inches max, 2.50 inches max, 2.500 inches max are taken to imply that, for purposes of determining conformance with specifications, an observed value or a calculated value should be rounded off to the nearest 0.1 inch, 0.01 inch, 0.001 inch, respectively, and then compared with the specification limit.

API 1509, *API Engine Oil Licensing and Certification System*, 12th Edition, January 1993. Table D-1, page 19.

Fuel Efficiency ASTM RR-D:2-1204 Sequence VI Test improvement (EFEI) 2.7% (min).

No. 14

Question: What is the difference between Table L-1 “Tolerance Limits for Standard Audit” and Table L-2 “Limits for Expanded Audit” in Annex L? Are Table L-1 and Table L-2 applied to API SH oils throughout the world? Is there any difference in their frequency?

Answer: Each oil selected for testing under the provisions of the Aftermarket Audit Program (AMAP) will be audited using the tests in Table L-1, as appropriate for the viscosity grade. Table G-1 should be consulted for guidance on tests that apply to different viscosity grades for SH oils. Oils for testing and the frequency of testing under Table L-2 will be selected by reference to an API protocol. Audit samples are selected worldwide.

No. 15

Question: A marketer has successfully completed an ACC-registered DDC 6V92TA test on an SAE 15W-40 engine oil. This engine oil has also been qualified against API CH-4 through the application of Base Oil Interchange (BOI) according to Table E-9 of API 1509. Because it is API CH-4 qualified, it also meets the requirements for API CF (i.e., Caterpillar 1M-PC testing is waived according to Table E-6 of API 1509).

Does the SAE 15W-40 described above qualify for licensing as API CF-2?

Answer: The SAE 15W-40 oil qualifies for API CF-2 because it passed the 6V92TA test, as required by API 1509. The question correctly notes that CAT 1M-PC testing is waived because the product meets CH-4 interchange requirements as noted in footnote c of Table E-6.

No. 16

Question: A company uses the solvent refining process to produce 150N Group I base stocks at separate refineries. Refined from different crude oil sources, the base stocks display unique properties when tested according to ASTM D445, D 2270, D 4052, and D 2622.

Are these base stocks considered the same base stock slate per E.1.2.2 of API 1509, 14th Edition?

Answer: The two stocks as described above would not be considered as coming from the same base stock slate as defined in E.1.2.2 of API 1509. That definition refers to base stocks in the same grouping and from the same manufacturer but having different viscosities. The two stocks described above have the same viscosity. It would be more likely that they could be called the same base stock if they were produced to the same specifications, used the same formulation, and had the same product identifier (see API 1509, E.1.2.1).

If the company chooses to consider both 150N base stocks the same, there are some issues that need to be taken into account. Since the base stocks display some unique properties, the company needs to select the more severe of the two stocks to conduct performance testing or commit to proving equivalent performance by testing both. That responsibility is not removed by producing them under the same specification.

If the company chooses to identify the Group I base stocks separately, they would be subject to the applicable base oil interchange guidelines in Annex E of API 1509.

No. 17

Question: A single base stock manufacturer makes Group I, Group II, and/or Group III base stocks by a variety of different processes. This includes manufacturing base stocks by mixing a Group I with a Group II (or Group III) or mixing a Group II with a Group III. This mixed base stock is associated with a manufacturer's specification and product identification number. According to API 1509, this mixed Group base stock should be marketed as a Group I, or Group II, or Group III base stock based on the saturates, sulfur and VI analysis of the product as sold. For example:

- If the saturates are < 90%, and sulfur is > 0.03%, and VI is > 80 and < 120, the base stock is a Group I.
- If the saturates are > 90%, and sulfur is < 0.03%, and VI is > 80 and < 120, the base stock is a Group II.
- If the saturates are > 90%, and sulfur is > 0.03%, and VI is > 80 and < 120, the base stock is a Group I.
- If the saturates are > 90%, and sulfur is < 0.03%, and VI is > 120, the base stock is a Group III.

There has been some debate on this issue, especially on the correct labeling of the third example listed above. Do the examples above correctly interpret the guidelines set forth in API 1509?

It is understood that the base stock manufacturer retains responsibility for supplying commercial product with performance capability at least equivalent to that tested in formulations. It is also understood that API 1509 does not limit base stocks by manufacturing process. According to E.1.2.1 of API 1509, “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.”

Answer: The four examples above do correctly interpret the base stock category guidelines set forth in E.1.3 of API 1509. In the third example, the high sulfur content makes the base stock a Group I. According to API 1509, “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.”

No. 18

Question: A marketer of a fully qualified SAE 10W-40 API CH-4/SJ product wishes to substitute Group III/IV base oils for the Group I base oils used in the original formulation. The marketer believes this substitution is permitted based on a clause in Annex I Section 5 of the ACC Code of Practice: “Following completion of a program according to the ACC Code of Practice, substitution of Group III or Group IV base stock for Group I and/or Group II base stock is allowed with Level 2 support.” The marketer’s Level 2 support is full engine test data on an SAE 0W-30 API CH-4/SJ oil using a mixture of Group III and Group IV base oils.

Can a marketer use Annex I, Section 5 of the ACC Code of Practice to justify the substitution of Group III and Group IV base oils for Group I oils in a fully qualified SAE 10W-40 API CH-4/SJ product without further testing?

Answer: API 1509 contains the only authorized base oil interchange (BOI) and viscosity grade read across (VGRA) guidelines for API-licensed products. The ACC Code of Practice is not applicable in this situation.

Taking into account the base oil information provided above, a marketer could qualify the 10W-40 API CH-4/SJ formulation in at least two ways:

- Run complete engine testing for both the CH-4 and SJ categories as recommended in Annex E of API 1509.
- Use the VGRA guidelines in Annex F of API 1509. These recommend complete engine testing for CH-4 proof of performance but could offer some relief for SJ proof of performance.

The marketer of the formulations has the final responsibility for assuring that the products meet API requirements.

No. 19

Question: A marketer wants to qualify a new SJ engine oil formulation using SL/Energy Conserving tests and results from a double-length Sequence IIIE engine test in lieu of a Sequence IIIE test. The API Lubricants Standards Group approved the use of SL/Energy Conserving tests to qualify SJ oils as of May 1, 2000. The committee also instituted Provisional Licensing on that date to address a shortage of parts limiting the availability of Sequence IIIE tests.

Can a double-length Sequence IIIE be used to qualify a formulation for full SJ licensing?

Answer: No, the formulation cannot qualify for full licensing using the double-length Sequence IIIE results. To qualify for SJ, an oil must meet the most recent technical criteria set forth in ASTM D4485 (see 3.4.2 of API 1509). Currently, D 4485 does not include performance criteria for double-length IIIE’s.

Assuming the marketer cannot run a standard IIIE, his only recourse for licensing the SJ formulation at this time is to apply for Provisional Licensing. The procedures for Provisional Licensing require the marketer to submit Level 2 support data as described in the ACC Code of Practice. Although the double-length IIIE could not be used to qualify the formulation for full licensing, its results can be used as Level 2 support for Provisional Licensing.

No. 20

Question: On Page 3 of 3 of Part B of the API Application for Licensure, a note states the following: "Additionally, I attest that all engine and bench test data submitted or referred to on this form has been generated using ASTM/ACC calibrated instruments when applicable."

In the statement above, what does the phrase "when applicable" mean. The hypothetical question below should help to illustrate the question:

At the start of GF-2, if a marketer ran a D 5133 Gelation Index test one day prior to the start of TMC surveillance, would this data have been acceptable? One argument would state that since TMC calibration did not apply at the time of the test, the data should be acceptable. Another argument would state that since ASTM intended to calibrate the test—and was in the process of doing so—the data are not valid because it did not come from calibrated equipment.

Answer: Part B of the API Application for Licensure includes the phrase "when applicable" to cover those situations where a calibration requirement does not exist for a test at the time an application for licensure is filed with API. If ASTM has a calibration requirement in place for a test at the time an application is filed, then a calibrated result is required.

If, as noted in the hypothetical question above, a marketer runs a Gelation Index test one day prior to the start of TMC surveillance, the test result would be acceptable only if the marketer files the application for licensure the same day. The result would not be acceptable on an application filed the day after TMC surveillance has begun. This interpretation also applies in a situation where one marketer submits an application for a license before a calibration requirement is in place, and another marketer submits one after the requirement has been implemented. The second marketer must provide a result from a calibrated test.

Please note that the marketer of the formulations has the final responsibility for assuring its products meet API requirements.

No. 21

Question: A marketer of a fully qualified SAE 10W-40 API SJ/CF product wishes to replace 30 percent of the original formulation's Group I base oil with a Group IV and market the product as an SAE 5W-40 API SJ/CF engine oil without further engine testing. The marketer believes this change is possible according to Table E-2 of API 1509. The DI package and VI remain the same, and the base oil viscosities at 100°C are nearly identical. The 5W-40 viscosity grade is a result of the introduction of PAO.

Can a marketer replace 30 percent of a fully qualified 10W-40 SJ/CF's Group I base oil with a Group IV and market the product as a 5W-40 SJ/CF without further testing?

Answer: The answer to the question is no. The marketer must perform additional CF testing to qualify the 5W-40 oil.

To understand why further testing is required, a review of the guidelines for base oil interchange (BOI) and viscosity grade read across (VGRA) found in Annex E and Annex F of API 1509 is necessary. Under the guidelines spelled out in Annex E, the BOI described in the question above is possible. Tables E-2 (for SJ) and E-6 (for CF) permit the replacement of up to 30 percent of Group I base oil with a Group IV.

With the question of BOI settled, the marketer must then turn to the VGRA rules in Annex F. Again, the SJ and CF guidelines must be addressed separately. For SJ oils, read across from a viscosity grade is permitted as long as three criteria are met:

- The detergent (dispersant)-inhibitor (DI) content of the read-across viscosity grade shall be equal to or higher than that of the original viscosity grade. The increase in DI is limited to the maximum allowed by the ACC Code of Practice.

- Base stock blend kinematic viscosity at 100°C of the read-across viscosity grade must be equal to or higher than that of the original viscosity grade, considering the precision of the test method.

- The viscosity modifier (VM) content of the read-across viscosity grade must be equal to or lower than that of the original viscosity grade.

If all these criteria are met, the marketer does not have to run additional SJ tests. However, no such criteria exist for CF. There are currently no read across rules for CF oils that would allow a marketer to read across from a 10W-40 oil to a 5W-40. Further testing on the 5W-40 oil is required to qualify it as CF.

No. 22

Question: Does the blending of base stocks alone constitute manufacturing?

Answer: Base stock blending may be part of the manufacturing process but does not alone constitute manufacturing of a base stock. All base stock components used to blend a base stock must be produced by a single manufacturer; blended to meet the same manufacturer's specification for that base stock; and identified by a unique formula, product identification number, or both.

No. 23

Question: Are there any geographical restrictions on the manufacturer?

Answer: The base stock definition in API 1509, Annex E, section E.1.2.1, states that a base stock is independent of manufacturing location as long as the base stock is produced by a single manufacturer to the same specification, the base stock meets the manufacturer's specification, and the base stock is identified by a unique formula.

No. 24

Question: Does the API definition of a base stock conflict with the ATIEL letter of conformance for base stock manufacturers which requires conformance with an ISO 9001 or equivalent quality system?

Answer: API 1509 does not explicitly require that a base stock manufacturer adhere to a quality system such as ISO 9001, but such a system would help ensure a base stock meets the definition of base stock in E.1.2.1 of Annex E.

Annex N

EOLCS Licensing Clarifications

Licensing Clarifications are provided to assist Licensees in meeting licensing requirements.

Licensing Clarification: February 5, 1993

Question: A foreign oil company (API licensed) wishes to keep confidential the additive and VI improver packages it is providing to one of its customers. The customer is selling the oil under its name (as a "rebrand") and will be licensed by API. The oil company proposes, as an alternative to providing all the information to the customer, to provide only a proprietary code for the additive and VI improver packages—which will mask the name of the additive manufacturer. Thus, the customer will receive the ACC candidate data package with coded data. Can the customer be licensed by API under these circumstances?

Answer: Yes, the customer can be licensed.

What API does require for licensing is a "YES" attestation in the block related to the line "ACC Petroleum Additives Panel Product Approval Code of Practice" on Part B of the application form (This "YES" attestation is required for "S" Category and ILSAC licensed oils only, at the present time.)

As an API licensee, the customer can receive from API an inquiry about any oil which it has licensed. It is possible that as a result of a monitoring or enforcement inquiry API will request of the licensee certain information which might include information on the VI Improver, for example. In that case the licensee would be required to provide to API, as specified in the license agreement, all necessary information to satisfy the monitoring or enforcement request.

Licensing Clarification: March 31, 1993

Question: The API Application for Licensure form includes spaces for several oil brands and viscosities. It is assumed that alternate brand names for the same oil (and the same viscosity) are acceptable for inclusion on this form.

Answer: Each product, defined as a separate brand or viscosity grade, requires a separate PART B in the Application for Licensure package. The purpose of this requirement is to insure that oils selected from the market for analysis in API's aftermarket audit program can be identified and matched with the data presented for licensing. For example, if the same oil (SAE viscosity grade) is packaged under the label XYZ as well as another label ABC, they are separate oils for purposes of licensing and should be submitted as separate candidates for licensing.

Licensing Clarification: March 31, 1993

Question: Once the Application Form has been submitted and the license obtained, is it possible to change or modify a brand name? Or does a new Application Form and a further administration fee need to be paid?

