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1 of 101

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Table of Contents

1. Introduction ... 8
1.1 Symbols and Abbreviations ... 9
1.2 Pooling Across Environments ... 10
1.3 Basis Value Computational Process ... 11
1.4 Modified Coefficient of Variation (CV) Method ... 11
2. Background ... 13
2.1 ASAP Statistical Formulas and Computations ... 13
2.1.1 Basic Descriptive Statistics ... 13
2.1.2 Statistics for Pooled Data ... 13
2.1.3 Basis Value Computations ... 14
2.1.4 Modified Coefficient of Variation ... 15
2.1.5 Determination of Outliers ... 16
2.1.6 The k-Samin......... 16Determ.......................Dar.....Te102 51...9 90 67.....2.......20001 Tst....

List of Figures

Figure 4:1 Batch plot for LT strength normalized ... 38
Figure 4:2 Batch plot for LC strength normalized ... 40
Figure 4:3: Batch Plot for TT strength as measured ... 42
Figure 4:4: Batch Plot for TC strength as measured ... 44
Figure 4:5: Batch Plot for UNT0 strength normalized ... 46
Figure 4:6: Batch Plot for UNC0 strength normalized ... 49
Figure 4:7: Batch plot for IPS 0.2% Offset strength ... 52
Figure 4:8: Batch plot for IPS strength at 5% strain ... 52
Figure 4:9: Batch plot for SBS as measured ... 54
Figure 5:1: Batch plot for OHT1 strength normalized ... 57
Figure 5:2: Batch plot for OHT2 strength normalized ... 58
Figure 5:3: Batch plot for OHT3 strength normalized ... 60
Figure 5:4: Batch plot for OHC1 strength normalized ... 62
Figure 5:5: Batch plot for OHC2 strength normalized ... 64
Figure 5:6: Batch plot for OHC3 strength normalized ... 66
Figure 5:7: Batch plot for UNT1 strength normalized ... 68
Figure 5:8: Batch plot for UNT2 strength normalized ... 70
Figure 5:9: Batch plot for UNT3 strength normalized ... 72
Figure 5:10: Batch plot for UNC1 strength normalized ... 74
Figure 5:11: Batch plot for UNC2 strength normalized ... 76
Figure 5:12: Batch plot for UNC3 strength normalized ... 78
Figure 5:13: Batch plot for LSBS strength as measured ... 80
Figure 5:14: Batch plot for FHT1 strength normalized ... 82
Figure 5:15: Batch plot for FHT2 strength normalized ... 84
Figure 5:16: Batch plot for FHT3 strength normalized ... 85
Figure 5:17: Batch plot for FHC1 strength normalized ... 86
Figure 5:18: Batch plot for FHC2 strength normalized ... 88
Figure 5:19: Batch plot for FHC3 strength normalized ... 90
Figure 5:20: Batch plot for PB1 strength normalized ... 92
Figure 5:21: Batch plot for PB2 strength normalized ... 94
Figure 5:22: Batch plot for PB3 strength normalized ... 96
Figure 5:23: Plot of CAI strength data normalized ... 98
Figure 5:24: Plot of ILT and CBS data ... 99

List of Tables

Table 1-1: Test Property Abbreviations 9
Table 1-2: Test Property Symbols 10
Table 1-3: Environmental Conditions Abbreviations 10
Table 2-1: K factors for normal distribution 20
Table 2-2: Weibull Distribution Basis Value Factors 23
Table 2-3: B-Basis Hanson-Koopmans Table 26
Table 2-4: A-Basis Hanson-Koopmans Table 27
Table 2-5: B-Basis factors for small datasets using variability of corresponding large dataset 30
Table 3-1 : NCAMP recommended B-basis values for lamina test data 33
Table 3-2 : Recommended B-basis values for laminate test data 34
Table 3-3: Summary of Test Results for Lamina Data 35
Table 3-4: Summary of Test Results for Laminate Data 36
Table 4-1: Statistics, Basis Values and Estimates for LT strength from UNT0 data 39
Table 4-2: Statistics from LT modulus 39
Table 4-3: Statistics, Basis Values and Estimates for LC strength normalized from UNC0 41
Table 4-4: Statistics from LC modulus 41
Table 4-5: Statistics, Basis Values and Estimates for TT Strength data as measured 43
Table 4-6: Statistics from TT Modulus data as measured 43
Table 4-7: Statistics, Basis Values and Estimates for TC Strength data 45
Table 4-8: Statistics from TC Modulus data 45
Table 4-9: Statistics, Basis Values and Estimates for UNT0 Strength data 47
Table 4-10: Statistics from UNT0 Modulus data 47
Table 4-11: Statistics, Basis Values and Estimates for UNC0 Strength data 49
Table 4-12: Statistics from UNC0 Modulus data 50
Table 4-13: Statistics, Basis Values and Estimates for IPS Strength data 53
Table 4-14: Statistics for IPS modulus 53
Table 4-15: Statistics, Basis Values and Estimates for SBS data 55
Table 5-1: Statistics, Basis Values and Estimates for OHT1 Strength data 57
Table 5-2: Statistics, Basis Values and Estimates for OHT2 Strength data 59
Table 5-3: Statistics, Basis Values and Estimates for OHT3 [illegible]

