To: API Lubricants Group
Cc: Lubricants Group Mailing List
API

Ballot for Annex P – New API Guidelines for Use of Single Technology Matrix

On August 18, 2021, the BOI/VGRA Chair reported the work had been completed on Annex P – New API Guidelines for Use of Single Technology Matrix. The BOI/VGRA Task Force and the STM Work Group had recently completed their work on the New Annex P. The BOI/VGRA Presentation summarized significant changes in the New Annex P. (Attachment 1)

After the presentation the Lubricants Group had an opportunity for discussion and questions. A draft of Annex P is provided with this Ballot. (Attachment 2)

The Lubricants Group discussion led to a Motion to **Ballot Annex P – New API Guidelines for Use of Single Technology Matrix.**

Motion by Eric Kalberer

Second by Bill O'Ryan

Motion

Move to ballot Annex P for inclusion in API 1509 using the current draft of Annex P.

Voice Vote:

- Negative: 0
- Abstain: 2
- Approve: 18

Motion Passed: Issue a Ballot for Annex P – New API Guidelines for Use of Single Technology Matrix.

Lubricants Group Members should use the API Ballot System to cast their vote and make comments. The Ballot Link is: http://Ballots.api.org. The Lubricants Group Member votes will be counted, and all received comments reviewed and considered before the ballot results are final.

Non-Lubricants Group Members should comment on the Ballot Motion using the Ballot system. The Ballot Link is: http://Ballots.api.org. All comments on the Ballot Motion will be reviewed before the ballot results are final.

Ballot will close on September 27, 2021. All Votes and Comments must be submitted by the close of business on that day.

Attachment 1

Report to API Lubricant Standards Group

“Annex U” - API Guidelines for Use of a Single Technology Matrix (STM)

“Annex U” - API Guidelines for Use of a Single Technology Matrix

Report to API Lubricant Standards Group

August 2021

Agenda

- Background and overview of “Annex U”
- Highlight new format and terms
- Properties of Interest
- Discussion

Background and Basis for New STM Annex

- Many stakeholders felt many aspects of Annex R were open to interpretation (unintended) and wanted to clarify the document
- Attempts clarify were unsuccessful – they constantly led proposed changes that were more than editorial.
- A new annex was proposed and the STM Work Group was tasked with assembling a new document.
- The work group representation consisted of a mix of AdCo's, Oil Marketers, and base oil marketers.
- Meetings over ~ 2 year timeline
- Document was sent to API BOI-VGRA for a discussion amongst the entire task force representation and then brough here to LSG.

“Annex U”

- “Annex U” is what the new STM annex has been referred as a placeholder, however, it may end up as a different Annex designation. Likely to be Annex P.

- “Annex U” application is currently proposed to apply to the Seq IIIH (IIIH, IIIH60-80, IIIH60, IIIH70)
  - Could be applied to other tests in the future

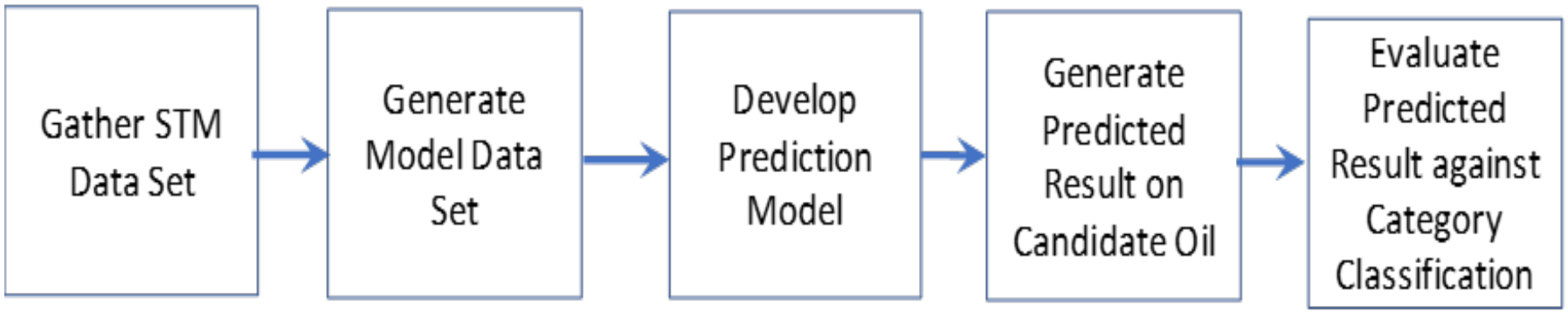
- “Annex U” is separate and distinct from Annex R
  - Annex R will remain intact and apply to Seq IIIF, IIIFHD, and IIIG
  - Annex R will not be modified or used for new tests
  - Annex R was unclear which resulted in different practices