Answer: If a licensee desires to change or modify a brand name for a specific product, a new Part B must be completed and submitted to API for approval. No additional fees are required.

Licensing Clarification: June 30, 1993

Question: API licenses two marks. What is the correct way to refer to these marks which are identified in API 1509, as ". . . the API Service Symbol and the ILSAC Certification Mark." (Section 5.1.) Our company wishes to advertise these marks to both our retail and bulk customers. However, "ILSAC" and "Service Symbol" have no meaning for most customers. What other labelling or identifying terminology are we permitted to use when referring to the marks?

Answer: Section 5.1. specifies the official names of the two marks.

Licensing Clarification: June 30, 1993

Question: We wish to license a product but to market it under more than one name. For example, we plan to market a single formulation in a number of different geographical locations. How should we proceed?

Answer: The EOLCS aftermarket audit program will match the data obtained from an analysis of marketplace samples with the data submitted to API for licensing, for the same formulation. The brand name is one of the elements required to make the match. Therefore, the name of each brand must be available to API. You should submit a separate Part B for each brand.

Licensing Clarification: November 15, 1993

Question: May the words “Energy Conserving” or “Energy Conserving II” or “API Service” be translated into a foreign language within the API Service Symbol (“Donut”).

Answer: No.

Licensing Clarification: April 16, 2001

Question: Can an API engine oil licensee prepackage API Service Category SL products with API SL in the Service Symbol “Donut” in advance of the July 1, 2001 date of first licensing? The licensee understands API SL products cannot be offered for sale before the July 1 date, but it would like to have products ready for sale on that date.

Answer: Yes, a marketer may package products displaying API SL in the API Service Symbol before July 1, 2001, but those products cannot be offered for sale before July 1. This assumes the marketer has completed all necessary API licensing requirements.

Annex O

API Guidelines for Use of Single Technology Matrix

O.1 GENERAL

A Single Technology Matrix (STM) approach may be used in addition to the Base Oil Interchangeability (BOI) and SAE Viscosity-Grade Testing (VGRA) Guidelines included in Annex E and Annex F. The STM approach must follow the guidelines outlined in O.2 and any engine-test-specific amendments listed in O.6.

O.1.1 INTRODUCTION

The BOI/VGRA guidelines in API 1509 are developed through industry consensus. Each guideline is generally derived using the 'minimum quality and quantity of data' rule. This rule requires that three technologies from at least two companies agree on the characteristic behavior of the base oil and/or SAE viscosity grade. This process has the benefit of industry consensus and public display of data, but it is not without limitations: reaching consensus on guidelines is often slow, over-testing in some areas occurs, and the type of data that can be viewed is limited.

The STM approach encompasses a technology or family of technologies from a single supplier in lieu of at least three technologies from different suppliers. The purpose of this approach is to offer an alternate, cost-effective, and technically valid process to demonstrate the performance capability of an additive technology. The matrix can be as broad or narrow in its application as are the industry guidelines. Note that while the guidelines developed through the traditional three-technologies approach applies to all technologies tested in the future, the guidelines developed from a Single Technology Matrix approach apply only to the technology or technologies used in that Matrix.

The additive technology supplier will provide the Oil Marketer with appropriate information from the Single Technology Matrix that the Oil Marketer may elect to utilize in applying for an API License.

O.1.2 DEFINITIONS

O.1.2.1 A *Single Technology* as designed for use in a Single Technology Matrix is a single additive package (DI) at a constant treat rate, with a single viscosity modifier, and in a single viscosity grade.

O.1.2.2 A *Modified Technology* as designed for use in a Single Technology Matrix is a minor formulation modification to a Single Technology and/or a viscosity grade change to a Single Technology.

O.1.2.3 A *Single Technology Matrix* consists of a group of data meeting the criteria outlined in O.2. The test results in the matrix reflect data from a Single Technology as described in O.1.2.1 and, if necessary, a Modified Technology as described in O.1.2.2

O.1.2.4 A *Multiple Technology Matrix* consists of two or more Single Technology Matrices meeting the criteria outlined in R.2. A Multiple Technology Matrix developed within an API category cannot extend to future API categories unless recommended by the API BOI/VGRA Task Force and approved by the API Lubricants Standards Group.

O.1.2.5 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.

O.1.2.6 A Base Oil used in a Technology Matrix can consist of a single base stock or a blend of base stocks. The Base Oil can consist of the same or multiple slates of base stocks. The *Base Oil* is defined, at minimum, by the following variables:

a. Base Oil Saturates (ASTM D2007)

b. Base Oil Sulfur (API Approved Tests from Annex E, Table E-1)

c. Base Oil Viscosity at 100°C (ASTM D445)
d. Base Oil Viscosity Index (ASTM D2270)

e. Noack Volatility of the fully formulated oil (finished oil) (ASTM D5800)

O.1.2.7 An *Outlier* is a test result in which the Studentized Residual for that observation from the analysis is at the one-sided 97.5th percentile, or beyond, on a Student T distribution.

O.1.2.8 A *Spread Requirement* is a stipulation on the base oil variable results in the Matrix that facilitates a symmetric spread in those results. For the base oil variable of interest, the number of base oils on either side of the mean of all base oils in the matrix must be equal, or within 1 of equal (if the total number of base oils is an odd number) in order to satisfy the spread requirements. Note that there is a default spread requirement for base oil saturates for all engine test types unless the Spread Requirement Waiver for Saturates applies.

O.1.2.9 The *Spread Requirement Waiver for Saturates* allows for the elimination of any spread requirement for saturates, if, and only if, every base oil AND base stock in the matrix is Group II, Group III, and/or Group IV.

O.1.2.10 A *Minor Formulation Modification* is a change made within a Single Technology Matrix to the Single Technology formulation with the intent to improve the performance of the formulation. Such a change creates a Modified Technology within the Single Technology Matrix. Base oil interchange on future base oils may only be granted for the last Modified Technology from the Single Technology Matrix. The guidelines and rules for Minor Formulation Modifications are defined in the American Chemistry Council Product Approval Code of Practice.

O.1.2.11 A *Viscosity Grade Change* is a change made within a Single Technology Matrix to the viscosity grade of the Single Technology in the direction of previously approved API 1509 Viscosity Grade Read Across Guidelines. Such a change creates a Modified Technology within the Single Technology Matrix. Base oil interchange on future base oils may only be granted for the least difficult viscosity grade tested in the Single Technology Matrix as defined by API 1509 Viscosity Grade Read Across Guidelines.

O.2 SCOPE AND CRITERIA FOR A SINGLE TECHNOLOGY MATRIX

O.2.1 MATRIX DATA CRITERIA

The Matrix data must be developed using a Single Technology as described in O.1.2.1, and, if necessary, a Modified Technology or Modified Technologies as described in O.1.2.2. A minimum of X operationally valid tests on X different base oils is required for a suitable matrix (see Table O-1). X is either equal to 5 or equal to the number of base oil variables of interest plus 2 (to ensure that there are enough degrees of freedom to estimate the error term from the matrix), whichever is greater. Note, however, that for every Modified Technology used in the matrix, X must increase by 1. Base oil variables of interest are determined by the API BOI/VGRA Task Force on a per test-type basis. The range of base oil variables of interest plus, if not included in that list, the ranges of base oil VI, base oil sulfur, base oil saturates, base oil viscosity at 100°C and finished oil Noack volatility (note that finished oil Noack volatility is considered a base oil variable for this STM application even though the volatility measurement is on the finished fluid) in that Matrix must cover any base oil interchange. To extend to another base oil beyond this range would require at least one additional test using a base oil that extends the range.

The base oil saturates in the Matrix must also meet a spread requirement (unless the Spread Requirement Waiver for Saturates applies). The number of base oils on either side of the mean saturates of all the base oils in the matrix must be equal (or within 1 of equal if the total number of base oils is an odd number).

To improve data efficiencies, multiple Single Technology Matrices may be combined and analyzed. This combination is known as the Multiple Technology Matrix. Whereas X tests on X different base oils are required from the first Single Technology Matrix, only X-1 operationally valid tests on X-1 different base oils are required from an additional

Single Technology Matrix if that second Matrix is combined and analyzed with the first. If a third Single Technology Matrix is combined with the first two, that third Matrix would need a minimum of X-2 operationally valid tests on X-2 different base oils. Any additional Single Technology Matrices combined and analyzed with the others would require a minimum of X-2 operationally valid tests on X-2 different base oils. Note that in this combined Multiple Technology Matrix, the extremes of the base oils in terms of saturates, sulfur, VI, base oil viscosity, and other pertinent parameters must be represented, and the spread requirement for saturates must be satisfied for each new technology.

Note: A Multiple Technology Matrix developed within an API category cannot extend to future API categories unless recommended by the API BOI/VGRA Task Force and approved by the API Lubricants Standards Group.

Table O-1—Minimum Number of Base Oils for Matrix

Technology in the Matrix	Minimum Number of Base Oils per Technology
First Technology	The greater of 5 or (defined base oil variables + 2): Add 1 base oil for each Modified Technology within the first technology
Second Technology	The greater of 4 or (defined base oil variables + 1): Add 1 base oil for each Modified Technology within the second technology
Third Technology and Subsequent Technologies	The greater of 3 or (defined base oil variables): Add 1 base oil for each Modified Technology within each technology

O.2.2 INTERCHANGE CRITERIA BASED ON STATISTICAL CONFIDENCE LIMITS

Based on the Matrix and subsequent analysis, the predicted engine test result for the new base oil (interchange base oil) must meet the performance specification of interest. In addition, the 95% confidence interval for the predicted mean performance (based on the Student T distribution) must be within the performance specification of interest. If, however, this confidence interval extends beyond the pass limit into the fail region of the specification, then, and only then, the width of the 95% confidence interval (based on the Student T distribution) for the predicted mean performance cannot be greater than the width of the 95% confidence interval (based on the Normal Frequency Distribution and the current standard deviation of the test used in the calculation of severity adjustments as defined in ASTM Test Monitoring Center Technical Memorandum 94-200, Annex C of the LTMS Manual) for the mean based on a single test result at the predicted performance level. Although the confidence intervals must be calculated in the appropriate transformed units, the comparison must be made in original units.

Given that the interchange criteria from the Matrix and statistical analysis are met, base oil interchange may be used for the technology from the Single Technology Matrix and/or the technologies from the Multiple Technology Matrix. Base oil interchange may also be used for all minor formulation modifications of these technologies with the proper Level 1 and/or Level 2 Support as defined in Annex H of the *American Chemistry Council Product Approval Code of Practice* (ACC Code of Practice).

The Matrix data and analysis must be shown to the Oil Marketer. A test result for a test parameter may be declared as an outlier and dropped from the analysis in accordance with O.2.4. However, the minimum number of base oils per technology criteria as outlined in O.2.1 as well as all other analysis and confidence limit requirements must be met. The observation must be an outlier for it to be dropped from the analysis. While observations may be dropped according to the Multiple Test Evaluation Procedure (MTEP)[1] to determine pass/fail, those observations may not be dropped from the Single Technology Matrix analysis unless declared an outlier according to O.2.4.

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[1] The Multiple Test Evaluation Procedure (MTEP) is any data-based approach for evaluation of the quality and performance of a formulation where more than one test has been run.

The use of American Chemistry Council accepted MTEP ensures that all test sponsors base the performance representation of engine oils on a uniform treatment of data. Appendix F of the ACC Petroleum Additives Product Approval Code of Practice provides detailed instructions on how to perform calculations using all of the relevant Multiple Test Evaluation Procedures and guidelines to use for specifications that do not indicate how to handle test data.

Appendix F of the ACC Petroleum Additives Product Approval Code of Practice can be found at the ACC web site www.AmericanChemistry.com

Non-conformance through an audit will be subject to enforcement action as described in Section 8.

O.2.3 CALCULATION OF WIDTH OF 95% CONFIDENCE INTERVAL

O.2.3.1 Confidence Interval Width for a Mean Based on a Single Test Result

$$2 \times Z_{0.05} \times \sigma$$

Where:

$Z_{0.05}$ = 1.96

σ = current standard deviation of the test used in the calculation of severity adjustments as defined in ASTM Test Monitoring Center Technical Memorandum 94-200, Annex C, of the LTMS Manual.

This is the shortcut method for calculating the width of the confidence interval. If a transformation is required, the shortcut method cannot be used. The actual confidence interval must be calculated for the predicted result for the oil on the transformed scale. This is done by adding and subtracting $Z_{0.05} \times \sigma$ from the predicted test result, transforming the confidence limits back, and then subtracting the limits on the original scale.

O.2.3.2 Predicted Test Result Confidence Interval Width

$$2 \times t_{0.05,df} \times S \times \sqrt{h_i}$$

Where:

$t_{0.05,df}$ = Student T distribution at the 95% Confidence Level with degrees of freedom equal to the degrees of freedom used in the estimate of the Root Mean Squared Error (RMSE)

S = Root Mean Squared Error from the analysis

h_i = $x_i (X'X)^{-1} x_i'$

X = the factor matrix

x_i = a particular factor setting

This is the shortcut method for calculating the width of the confidence interval. If a transformation is required, the shortcut method cannot be used. The actual confidence interval must be calculated for the predicted result for the oil on the transformed scale. This is done by adding and subtracting $t_{0.05,df} \times S \times \sqrt{h_i}$ from the transformed predicted result, transforming the confidence limits back, and then subtracting the limits on the original scale.