Table 5-16: Statistics from UNC2 Modulus data 77
Table 5-17: Statistics, Basis Values and Estimates for UNC3 Strength data 78
Table 5-18: Statistics from UNC3 Modulus Data 79
Table 5-19: Statistics, Basis Values and Estimates for LSBS Strength data 81
Table 5-20: Statistics, Basis Values and Estimates for FHT1 Strength data 83
Table 5-21: Statistics, Basis Values and Estimates for FHT2 Strength data 84
Table 5-22: Statistics, Basis Values and Estimates for FHT3 Strength data 85
Table 5-23: Statistics, Basis Values and Estimates for FHC1 Strength data 87
Table 5-24: Statistics, Basis Values and Estimates for FHC2 Strength data 89
Table 5-25: Statistics, Basis Values and Estimates for FHC3 Strength data 91
Table 5-26: Statistics, Basis Values and Estimates for PB1 2% Offset Strength data 93
Table 5-27: Statistics, Basis Values and Estimates for PB2 2% Offset Strength data 95
Table 5-28: Statistics, Basis Values and Estimates for PB3 2% Offset Strength data 97
Table 5-29: Statistics for CAI data 98
Table 5-30: Statistics for ILT and CBS data 99
Table 6-1: List of outliers 100

1. Introduction

This report contains statistical analysis of ACG MTM45-1 HTS(12K) Unitape material property data published in NCAMP Test Report CAM-RP-2009-010 Rev B. The lamina and laminate material property data have been generated with FAA oversight through FAA Special Project Number SP3505WI-Q and also meet the requirements outlined in NCAMP Standard Operating Procedure NSP 100. The test panels, test specimens, and test setups have been conformed by the FAA and the testing has been witnessed by the FAA.

B-Basis values and estimates were calculated using a variety of techniques that are detailed in section two. Qualification material was procured in accordance with ACG material specification ACGM 1001-14 Revision A dated May 25, 2006. An equivalent NCAMP Material Specification NMS 451/14 which contains specification limits that are derived from guidelines in DOT/FAA/AR-03/19 has been created. The qualification test panels were fabricated per ACGP1001-02 using “MH” cure cycle. An equivalent NCAMP Process Specification NPS 81451 with baseline “MH” cure cycle has been created. The panels were fabricated at Bell Helicopter Textron lnc., 600 East Hurst Blvd. Hurst, TX 76053. The ACG Test Plan AI/TR/1392 Revision E was used for this qualification program. The testing was performed at the National Institute for Aviation Research (NIAR) in Wichita, Kansas.

Basis numbers are labeled as ‘values’ when the data meets all the requirements of CMH-17 Rev G. When those requirements are not met, they will be labeled as ‘estimates.’ When the data

Part fabricators that wish to utilize the material property data, allowables, and specifications may be able to do so by demonstrating the capability to reproduce the original material properties; a process known as equivalency. More information about this equivalency process including the test statistics and its limitations can be found in Section 6 of DOT/FAA/AR-03/19 and Section 8.4.1 of CMH-17 Rev G. The applicability of equivalency process must be evaluated on program-by-program basis by the applicant and certifying agency. The applicant and certifying agency must agree that the equivalency test plan along with the equivalency process described in Section 6 of DOT/FAA/AR-03/19 and Section 8.4.1 of CMH-17 Rev G are adequate for the given program.

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 451/14. NMS 451/14 has additional requirements that are listed in its prepreg process control document (PCD), fiber specification, fiber PCD, and other raw material specifications and PCDs which impose essential quality controls on the raw materials and raw material manufacturing equipment and processes. Aircraft companies and certifying agencies should assume that the material property data published in this report is not applicable when the material is not procured to NCAMP Material Specification NMS 451/14. NMS 451/14 is a free, publicly available, non-proprietar

Test Property	**Symbol**
Longitudinal Compression Strength	F_1^{cu}
Longitudinal Compression Modulus	E_1^{c}
Longitudinal Compression Poisson's Ratio	$_{12}^{c}$
Longitudinal Tension Strength	F_1^{tu}
Longitudinal Tension Modulus	E_1^{t}
Transverse Compression Strength	F_2^{cu}
Transverse Compression Modulus	E_2^{c}
Transverse Compression Poisson's Ratio	$_{21}^{c}$
Transverse Tension Strength	F_2^{tu}
Transverse Tension Modulus	E_2^{t}
In Plane Shear Strength at 5% strain	$F_{12}^{s5\%}$
In Plane Shear Strength at 0.2% offset	$F_{12}^{s0.2\%}$
In Plane Shear Modulus	G_{12}^{s}

Table 1-2: Test Property Symbols

Environmental Condition	**Abbreviation**
Cold Temperature Dry (í65°)	CTD
Room Temperature Dry (75°)	RTD
Elevated Temperature Dry (200°)	ETD
Elevated Temperature Wet (200°)	ETW
Elevated Temperature Wet (250°)	ETW2

Table 1-3: Environmental Conditions Abbreviations

Tests with a number immediately after the abbreviation indicate the lay-up:

1 = "Quasi-Isotropic"
2 = "Soft"
3 = "Hard"

EX: OHT1 is an open hole tension test with a Quasi-Isotropic layup.

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2009-010 Rev B.

1.2 Pooling Across Environments

When pooling across environments was allowable, the pooled co-efficient of variation was used. ASAP (**A**GATE **S**tatistical **A**nalysis **P**rogram) 2008 version 1.0 was used to determine if pooling was allowable and to compute the pooled coefficient of variation for those tests. In these cases, the modified coefficient of variation based on the pooled data was used to compute the basis values.

When pooling across environments was not advisable because the data was not eligible for pooling and engineering judgment indicated there was no justification for overriding the result, then B-Basis values were computed for each environmental condition separately using Stat17 version 5.