- Generating the new STM Annex had 2 broad goals:
  - Remove/minimize ambiguity of the STM approach
    - “Annex U” is written to be clear about the general STM approach and specific engine test requirements

  - Define the Base Oil Properties of Interest for the Seq IIIH
    - What defines the Range of Key Properties for base oils in application of the STM concept to the Sequence IIIH engine test?

STM Overview

Generic Flowchart Overview for STM Generation



Provided for illustrative overview purposes. It is not intended to be prescriptive.

Annex U - Highlights

- Document structured to have an overview and definition of terms at the front
- Table of Contents is provided
  - U.1 General Principles, Introduction and Definitions
  - U.2 STM Development
  - U.3 Notification of Use
  - U.4 Engine Tests Approved for STM
  - U.5 Calculation and Method Details
  - U.6 Examples
- Important terms are *italicized* and defined to better explain the process of developing and using *Single Technology Matrix* and to reduce the opportunity for misinterpretation
  - Attention was given to maintain consistent wording in the document
- Made the document easier to read and understand how an STM is developed and used
- General readers can focus on U.1-U.4 while Stats people will like U.5-U.6

What is New for “Annex U”

- Cannot use STM model to predict a pass when an actual test has been a fail- within the defined ranges of the *Model Data Set* (see U.1.2.11.3)
- STM data set includes the listing of failing data
    - Failing data is available to Marketer in the *Single Technology Matrix Data Set*
    - *Model Data Set* is a subset of the *Single Technology Matrix Data Set*
- There are three ways to satisfy the *Spread Requirement* (see U.1.2.8)
- *Testing Period Date Range* has been added to Annex U
- The *Multiple Technology Matrix* concept has been excluded in Annex U
- Many new definitions have been added to Annex U to enhance clarity
- “Annex U” is written to be clear about the general STM approach and the engine test specific requirements

Timeline – Properties of Interest

- 2012ish: Annex R clarification work begins with the STM Work Group
- 2012 – 2018: Process morphs from Annex R update to Annex U development under the STM Work Group
- 2019-June: Annex R properties of interest proposed for adoption into “Annex U” IIIH STM. Supported by data from 3 ACC members
- 2020-Feb/Oct: Proposal of additional properties of interest for STM task force consideration by ExxonMobil.
- Present: Multiple IIIH data sets evaluated using the Annex R properties of interest and an alternative set.
  - Majority agree to adopt Annex R, but not full consensus.

Properties of Interest Discussion Overview

- A data-based decision was made to include Annex R Properties of Interest in the “Annex U” document.
  - Numerous discussions at work group and task force levels
  - Original Annex R properties considered sufficient predictors of Seq IIIH performance.
  - Effort to support and complexity were part of that decision.

- The decision to adopt Annex R properties was not a full consensus.
  - Majority agreed to bring this to Lubricants Group as a full consensus was not possible at either the STM work group or BOI-VGRA task force level.

BOI-VGRA Recommendation to LG

- After several discussions and review of comments at BOI VGRA, the task force recommends that Lubricant's Group review and ballot the document now titled "Annex P"
  - The last draft document being re-cast as "Annex P" was last known as ATT03Oronite-Annex U_May 15-2021_labi edits

Motion to Ballot

- Motion by Eric Kalberer
- Second by Bill O'Ryan

- Move to ballot Annex P for inclusion in API 1509 using the current draft of Annex P.
- Negatives = 0
- Abstain = 2
- Approve = Balance
- Motion Carries – Ballot to be issued for Annex P STM

Thank You

New Terms- See U.1.2; Excerpts Below

- **U.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*

- **U.1.2.4.2** *A Model Data Set* consists of *Data* from the *Single Technology Matrix Data Set*

- **U.1.2.7** 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*

- **U.1.2.11.3** A *Successful Predicted Test Result* is a *Predicted Test Result* that is a *Passing Test Result* (U.1.2.12), and, in which, all *Data Set*, model and process guidelines and requirements outlined in Sections U.1 through U.3 (and any additional requirements listed in Section U.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 U.2).
- "*Range of Key Properties*" is used in a number of locations throughout the document to harmonize the language that best signifies maximum and minimum values that define the base oil properties of interest data set for a single technology matrix.