O.2.4 CALCULATION OF THE STUDENTIZED RESIDUAL AND OUTLIER TEST

$$e^*_i = e_i / (S(i) \times (\sqrt{1-h_i}))$$

Where:

e^*_i = the Studentized Residual, which is distributed closely to the Student T distribution. In this application, the ith observation for a test parameter may be declared as an outlier and removed

from the analysis if e^*_i is greater than the one sided $t_{0.025,df}$ with degrees of freedom equal to the degrees of freedom used in the estimate of the Root Mean Squared Error

e_i = the residual from the analysis, the actual test result for the ith observation for a parameter minus the predicted test result for the ith observation for a parameter

S(i) = Root Mean Squared Error from the analysis with the ith observation removed from the analysis

h_i = $x_i (X'X)^{-1} x_i'$

X = the factor matrix

x_i = a particular factor setting

O.3 SUMMARY OF REQUIREMENTS FOR THE SINGLE TECHNOLOGY MATRIX

The requirements for the Single Technology Matrix are summarized below:

a. A new test is developed and introduced as a part of a new specification.

b. The API BOI/VGRA Task Force reviews the new test, defines the critical base oil variables, and recommends use of the Single Technology Matrix.

c. The API Lubricants Standards Group approves the critical base oil variables and use of the Single Technology Matrix for the new test.

d. The Matrix Data Criteria must be met as defined in O.2.1.

e. All tests in the development of the Single Technology Matrix dataset and analysis must be registered according to the ACC Code of Practice.

f. The single technology must pass within a single test result or by using the appropriate MTEP for each base oil in the Single Technology Matrix for all relevant test parameters. If not, a Minor Formulation Modification or a Viscosity Grade Change may be made to the Single Technology to create a Modified Technology within the Single Technology Matrix. The Modified Technology must then pass all remaining base oils, not passed using the Single Technology, within a single test result or by using the appropriate MTEP for all relevant test parameters. The minimum number of base oils in the Single Technology Matrix MUST increase by one (1) for every Modified Technology used to demonstrate an acceptable Single Technology Matrix for future Base Oil Interchange.

g. Test results or observations dropped for evaluation in an MTEP procedure may not be dropped from the Single Technology Matrix analysis unless declared an outlier according to O.2.4.

h. The width of the 95% confidence interval (based on the Student T distribution) for the predicted mean performance based on the Single Technology Matrix model cannot be greater than the width of the 95% confidence interval (based on the Normal Frequency Distribution and the current standard deviation of the test used in the calculation of severity adjustments as defined in ASTM Test Monitoring Center Technical Memorandum 94-200, Annex C, of the LTMS Manual) for the mean based on a single test result at the predicted performance level UNLESS the 95% confidence interval for the predicted mean performance (based on the Student T distribution) is within the performance specification of interest (see O.2.2).

i. Single Technology Matrix results must be included in ACC candidate data packages.

j. Notification of use of Single Technology Matrix data for API licensure will be present on an Oil Marketer's API License Form and must be checked if used. An example is provided in O.5.

k. API will survey additive companies on a regular basis for Single Technology Matrix data.

O.4 EXAMPLES FOR SINGLE TECHNOLOGY MATRIX APPROACH

Note: The examples below only use some of the base oil variables required for the Single Technology Matrix. All of the required variables must be used when a Single Technology Matrix is being assembled.

O.4.1 EXAMPLE 1

Do we have base oil interchange for Technology 1 shown in Table O-2 in a new base oil that is 75% saturates in a test where the pass limit is a minimum of 8.0?

Table O-2—Example 1 Variables

Technology	Base Oil	Saturates	Test Result
1	1	60	8.1
1	2	70	8.6
1	3	80	8.4
1	4	90	8.9
1	5	100	9.2

There are two base oils with saturates above and two base oils with saturates below the mean saturates of all base oils. Therefore, the spread requirement for saturates is satisfied.

The Model based on saturates has an R^2 of 85% with a RMSE of 0.1889 with 3 degrees of freedom. The width of the 95% Confidence Interval for Technology 1 in the new base oil is 0.5702.

The industry standard deviation for the test is 0.25; therefore, a reasonable and fair estimate of the width of the 95% Confidence Interval for the mean based on a single test result is 0.98.

Since the width of the Confidence Interval from the Model is less than the width of the Confidence Interval for the mean based on a single test result, we have base oil interchange.

O.4.2 EXAMPLE 2

Do we have base oil interchange for Technology 1 shown in Table ***O-3*** in a new base oil that is 75% saturates in a test where the pass limit is a minimum of 8.0?

Table O-3—Example 2 Variables

Technology	Base Oil	Saturates	Test Result
1	1	60	8.6
1	2	70	8.4
1	3	80	9.2
1	4	90	8.1
1	5	100	8.9

There are two base oils with saturates above and two base oils with saturates below the mean saturates of all base oils. Therefore, the spread requirement for saturates is satisfied.

The Model is just the mean of the data with a RMSE of 0.4278 with 4 degrees of freedom. The width of the 95% Confidence Interval for Technology 1 in the new base oil is 0.5311.

The industry standard deviation for the test is 0.25; therefore, a reasonable and fair estimate of the width of the 95% Confidence Interval for the mean based on a single test result is 0.98.

Since the width of the Confidence Interval from the Model is less than the width of the Confidence Interval for the mean based on a single test result, we have base oil interchange.

O.4.3 EXAMPLES 3A AND 3B

O.4.3.1 Example 3A

Do we have base oil interchange for Technology 1 shown in Table O-4A in a new base oil that is 75% saturates in a test where the pass limit is a minimum of 8.0?

Table O-4A—Example 3A Variables

Technology	Base Oil	Saturates	Test Result
1	1	60	8.6
1	2	91	8.4
1	3	93	9.2
1	4	96	8.1
1	5	100	8.9

No. There are four base oils above the mean saturates of all of the base oils in the matrix (mean saturates = 88) and only one base oil below the mean. Therefore, the spread requirement is not satisfied, and we cannot analyze this Matrix for base oil interchange.

O.4.3.2 Example 3B

Do we have base oil interchange for Technology 1 shown in Table O-4B in a new base oil that is 95% saturates in a test where the pass limit is a minimum of 8.0?

Table O-4A—Example 3A Variables

Technology	Base Oil	Saturates	Test Result
1	1	90	8.6
1	2	97	8.4
1	3	98	9.2
1	4	99	8.1
1	5	100	8.9

Although there are four base oils above the mean saturates of all of the base oils in the matrix (mean saturates = 96.8) and only one base oil below the mean, the spread requirement for saturates is waived because all base oils (and for the purpose of this example, all base stocks) are Group II. The calculations on the test results are the same as O.4.2, and we would have base oil interchange.

O.4.4 EXAMPLE 4

Do we have base oil interchange for Technology 1 shown in Table O-5 in a new base oil that is 75% saturates in a test where the pass limit is a minimum of 8.0?

Table O-5—Example 4 Variables

Technology	Base Oil		Saturates	Test Result
1	1		60	9.8
1	2		70	7.1
1	2		70	8.9
1	3		80	8.9
1	4		90	5.0
1	4		90	7.9
1	4		90	8.1
1	5		100	9.4

There are two base oils with saturates above and two base oils with saturates below the mean saturates of all base oils. Therefore, the spread requirement for saturates is satisfied.

The Model is just the mean of the data with a RMSE of 1.535 with 7 degrees of freedom. The width of the 95% Confidence Interval for Technology 1 in the New Base Oil is 2.5670 (the 95% Confidence Interval is 6.9 to 9.4).

The Industry standard deviation for the test is 0.25; therefore, a reasonable and fair estimate of the width of the 95% Confidence Interval for the mean based on a single test result is 0.98.

Since the width of the Confidence Interval from the Model is more than the width of the Confidence Interval for the mean based on a single test result AND the lower end of the Confidence Interval from the model (6.9) extends below the pass limit of 8.0, we DO NOT have Base Oil Interchange.

However, we notice that the test result of 5.0 is unusually low. The Studentized Residual for this observation is 3.6, which is greater than the one sided $t_{0.025,7}$ of 2.4. The observation may then be removed from the analysis since the number of base oils remains at five. If the observation were to be removed as an outlier, then the lower end of the Confidence Interval for Technology 1 in the New Base Oil would be greater than the pass limit (the width would also be less than 0.98), and we would have Base Oil Interchange.

O.4.5 EXAMPLE 5

Do we have base oil interchange for Technology 1 shown in Table O-6 in a new base oil that is 75% saturates in a test where the pass limit is a minimum of 8.0?

Table O-6—Example 5 Variables

Technology	Base Oil	Saturates	Test Result
1	1	60	9.8
1	2	70	7.1
1	2	70	8.0
1	3	80	8.9
1	4	90	5.0
1	4	90	7.9
1	4	90	8.1
1	5	100	9.4

No. We do not have a pass in Base Oil Number 2 for this Technology. Note that we do have a pass in Base Oil Number 4 using MTAC.

O.4.6 EXAMPLE 6

Do we have base oil interchange for both Technology 1 and Technology 2 shown in Table O-7 in a new base oil that falls between the extremes of the base oil characteristics in a test where the pass limit is a minimum of 8.0?

Table O-7—Example 6 Variables

Technology	Base Oil	Base Oil Characteristics	Test Result
1	1	Extreme High	8.1
1	2	Medium	8.6
1	3	Low	8.4
1	4	High	8.9
1	5	Extreme Low	9.2
2	1	Extreme High	8.9
2	6	Medium	9.2
2	7	High	9.6
2	5	Extreme Low	8.8

The Model based on Technology 1 has an R^2 of 32% with a RMSE of 0.3999 with 7 degrees of freedom. The width of the 95% Confidence Interval for Technology 1 in the new base oil is 0.846. The width of the 95% Confidence Interval for Technology 2 in the new base oil is 0.946.

The industry standard deviation for the test is 0.25; therefore, a reasonable and fair estimate of the width of the 95% Confidence Interval for the mean based on a single test result is 0.98.

Since the width of the Confidence Interval from the Model is less than the width of the Confidence Interval for the mean based on a single test result for both Technologies, we have base oil interchange for both Technologies.

O.4.7 EXAMPLE 7

Do we have base oil interchange for Technology 1 shown in Table O-8 in a new base oil that is 75% saturates in a test where the pass limit is a minimum of 8.0?

Table O-8—Example 7 Variables

Technology	Base Oil	Saturates	Test Result
1	1	60	8.5
1	2	70	7.1
1A	2	70	8.6
1A	3	80	8.9
1A	4	90	5.0
1A	4	90	8.9
1B	4	90	8.8
1B	5	100	9.0

No. Since we have made two minor formulation modifications, we would need test results in two additional base oils. Also note that Technology 1 is not eligible for base oil interchange. Only Technology 1B is eligible.

O.4.8 EXAMPLE 8

Do we have base oil interchange for Technology 1B shown in Table O-9 in a new base oil that is 75% saturates in a test where the pass limit is a minimum of 8.0?

Table O-9—Example 8 Variables

Technology	Base Oil	Saturates	Test Result
1	1	60	8.5
1	2	70	7.1
1A	2	70	8.6
1A	3	80	8.9
1A	4	90	5.0
1A	4	90	8.9
1B	4	90	8.8
1B	5	100	9.0
1B	6	75	8.7
1B	7	85	8.7

Yes, assuming that Technology 1A and Technology 1B are minor formulation modifications as defined in the American Chemistry Council Product Approval Code of Practice. We have added two base oils to compensate for the two Modified Technologies, the spread requirement is satisfied, and the width of the Confidence Interval from the Model is less than the width of the Confidence Interval for the mean based on a single test result (assuming an industry standard deviation of 0.25). Note, however, that we only have interchange when using Technology 1B. We do not have interchange when using Technology 1 or Technology 1A.

O.5 NOTIFICATION OF SINGLE TECHNOLOGY MATRIX USE TO API

Oil Marketers must notify API on Parts B and Q of the EOLCS Application for Licensure whenever Single Technology Matrix data is used to qualify an oil formulation for API licensing. The EOLCS Online Application includes check boxes that specifically ask if STM has been used. It is below the BOI and VGRA check boxes. The EOLCS Online Application also asks the Oil Marketer to identify which test(s) use the STM support data. An example of the information requested is shown in Figure O-1.

Note: The Oil Marketer must have the STM support data on-file.

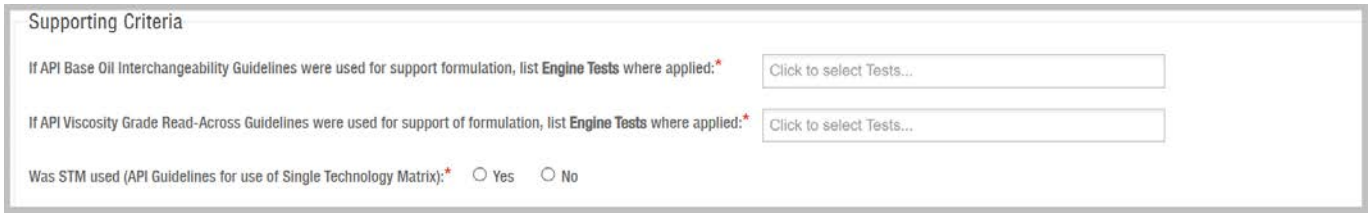


Figure O-1—Example of STM Check-Off in EOLCS Online Application

O.6 SPECIFIC ENGINE TESTS APPROVED FOR STM

O.6.1 SEQUENCE IIIF

The critical base oil variables are:

- Base Oil Saturates (ASTM D2007)
- Base Oil Sulfur (except when base oil sulfur level is less than or equal to 0.03%) (API approved tests from Annex E, Table E-1)
- Base Oil Viscosity at 100°C (ASTM D445)
- Base Oil Viscosity Index (ASTM D2270)
- Noack Volatility of the fully formulated oil (finished oil) (ASTM D5800)

The Single Technology Matrix must consist of at least 7 different base oils. The relevant test parameters are:

- Percent Viscosity Increase at 80 Hours
- Weighted Piston Deposits
- Average Piston Varnish
- Average Camshaft plus Lifter Wear
- Stuck Rings

The Single Technology Matrix must consist of a minimum number of base oils consistent with Table O-1. Each technology in the STM must pass each relevant test parameter (within 1 test or by MTAC) in each base oil.