1.3 Basis Value Computational Process

The general form to compute engineering basis values is: basis value = $\bar{X} \quad kS$ where k is a factor based on the sample size and the distribution of the sample data. There are many different methods to determine the value of k in this equation, depending on the sample size and the distribution of the data. In addition, the computational formula used for the standard deviation, S, may vary depending on the distribution of the data. The details of those different computations and when each should be used are in section 2.0.

In some cases a transformation of the data to fit the assumption of the modified CV resulted in the transformed data passing the ADK test and thus the data can be pooled only for the modified CV method.

NCAMP recommends that if a user decides to use the basis values that are calculated from as-measured CV, the specification limits and control limits be calculated with as-measured CV also. Similarly, if a user decides to use the basis values that are calculated from modified CV, the specification limits and control limits be calculated with modified CV also. This will ensure that the link between material allowables, specification limits, and control limits is maintained.

Pooled Std. Dev. ____________

$$N = \sum_{j=1}^{r} n_j$$

$$f = N - r$$

$$q(f) = 1 - \frac{2.323}{\sqrt{f}} + \frac{1.064}{f} + \frac{0.9157}{f\sqrt{f}} - \frac{0.6530}{f^2} \quad \textbf{Equation 9}$$

$$b_B(f) = \frac{1.1372}{\sqrt{f}} - \frac{0.49162}{f} + \frac{0.18612}{f\sqrt{f}} \quad \textbf{Equation 10}$$

$$c_B(f) = 0.36961 + \frac{0.0040342}{\sqrt{f}} - \frac{0.71750}{f} + \frac{0.19693}{f\sqrt{f}} \quad \textbf{Equation 11}$$

$$b_A(f) = \frac{2.0643}{\sqrt{f}} - \frac{0.95145}{f} + \frac{0.51251}{f\sqrt{f}} \quad \textbf{Equation 12}$$

$$c_A(f) = 0.36961 + \frac{0.0026958}{\sqrt{f}} - \frac{0.65201}{f} + \frac{0.011320}{f\sqrt{f}} \quad \textbf{Equation 13}$$

2.1.4 Modified Coefficient of Variation

The coefficient of variation is modified according to the following rules:

$$\textbf{Modified CV} = CV^* = \begin{cases} .06 & \text{if } CV < .04 \\ \frac{CV}{2} + .04 & \text{if } .04 \le CV < .08 \\ CV & \text{if } CV \ge .08 \end{cases} \quad \textbf{Equation 14}$$

This is converted to percent by multiplying by 100%.

CV^* is used to compute a modified standard deviation S^*.

$$S^* = CV^* \cdot \bar{X} \quad \textbf{Equation 15}$$

To compute the pooled standard deviation based on the modified CV:

$$S_p^* = \sqrt{\frac{\sum_{i=1}^{k} (n_i - 1)\left(CV_i^* \cdot \bar{X}_i\right)^2}{\sum_{i=1}^{k} (n_i - 1)}} \quad \textbf{Equation 16}$$

The A-basis and B-basis values under the assumption of the modified CV method are computed by replacing S with S^*.

2.1.4.1 Transformation of data based on Modified CV

In order to determine if the data would pass the diagnostic tests under the assumption of the modified CV, the data must be transformed such that the batch means remain the same while the standard deviation of transformed data (all batches) matches the modified standard deviation.

To accomplish this requires a transformation in two steps:

Step 1: Apply the modified CV rules to each batch and compute the modified standard deviation $S_i^* = CV^* \cdot \bar{X}_i$ for each batch. Transform the data in each batch as follows:

$$X'_{ij} = C_i \left(X_{ij} - \bar{X}_i \right) + \bar{X}_i \qquad \text{Equation 17}$$

$$C_i = \frac{S_i^*}{S_i} \qquad \text{Equation 18}$$

Run the Anderson-Darling k-sample test for batch equivalence (see section 2.1.6) on the transformed data. If it passes, proceed to step 2. If not, stop. The data cannot be pooled.

Step 2: Another transformation is needed as applying the modified CV to each batch leads to a larger CV for the combined data than when applying the modified CV rules to the combined data (due to the addition of between batch variation when combining data from multiple batches). In order to alter the data to match S^*, the transformed data is transformed again, this time setting using the same value of C' for all batches.

$$X''_{ij} = C' \left(X'_{ij} - \bar{X}'_i \right) + \bar{X}_i \qquad \text{Equation 19}$$

$$C' = \sqrt{\frac{SSE^*}{SSE'}} \qquad \text{Equation 20}$$

$$SSE^* = (n-1)\left(CV^* \cdot \bar{X} \right)^2 - \sum_{i=1}^{k} n_i \left(\bar{X}_i - \bar{X} \right)^2 \qquad \text{Equation 21}$$

$$SSE' = \sum_{i=1}^{k} \sum_{j=1}^{n_i} \left(X'_{ij} - \bar{X}_i \right)^2 \qquad \text{Equation 22}$$

Once this second transformation has been completed, the k-sample Anderson Darling test for batch equivalence can be run on the transformed data to determine if the modified co-efficient of variation will permit pooling of the data.

2.1.5 Determination of Outliers

Outliers are identified using the Maximum Normed Residual Test for Outliers as specified in CMH-17 Rev G.

$$MNR = \frac{\max_{\text{all } i} \left| X_i - \bar{X} \right|}{S}, \quad i = 1 \ldots n \qquad \text{Equation 23}$$

$$C \quad \frac{n \quad 1}{\sqrt{n}}\sqrt{\frac{t^2}{n \quad 2 \quad t^2}}$$ **Equation 24**

where t is the 1 $\frac{.05}{2n}$ quartile of a t distribution with n í2 degrees of freedom.

