Designation: D7155 – 11

Standard Practice for Evaluating Compatibility of Mixtures of Turbine Lubricating Oils[1]

This standard is issued under the fixed designation D7155; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the compatibility of mixtures of turbine lubricating oils of the same ISO VG grade and type as defined by Specification D4304. The Tier 1 method compares the visual appearances of specific mixtures with those of the neat oils after storage at specified conditions.

1.2 If the current in-service oil is causing problems or if circumstances indicate the need for additional testing, a Tier 2 method compares selected performance properties of the mixture and its constituent oils.

1.3 The Tier 1 and Tier 2 methods can be used to evaluate new (unused) lubricant compatibility or the effects of adding new (unused) lubricant to in-service lubricant in the system.

1.4 This practice does not evaluate the wear prevention characteristics, load carrying capacity, or the mechanical shear stability of lubricants mixtures while in service. If anti-wear (AW), extreme pressure (EP), or shear stability are to be evaluated, further testing of these parameters may be required.

1.4.1 *Tier 1*—Mixtures of the two constituent oils to be evaluated are prepared at specified proportions, stored in an oven at 65°C for 168 h, and then evaluated for changes in physical appearance.

1.4.2 *Tier 1*—Mixtures of the two constituent oils to be evaluated are prepared at specified proportions, stored in an oven at 65°C for 168 h, and then evaluated for changes physical appearance and parameters detailed in 7.3.

1.5 Mixtures of the two constituent oils are evaluated in a primary testing protocol using the following standards:

Appearance (Tier 1 and Tier 2)	Appendix X1
Kinematic Viscosity	Test Method D445
Acidity	Test Methods D664 and D974
Pentane Insoluble	Test Method D893
Copper Corrosion	Test Method D130
Rust Prevention	Test Method D665
Foaming Characteristics	Test Method D892
Air Release Properties	Test Method D3427
Water Separability	Test Method D1401
Oxidation Stability Test	Note 1

1.5.1 For compatible mixtures, a supplemental (nonmandatory) testing scheme is suggested when circumstances indicate the need for additional testing the beyond Tier 2 primary recommended tests.

NOTE 1—The oxidation stability test method should be selected based on the product type and in agreement with the lubricant supplier (see Appendix X2 for options). Unlike other tests described in this practice, the impact on oxidation stability may not be easily interpreted with a pass/fail rating. The user is encouraged to contact the lubricant supplier for assistance in the evaluation of the data.

1.6 Sequential or concurrent testing is continued until the test requestor or user is satisfied that the intent of this practice has been met. If any mixture fails the Tier 1 visual appearance method or any of the Tier 2 primary tests, when requested, the oils are incompatible. If all mixtures pass the Tier 1 or Tier 2 tests, the oils are considered compatible by those methods.

1.7 This practice applies only to lubricating oils having characteristics suitable for evaluation by the suggested test methods. If the scope of a specific test method limits testing to those oils within a specified range of properties, oils outside that range cannot be tested for compatibility by that test method.

1.8 This practice may be used to evaluate the compatibility of different types and grades of oil. However, it is not intended to evaluate such mixtures. The user is advised to consult with suppliers in these situations.

1.9 This practice does not purport to cover all test methods that could be employed.

1.10 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.11 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.C0 on Turbine Oils.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
D611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents
D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration
D665 Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water
D892 Test Method for Foaming Characteristics of Lubricating Oils
D893 Test Method for Insolubles in Used Lubricating Oils
D974 Test Method for Acid and Base Number by Color-Indicator Titration
D1401 Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
D2270 Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100°C
D2272 Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel
D3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
D3427 Test Method for Air Release Properties of Petroleum Oils
D4304 Specification for Mineral Lubricating Oil Used in Steam or Gas Turbines
D4310 Test Method for Determination of Sludging and Corrosion Tendencies of Inhibited Mineral Oils
D5185 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)
D5846 Test Method for Universal Oxidation Test for Hydraulic and Turbine Oils Using the Universal Oxidation Test Apparatus
D6186 Test Method for Oxidation Induction Time of Lubricating Oils by Pressure Differential Scanning Calorimetry (PDSC)
D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
D6514 Test Method for High Temperature Universal Oxidation Test for Turbine Oils

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *compatibility, n*—of lubricating oils, the ability of lubricating oils to mix together without significant degradation of properties or performance.

3.1.1.1 *Discussion*—When a mixture of two oils has properties or performance significantly inferior to both of the constituent oils, then the two oils are incompatible. If the properties are inferior to those of one neat oil but not inferior to those of the other, then such is not necessarily considered an indication of incompatibility. To be considered significantly inferior, the property of the mixture would be worse than the poorer of the two neat oils by an amount exceeding the repeatability (or in the case of third party verification testing, the reproducibility) of the test method used to evaluate the property. (See fail and pass.)