Confidence Intervals are applicable to each relevant test parameter except Average Camshaft plus Lifter Wear and Stuck Rings.

Passenger car motor oil (PCMO) technologies cannot be used with heavy duty diesel engine oil (HDEO) technologies in the same Multiple Technology Matrix. If a Multiple Technology Matrix is used, it must consist of either all PCMO technology or all HDEO technology.

In addition to any default spread requirements, there is a spread requirement for base oil viscosity index.

O.6.2 DETAILED EXAMPLE USING THE SEQUENCE IIIF

Table O-10—Sequence IIIF Parameters for Example Using STM

Base Oil	Base Oil Saturates D 2007	Base Oil Sulfur D 4294	Finished Oil Noack Volatility D 5800	Base Oil Viscosity @ 100°C D 445	Base Oil Viscosity Index D 2270	IIIF Percent Viscosity Increase	IIIF Weighted Piston Deposits	IIIF Average Piston Varnish	IIIF Average Cam plus Lifter Wear	IIIF Stuck Rings
1	75.4	0.2049	16.9	5.61	105	311.2	4.92	9.1	10.8	0
1	75.4	0.2049	16.9	5.61	105	190	4.44	9.4	7.0	0
2	68.3	0.3055	18.2	4.46	100	270.4	4.17	9.1	7.9	0
3	70.7	0.3132	15.8	4.39	102	108.3	3.76	8.9	6.8	0
3	70.7	0.3132	15.8	4.39	102	268	4.44	9.1	8.2	0
4	66.7	0.2171	16.6	4.86	104	111.4	5.20	9.2	7.7	0
5	73.9	0.3423	13.9	5.10	103	162.1	4.32	9.2	5.6	0
6	84.1	0.0740	14.7	5.47	102	67	4.2	9.4	5.1	0
7	61.2	0.3641	16.0	4.31	96	311.1	3.95	9.5	8.7	0
7	61.2	0.3641	16.0	4.31	96	212	3.97	9.5	5.7	0
New	72	0.25	16.2	5.00	102					

Step 1: Do we have enough base oils in the Matrix?

Yes. We have 7 base oils in the Matrix. The minimum number of tests is the number of critical base oil variables (saturates, sulfur, viscosity at 100°C, and viscosity index) and the Noack volatility of the fully formulated oil plus two.

Step 2: Do we satisfy the spread requirement for both saturates and base oil viscosity index?

Yes. There are four base oils with saturates below the mean saturates of all base oils of 71.5 and three base oils above this mean. There are four base oils with a base oil viscosity index below the mean base oil viscosity index of all base oils of 102.1 and three base oils above this mean.

Step 3: Do we pass Technology 1 in every base oil in the Matrix?

Yes. Some pass with one test and some pass by MTAC.

Step 4: Do we predict a pass for Technology 1 in the new base oil based on the analysis of the Matrix?

Yes. The prediction for the new base oil is based on a very simple model (see Table O-11), the average over all other base oils since no base oil effects were evident with this technology over the range tested.

Table O-11—Step 4: Model Predicted

Base Oil	Base Oil Saturates D 2007	Base Oil Sulfur D 4294	Finished Oil Noack Volatility D 5800	Base Oil Viscosity @ 100°C D 445	Base Oil Viscosity Index D 2270	Model Predicted				
						IIIF Percent Viscosity Increase	IIIF Weighted Piston Deposits	IIIF Average Piston Varnish	IIIF Average Cam plus Lifter Wear	IIIF Stuck Rings
New	72	0.25	16.2	5.00	102	201	4.3	9.2	7.4	0

Step 5: Are there any outliers?

Possible outliers would include test results in which the Studentized residuals exceed the Student T distribution at the one-sided 0.025 percentile with degrees of freedom used in the calculation of the Root Mean Squared Error from the model, which is 9.

$$t_{0.05,9} = 2.262$$

According to the calculations in O.2.4, there are two possible outliers (see Table O-12). These outliers should be investigated as to their possible cause. Given that an investigation has not yet taken place, the outliers are not removed in this example. After future investigation, the test sponsor may remove these identified outliers on a parameter-by-parameter basis. However, please note that the outlier of 2.65 identified for Weighted Piston Deposits CANNOT be removed unless another test is run on this Technology to bring the number of base oils in the Matrix for Weighted Piston Deposits back to seven.

Table O-12—Step 5: Studentized Residuals

Test Number	IIIF Percent Viscosity Increase	IIIF Weighted Piston Deposits	IIIF Average Piston Varnish	IIIF Average Cam plus Lifter Wear	IIIF Stuck Rings
1	1.38	1.47	-0.71	*2.86*	0
2	-0.13	0.23	0.82	-0.20	0
3	0.81	-0.38	-0.71	0.32	0
4	-1.13	-1.45	-2.09	-0.32	0
5	0.78	0.23	-0.71	0.50	0
6	-1.08	*2.65*	-0.20	0.20	0
7	-0.45	-0.04	-0.20	-1.09	0
8	-1.79	-0.31	0.82	-1.48	0
9	1.38	-0.91	1.44	0.82	0
10	0.12	-0.86	1.44	-1.02	0

Step 6: Is the lower end of the 95% Confidence Interval (based on the Student T distribution) for the predicted mean performance based on the Single Technology Matrix model within the pass region for all relevant test parameters? If not, is the width of the 95% Confidence Interval (based on the Student T distribution) for the predicted mean performance based on the Single Technology Matrix model less than or equal to the width of the 95% Confidence Interval (based on the Normal Frequency Distribution and the current standard deviation of the test used in the calculation of severity adjustments as defined in ASTM Test Monitoring Center Technical Memorandum 94-200, Annex C, of the LTMS Manual) for the mean based on a single test result at the predicted performance level for all relevant test parameters?

Yes. Calculations are presented below for Percent Viscosity Increase and summarized for all other test parameters.

Confidence Interval for the Mean Based on a Single Test Result:

$$\text{Transform(Result)} + (Z_{0.05} \times \sigma) \quad \text{to} \quad \text{Transform(Result)} - (Z_{0.05} \times \sigma)$$

Where:

Result = predicted test result for the new Base Oil based on the STM analysis

Transform = Industry transformation for this test; the inverse square root

σ = current standard deviation of the test used in the calculation of severity adjustments as defined in ASTM Test Monitoring Center Technical Memorandum 94-200, Annex C, of the LTMS Manual.

$$1/(\text{Result})^{1/2} + (1.96 \times 0.0129546) \quad \text{to} \quad 1/(\text{Result})^{1/2} - (1.96 \times 0.0129546)$$

$$1/(201)^{1/2} + (1.96 \times 0.0129546) \quad \text{to} \quad 1/(201)^{1/2} - (1.96 \times 0.0129546)$$

0.0959 to 0.0451 in transformed units

95% Confidence Interval for the true mean of Percent Viscosity Increase based on a single test result using the industry-published standard deviation equals 109 to 491

The width of the Confidence Interval in original units equals 491 – 109 = 382

Predicted Test Result Confidence Interval Width:

$$\text{Transform(Result)} + (t_{0.05,df} \times S \times \sqrt{h_i}) \quad \text{to} \quad \text{Transform(Result)} - (t_{0.05,df} \times S \times \sqrt{h_i})$$

Where:

Result = predicted test result for the new base oil based on the STM analysis

Transform = transformation used in this STM analysis: none

S = Root Mean Squared Error (RMSE) from this STM analysis

df = degrees of freedom used in calculating the RMSE

(Result) – (2.262 x 88.13112 x 0.3162) to (Result) + (2.262 x 88.13112 x 0.3162)

(201) – (63.0353) to (201) + (63.0353)

95% Confidence Interval for the true mean of Percent Viscosity Increase based on the data and analysis of the STM equals 138 to 264.

The width of the Confidence Interval in original units equals 264 – 138 = 126. A summary of the confidence interval widths is shown in Table O-13.

Table O-13—Summary of Confidence Interval Widths

IIIF Parameter	Confidence Interval Width for a Mean Based on a Single Test Result	Predicted Test Result Confidence Interval Width	Predicted Test Result Confidence Interval Width Smaller?
Percent Viscosity Increase	382	126	YES
Weighted Piston Deposits	2.58	0.63	YES
Average Piston Varnish	0.86	0.29	YES

Step 7: Do we have base oil interchange for Technology 1 in a new base oil that is within the ranges for base oil saturates, sulfur, viscosity, viscosity index, and blend volatility in the Sequence IIIF?

Yes

O.6.3 SEQUENCE IIIF-HD

The critical base oil variables are:

- Base Oil Saturates (ASTM D2007)
- Base Oil Sulfur (except when base oil sulfur level is less than or equal to 0.03%) (API approved tests from Annex E, Table E-1)
- Base Oil Viscosity at 100°C (ASTM D445)
- Base Oil Viscosity Index (ASTM D2270)
- Noack Volatility of the fully formulated oil (finished oil) (ASTM D5800)

The Single Technology Matrix must consist of at least 7 different base oils. The relevant test parameter is:

- Percent Viscosity Increase at 60 Hours

The Single Technology Matrix must consist of a minimum number of base oils consistent with Table O-1. Each technology in the STM must pass each relevant test parameter (within 1 test or by MTAC) in each base oil.

Confidence Intervals are applicable to each relevant test parameter except Hot Stuck Piston Rings.

Passenger car motor oil (PCMO) technologies cannot be used with heavy duty diesel engine oil (HDEO) technologies in the same Multiple Technology Matrix. If a Multiple Technology Matrix is used, it must consist of either all PCMO technology or all HDEO technology.

In addition to any default spread requirements, there is a spread requirement for base oil viscosity index.

O.6.4 SEQUENCE IIIG

The critical base oil variables are:

- Base Oil Saturates (ASTM D2007)
- Base Oil Sulfur (except when base oil sulfur level is less than or equal to 0.03%) (API approved tests from Annex E, Table E-1)
- Base Oil Viscosity at 100°C (ASTM D445)
- Base Oil Viscosity Index (ASTM D2270)
- Noack Volatility of the fully formulated oil (finished oil) (ASTM D5800)

The Single Technology Matrix must consist of at least 7 different base oils. The relevant test parameters are:

- Percent Viscosity Increase at 100 Hours
- Weighted Piston Deposits
- Average Cam plus Lifter Wear
- Hot Stuck Piston Rings

The Single Technology Matrix must consist of a minimum number of base oils consistent with Table O-1. Each technology in the STM must pass each relevant test parameter (within 1 test or by MTAC) in each base oil.

Confidence Intervals are applicable to each relevant test parameter except Hot Stuck Piston Rings.

Passenger car motor oil (PCMO) technologies cannot be used with heavy duty diesel engine oil (HDEO) technologies in the same Multiple Technology Matrix. If a Multiple Technology Matrix is used, it must consist of either all PCMO technology or all HDEO technology.

In addition to any default spread requirements, there is a spread requirement for base oil viscosity index.

O.6.5 SEQUENCE IIIGA

The critical base oil variables are:

- Base Oil Saturates (ASTM D2007)
- Base Oil Sulfur (except when base oil sulfur level is less than or equal to 0.03%) (API approved tests from Annex E, Table E-1)
- Base Oil Viscosity at 100°C (ASTM D445)
- Base Oil Viscosity Index (ASTM D2270)
- Noack Volatility of the fully formulated oil (finished oil) (ASTM D5800)

The Single Technology Matrix must consist of at least 7 different base oils. The relevant test parameter is:

- MRV TP-1

The Single Technology Matrix must consist of a minimum number of base oils consistent with Table O-1. Each technology in the STM must pass the relevant test parameter (MTAC is not applicable) in each base oil.

Confidence Intervals are not applicable to MRV TP-1 due to the nature of test result distribution and extraordinary size of the test variability.

Passenger Car Motor Oil (PCMO) technologies cannot be used with Heavy Duty Engine Oil (HDEO) technologies in the same Multiple Technology Matrix. If a Multiple Technology Matrix is used it must consist of either all PCMO technology or all HDEO technology.

In addition to any default spread requirements, there is a spread requirement for base oil viscosity index.

An additional requirement for use of the Sequence IIIGA matrix is that the fresh oil MRV of the candidate oil, blended to the same viscosity grade, is equal to or less than the fresh oil MRV of at least one of the passing oils in the matrix, within the precision of the test. ASTM D4684 MRV testing is to be carried out at the appropriate temperature as defined in SAE J300.