If MNR > C, then the X_i associated with the MNR is considered to be an outlier. If an outlier exists, then the X_i associated with the MNR is dropped fr

$$a = (4g - 6)(k - 1) + (10 - 6g)S$$

$$b = (2g - 4)k^2 + 8Tk + (2g - 14T - 4)S - 8T + 4g - 6$$

$$c = (6T + 2g - 2)k^2 + (4T - 4g + 6)k + (2T - 6)S + 4T$$

$$d = (2T + 6)k^2 - 4Tk$$

$$S = \sum_{i=1}^{k} \frac{1}{n_i}$$

$$T = \sum_{i=1}^{n-1} \frac{1}{i}$$

$$g = \sum_{i=1}^{n-2} \sum_{j=i+1}^{n-1} \frac{1}{(n-i)j}$$

The data is considered to have failed this test (i.e. the batches are not from the same population) when the test statistic is greater than the critical value. For more information on this procedure, see reference 3.

2.1.7 The Anderson Darling Test for Normality

Normal Distribution:

This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if, in fact, the data are a sample from a normal population. If OSL > 0.05, the data is considered sufficiently close to a normal distribution.

2.1.8 Levene's Test for Equality of Coefficient of Variation

Levene's test performs an Analysis of Variance on the absolute deviations from their sample medians. The absolute value of the deviation from the median is computed for each data value. $w_{ij} = \left| y_{ij} - \tilde{y}_i \right|$ An F-test is then performed on the transformed data values as follows:

An observed significance level (OSL) based on the Anderson-Darling test statistic is computed for each test. The OSL measures the probability of observing an Anderson-Darling test statistic at least as extreme as the value calculated if the distribution under consideration is in fact the underlying distribution of the data. In other words, the OSL is the probability of obtaining a value of the test statistic at least as large as that obtained if the hypothesis that the data are actually from the distribution being tested is true. If the OSL is less than or equal to 0.05, then the assumption that the data are from the distribution being tested is rejected with at most a five percent risk of being in error.

If the normal distribution has an OSL greater than 0.05, then the data is assumed to be from a population with a normal distribution. If not, then if either the Weibull or lognormal distributions has an OSL greater than 0.05, then one of those can be used. If neither of these distributions has an OSL greater than 0.05, a non-parametric approach is used.

In what follows, unless otherwise noted, the sample size is denoted by n, the sample observations by $x_1, ..., x_n$, and the sample observations ordered from least to greatest by $x_{(1)}, ..., x_{(n)}$.

2.2.2 Computing Normal Distribution Basis Values

Stat17 uses a table of values for the k-factors (shown in Table 2-1) and a slightly different formula than ASAP to compute approximate k-values for the normal distribution when the sample size is larger than 15.

N	B-basis	A-basis
2	20.581	37.094
3	6.157	10.553
4	4.163	7.042
5	3.408	5.741
6	3.007	5.062
7	2.756	4.642
8	2.583	4.354
9	2.454	4.143
10	2.355	3.981
11	2.276	3.852

This approximation is accurate to within 0.2%

The two-parameter Weibull distribution is considered by comparing the cumulative Weibull distribution function that best fits the data with the cumulative distribution function of the data. Using the shape and scale parameter estimates from section 2.2.2.3.1, let

$$z_i = \left[x_i/\hat{\alpha}\right]^{\hat{\beta}}, \text{ for } i = 1, \ldots, n \qquad \textbf{Equation 38}$$

The Anderson-Darling test statistic is

$$AD = \sum_{i=1}^{n} \frac{1-2i}{n} \left\{ \ln\left[1-\exp\left(-z_{(i)}\right)\right] - z_{(n+1-i)} \right\} - n \qquad \textbf{Equation 39}$$

and the observed significance level is

$$OSL = 1/\left\{1+\exp[-0.10+1.24\ln(AD^*)+4.48AD^*]\right\} \qquad \textbf{Equation 40}$$

where

$$AD^* = \left(1+\frac{0.2}{\sqrt{n}}\right) AD \qquad \text{Equation 41}$$

This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if in fact the data is a sample from a two-parameter Weibull distribution. If $OSL \leq 0.05$, one may conclude (at a five percent risk of being in error) that the population does not have a two-parameter Weibull distribution. Otherwise, the hypothesis that the population has a two-parameter Weibull distribution is not rejected. For further information on these procedures, see reference 6.

2.2.2.3.3 Basis value calculations for the Weibull distribution

For the two-parameter Weibull distribution, the B-basis value is

$$B = \hat{q}\, e^{\left(-V/\hat{\beta}\sqrt{n}\right)} \qquad \textbf{Equation 42}$$

where

$$\hat{q} = \hat{\alpha}\left(0.10536\right)^{1/\hat{\beta}} \qquad \textbf{Equation 43}$$

To calculate the A-basis value, substitute the equation below for the equation above.

$$\hat{q} = \hat{\alpha}(0.01005)^{1/\hat{\beta}} \qquad \textbf{Equation 44}$$

V is the value in Table 2-2. when the sample size is less than 16. For sample sizes of 16 or larger, a numerical approximation to the V values is given in the two equations immediately below.

$$V_B = 3.803 \cdot \exp\left[1.79 - 0.516\ln(n) - \frac{5.1}{n-1}\right]$$ **Equation 45**

$$V_A = 6.649 \cdot \exp\left[2.55 - 0.526\ln(n) - \frac{4.76}{n}\right]$$ **Equation 46**

The Anderson-Darling statistic is then computed using the linked equation above and the observed significance level (OSL) is computed using the linked equation above . This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if in fact the data are a sample from a lognormal distribution. If OSL d0.05, one may conclude (at a five percent risk of being in error) that the population is not lognormally

The B-basis value is the r_B^{th} lowest observation in the data set, while the A-basis values are the r_A^{th} lowest observation in the data set. For example, in a sample of size n = 30, the lowest (r = 1) observation is the B-basis value. Further information on this procedure may be found in reference 7.