3.1.2 *fail, n—in compatibility testing of oil mixtures*, a test result that is inferior to that of the poorer of the two constituent oils by an amount exceeding the repeatability of the test method used for the evaluation.

3.1.3 *pass, n—in compatibility testing of oil mixtures*, a test result that is equal to or better than that of the poorer of the two constituent oils.

3.1.4 *primary compatibility tests, n— of lubricating oils*, those test methods employed in the Tier 2 method to evaluate the impact on performance properties when circumstances indicate the need for additional testing.

3.1.4.1 *Discussion*—The test methods considered the most relevant in the evaluation of turbine oils, insofar as they provide the most information with the least expenditure of testing resources.

3.1.5 *secondary compatibility tests, n—of lubricating oils*, those test methods used to evaluate compatibility when the primary compatibility tests are insufficient or inconclusive.

3.1.5.1 *Discussion*—Such tests are driven by the critical features of a given application. For example, if the application subjects the oil to extraordinary high temperature an evaluation of the onset of oxidation at various temperatures using differential scanning calorimetry to construct an Arrhenius plot may be warranted. Aniline Point might be added to evaluate the relative difference in solvency characteristics. Secondary compatibility tests are suggested, but not required, by this practice.

3.1.6 *type and grade, n*—Type and grade refer to lubricants of the same general type such as Rust and Oxidation Inhibited turbine oil (R) and ISO Viscosity grades

3.1.7 *10:90 mixture, n*—a uniform blend of 10 % by volume of one oil with 90 % by volume of a second oil.

3.1.8 *50:50 mixture, n*—a uniform blend of 50 % by volume of each of two component oils.

3.1.9 *90:10 mixture, n*—a uniform blend of 90 % by volume of one oil with 10 % by volume of a second oil.

4. Summary of Practice

4.1 *Option 1*—Prepare a 50:50 mixture of two oils to be evaluated for compatibility. This mixture and the two neat, constituent oils are tested using the primary compatibility tests. Depending on the performance of the mixture, relative to those of the constituent oils, 10:90 and 90:10 mixtures may need to be tested in addition.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4.2 *Option 2*—Instead of testing mixtures in sequential order, 10:90 and 90:10 mixtures are tested at the same time the 50:50 mixture is evaluated. If all mixtures pass the primary compatibility tests, or if the application requires the evaluation of specific properties, secondary compatibility tests can be employed for further evaluation. Such tests can be run concurrently, if desired.

5. Significance and Use

5.1 The compatibility of oils can be important for users of oil-lubricated equipment. It is well known that the mixing of two oils can produce a substance markedly inferior to either of its constituent materials. One or more of the following can occur:

5.1.1 A mixture of incompatible oils most often forms a precipitate.

5.1.2 The precipitate will form unwanted deposits in the lubrication system, plug filters and oil passageways.

5.1.3 Such events can lead to catastrophic equipment failures.

5.2 Because of such occurrences, lubricant suppliers recommend evaluating compatibility of lubricating oil of different formulations and sources prior to mixing. Equipment users most often do not have the resources to evaluate oil compatibility and must rely on their suppliers. Mixing of oils is a highly imprudent practice without first determining the compatibility.

5.3 Although new turbine oils may be compatible, in-service oil of the same type may be degraded or contaminated to such an extent that the new oil added may not be compatible with the system oil. In-service oil compatibility with new oil additions should be evaluated on a case by case basis.

5.4 The oxidation resistance of different oils of the same type can vary widely, and compatibility does not imply equivalent performance.

6. Apparatus

6.1 The equipment and materials required for this practice shall be those required by the test methods used to evaluate compatibility.

6.1.1 *Laboratory Oven,* static-air or stirred-air type, capable of maintaining the test temperature within ±3°C and equipped with one or more grill-type wire shelves.

6.1.2 *Laboratory Cooler,* capable of maintaining the test temperature within ±3°C.

6.1.3 *Reflector Flood Lamp,* 150 watt.

7. Procedure

7.1 Testing is conducted using either of two options (see Section 5.4) for mixture proportions as agreed upon with the test requestor or user and dependent on the available sample volumes supplied. Either the sequential testing protocol described in Option 1 or the concurrent testing protocol described in Option 2 can be used. Using Option 1, a 50:50 mixture and the two constituent oils are tested. If this mixture is found compatible, 10:90 and 90:10 mixtures which reflect drain-and fill conversion or make up proportions may be tested. Using Option 2, all mixtures (10:90, 50:50, and 90:10) and the two constituent oils are tested concurrently. At the discretion of the interested parties, the testing may be continued even after an incompatible test result is observed.

7.2 *Preparation of Mixtures (Tier 1 and Tier 2)*—Prepare mixtures similarly, regardless of whether one or three mixtures of differing ratios will be tested sequentially or concurrently.

