

## Volvo T-13 Fuel Requirements

**AX.1 Fuel Requirements** - The Volvo T-13 Test shall use a fuel meeting the PC-10 specification located on the TMC website, and that has been approved for use through the process defined by the Mack/Volvo Surveillance Panel for acceptance.

AX.1.1 For a fuel to be approved for the Volvo T-13 test, the fuel supplier shall demonstrate, through chemical analyses and engine testing, that the fuel provides the same performance as a currently approved fuel. The supplier shall provide a Certificate of Analysis (COA) documenting that the fuel meets the current PC-10 fuel specification, as well as conducting a prove-out program.

AX.1.2 The fuel supplier shall conduct a full COA analysis for each batch produced.

AX.1.3 An individual lab may not bring a new fuel supplier into use, even following the criteria noted in the approval process, without the notification and review of the Surveillance Panel.

### AX.2 Prove-Out Program

AX.2.1 The prove-out program is to be run entirely on a single test stand in a single test laboratory. The chosen test stand shall have a history of at least three (3) successful calibration tests in the last four (4) years, the first LTMS appearance for the stand being over one year prior to the start of the prove-out program, and shall not have had a current lapse in calibration of greater than one calibration period.

AX.2.1.1 The prove-out program will be run using reference oil 823 (or subsequent approved oil re-blends). The alternate fuel will be evaluated based on results of the FTIR peak height oxidation (IRPH) and percent increase in viscosity at 40°C from 300 to 360 hour (KV40) parameters.

AX.2.1.2 The chosen stand shall conduct a calibration test on oil 823 on currently approved fuel and the test shall meet all LTMS calibration acceptance criteria.

AX.2.1.3 Based on the results of the test, determine the new stand-level exponentially weighted moving average, or  $Z_i$  value, for the IRPH and KV40 parameters.  $Z_i$  is as defined in the LTMS document. The  $Z_i$  value calculated for each parameter immediately after the calibration test will be referred to as  $Z_{cal}$  in the subsequent sections. Also, calculate the average front and rear exhausts manifold temperatures and average engine torque output.

AX.2.1.4 The same stand shall immediately conduct two (2) tests on oil 823 using the alternate fuel. Prior to running these two tests, notify the TMC if the results will be solely for prove-out or for stand calibration as well. It will be at the discretion of the test laboratory to determine if the stand's calibration status will be impacted by the prove-out program or not.

AX.2.1.5 For each test, calculate the difference between the standardized test result  $Y_i$  and the previously determined  $Z_{cal}$  value for each parameter. This difference is the prediction error, or  $E_i$  value.

$$E_i = Y_i - Z_{cal}$$

Note that because of the use of  $Z_{cal}$  instead of  $Z_{i-1}$ , this is slightly different than the definition of  $E_i$  in the LTMS document.  $Y_i$  is defined as in the LTMS document:

$$Y_i = \frac{R_i - M}{S}$$

where:

$Y_i$  = standardized test result at test order  $i$

$R_i$  = actual reference oil test result at test order  $i$ ,

$M$  = reference oil target mean from LTMS, and

$S$  = reference oil target standard deviation from LTMS.

AX.2.1.6 Similar to the calibration tests, calculate the average tailpipe temperature and average load.

### **AX.3 Fuel Acceptance Criteria**

AX.3.1 The results of the prove-out testing must meet the following criteria (basis for operational uncontrolled parameter ranges found in figure AX.1):

AX.3.1.1 For IRPH and KV40, the calculated  $E_i$  value shall be within +/- 1.734 for both tests.

AX.3.1.2 The average tailpipe temperature for both tests shall be within +/- 15°C of the calibration test.

AX.3.1.3 The average torque for each test shall be within +/- 35 N-m of the calibration test.

AX.3.1.4 Both alternate fuel tests shall be operationally valid with no negative Quality Index (QI) values.

AX.3.2 Fuel prove-out runs will count against the calibration interval and the stand can return to the existing calibration period on the previously approved fuel, after flushing the fuel lines, unless the SP agrees to an alternative plan prior to the start of the matrix.

AX.3.3 The Surveillance Panel will approve the fuel for use following confirmation of these results. If the supplier believes the fuel is providing equivalent performance to the current approved fuel without meeting the criteria listed above, they may petition the surveillance panel to conduct an additional review. At this point, the actions taken by the Surveillance Panel to accept or reject the fuel will vary depending on the results and judgement of the panel members.

AX.3.4 A list of approved fuel suppliers for the Volvo T-13 test is maintained on the TMC website.

*AX.4 Introduction of a Surveillance Panel Approved Fuel* – A lab may utilize any fuel that has been approved by the Surveillance panel for use with the Volvo T-13 which has previously conducted a full “Prove-Out Program” and been approved at the Surveillance Panel.

AX.4.1 A new fuel for a lab is one that has never previously completed an acceptable calibration test in that lab. Notify the Test Monitoring Center when a calibration oil is requested that a new fuel supplier will be utilized.

AX.4.2 The first run on a new fuel in a lab shall meet level 2  $E_i$  criteria as defined in the LTMS document. In the case that a level 2  $E_i$  alarm is exceeded but not a level 3 alarm, a second test may be run and the stand considered calibrated as long as the second test also falls within the level 3  $E_i$  alarm limits.

AX.4.3 Once a lab has successfully calibrated with the new fuel, lab severity adjustments will be recalculated and applied to all candidate tests across all stands until the next calibration test.

AX.4.4 For a laboratory with multiple stands it is permissible for multiple fuels to be in use simultaneously until the old fuel is depleted. A fuel that has been approved for use by the panel and has successfully calibrated in one stand in a lab is automatically approved for candidate tests in any other lab/stand combinations within the lab.

AX.4.5 A particular lab/stand combination can only transition from the previously calibrated fuel to the most recently calibrated fuel, and not back to the previous fuel once the new fuel has been utilized until the next successful calibration test. The intent is to not alternate fuels within a reference interval for candidate tests.

AX.5 *Transition Between Approved Fuels* - Transitioning between two fuels that have previously been approved for use in a particular stand can occur with no additional requirements outside of those listed in the LTMS for the calibration of an existing stand.

AX.6 *Fuel Supply Tanks* - The fuel tank located at a laboratory and supplying fuel to the test stand must be addressed in one of two ways prior to being loaded with a new fuel source.

AX.6.1 If the tank was previously filled with an unapproved fuel for the Volvo T-13 test, the tank should be fully drained and cleaned.

AX.6.2 If an approved fuel was in the tank, the overall capacity of the tank must be below 5% prior to refilling with enough volume to complete a Volvo T-13 test (approximately 7,900 gallons) or up to its maximum safe capacity.

AX.6.3 Fuel shall also be flushed through all lines connecting the supply tank to the test cell. Due to variation in line volumes from lab/stand combinations, a set volume is not defined here. Enough fuel should be flushed to ensure that the entire line volume has been changed over to the new fuel.

Figure AX.1