2.2.3.2 Non-parametric Basis Values for small samples

The Hanson-Koopmans method (references 8 and 9) is used for obtaining a B-basis value for sample sizes not exceeding 28 and A-basis values for sample sizes less than 299. This procedure requires the assumption that the observations are a random sample from a population for which the logarithm of the cumulative distribution function is concave, an assumption satisfied by a large class of probability distributions. There is substantial empirical evidence that suggests that composite strength data satisfies this assumption.

The Hanson-Koopmans B-basis value is:

$$B = x_{(r)} \left[\frac{x_{(1)}}{x_{(r)}} \right]^{k} \qquad \textbf{Equation 50}$$

The A-basis value is:

$$A = x_{(n)} \left[\frac{x_{(1)}}{x_{(n)}} \right]^{k} \qquad \textbf{Equation 51}$$

where $x_{(n)}$ is the largest data value, $x_{(1)}$ is the smallest, and $x_{(r)}$ is the r^{th} largest data value. The values of r and k depend on n and are listed in Table 2-3. This method is not used for the B-basis value when $x_{(r)} = x_{(1)}$.

The Hanson-Koopmans method can be used to calculate A-basis values for n less than 299. Find the value k_A corresponding to the sample size n in Table 2-4. For an A-basis value that meets the requirements of CMH-17 Rev G, there must be at least five batches represented in the data and at least 55 data points. For a B-basis value, there must be at least three batches represented in the data and at least 18 data points.

B-Basis Hanson-Koopmans Table		
n	r	k
2	2	35.177
3	3	7.859
4	4	4.505
5	4	4.101
6	5	3.064
7	5	2.858
8	6	2.382
9	6	2.253
10	6	2.137
11	7	1.897
12	7	1.814
13	7	1.738
14	8	1.599
15	8	1.540
16	8	1.485
17	8	1.434
18	9	1.354
19	9	1.311
20	10	1.253
21	10	1.218
22	10	1.184
23	11	1.143
24	11	1.114
25	11	1.087
26	11	1.060
27	11	1.035
28	12	1.010

Table 2-3: B-Basis Hanson-Koopmans Table

A-Basis Hanson-Koopmans Table

n	k	n	k	n	k
2	80.00380	38	1.79301	96	1.32324
3	16.91220	39	1.77546	98	1.31553
4	9.49579	40	1.75868	100	1.30806
5	6.89049	41	1.74260	105	1.29036
6	5.57681	42	1.72718	110	1.27392
7	4.78352	43	1.71239	115	1.25859
8	4.25011	44	1.69817	120	1.24425
9	3.86502	45	1.68449	125	1.23080
10	3.57267	46	1.67132	130	1.21814
11	3.34227	47	1.65862	135	1.20620
12	3.15540	48	1.64638	140	1.19491
13	3.00033	49	1.63456	145	1.18421
14	2.86924	50	1.62313	150	1.17406
15	2.75672	52	1.60139	155	1.16440
16	2.65889	54	1.58101	160	1.15519
17	2.57290	56	1.56184	165	1.14640
18	2.49660	58	1.54377	170	1.13801
19	2.42833	60	1.52670	175	1.12997
20	2.36683	62	1.51053	180	1.12226
21	2.31106	64	1.49520	185	1.11486
22	2.26020	66	1.48063	190	1.10776
23	2.21359	68	1.46675	195	1.10092
24	2.17067	70	1.45352	200	1.09434
25	2.13100	72	1.44089	205	1.08799
26	2.09419	74	1.42881	210	1.08187
27	2.05991	76	1.41724	215	1.07595
28	2.02790	78	1.40614	220	1.07024
29	1.99791	80	1.39549	225	1.06471
30	1.96975	82	1.38525	230	1.05935
31	1.94324	84	1.37541	235	1.05417
32	1.91822	86	1.36592	240	1.04914
33	1.89457	88	1.35678	245	1.04426
34	1.87215	90	1.34796	250	1.03952
35	1.85088	92	1.33944	275	1.01773
36	1.83065	94	1.33120	299	1.00000
37	1.81139				

$$u = \frac{MSB}{MSE} \qquad \textbf{Equation 59}$$

If u is less than one, it is set equal to one. The tolerance limit factor is

$$T = \frac{k_0 - \frac{k_1}{\sqrt{nc}} + (k_1 - k_0)\sqrt{\frac{u}{u + nc - 1}}}{1 - \frac{1}{\sqrt{nc}}} \qquad \textbf{Equation 60}$$

The basis value is $\bar{x} - TS$.

The ANOVA method can produce extremely conservative basis values when a small number of batches are available. Therefore, when less than five (5) batches are available and the ANOVA method is used, the basis values produced will be listed as estimates.