7.2.1 Prepare a fresh 50:50 mixture of the two oils to be evaluated for compatibility. (neat, constituent oils are designated A and B.) Determine the amounts to be mixed from the amount of oil required by the tests. Prepare at least 10 % more mixture than is actually needed for the tests. Do not prepare more than can be used immediately. No more than 30 days should elapse between mixture preparation and the start of any test.

7.2.2 Add equal amounts ±1% of all oils, A and B neat oils, and the 50:50 mixture into separate clean, dry, glass beakers, and mix thoroughly

7.2.3 Heat the beaker and mixtures in the oven at 65 ± 3°C (149 ± 5.4°F) for a minimum of 168 h (± 1 h) for Tier 1 or Tier 2 testing. Samples may be removed after a minimum of 24 h (± 0.5 h) to conduct the Tier 2 primary tests, if requested

NOTE 2—Longer oven storage times may be employed with agreement between the parties involved.

7.2.4 Remove the beakers from the oven, and allow them to cool to room temperature before evaluating appearance.

7.2.5 Observe the oil per 7.2.4 upon reaching room temperature within 1 h (±0.5 h) in accordance with Appendix X1. If the oils display an incompatible result, further testing is not required. Conclude the test, and report in accordance with Section 8. If the results are satisfactory, proceed to 7.2.6.

7.2.6 Cool the beaker containing the oil mixtures to at least 0°C (or agreed upon temperature) for 24 h (±0.5 h). Longer times may be employed with agreement between the parties involved. Remove from the cooler and bring to room temperature.

7.2.7 Observe the oil in accordance with Appendix X1. If the oils display an incompatible result, conclude the test, and report in accordance with Section 8. If the results are satisfactory and Tier 2 level testing is to be conducted, proceed to 7.3. If Tier 1 testing was requested the testing can be concluded and reported.

NOTE 3—Use great care when preparing the contents of the beaker for some tests. Semi-solid material not visible to the unaided eye may have settled to the bottom of the vessel. This material needs to be thoroughly mixed back into the sample prior to Tier 2 testing for insolubles and the like.

7.3 *Tier 2 Testing*—If resources permit, the specified tests can be performed concurrently. Otherwise, any sequence of these tests can be used.

7.3.1 *Viscosity*—Determine and record the viscosity as described in Test Method D445.

7.3.1.1 The mixture is considered to be compatible, and its results shall be recorded as *compatible* or *pass* if the viscosity is that of either constituent oil or if it is between them. If the viscosity of the mixture is less than the lower viscosity oil or greater than higher viscosity oil by an amount greater than

repeatability of the test method, record as *incompatible* or *fail*. The temperature at which the viscosity is performed to determine the ISO Viscosity Grade is 40°C. To obtain the viscosity index, in accordance with Practice D2270, an additional viscosity must be performed at 100°C.

7.3.2 *Acid Number*—Determine and record the acid number as described in Test Methods D664 or D974.

7.3.2.1 The mixture is considered to be compatible if the acid number of the mixture is between or equal to either constituent oil. Record as *compatible* or *pass*. If the acid number of the mixture is less than or greater than the constituent oils by an amount greater than repeatability of the test method, record as *incompatible* or *fail*.

7.3.3 *Pentane Insolubles*—Determine the pentane insoluble content using Test Method D893. The mixture is considered to be compatible if the pentane insoluble content of the mixture is equal to or less than either constituent oil. Record as *compatible* or *pass*. If the insoluble content of the mixture is greater than the constituent oils by an amount greater than repeatability of the test method, record as *incompatible* or *fail*

7.3.3.1 *Foaming Characteristics*—Determine and record the foaming characteristic as described in Test Method D892. The mixture is considered to be compatible if the foaming characteristic of the mixture is equal to or less than either constituent oil. Record as *compatible* or *pass*. If the foaming characteristic of the mixture is greater than the constituent oils by an amount greater than repeatability of the test method, record as *incompatible* or *fail*.

7.3.4 *Air Release Properties*—Determine and record the air mixture as described in Test Methods D3427.

7.3.4.1 The mixture is considered to be compatible if the air release properties of the mixture is equal to or less than either constituent oil. Record as *compatible* or *pass*. If the air release properties of the mixture is greater than the constituent oils by an amount greater than repeatability of the test method, record as *incompatible* or *fail*.

7.3.5 *Water Separability*—Determine and record the water separability results as described in Test Method D1401. The mixture is considered to be compatible if the water separability of the mixture is equal to or better than either constituent oil. Record as *compatible* or *pass*. If the water separability of the mixture is worse than the constituent oils by an amount greater than repeatability of the test method, record as *incompatible* or *fail*.