Annex P
API Guidelines for Use of a Single Technology Matrix

P.0 TABLE OF CONTENTS

P.1 GENERAL PRINCIPLES AND REQUIREMENTS

The *Single Technology Matrix*, or *STM,* is a data-based approach for predicting the performance of a specific *Technology* in a specific *Base Oil*. The *Prediction Model* for testing a *Candidate Oil* based upon its *Base Oil Properties of Interest* applies only to the *Final Technology*. A *Successful Predicted Test Result* may be used in lieu of an engine test result for a *Candidate Oil*. The *Successful Predicted Test Result* and *STM* support documentation are reported in the American Chemistry Council (ACC) Code of Practice Candidate Data Package.

STM, as outlined in Annex P, is only applicable to engine tests documented in Section P.4. To incorporate any additional engine test(s), it is necessary to understand the key physical and chemical properties that potentially influence the test result variability for that engine test. The engine test may then be added to Section P.4 with those defining *Base Oil Properties of Interest* after recommendation by the API BOI/VGRA Task Force and adoption by the API Lubricants Standards Group.

STM must follow the guidelines and requirements outlined in Sections P.1 through P.3, as well as any and all engine test specific guidelines and requirements listed for that engine test in Section P.4. *STM* only covers *Base Oils* comprised of *Base Stocks* belonging to API Groups I, II, III, and IV.

P.1.1 INTRODUCTION

STM applies to a specific *Technology*, for a specific API Performance Category, within a defined *Testing Period Date Range* which is bound by *Base Oil Properties of Interest* that span a *Range of Key Properties.* The analysis of the *Model Data Set* establishes a *Prediction Mode*l for use within this *Range of Key Properties.* The *Prediction Model* is used to generate a *Predicted Test Result* for a *Candidate Oil*. If all *Data Set*, model and process guidelines, and requirements outlined in Sections P.1 through P.3 (and any additional requirements listed in Section P.4 for the specific engine test) are met, a *Successful Predicted Test Result* is used in lieu of an engine test result to support API license claims for the *Candidate Oil*.

The purpose of this Annex is to define the process, requirements, key terms, applicable engine tests, and to provide illustrative examples. Key terms with definitions will appear in *italics* throughout this Annex.

P.1.2 DEFINITIONS

In order to better understand the development and application of an *STM*, these key terms are required.

P.1.2.1 The *Single Technology Matrix (STM)* is a data-based approach for predicting the performance of a specific *Technology* in a specific *Base Oil* for a specific API Performance Category. It is based on operationally valid test data from a single supplier *Technology*, tested in a variety of *Base Oils*. The *Prediction Model* for testing a *Candidate Oil* based upon its *Base Oil Properties of Interest* applies only to the *Final Technology*.

P.1.2.2 *Technology*

P.1.2.2.1 A *Single Technology* is a single additive package (DI) at a constant treat rate, with a single viscosity modifier, and in a single viscosity-grade.

P.1.2.2.2 A *Modified Technology* contains a specific change to the *Single Technology*. The only allowed changes are (1) a *Minor Formulation Modification* and (2) a *Viscosity-Grade Change*. A *Modified Technology* may itself be modified. For each *Modified Technology*, *PASSES* must increase by 1 {one additional passing test is required by adding one unique *Base Oil* to the *Model Data Set*}.

P.1.2.2.3 A *Final Technology* is comprised of the maximum DI treatment level of all *Modified Technologies* (which, in fact, may only be the *Single Technology* if no changes have been made) in the least-difficult tested viscosity-grade according to the VGRA tables in API 1509 Annex F for the engine test of interest listed in P.4.

P.1.2.3 *Data*, as part of a *Data Set*, refers to test results for the specified test; coded technology, formulation and viscosity modifier information; DI and DI Formulation Modification treatment levels; test logistics such as Lab, Completion Date and ACC Registration Code; *Base Oils*; Base Oil Group; and *Base Oil Properties of Interest*.

P.1.2.4 *Data Set*

P.1.2.4.1 A *Single Technology Matrix Data Set* contains the relevant *Data* for *STM*. It consists of relevant passing and failing *Data* found during a due diligence search for tested *Finished Oils* within the relevant bounds of the *Technology*, the *Base Oil Properties of Interest* and a defined *Testing Period Date Range*. Only operationally valid and interpretable tests registered according to the ACC Code of Practice may be in this data set.

P.1.2.4.2 *A Model Data Set* consists of *Data* from the *Single Technology Matrix Data Set,* and is subject to the requirements, criteria and definitions for:

a) *Spread Requirement*
b) *Base Oil Properties of Interest*
c) *PASSES*
d) Test Specific Requirements in P.4

Outliers and *Data* that compromise the *Spread Requirement* are removed from the *Model Data Set*. However, they are retained in the *Single Technology Matrix Data Set*. Items a) through d) above must be re-evaluated and be met after any *Data* removal.

If items a) through d) are met, inclusion of failing data (see P.1.2.12) for the definition of a *Passing Test Result*) is at the discretion of the model developer.

P.1.2.5 Base Oil, Base Stock and Candidate Definitions

P.1.2.5.1 A *Base Stock* is defined in Annex E, Section E.1.2.1.

P.1.2.5.2 A *Base Stock Slate* is defined in Annex E, Section E.1.2.2.

P.1.2.5.3 A *Base Oil* is defined in Annex E, Section E.1.2.3 and characterized by the relevant *Base Oil Properties of Interest*.

Base Oils for use in Annex P may only be comprised of *Base Stocks* belonging to API Groups I, II, III, and IV.

P.1.2.5.4 A *Candidate Base Oil* is a new *Base Oil* for which a qualification is desired with the *Final Technology* by utilizing *STM*.

P.1.2.5.5 A *Candidate Oil, for use in Annex P,* is a *Candidate Base Oil* blended with the *Final Technology*, which includes a specified viscosity-grade, for a specific performance test in a specific API Performance Category whose performance is being predicted by an existing *Prediction Model*. The *Candidate Oil's* relevant *Base Oil Properties of Interest* shall fall within the *Range of Key Properties*.

P.1.2.5.6 A *Finished Oil* is a *Base Oil* blended with a *Technology*.

P.1.2.6 The *Base Oil Properties of Interest* are *Base Oil* or *Finished Oil* properties recommended by the API BOI/VGRA Task Force and adopted by the API Lubricants Standards Group as meaningful and influential to engine test performance for the test covered by Annex P. The *Base Oil Properties of Interest* are test type specific and are defined in Section P.4 for each test type. They are among the potential predictor variables for the *Prediction Model*.

To incorporate an engine test(s) into Annex P, it is necessary to understand the key physical and chemical base oil properties that, potentially, influence the test result variability for that engine test. The engine test may then be added to Section P.4 with those defining *Base Oil Properties of Interest* after recommendation by the API BOI/VGRA Task Force and adoption by the API Lubricants Standards Group.

The *Base Oil Properties of Interest* reported should accurately reflect the batches of *Base Stocks* used in the *STM*. This can be accomplished by one of three ways and the selected method should be documented. A recommended practice for documentation is to follow the requirements of the American Chemistry Council (ACC) Product Approval Code of Practice, Appendix E, Section 4.b.

The three *Base Oil* Analysis methods are:

a) A direct analysis of the *Base Oil Properties of Interest* for the *Base Oil* and *Finished Oil*.

b) Calculation of the *Base Oil Properties of Interest* from values associated with the individual *Base Stocks* comprising the *Base Oil* and *Finished Oil*.

c) Historical Base Oil/Stock properties analysis. If one is relying on historical Base Oil/Stock data, an effort should be made to accurately reflect the properties used with an explanation provided.

P.1.2.7 The *Range of Key Properties* is set by the range of *Base Oil Properties of Interest* of the *Finished Oils* in the *Model Data Set*.

P.1.2.8 The *Testing Period Date Range* is the continuous date range (the range must be one, continuous, date range) that encompasses all *Data* from a *Single Technology Matrix Data Set*. This is for the purposes of the analysis only. The *Predicted Test Results* will necessarily arise after the last test completed in the *Testing Period Date Range*.

P.1.2.9 A *Spread Requirement* is a stipulation on the *Base Oil Properties of Interest* in the *Model Data Set* that facilitates spread in those properties. For each *Base Oil Property of Interest* that must meet the spread requirement as listed in Section P.4 can do so by satisfying at least 1 of the 3 below listed criteria:

a) The number of *Base Oils* on either side of the mean must be within a count of 1 or equal in number. Any *Base Oils* at the mean should be counted as zero (not counted on either side).
b) The percentage of *Base Oils* on each side of the mean must be at least 33%. Any *Base Oils* at the mean are not considered on a side.
c) Using ASTM E178 One-Sided Test with the standard deviation being calculated from the same sample and an upper significance of 10%, the critical values of *T* must not be exceeded.

A *Base Oil* may need to be repeated in testing; but, the *Base Oil Properties of Interest* only count once in the Spread Requirement calculations. A *Base Oil* repeat may be the result of Multiple Test Evaluation Procedure (MTEP) as defined in ACC Code of Practice Appendix F or use of a *Modified Technology*.

P.1.2.10 *Minor Formulation Modification* guidelines are described in the American Chemistry Council (ACC) Code of Practice. *Minor Formulation Modifications* are permissible, but each modification requires an additional unique *Base Oil* in the *Model Data Set* and an increase in *PASSES,* as it constitutes and creates a *Modified Technology*.

P.1.2.11 A *Viscosity-Grade Change* is any change in viscosity-grade among the *Finished Oils* in the *Model Data Set*. It is permissible, but each change requires an additional unique *Base Oil* in the *Model Data Set* and an increase in *PASSES,* as it constitutes and creates a *Modified Technology*.

P.1.2.12 Model and Prediction Definitions

P.1.2.12.1 A *Prediction Model* is a mathematical equation formed through statistical analysis of the *Model Data Set* used to generate the *Predicted Test Result*.

P.1.2.12.2 The *Predicted Test Result* is the *Prediction Model*-generated test result for a *Candidate Oil*.

P.1.2.12.3 A *Successful Predicted Test Result* is a *Predicted Test Result* that is a *Passing Test Result* (P.1.2.12), and, in which, all *Data Set*, model and process guidelines and requirements outlined in Sections P.1 through P.3 (and any additional requirements listed in Section P.4 for the specific engine test) are met. It may be used in lieu of an actual engine test result; however, a *Successful Predicted Test Result* cannot be used to override a failing test result (details in P.2). Future engine test data that are outside of the Testing Period Date Range do not affect this Successful Predicted Test Result.

P.1.2.13 A *Passing Test Result* is either an ACC Registered test result or *Predicted Test Result* that meets or exceeds requirements as defined by the performance category documentation for the test in the intended API license service category. It may be obtained from a single test or by using the appropriate MTEP.

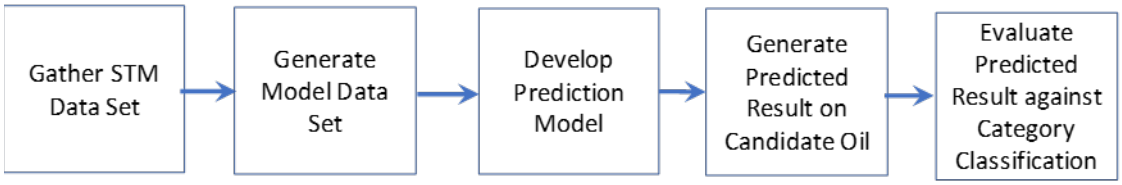
P.1.2.14 An *Outlier* is a test result in which the absolute value of the Studentized Residual for that observation from the analysis is at the cumulative 97.5th percentile, or beyond, on a Student *t* distribution. Outlier test results must be shown in the *Single Technology Matrix Data Set* even if removed from the *Model Data Set*.

P.1.2.15 *PASSES* is the minimum number of ACC Registered *Passing Test Results* required from unique *Base Oils* used to build the *Model Data Set* while satisfying the *Spread Requirements*. In general *PASSES* is equal to the number of *Base Oil Properties of Interest* relevant to the test plus 2 (to calculate confidence intervals). However, note that *PASSES* for each test is specifically defined in P.4. Regardless of the engine test, *PASSES* can never be less than 5. For each *Modified Technology*, *PASSES* must increase by 1.

P.1.2.16 The *Confidence Interval Requirement* (see P.5.4 for implementation) is a requirement for a *Successful Predicted Test Result*. The evaluation of the requirement is based on the calculation of confidence intervals for the *Predicted Test Result*.

P.2 THE SINGLE TECHNOLOGY MATRIX: DEVELOPMENT OVERVIEW

Generic Flowchart Overview for STM Generation



Provided for illustrative overview purposes. It is not intended to be prescriptive.

- Determine *PASSES* which is the minimum number of *Passing Test Results* required from unique *Base Oils* used to build the *Model Data Set* while satisfying the *Spread Requirements*. In general *PASSES* is calculated as the number of *Base Oil Properties of Interest* relevant to the test plus 2 (it is specifically defined for each

engine test in P.4). This is a minimum requirement to calculate confidence intervals. Regardless of the engine test, *PASSES* can never be less than 5. For each *Modified Technology*, *PASSES* must increase by 1.

- Generate, document and store a *Single Technology Matrix Data Set* which contains the relevant *Data* for *STM*. It consists of relevant passing and failing *Data* found during a due diligence search for tested finished oils within the relevant bounds of the *Technology*, the *Base Oil Properties of Interest* and a defined *Testing Period Date Range*. Only operationally valid and interpretable tests registered according to the ACC Code of Practice may be in this data set.