2.3 Single Batch and Two Batch Estimates using Modified CV

This method has not been approved for use by the CMH-17 organization. Values computed in this manner are estimates only. It is used only when fewer than three batches are available and no valid B-basis value could be computed using any other method. The estimate is made using the mean of the data and setting the coefficient of variation to 8 percent if it was less than that. A modified standard deviation (S_{adj}) was computed by multiplying the mean by 0.08 and computing the A and B-basis values using this inflated value for the standard deviation.

Estimated B-Basis = $\bar{X} - k_b S_{adj} = \bar{X} - k_b (0.08 \bar{X})$ **Equation 61**

2.4 Lamina Variability Method (LVM)

This method has not been approved for use by the CMH-17 organization. Values computed in this manner are estimates only. It is used only when the sample size is less than 16 and no valid B-basis value could be computed using any other method. The prime assumption for applying the LVM is that the intrinsic strength variability of the laminate (small) dataset is no greater than the strength variability of the lamina (large) dataset. This assumption was tested and found to be reasonable for composite materials as documented by Tomblved-ationenc-onm

When used in conjunction with the modified CV approach, a minimum value of 8% is used for the CV.

Mod CV LVM Estimated B-Basis = $\bar{X}_1 \quad K_{N_1,N_2} \quad \bar{X}_1 \; \text{Max } 8\%, CV_1, CV_2$ **Equation 63**

With:

$\bar{X}_1$ the mean of the laminate (small dataset)
N_1 the sample size of the laminate (small dataset)
N_2 the sample size of the lamina (large dataset)
CV_2

formula. Unless stated otherwise, the 0° lamina strength values were derived using the following formula:

$F_{0}^{u} = F_{0^\circ/90^\circ}^{u} \cdot BF$ where BF is the backout factor.

$F_{0^\circ/90^\circ}^{u}$ = UNC0 or UNT0 strength values

$$BF = \frac{E_1\left\{V_0 E_2 + (1 - V_0) E_1\right\} - (\nu_{12} E_2)^2}{\left[V_0 E_1 + (1 - V_0) E_2\right]\left[V_0 E_2 + (1 - V_0) E_1\right] - (\nu_{12} E_2)^2} \qquad \textbf{Equation 64}$$

V_0=fraction of 0º plies in the cross-ply laminate (½ for UNT0 and 1/3 for UNC0)

E_1 = Average across of batches of modulus for LC and LT as appropriate

E_2 = Average across of batches of modulus for TC and TT as appropriate

ν_{12} = major Poisson’s ratio of 0º plies from an average of all batches

This formula can also be found in CMH-17 Rev G in section 2.4.2, equation 2.4.2.1(b).

In computing these strength values, the values for each environment are computed separately.

3. Summary Tables

The basis values for all tests are summarized in the following tables. The NCAMP recommended B-basis values meet all requirements of CMH-17 Rev G. However, not all test data meets those requirements. The summary tables provide a complete listing of all computed basis values and estimates of basis values. Data that does not meet the requirements of CMH-17 Rev G are shown in shaded boxes and labeled as estimates. Basis values computed with the modified coefficient of variation (CV) are presented whenever possible. Basis values and estimates computed without that modification are presented for all tests.

3.1 NCAMP Recommended B-basis Values

The following rules are used in determining what B-basis value, if any, is included in tables Table 3-1and Table 3-2 of recommended values.

1. Recommended values are NEVER estimates. Only B-basis values that meet all requirements of CMH-17 Rev G are recommended.
2. Modified CV basis values are preferred. Recommended values will be the modified CV basis value when available. The CV provided with the recommended basis value will be the one used in the computation of the basis value.
3. Only normalized basis values are given for properties that are normalized.
4. ANOVA B-basis values are not recommended since only three batches of material are available and CMH-17 Rev G recommends that no less than five batches be used when computing basis values with the ANOVA method.
5. Caution is recommended with B-Basis values calculated from STAT17 when the B-basis value is 90% or more of the average value. Basis values of 90% or more of the mean value imply that the CV is unusually low and may not be conservative. Such values will be indicated.
6. If the data appear questionable (e.g. when the CTD-RTD-ETW trend of the basis values are not consistent with the CTD-RTD-ETW trend of the average values), then the B-basis values will not be recommended.

Lamina Strength Tests

						0.2% Offset	5% Strain
B-basis	274.27	204.42	8.01	31.12	16.97	7.57**	10.59
Mean	306.98	232.59	8.91	36.64	19.55	8.34	12.01
CV	6.00	8.25	6.57	7.98	6.79	8.29	6.00
B-basis	278.02	165.13	7.82	24.93	12.82	NA:A	8.99
Mean	310.72	193.30	8.72	28.29	14.52	6.07	10.18
CV	6.00	6.52	7.64	6.08	6.00	2.19	6.00
B-basis					9.48		
Mean					10.74		
CV					6.00		
B-basis	287.18	148.11	3.67	15.33	7.50	3.22	5.14
Mean	319.89	176.2319.89	.	776.7(.)-48.9(506-2766.8(6.)-42.1(57)-2747.8(5.)-48.9(1)6.7(65]TJ0 -1			

Laminate Strength Tests

B-basis	54.69		NA:A		103.50			
Mean	61.17		64.25		115.96			
CV	6.00		3.94		6.00			
B-basis	53.99	42.45	NA:I	NA:I	106.06	78.72	91.81	9.74
Mean	60.47	47.44	64.63	66.64	118.52	88.02	102.47	11.22
CV	6.00	6.00	1.99	7.13	6.00	6.00	6.14	6.74
B-basis	56.17	33.30		39.06	NA:I	52.63	81.01	5.22
Mean	62.64	38.28		46.16	111.76	61.81	91.67	5.91
CV	6.00	7.41		7.89	1.95	8.61	6.00	6.00
B-basis	40.61		NA:I		NA:I			
Mean	45.99		47.97		73.34			
CV	6.00		1.72		2.08			
B-basis	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	

3.2 Lamina and Laminate Summary Tables

Material:	Advanced Composites Group - MTM45-1 HTS(12K) Unitape
Resin:	

4. Lamina Test Results, Statistics, Basis Values and Graphs

Test data for fiber dominated properties was normalized according to nominal cured ply thickness. Both normalized and as measured statistics were included in the tables, but only the normalized data values were graphed. Test failures, outliers and explanations regarding computational choices were noted in the accompanying text for each test.