Attachment 2

Annex P

API Guidelines for Use of a Single Technology Matrix (STM)

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 Model* 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.

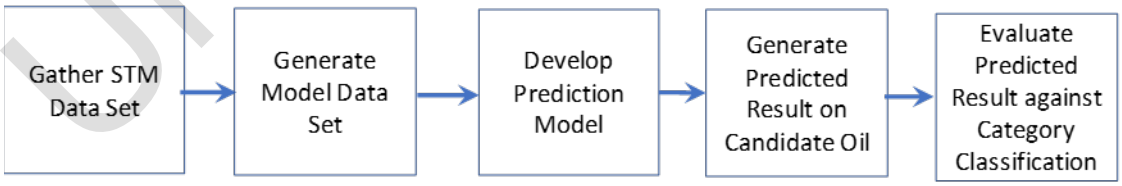
P.1.2.14 An *Outlier* is a test result in which the absolute value of the Studentized Residual for that observation from the analysis is at the cumulative 97.5th percentile, or beyond, on a Student *t* distribution. Outlier test results must be shown in the *Single Technology Matrix Data Set* even if 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)*

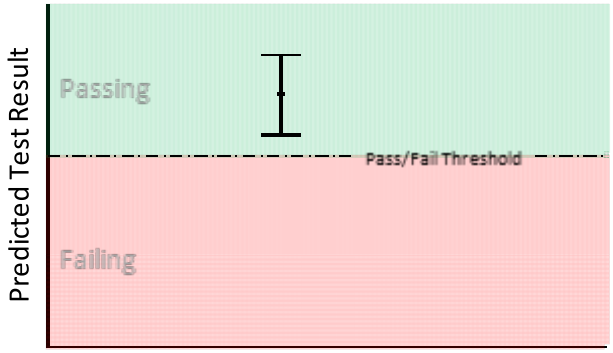
X = the factor matrix

x_i = the predictor variable setting (for the *Predicted Result*)

T = Transpose

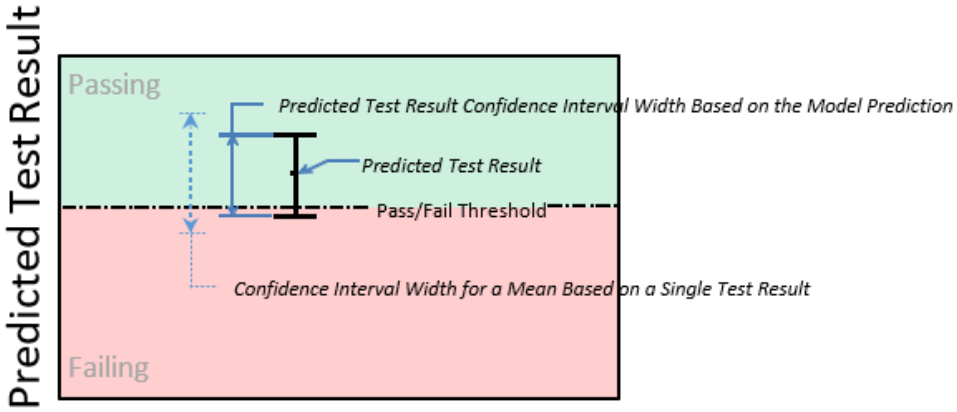
P.5.4 CONFIDENCE INTERVAL REQUIREMENT

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 *Outlier*, 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 = (Predicted Test Result + $Z_{0.975} * \sigma$) – (Predicted Test Result - $Z_{0.975} * \sigma$)

CIW_1 = (Predicted Test Result + 1.96∗0.02) – (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.