  While modeling and analysis may be performed on only a subset of this data set (*the Model Data Set*), the *Single Technology Matrix Data Set* may be requested and must be available upon request (see P.3).

- Generate, document and store a *Model Data Set* which consists of *Data* from the *Single Technology Matrix Data Set (see P.1.2.4.2).*

- The requirement for *PASSES, Spread Requirement* and any additional test specific requirements in P.4 must be satisfied in the *Model Data Set* to proceed.

- Develop a *Prediction Model* for the required pass/fail test parameters listed for the specific engine test in P.4 using the *Data* in the *Model Data Set*. Details located in P.5.1. Use the *Prediction Model* to generate a *Predicted Test Result* for the *Candidate Oil*.

  The techniques and the final form of the model are up to the model developer, but the model must have enough degrees of freedom to estimate an error term. Examples of different modeling techniques may include a simple mean, generalized linear models, least-squares regression, Bayesian Model Averaging, etc.

- The Outlier Test (details located in P.5.2) is optional. If an *Outlier* is identified through the Outlier Test, and removed from the *Model Data Set*, it must be removed in its entirety (all pass/fail test parameters regardless of individual *Outlier* status), and it still must remain in the *Single Technology Matrix Data Set* (documented as an *Outlier*). P.2 must be revisited.

  Note: While observations may be dropped according to MTEP to determine pass/fail, the dropped observations are not necessarily *Outliers*, and, therefore, must not be dropped from the *Model Data Set* unless identified and declared an *Outlier*.

- For each pass/fail test parameter identified for the specific engine test in P.4, the *Predicted Result* must also be a *Passing Test Result* for the *Candidate Oil.*

  If the *Candidate Base Oil* is also a *Base Oil* used in a *Finished Oil* in the *Single Technology Matrix Dataset* that is not a *Passing Result* (even if declared an *Outlier*), AND, there are no other *Passing Results* on any *Finished Oils* with the *Candidate Base Oil* in the *Single Technology Matrix Dataset*, the *Predicted Result* CANNOT be used in lieu of an actual test result for this *Base Oil*.

- The *Confidence Interval Requirement* (for test parameters specifically listed in P.5) must be met.

  A Confidence Interval, which is generated for each model and *Candidate Oil*, is a mathematical interval that covers a *Predicted Test Result* for a future single test or the mean of such future tests with a degree of confidence. Calculation details are located in P.5.3 and P.5.4.

- The *Successful Predicted Test Result* may be used in lieu of an actual engine test result.

  The *Successful Predicted Test Result* for the Category is provided to the Marketer in the American Chemistry Council (ACC) Code of Practice Candidate Data Package (CDP). With a *Successful*

Predicted Test Result on a *Candidate Oil*, minor formulation modifications as per American Chemistry Council Product Approval Code of Practice (Appendix H and I) and VGRA as per API 1509 Viscosity Grade Read Across Guidelines (Annex F) may be applied.

Future engine test data that are outside of the *Testing Period Date Range* do not affect this *Successful Predicted Test Result*; however, a future *Successful Predicted Test Result* cannot be used to override a future failing test result.

It is possible that the *Successful Predicted Test Result* may be applicable to more than one API Service Category (these categories may, or may not, have different pass/fail limits and/or different MTEP criteria). P.2 must be revisited for every new API Service Category.

- It may be desirable to extend or expand the range of the DI, viscosity-grade, *Base Oils* and/or Range of Key Properties beyond the scope and range of the *Successful Predicted Test Result*. This may be accomplished by accumulating additional engine test results by either running additional tests or expanding the *Testing Period Date Range.* A new *Single Technology Matrix Dataset* must be gathered. P.2 must be revisited.

P.3 NOTIFICATION OF SINGLE TECHNOLOGY MATRIX USE

The *Model Data Set* and *Successful Predicted Test Result* are available to the Oil Marketer within the Candidate Data Package. Oil Marketers must notify API on the EOLCS Application for Licensure whenever *STM* is used to qualify an oil formulation for API licensing. The on-line license application asks the question if *STM* has been used or not. When asked to provide a Formulation/Stand Code on the licensing form, any one of the actual test stand codes from the *Model Data Set* can be listed on the licensing form.

- The Oil Marketer can request the analyses that were used for the *Successful Predicted Test Result.*
- Other relevant parties with an interest can also request the analyses that were used for the *Successful Predicted Test Result*.

P.4 SPECIFIC ENGINE TESTS APPROVED FOR STM

All criteria and requirements per P.2 must be satisfied (unless specifically exempted for the listed engine test).

Any and all additional criteria and requirements listed for each specific engine test must be satisfied.

P.4.1 SEQUENCE IIIH (ASTM D8111 & SERVICE CATEGORIES LISTED IN D4485) WITH ANNEXES (60, 70, 80, AND 90 HOUR VERSIONS)

The *Base Oil Properties of Interest* and requirement for *PASSES* depend upon the test type and test parameters.

P.4.1.1 Base Oil Properties of Interest and PASSES

Refer to **Table P-1** for *Properties of Interest*.

It is understood that when comparing base stock properties, the precision of the methods listed is taken into consideration.

In any case where base stocks of more than one group are part of the same *Model Data Set*, the most severe testing requirement applies.

Table P-1 Base Oil Properties of Interest for ALL Seq. IIIH Test Types

			Base Oil Sulfur[1]	*Base Oil Saturates*[2]	*Base Oil Viscosity (@100C)*[3]	*Base Oil Viscosity Index*[4]	*NOACK (Finished Oil)*[5]	
Test Type	Test Parameter	Base Oil Group	Required	Required	Required	Required	Required	Min Number of PASSES
IIIH	PVIS	Group I	X	X (SR)	X	X (SR)	X	7
	WPD							
	HSR[6]							
IIIH	PVIS	Group II - IV	--	X	X	X (SR)	X	6
	WPD							
	HSR[6]							
IIIH60-80	PVIS	Group I	X	X (SR)	X	X (SR)	X	7
IIIH60-80	PVIS	Group II - IV	--	X	X	X (SR)	X	6
IIIH60	PVIS	Group I	X	X (SR)	X	X (SR)	X	7
IIIH60	PVIS	Group II - IV	--	X	X	X (SR)	X	6
IIIH70	PVIS	Group I	X	X (SR)	X	X (SR)	X	7
	WPD							
	APV							
IIIH70	PVIS	Group II - IV	--	X	X	X (SR)	X	6
	WPD							
	APV							

Test Parameter Legend: WPD: Weighted Piston Deposits, APV: Average Piston Varnish, PVIS: Percent Viscosity Increase, HSR: Hot Stuck Rings

X - Indicates that it is required, SR - Indicates that Spread Requirement is required

Notes:

1) Base Oil Sulfur (API approved tests Annex E,Table E-1)
2) Base Oil Saturates (API approved tests Annex E,Table E-1)
3) Base Oil Viscosity at 100°C (ASTM D445)
4) Base Oil Viscosity Index (ASTM D2270)
5) Finished Oil NOACK (ASTM D5800)
6) Confidence Interval not required

P.5 CALCULATION AND METHOD DETAILS

P.5.1 PREDICTION MODEL

A *Prediction Model* is a mathematical equation formed through statistical analysis of the *Model Data Set*. The model response is used to generate the *Predicted Test Result*.

Statistical methods and techniques are used to link the model response (in this case, a pass/fail test parameter) as a function of the available predictor variables (in this case, *Base Oil Parameters of Interest*, Test Lab, viscosity-grade, DI and DI Formulation Modification treatment levels). The techniques and the final form of the model are up to the model developer, but the model must have enough degrees of freedom to estimate an error term. Examples of different modeling techniques may include a simple mean, generalized linear models, least-squares regression, Bayesian Model Averaging, etc. The estimated error is used in the Calculation of Confidence Intervals and the *Confidence Interval Width* requirement criteria.

It is recommended, though not required, that the test results are analyzed and modeled with transformations identified and used in the ASTM Lubricant Test Monitoring System. However, use, or non-use, of any transformations are up to the model developer.

P.5.2 OUTLIER TEST

$$e^*_i = e_i / (S_{(i)} * (\sqrt{1-h_i}))$$

Where:

e^*_i = the Studentized Residual, which is distributed closely to the Student *t* distribution. In this application, the i^{th} observation for a test parameter may be declared as an outlier and removed from the analysis if e^*_i is greater than $t_{0.975,df1}$

e_i = the absolute value of the residual from the analysis for the i^{th} observation for a parameter
ABSOLUTE VALUE (Actual Test Result – Predicted Test Result)

df = Degrees of freedom

df1 = n – p - 1
n=Number of test results in the data set used in the analysis
p=Number of regression parameters including the intercept

$S_{(i)}$ = Root Mean Squared Error from the analysis with the i^{th} observation removed from the analysis

h_i = $x_i (X^T X)^{-1} x_i^T$ *(the hat matrix)*

X = the predictor variable matrix

x_i = the predictor variable setting *(for the Predicted Result)*

T = Transpose

P.5.3 CALCULATION OF CONFIDENCE INTERVALS AND CONFIDENCE INTERVAL WIDTHS

P.5.3.1 Industry Confidence Interval and Width for a Future Single Test Result (CIW_1)

$$UpperP = BACK\ TRANSFORM\{Transformed\ Predicted\ Test\ Result + Z_{0.975} * \sigma\}$$

$$LowerP = BACK\ TRANSFORM\{Transformed\ Predicted\ Test\ Result - Z_{0.975} * \sigma\}$$

$$CIW_1 = ABSOLUTE\ VALUE(UpperP - LowerP)$$

Where:

We assume that the *Predicted Test Result* is a known, mean test result

$Z_{0.975}$ = 1.96 (distance from mean for Standard Normal distribution with cumulative area of 0.975)
This equates to a 95% 2-sided Confidence Interval

σ = current standard deviation of the test used in the calculation of severity adjustments as defined in the ASTM Lubricant Test Monitoring System which may be on a transformed scale; if σ is not published then CIW_1 cannot be calculated

If σ is in transformed units, the confidence interval must be calculated for the *Predicted Test Result* for the *Candidate Oil* on the transformed scale, and then BACK TRANSFORMED

Transformed = the transformation, if used, as defined in the ASTM Lubricant Test Monitoring System

BACK TRANSFORM = the back transformation, if applicable, to convert transformed results back to the original scale

UpperP =Upper Limit of the Confidence Interval

LowerP =Lower Limit of the Confidence Interval

P.5.3.2 Estimated Test Result Confidence Interval and Width for the Mean (CIW_2)

$$\text{UpperM} = \text{BACK TRANSFORM}\{\text{Transformed Predicted Test Result} + t_{0.975,df} * S * \sqrt{h_i}\}$$

$$\text{LowerM} = \text{BACK TRANSFORM}\{\text{Transformed Predicted Test Result} - t_{0.975,df} * S * \sqrt{h_i}\}$$

$$CIW_2 = \text{ABSOLUTE VALUE}(\text{UpperM} - \text{LowerM})$$

Where:

The *Predicted Test Result* is for the mean, and is not assumed to be known

$t_{0.975,df}$ = distance from mean for Student *t* distribution with cumulative area of 0.975
This equates to a 95% 2-sided Confidence Interval

df = n – p
n=Number of test results in the data set used in the analysis
p=Number of regression parameters including the intercept

S = Root Mean Squared Error from the analysis which may be on the transformed scale

If S is in transformed units, the confidence interval must be calculated for the *Predicted Test Result* for the *Candidate Oil* on the transformed scale, and then BACK TRANSFORMED

Transformed = the transformation, if used, as defined by the Model Developer

BACK TRANSFORM = the back transformation, if applicable, to convert transformed results back to the original scale

UpperM =Upper Limit of the Confidence Interval

LowerM =Lower Limit of the Confidence Interval

$h_i = x_i (X^T X)^{-1} x_i^T$ *(the diagonal of the hat matrix)*

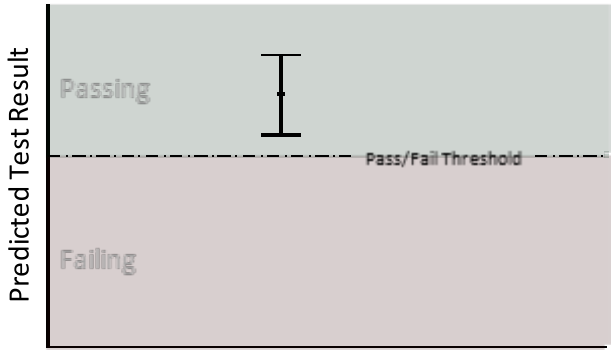
X = the factor matrix

x_i = the predictor variable setting (for the *Predicted Result*)

T = Transpose

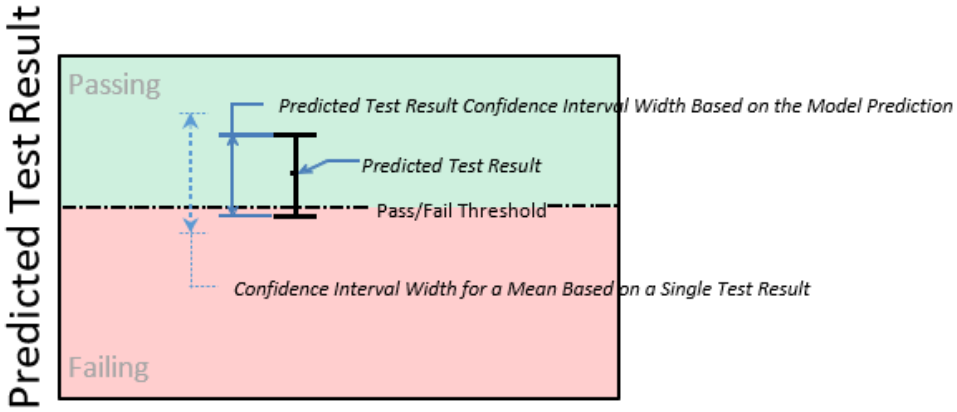
P.5.4 CONFIDENCE INTERVAL REQUIREMENT

CIR1: LowerM and UpperM are both a *Passing Test Result*
Then: PASS Confidence Interval Requirement



CIR1: Predicted Confidence Interval above Pass/Fail Limit Threshold

CIR2: If $CIW_2 <= CIW_1$
Then: PASS Confidence Interval Requirement



CIR2: CI width of Model Prediction less than CI width for a Mean based on a Single Test Result

If CIR1 (If Calculatable) is true OR CIR2 is true
Then: PASS Confidence Interval Requirement

CIR: Confidence Interval Requirement

P.5.5 SPREAD REQUIREMENT MEASUREMENTS

When performing the spread calculations for the *Spread Requirement*, all raw data and data means must be properly formatted according to the specific ASTM test procedure and using the ASTM E29 standard practice for rounding. If not specified in the ASTM test procedure:

Round Saturates to the nearest tenths place using ASTM E29 rounding.