All individual specimen results are graphed for each test by batch and environmental condition with a line indicating the recommended basis values for each environmental condition. The data is jittered (moved slightly to the left or right) in order for all specimen values to be clearly visible. The strength values are always graphed on the vertical axis with the scale adjusted to include all data values and their corresponding basis values. The vertical axis may not include zero. The horizontal axis values will vary depending on the data and how much overlapping of there was of the data within and between batches. When there was little variation, the batches were graphed from left to right and the environmental conditions were identified by the shape and color of the symbol used to plot the data. Otherwise, the environmental conditions were graphed from left to right and the batches were identified by the shape and color of the symbol.

When a dataset fails the Anderson-Darling k-sample (ADK) test for batch-to-batch variation an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this qualification dataset has only three batches, the basis values computed using ANOVA are considered estimates only. However, the basis values resulting from the ANOVA method using only three batches may be overly conservative. The ADK test is performed again after a transformation of the data according to the assumptions of the modified CV method (see section 2.1.4for details). If the dataset still passes the ADK test at this point, modified CV basis values are provided. If the dataset does not pass the ADK test after the transformation, estimates may be computed using the modified CV method per the guidelines in CMH-17 Rev G section 8.3.10.

4.1 Longitudinal Tension (LT) Properties

The strength values for the LT data were derived from the UNT0 data according to the alternate equation (equation) 65 provided in section 2.5.1. The CTD and RTD data could be pooled, but the ETW and ETW2 data failed the Anderson Darling k-sample test (ADK) for batch-to-batch variation. This means those datasets require the ANOVA method to compute basis values which may result in overly conservative estimates of the basis values. However, the pooled dataset did pass the normality test, and ETW and ETW2 both passed the ADK test under the modified CV transformation, so the pooled modified CV values are provided for that dataset.

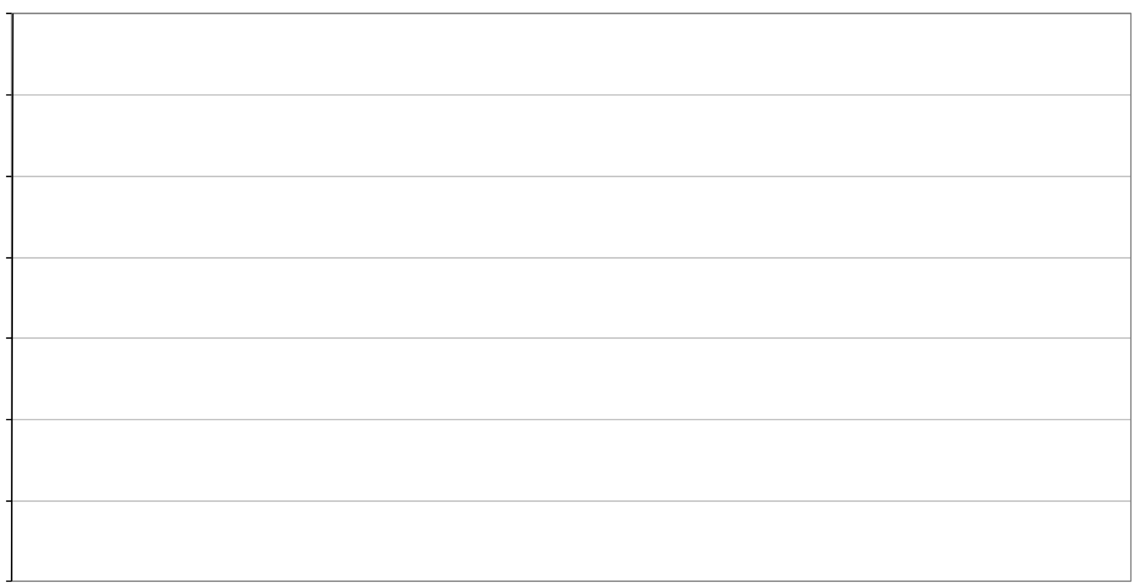
There were no outliers. Statistics, estimates and basis values are given for strength data in Table 4-1 and for the modulus data in Table 4-2. The normalized data and the B-basis values and B-estimates are shown graphically in Figure 4:1.

4.2 Longitudinal Compression (LC) Properties

The strength values for the LC data were derived from the UNC0 data according to the alternate equation (equation 65) provided in section 2.5.1. The CTD and ETW2 datasets did not pass the normality test, but the pooled dataset was sufficiently close to normal for pooling across environments to be acceptable.

There were two outliers, both in batch 2 on the high side. The outlier in the ETW environment is only for the normalized data after pooling the three batches. The outlier in the ETW2 environment is for both as measured and normalized data and is an outlier before, but not after pooling the three batches. The outliers were retained for this analysis.

