

**A10. PROCEDURE FOR THE ADJUSTMENT OF ELASTOMER SPECIFICATION LIMITS TO TAKE ACCOUNT OF TEST VARIABILITY**

**A10.1 Background**

A10.1.1 This annex describes a statistical method for adjusting the elastomer specification limits shown for the CI-4 category in Table 3 to take account of the inherent test variability. The need to take account of the inherent test variability arises because batch-to-batch, sheet-to-sheet and within-sheet variations in the properties of the reference elastomers (the four elastomers specified in Table 3, noted above) can be sufficiently large that they complicate making a decision as to whether or not a test oil has passed the elastomer compatibility specification.

A10.1.2 The adjusted specification limits are referred to as the acceptance criteria (see A10.4). The latter in fact being the specification limits adjusted for an amount to account for test variability. For a candidate oil to be in conformance with the specification limits, the candidate-oil results shall lie within the range defined by the acceptance criteria.

A10.1.3 The statistical method for determining the acceptance criteria uses updated information about the industry test variability relevant to the time frame in which the candidate oil is tested. The TMC provides the updated information which is based on test results obtained by different test laboratories with different batches of reference elastomers on the same TMC 1006 reference oil.

**A10.2 Specification Limits**

The elastomer specification limits are shown for the CI-4 category in Table 3. (These are reproduced in Table A10.4.3.1 at the end of this annex for comparison purposes.) The specification involves sixteen criteria. These criteria are the specified limits for the four elastomer types [nitrile (NBR), silicone (VMQ), polyacrylate

(ACM) and fluoroelastomer (FKM)], with changes in four properties (volume, Durometer A hardness, tensile strength and elongation at break). Acceptable performance in any particular criterion (e.g., nitrile volume change) is defined as satisfying the acceptance limits.

The acceptance limits are bounded by an adjusted specification limit at each end in some cases, and an adjusted specification limit at one end and an adjusted mean *Ref* value limit on the other end. (*Ref* stands for the mean value for the reference oil TMC 1006, which is run in parallel with the candidate oil as a control for every experiment.)

**A10.3 Inherent Test Variability**

To determine whether a candidate oil’s performance is consistent with that defined by the specification limits given in Table 3, the inherent variability of the test, as indicated by the standard deviation estimates of the four reference elastomers and the four performance parameters, needs to be accounted for. Table A10.3 shows examples of the standard deviation estimates, as reported by the TMC. The standard deviation estimates, applicable at the time the test oils are evaluated, can be obtained from the TMC website ([www.astm.tmc.cmu.edu/refdata/bench/alastomer\\_pc-9/](http://www.astm.tmc.cmu.edu/refdata/bench/alastomer_pc-9/)).

**TABLE A10.3 Example of Total and Within-Laboratory Standard Deviation Estimates for the Four Reference Elastomers<sup>A</sup>**

Elastomer		% volume change	Hardness change	% change in tensile strength	% change in elongation
Nitrile (NBR)	Total	0.91	1.84	7.67	7.66
Nitrile (NBR)	Within-Lab	0.91	1.51	7.44	7.66
Silicone (VMQ)	Total	2.33	2.59	5.40	9.98
Silicone (VMQ)	Within-Lab	2.30	1.57	5.37	9.97
Polyacrylate (ACM)	Total	0.83	1.92	10.19	11.20
Polyacrylate (ACM))	Within-Lab	0.81	1.90	10.17	11.11
Fluoroelastomer (FKM)	Total	0.16	2.40	5.59	10.48
Fluoroelastomer (FKM)	Within-	0.13	1.82	5.27	8.44

	Lab				
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<sup>A</sup>Applicable for the period March 1, 2004 to March 15, 2004, as reported on the TMC website (see [www.astm.tmc.cmu.edu/refdata/bench/alastomer\\_pc-9/](http://www.astm.tmc.cmu.edu/refdata/bench/alastomer_pc-9/)).

## A10.4 Acceptance Limits

The *acceptance* limits are determined as the specification limits adjusted (in absolute value) by an amount to account for the test variability.

### A10.4.1 Calculation of Fixed (i.e. the numerical limits) Acceptance Limits

A10.4.1.1 Calculate the standard error of the test oil mean, *se*, by dividing the appropriate Total standard deviation estimate,  $\sigma_T$ , by the square root of the number of observations in the sample:

$$se = \sigma_T / \sqrt{N}$$

where *N* is the number of observations and is generally six.

A10.4.1.2 Multiply the standard error of the test oil mean by 2.0.

A10.4.1.3 Add or subtract the result to or from the respective upper or lower Specification Limits to obtain the Fixed Acceptance Limit(s).

### A10.4.2 Calculation of Variable (i.e. when *Ref* is one of the limits) Acceptance Limits

A10.4.2.1 Calculate the standard error of the test oil mean, *se*, by dividing the appropriate Within-Lab standard deviation estimate,  $\sigma_T$ , by the square root of the number of observations in the sample:

$$se = \sigma_T / \sqrt{N}$$

where *N* is the number of observations and is generally six.

A10.4.2.2 Multiply the standard error of the test oil mean by 2.8.

A10.4.2.3 Add or subtract the result to or from *Ref* (the mean result obtained with TMC 1006, run in parallel with the test oil) to obtain either the upper or lower Variable Acceptance Limit, respectively.

A10.4.3 *Acceptance limits for all parameters.* Table A10.4.3 shows an example of the calculated acceptance limits for all thirty-two parameters.

**TABLE A10.4.3 An Example of Acceptance Limits (i.e., accounting for test variability) for the Four Reference Elastomers) Applicable for the Period March 1, 2004 to March 5, 2004<sup>A</sup>**

Elastomer	Change in volume, %	Change in hardness, Points	Change in tensile strength, MPa	Change in elongation at break, %
Nitrile	(5.7, -3.7)	(8.5, -6.5)	(16.3, Ref - 8.5)	(16.3, Ref - 8.8)
Silicone	(Ref + 2.6, - 4.9)	(7.1, Ref -1.8)	(14.4, -49.4)	(28.1, -38.1)
Polyacrylate	(5.7, -3.7)	(9.6, -6.6)	(26.3, -23.3)	(19.1, -44.1)
Fluoroelastomer	(5.1, -2.1)	(9.0, -7.0)	(14.6, Ref - 6.0)	(18.6, Ref - 9.6)

<sup>A</sup> Based on specification limits given in Table 3 (D 4485) and standard deviation estimates shown in Table A10.3..

A10.4.3.1 The following Table A10.4.3.1 provides the specification limits (identical to Table 3 in D 4485) for comparison with the above acceptance limits.

**TABLE A10.4.3.1 Specification Limits for the Elastomer Test Method as part of the CI-4 Category (i.e., not accounting for test variability)<sup>A</sup>**

Elastomer	Change in volume, %	Change in hardness, Points	Change in tensile strength, MPa	Change in elongation at break, %
Nitrile (NBR)	(+5, -3)	(+7, -5)	(+10, Ref)	(+10, Ref)
Silicone (VMQ)	(Ref, -3)	(+5, Ref)	(+10, -45)	(+20, -30)
Polyacrylate (ACM)	(+5, -3,	(+8, -5)	(+18, -15)	(+10, -35)
Fluoroelastomer (FKM)	(+5, --2)	(+7, -5)	(+10, Ref)	(+10, Ref)

<sup>A</sup> “Ref” is the mean value for the reference oil TMC 1006.