Round VI to whole numbers using ASTM E29 rounding. The rounding for VI is applied to each Base Oil in the Model Data Set and subsequent calculations such as the overall mean of the Base Oils.

Given that rounding is involved, when counting the number of *Base Oils* on either side of the mean, a *Base Oil Property of Interest* equal to the mean should be counted as zero.

P.6 SINGLE TECHNOLOGY MATRIX EXAMPLES

These are simplified examples that do not portray every detail of the process, but just enough details to highlight the purpose of the example. For illustrative purposes, examples may only use and display one *Property of Interest* even though there will be more than one in real practice. The test Pass Limit for all examples is a minimum of 8.0.

P.6.1 INITIAL FAILURE TO MEET *SPREAD REQUIREMENT*

- *PASSES* = MAXIMUM(5, *Properties of Interest*+2)
  PASSES = MAXIMUM(5, *1*+2)
  PASSES = 5

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
~~1~~	~~3~~	~~93.0~~	~~2.7~~	~~1/1/2019~~	Start date at 1/1/2020 and remove
1	1	60.0	8.6	1/1/2020	
1	2	91.0	8.4	1/2/2020	
1	3	93.0	9.2	1/3/2020	
1	4	96.0	8.1	1/4/2020	
1	5	100.0	8.9	1/5/2020	

- *Model Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	8.6	1/1/2020	
1	2	91.0	8.4	1/2/2020	
1	3	93.0	9.2	1/3/2020	
1	4	96.0	8.1	1/4/2020	
1	5	100.0	8.9	1/5/2020	

- EVALUATION

The mean Saturates of all the *Base Oils* = 88.0. At least one of three criteria must be met to satisfy the *Spread Requirement*.

a) The number of *Base Oils* on either side of the mean must be within a count of 1 or equal in number.
Four *Base Oils* above the mean and only one *Base Oil* below the mean. NOT SATISFIED.

b) The percentage of *Base Oils* on each side of the mean must be at least 33%.
20% of the *Base Oils* are below the mean. NOT SATISFIED.

c) Using ASTM E178 One-Sided Test with the standard deviation being calculated from the same sample and an upper significance of 10%, the critical values of *T* must not be exceeded.
T score of 1.75 exceeds critical value of 1.60. NOT SATISFIED.

Therefore, the *Spread Requirement* is not satisfied. There can be no *Successful Predicted Test Result*.

An additional test on Technology 1 is completed on 2/1/2020.

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
~~1~~	~~1~~	~~60.0~~	~~8.6~~	~~1/1/2020~~	Limit Saturates to >=90 and remove
1	2	91.0	8.4	1/2/2020	
1	3	93.0	9.2	1/3/2020	
1	4	96.0	8.1	1/4/2020	
1	5	100.0	8.9	1/5/2020	
1	6	90.0	8.5	2/1/2020	

- *Model Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	2	91.0	8.4	1/2/2020	
1	3	93.0	9.2	1/3/2020	
1	4	96.0	8.1	1/4/2020	
1	5	100.0	8.9	1/5/2020	
1	6	90.0	8.5	2/1/2020	

- EVALUATION

Since all *Base Oils* are above 90% Saturates and do not include any Group I, there is no *Spread Requirement*. A *Prediction Model* may be developed.

P.6.2 CREATE THE MODEL DATA SET TO SATISFY SPREAD REQUIREMENT

- *PASSES* = MAXIMUM(5, *Properties of Interest*+2)
  PASSES = MAXIMUM(5, *1*+2)
  PASSES = 5

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	8.1	1/1/2019	
1	2	62.0	8.6	1/1/2020	
1	3	64.0	8.4	1/2/2020	
1	4	66.0	9.2	1/3/2020	
1	5	68.0	8.8	1/4/2020	
1	6	70.0	8.9	1/5/2020	
1	7	72.0	9.2	1/6/2020	
1	8	100.0	9.2	1/7/2020	

- *Model Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	8.1	1/1/2019	
1	2	62.0	8.6	1/1/2020	
1	3	64.0	8.4	1/2/2020	
1	4	66.0	9.2	1/3/2020	
1	5	68.0	8.8	1/4/2020	
1	6	70.0	8.9	1/5/2020	
1	7	72.0	9.2	1/6/2020	

Base Oil 8 is eliminated from the *Model Data Set* to satisfy the *Spread Requirement*. (With Base Oil 8 removed, any of the 3 approaches satisfy the spread requirement and can be used in this example.)

P.6.3 TEST FAIL IN THE *MODEL DATA SET*

- *PASSES* = MAXIMUM(5, *Properties of Interest*+2)
  PASSES = MAXIMUM(5, *1*+2)
  PASSES = 5

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	8.1	1/1/2019	
1	2	89.0	8.6	1/1/2020	
1	3	100.0	8.4	1/2/2020	
1	4	100.0	9.2	1/3/2020	
1	5	100.0	8.8	1/4/2020	
1	6	100.0	8.9	1/5/2020	
1	7	100.0	7.9	1/6/2020	Failed Test
1	8	100.0	9.2	1/7/2020	

- *Model Data Set Option 1*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	3	100.0	8.4	1/2/2020	
1	4	100.0	9.2	1/3/2020	
1	5	100.0	8.8	1/4/2020	
1	6	100.0	8.9	1/5/2020	
1	7	100.0	7.9	1/6/2020	Failed Test
1	8	100.0	9.2	1/7/2020	

- *Model Data Set Option 2*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	3	100.0	8.4	1/2/2020	
1	4	100.0	9.2	1/3/2020	
1	5	100.0	8.8	1/4/2020	
1	6	100.0	8.9	1/5/2020	
1	8	100.0	9.2	1/7/2020	

In Option 1, the Model Developer drops all *Base Oils* below 90% to eliminate the *Spread Requirement* not satisfied in the *Single Technology Matrix Data Set*. In Option 2, the Model Developer chooses to drop Base Oil 7, though this is not necessary to satisfy the *Spread Requirement.* Both options are legitimate and allowed as it is at the discretion of the Model Developer whether to include failing data in the *Model Data Set.* However, in either option, a *Predicted Test Result* may not be generated for Base Oil 7 because it is a fail below the pass limit.

- *Model Data Set Option 3*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	8.1	1/1/2019	
1	2	89.0	8.6	1/1/2020	
1	3	100.0	8.4	1/2/2020	
1	4	100.0	9.2	1/3/2020	
1	7	100.0	7.9	1/6/2020	Failed Test
1	8	100.0	9.2	1/7/2020	

In Option 3, the Model Developer chooses to drop Base Oil 5 and Base Oil 6 to enable the inclusion of Group I while satisfying the *Spread Requirement*. Again, a *Predicted Test Result* may not be generated for Base Oil 7, even though it is in the *Model Data Set*, because it is a fail below the pass limit.

- *Model Data Set Option 4*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	8.1	1/1/2019	
1	2	89.0	8.6	1/1/2020	
1	3	100.0	8.4	1/2/2020	
1	4	100.0	9.2	1/3/2020	
1	6	100.0	8.9	1/5/2020	
1	8	100.0	9.2	1/7/2020	

In Option 4, the Model Developer chooses to drop Base Oil 5 and Base Oil 7. As stated earlier, inclusion of failing data is at the discretion of the Model Developer. Again, a *Predicted Test Result* may not be generated for Base Oil 7.

P.6.4 TEST FAIL AND PASS WITH THE SAME *BASE OIL* IN THE *MODEL DATA SET*

- *PASSES* = MAXIMUM(5, *Properties of Interest*+2)
  PASSES = MAXIMUM(5, *1*+2)
  PASSES = 5

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1B	1	60.0	8.1	1/1/2019	
1	6	100.0	7.7	6/1/2019	Failed Test Base Oil 6
1	7	100.0	9.2	6/2/2019	Pass Base Oil 7 for Technology 1
1A	7	100.0	9.2	6/3/2019	Pass Base Oil 7 for Technology 1A
1B	2	70.0	8.6	1/1/2020	
1B	3	80.0	8.4	1/2/2020	
1B	4	90.0	9.2	1/3/2020	
1B	5	100.0	8.8	1/4/2020	
1B	6	100.0	8.9	1/5/2020	Pass Base Oil 6 for Technology 1B
1B	7	100.0	7.9	1/6/2020	Failed Test Base Oil 7

- *Model Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1B	1	60.0	8.1	1/1/2019	
1B	2	70.0	8.6	1/1/2020	
1B	3	80.0	8.4	1/2/2020	
1B	4	90.0	9.2	1/3/2020	
1B	5	100.0	8.8	1/4/2020	
1B	6	100.0	8.9	1/5/2020	
1B	7	100.0	7.9	1/6/2020	Failed Test

Technology 1 and 1A are eliminated from the *Model Data Set* because they are not necessary for a Technology 1B *STM* (note that Technology 1A is a *Minor Formulation Modification* from Technology 1 and Technology 1B is a *Minor Formulation Modification* from 1A). They may remain, however, in the *Single Technology Matrix Data Set* because of the technology relationship through a *Minor Formulation Modification.* Inclusion of Base Oil 7 is up to the Model Developer.

In this case, a *Predicted Test Result* may be generated for Base Oil 6 and Base Oil 7 because a test pass was obtained on Base Oil 6 on 1/5/2020 and on Base Oil 7 on 6/2/2019 and 6/3/2019 on the *Technology*, and the *Data* is available in the *Single Technology Matrix Data Set*.

P.6.5 SPREAD REQUIREMENT AND MULTIPLE TESTS ON A *BASE OIL* IN THE *MODEL DATA SET*

- *PASSES* = MAXIMUM(5, *Properties of Interest*+2)
  PASSES = MAXIMUM(5, *1*+2)
  PASSES = 5

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	9.2	1/1/2019	
1	2	70.0	8.6	1/1/2020	
1	3	80.0	8.4	1/2/2020	
1	4	90.0	8.3	1/3/2020	
1	5	100.0	7.9	1/4/2020	MTAC Pass for Base Oil 5
1	5	100.0	7.9	1/5/2020	MTAC Pass for Base Oil 5
1	5	100.0	7.9	1/6/2020	MTAC Pass for Base Oil 5
1	5	100.0	8.4	1/7/2019	MTAC Pass for Base Oil 5

- *Model Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	9.2	1/1/2019	
1	2	70.0	8.6	1/1/2020	
1	3	80.0	8.4	1/2/2020	
1	4	90.0	8.3	1/3/2020	
1	5	100.0	7.9	1/4/2020	MTAC Pass for Base Oil 5
1	5	100.0	7.9	1/5/2020	MTAC Pass for Base Oil 5
1	5	100.0	7.9	1/6/2020	MTAC Pass for Base Oil 5
1	5	100.0	8.4	1/7/2019	MTAC Pass for Base Oil 5

A *Base Oil* is repeated in testing due to MTAC; but, the *Base Oil Properties of Interest* only count once in the *Spread Requirement* calculations. Therefore, all 4 tests with Base Oil 5 remain in the *Model Data Set*.