7.3.6 *Oxidation Stability*—Select the appropriate oxidation stability test based on the type of lubricant being investigated. Determine and record the oxidation stability as described in the selected test method. The mixture is considered to be compatible if the oxidation stability of the mixture is equal to or higher than either constituent oil. Record as *compatible* or *pass*. If the oxidation stability of the mixture is lower than the constituent oils by an amount greater than repeatability of the test method, record as *incompatible* or *fail*.

7.3.7 *Rust Prevention*—Determine and record the rust prevention results as described in Test Method D665. The mixture is considered to be compatible if the rust prevention characteristics test is a pass. Record as *compatible* or *pass*. If the rust prevention characteristics of the mixture is a fail, record as *incompatible* or *fail*.

7.3.8 *Copper Corrosion*—Determine and record the copper corrosion results as described in Test Method D130. The mixture is considered to be compatible if the copper corrosion characteristics test is equal to or better than either of the constituent oil alone. Record as *compatible* or *pass*. If the copper corrosion characteristics of the mixture is a fail, record as *incompatible* or *fail*.

7.4 For oils determined to be compatible in primary testing, the user, or by agreement, the user and supplier, should determine whether additional testing is required. Depending on the criticality of the specification requirements, selection should be made from the secondary compatibility tests listed in Appendix X2.

7.4.1 If all of the mixtures pass all primary tests and the selected secondary tests, the oils shall be reported as compatible. If any mixture passes all primary tests but fails one or more secondary tests, the oils shall be reported as generally compatible but incompatible in certain applications. The failed tests shall be reported as well as the applications suggested by these tests.

8. Report

8.1 Report the following information:

8.1.1 Identity of the constituent oils and the mix-ratios of the mixtures tested,

8.1.2 Whether the oils were found compatible or incompatible by Tier 1 or Tier 2 assessment, and if found incompatible, report the mixing ratio(s) found incompatible and in which test(s).

8.2 If supplementary testing procedures were used, report 8.1.1 and 8.1.2. In addition, report the test methods used in supplemental testing and whether the oils were found compatible or incompatible.

9. Precision and Bias

9.1 For complete precision and bias statements, see the pertinent test methods.

10. Keywords

10.1 compatibility; incompatibility; lubricant mixtures; lubricating oil; mixtures

APPENDIXES

(Nonmandatory Information)

X1. APPEARANCE RATING

X1.1 Lubricants opaque in character or in-service lubricants that are not bright, or contain sediment, or both, may not be suitable for Tier 1 evaluation. In such cases, the Tier 2 evaluation, excluding appearance, may be conducted in agreement with the test requester or user. Set up the appearance rating test using a 150-W reflector flood lamp.

X1.2 *Rate the Sediment*—Hold the sample beaker vertically, without disturbing the sample, about 10 in. in front of your eyes and in front of the flood lamp. View the sample bottle from the different directions, angles, and distances from the light source. Assign a sediment rating according the Table X1.1.

X1.3 *Rate for Fluid Appearance*—View the sample beaker from the side, looking directly through the product mixture. Assign a fluid rating according to Table X1.1. When samples are too dark to rate for fluid appearance, they may be rated by tilting sample on side and observing the material adhering to the beaker.

TABLE X1.1 Codes for Rating Compatibility of Turbine Oils

NOTE 1—The table in 1.5 is not all inclusive. There may be other characteristics that are an indication of incompatible lubricants. These may be phase separations, "fish eyes," gels,

Fluid Clarity	Sediment Rating	Description	Pass/Fail
0	...	Absolutely Bright	Pass
1	...	Bright	Pass
2	...	Very Slight Cloud	Fail
2.5	...	Medium Moderate Cloud	Fail
3	...	Moderate Cloud	Fail
4	...	Heavy Cloud	Fail
5	...	Detectable Floc	Fail
6	...	Heavy Floc	Fail
...	0	No Sediment	Pass
...	1	Very Slight Sediment	Fail
...	2	Slight Sediment	Fail
...	3	Heavy Sediment	Fail
...	4	Appreciably More Sediment than 3	Fail
Other Observations			

X2. SUGGESTED TEST METHODS FOR SUPPLEMENTAL TESTING

X2.1 The following test methods are suggested for consideration for evaluating compatibility of oil mixtures in specification-driven applications. Compatibility testing with these test methods should be applied cautiously, since full testing is more expensive and can take considerable test time.

D611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents
D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
D2270 Practice for Calculating Viscosity Index From Kinematic Viscosity at 40°C and 100°C
D2272 Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel
D3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
D4310 Test Method for Determination of the Sludging and Corrosion Tendencies of Inhibited Mineral Oils
D5185 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)
D5846 Test Method for Universal Oxidation Test for Hydraulic and Turbine Oils Using the Universal Oxidation Test Apparatus
D6186 Test Method for Oxidation Induction Time of Lubricating Oils by Pressure Differential Scanning Calorimetry (PDSC)
D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fisher Titration
D6514 Test Method for High Temperature Universal Oxidation Test for Turbine Oils