P.6.6 INSUFFICIENT NUMBER OF UNIQUE *BASE OILS* RESULTING IN *PASSING TEST RESULTS*

- *PASSES* = MAXIMUM(5, *Properties of Interest*+2)
  PASSES = MAXIMUM(5, *1*+2)
  PASSES = 5

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	9.8	1/1/2020	
1	2	70.0	7.1	1/2/2020	Not an MTAC Pass for Base Oil 2
1	2	70.0	8.0	1/3/2020	Not an MTAC Pass for Base Oil 2
1	3	80.0	8.9	1/4/2020	
1	4	90.0	7.9	1/5/2020	MTAC Pass for Base Oil 4
1	4	90.0	8.1	1/6/2020	MTAC Pass for Base Oil 4
1	5	100.0	9.4	1/7/2020	

- *Model Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	9.8	1/1/2020	
1	2	70.0	7.1	1/2/2020	Not an MTAC Pass for Base Oil 2
1	2	70.0	8.0	1/3/2020	Not an MTAC Pass for Base Oil 2
1	3	80.0	8.9	1/4/2020	
1	4	90.0	7.9	1/5/2020	MTAC Pass for Base Oil 4
1	4	90.0	8.1	1/6/2020	MTAC Pass for Base Oil 4
1	5	100.0	9.4	1/7/2020	

- EVALUATION

Base Oil 2 and Base Oil 4 are repeated in testing due to MTAC; but, the *Base Oil Properties of Interest* only count once in the *Spread Requirement* calculations. However, *PASSES* = 5, and we only have 4 unique *Base Oils* Resulting in *Passing Test Results*. Therefore, the *PASSES* requirement is not satisfied; and, there can be no *Successful Predicted Test Result.*

P.6.7 *SUCCESSFUL PREDICTED RESULT* DEPENDS ON THE *CANDIDATE BASE OIL*

- *PASSES* = MAXIMUM(5, *Properties of Interest*+2)
  PASSES = MAXIMUM(5, *1*+2)
  PASSES = 5

- *Single Technology Matrix Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	7.9	1/1/2020	MTAC Pass for Base Oil 1
1	1	60.0	8.1	1/2/2020	MTAC Pass for Base Oil 1
1	2	70.0	8.2	1/3/2020	
1	**99**	**77.0**	**3.1**	**1/4/2020**	**Declared Outlier in Analysis**
1A	3	75.0	8.2	1/5/2020	
1A	4	80.0	8.4	1/6/2020	
1A	5	85.0	8.4	1/7/2020	
1A	6	90.0	8.6	1/8/2020	
1A	7	100.0	8.7	1/9/2020	

- *Model Data Set*

Technology	Base Oil	Saturates	Test Result	Completion Date	Other/Comment
1	1	60.0	7.9	1/1/2020	MTAC Pass for Base Oil 1
1	1	60.0	8.1	1/2/2020	MTAC Pass for Base Oil 1
1	2	70.0	8.2	1/3/2020	
1A	3	75.0	8.2	1/5/2020	
1A	4	80.0	8.4	1/6/2020	
1A	5	85.0	8.4	1/7/2020	
1A	6	90.0	8.6	1/8/2020	
1A	7	100.0	8.7	1/9/2020	

- EVALUATION

Base Oil 1 is repeated in testing due to MTAC; but, the *Base Oil Properties of Interest* only count once in the *Spread Requirement* calculations. Therefore, all tests, except the *Outlie*r, remain in the *Model Data Set*. The mean Saturates of all the *Base Oils* = 80.0 and the *Spread Requirement* is satisfied. PASSES = 6 (5 + 1 for *Minor Formulation Modification*), and we have 7 unique *Base Oils* Resulting in *Passing Test Results*. Therefore, the *PASSES* requirement is satisfied.

- Develop *Prediction Model*

  Model: Result = 6.915 + 0.01804 Saturates

- Determine Outliers (Optional)

  First iteration of modeling is not shown in the example, but the test involving *Base Oil* 99 is declared an *Outlier* and removed from the *Model Data Set*. Since there are no *Passing Test Results* involving *Base Oil 99* in the *Single Technology Matrix Dataset*, we cannot generate a *Successful Predicted Test Result* involving this *Base Oil*. There are no subsequent *Outliers*.

- EVALUATION

Candidate Oil	*Technology/ Base Oil*	Saturates of *Candidate Base Oil*	Predicted Test Result from *Prediction Model*	*Predicted Result ≥ 8.0*	Other/Comment
Candidate Oil 1	1A / NEW	61.0	8.0	Yes	Must check Confidence Interval Requirement
Candidate Oil 2	1A / NEW	64.0	8.1	Yes	Must Check Confidence Interval Requirement
Candidate Oil 3	1 / NEW	Cannot use for Technology 1			
Candidate Oil 4	1A / **99**	Cannot use for Base Oil 99			

We may continue the process with Candidate Oil 1 and Candidate Oil 2 only.

- Calculate Confidence Intervals and Confidence Interval Widths

The Industry standard deviation for the test is 0.02 and there is no transformation.

$$CIW_1 = (\text{Predicted Test Result} + Z_{0.975} * \sigma) - (\text{Predicted Test Result} - Z_{0.975} * \sigma)$$

$$CIW_1 = (\text{Predicted Test Result} + 1.96 * 0.02) - (\text{Predicted Test Result} - 1.96 * 0.02)$$

$$CIW_1 = 0.08$$

Note that the details of the CIW_2 calculations are not shown in this example, but the results may be reproduced.

Candidate Oil	Predicted Test Result	CIW_1	Upper M	Lower M	CIW_2	Other/Comment
Candidate Oil 1	8.0	0.08	7.9	8.1	0.2	
Candidate Oil 2	8.1	0.08	8.0	8.2	0.2	

CIR1: LowerM and UpperM are both a *Passing Test Result*
Then: PASS Confidence Interval Requirement

CIR2: If $CIW_2 <= CIW_1$
Then: PASS Confidence Interval Requirement

- EVALUATION

Candidate Oil 1 fails both CIR1 and CIR2 of the *Confidence Interval Requirement*.
There is no *Successful Predicted Test Result* for *Candidate Oil* 1.

Candidate Oil 2 passes CIR1 but fails CIR2. We may proceed with *Candidate Oil* 2.

- *Successful Predicted Test Result* for *Candidate Oil* 2.

The *Predicted Test Result* for *Candidate Oil* 2 is a *Successful Predicted Test Result*. The *Successful Predicted Test Result* may be used in lieu of an actual engine test result.

Annex Q

Glossary

For the purposes of this standard, the following definitions apply:

Administrative Guidance Panel (AGP): A balanced body, consisting of three API and three automotive manufacturer (Ford, General Motors, and DaimlerChrysler) members, that will meet at least annually to evaluate the operation of the EOLCS program.

Aftermarket Audit Program (AMAP): See Section 8 and monitoring, enforcement, and conformance below.

American Automobile Manufacturers Association (AAMA): A trade association that represented car manufacturers headquartered in the United States. AAMA disbanded on May 1, 1999.

Note: On December 16, 1992, the Motor Vehicle Manufacturers Association of the United States (MVMA) changed its name to the American Automobile Manufacturers Association.

American Chemistry Council (ACC): A trade association formerly known as the Chemical Manufacturers Association (CMA) responsible for the development and administration of the Petroleum Additives Panel Product Approval Code of Practice (ACC Code of Practice; see Annex K).

American Petroleum Institute (API): A trade association that promotes U.S. petroleum interests, encourages development of petroleum technology, cooperates with the government in matters of national concern, and provides information on the petroleum industry to the government and the public.

API Base Oil Interchangeability Guidelines: A system that reduces testing costs by permitting the interchangeable use of certain base oils without requiring a full engine and bench test program for each of the base oils. This system is described in detail in Annex E.

API Certification Mark: An API Mark that remains the same for a given application (for example, gasoline, fuel-flexible, light-duty diesel) even if a new minimum engine oil standard or standards are developed.

API Guidelines for SAE Viscosity-Grade Engine Testing: Guidelines established for different oil viscosity grades that allow certain engine and bench test results to be used in lieu of additional testing. These guidelines are described in detail in Annex F.

API Mark: A mark licensed by API and used by oil marketers in connection with engine oil products to certify conformance with quality standards established under the API EOLCS.

API Service Symbol: An API Mark that identifies specific engine oil performance levels by means of alphanumeric Service Categories, SAE viscosity grades, and any currently applicable classifications, including but not restricted to, “Resource Conserving”, “SN PLUS” and “CI-4 PLUS” classifications as appropriate.

ASTM: A professional society that is responsible for the publication of test methods and the development of test evaluation techniques.

ASTM Test Monitoring Center: An entity within ASTM that monitors the calibration of engine test stands and laboratories (see referenced laboratory).

Base Oil: A base oil is the base stock or blend of base stocks used in a finished lubricant.

Base Oil Interchangeability Guidelines: See API Base Oil Interchangeability Guidelines above.

Base Stock: A base stock is a lubricant component that is produced by a single base stock manufacturer to the same specifications (independent of feed source or manufacturer’s location); that meets the same base stock manufacturer specification; and that is identified by a unique formula, product identification number, or both. Base stocks shall be substantially free from materials introduced through manufacturing, contamination, or previous use.

Base Stock Manufacturer: A base stock manufacturer is an organization that oversees the production of one or more base stocks by chemical transformation(s) and/or physical separation(s) yielding products defined by that manufacturer's specified physical and/or chemical properties.

Base Stock Slate: A product line of base stocks that have different viscosities but are in the same base stock group and from the same manufacturer.

Bench test: A laboratory test that measures various performance parameters of an engine oil.

Engine Oil: A lubricating agent that can be classified according to one or a combination of the viscosity grades identified in Table 1 of the most recent edition of SAE J300. Engine oils are also called motor oils. Engine oils include diesel engine oils and passenger car motor oils (PCMOs).

Engine Oil Licensing and Certification System (EOLCS): An administrative process and legally enforceable system by which API authorizes marketers of engine oil to display an API Mark or Marks on oils that meet specified industry standards, as prescribed in a formal licensing agreement.

Engine Oil Licensing and Certification System (EOLCS), Online Application

The EOLCS Online Application can be found at http://engineoil.api.org. The Online Application asks prospective licensees to provide and current licensees to maintain the following information on licensed oils:

a. Elemental analysis data.
b. Finished oil physical properties.
c. Additive and base oil information.
d. Engine test information (stand code from applicable category engine test, base oil interchange/viscosity grade read across use).
e. Product traceability code information.

Prospective and current licensees are also asked to provide and maintain company and contact information. This includes the following:

a. Company address, phone, fax, and website information.
b. Contact address, phone, fax, and email information.

Additionally, licensed marketers must complete the steps for annual renewal and may periodically be required to respond to audit findings. The audit process is described in Section 8.

Questions on the Online Application should be emailed to the API Helpdesk at eolcs@api.org . Helpdesk personnel can also be reached at 1-877-562-5187.

Engine Test: (also called engine sequence test or sequence test) A test of an oil's performance using a full-scale engine operating under laboratory conditions.

Formulation Identifier: An alphanumeric designation that permits traceability of samples in the marketplace by formulation.

Formulation/Stand Code: As defined in the ACC Code of Practice, a unique identification number that is assigned before engine testing to each candidate oil tested and that identifies the candidate's formulation, sponsor, blend, blend modification, test type, run number, testing laboratory, and test stand.

Independent Lubricant Manufacturers Association (ILMA): A trade association of businesses engaged in compounding, blending, formulating, packaging, marketing, and distributing lubricants.

Interindustry Advisory Group (IAG): Provides advice to the API/Automotive Manufacturers Administrative Guidance Panel regarding the API EOLCS. The Interindustry Advisory Group consists of representatives from organizations such as Ford, General Motors, and Chrysler; ACC; API; ASTM; EMA; ILMA; JAMA; PAJ; SAE; and the U.S. Army.

International Lubricant Specification Advisory Committee (ILSAC): A joint committee of Ford, General Motors, and Chrysler and JAMA members that assists in the development of new minimum oil performance standards.

Japan Automobile Manufacturers Association (JAMA): A trade association that represents automobile manufacturers headquartered in Japan.

License Number: An identification number that is issued to a marketer upon successful completion of the licensing process and is used for audit purposes.

Licensed Fingerprint: The physical and chemical properties of a licensed formulation as defined in the finished oil physical properties and elemental analysis sections of the EOLCS Online Application.

Monitoring, Enforcement, and Conformance: Aftermarket monitoring and enforcement to ensure that representation in the marketplace of API Marks to consumers and compliance with technical specifications are being adhered to, as stated in the API license agreement.

Oil Marketer: The marketing organization responsible for the integrity of a brand name and the representation of the branded product in the marketplace.

Online Application: See entry for *Engine Oil Licensing and Certification System (EOLCS), Online Application*

Passenger Car Motor Oils (PCMOs): Engine oils for passenger cars, light-duty trucks, and similar vehicles (see also engine oil).

Petroleum Additives Panel Product Approval Code of Practice (ACC Code): A system developed by ACC to register and account for engine tests to help ensure that a lubricant meets a given performance specification. This system is described in detail through the link found in Annex K.

Petroleum Association of Japan (PAJ): A trade association that represents petroleum companies headquartered in Japan and promotes Japanese petroleum interests.

Physical and Chemical Properties: The results from several analytical tests that measure various physical characteristics and ingredients (constituents) of an engine oil.

Product Traceability Code: A code that permits oil samples in the marketplace to be traced by formulation, date of packaging, and source of manufacture.

Provisional License: Authority granted by API to a marketer to permit the temporary licensing of a specific engine oil when one of the required engine tests has been declared “out of control” by ASTM. A provisional license may also be granted for an engine oil that is qualified by means of SAE viscosity-grade engine testing “read across” from another provisionally licensed engine oil (see 3.7 for details).

Referenced Laboratory: An engine testing laboratory that is monitored by the ASTM Test Monitoring Center’s blind reference oil system.

SAE: An engineering society founded to develop, collect, and disseminate knowledge of mobility technology.

Service Category: An alphanumeric code developed by API to specify a level of performance defined by API 1509, ASTM D4485 and/or SAE J183. As new Service Categories are developed, new alphanumeric codes may be assigned.

Severity Adjustments: Mathematically derived correction factors designed to minimize or eliminate laboratory biases. Severity adjustments are developed by the testing laboratory and confirmed by the ACC Monitoring Agency and the ASTM Test Monitoring Center.