Statistics, estimates and basis values are given for strength data in Table 4-3 and for the modulus data in Table 4-4. The normalized data and the B-basis values are shown graphically in Figure 4:2.



Transverse Tension Strength (ksi) As Measured				
Env	CTD	RTD	ETW	ETW2
Mean	8.91	8.72	4.56	4.36
Stdev	0.46	0.63	0.37	0.39
CV	5.13	7.27	8.02	9.05
Mod CV	6.57	7.64	8.02	9.05
Min	7.97	7.24	3.92	3.38
Max	9.66	10.24	5.04	4.72
No. Batches	3	3	3	3
No. Spec.	19	19	19	19
Basis Values and/or Estimates				
B-basis Value	8.09	7.90	3.74	3.54
A-estimate	7.54	7.36	3.20	3.00
Method	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates				
B-basis Value	8.01	7.82	3.67	3.47
A-estimate	7.42	7.23	3.07	2.87
Method	pooled	pooled	pooled	pooled

Table 4-5: Statistics, Basis Values and Estimates for TT Strength data as measured

Env	CTD	RTD	ETW	ETW2
Mean	1.31	1.20	1.04	0.84
Stdev	0.03	0.02	0.02	0.01
CV	1.96	2.04	2.14	1.67
Mod CV	6.00	6.00	6.00	6.00
Min	1.26	1.15	1.00	0.82
Max	1.36	1.23	1.06	0.87

Transverse Compression Strength (ksi) As Measured				
Env	CTD	RTD	ETW	ETW2
Mean	36.64	28.29	17.36	14.27
Stdev	2.92	1.18	0.50	0.48
CV	7.96	4.16	2.86	3.35
Mod CV	7.98	6.08	6.00	6.00
Min	30.85	26.19	16.56	13.65
Max	40.73	30.29	18.13	15.33
No. Batches	3	3	3	3
No. Spec.	22	19	19	20
Basis Values and/or Estimates				
B-basis value	31.14	25.99		
B-estimate			14.72	11.92
A-estimate	27.21	24.37	12.84	10.24
Method	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and/or Estimates				
B-basis Value	31.12	24.93	15.33	12.62
A-estimate	27.19	22.56	13.89	11.45
Method	Normal	Normal	Normal	Normal

Table 4-7: Statistics, Basis Values and Estimates for TC Strength data

Transverse Compression Modulus (msi) As Measured				
Env	CTD	RTD	ETW	ETW2
Mean	1.33	1.26	1.15	1.07
Stdev	0.06	0.06	0.04	0.06
CV	4.72	4.55	3.24	5.37
Mod CV	6.36	6.28	6.00	6.69
Min	1.22	1.17	1.11	0.98
Max	1.45	1.40	1.25	1.17
No. Batches	3	3	3	3
No. Spec.	22	19	19	20

Table 4-8: Statistics from TC Modulus data

4.5 0°/90º Unnotched Tensio

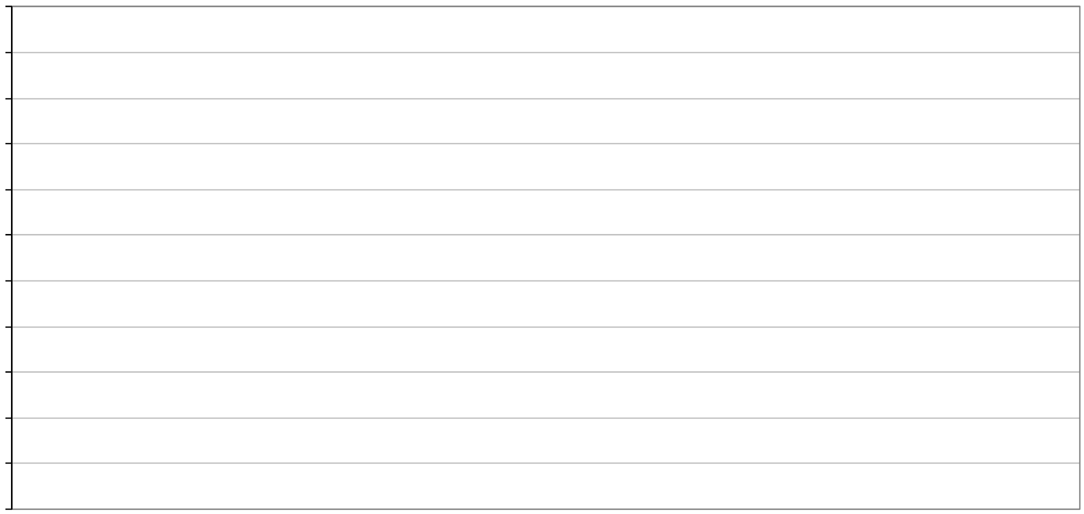
[redacted]/C

[redacted]	
[redacted]	
[redacted]	ETW2
[redacted]	164.18
[redacted]	4.01
[redacted]	2.44
[redacted]	6.00
[redacted]	154.91
[redacted]	169.82
[redacted]	3
[redacted]	19
[redacted]	
[redacted]	
[redacted]	147.36
[redacted]	135.36
[redacted]	ANOVA
[redacted]	
[redacted]	147.22
[redacted]	135.98
[redacted]	pooled

[redacted]s).2(d)-1.2((ion)4.8(1(U 597

[redacted]	ETW2
[redacted]	10.28
[redacted]	0.26
[redacted]	2.54
[redacted]	6.00
[redacted]	9.79
[redacted]	10.85
[redacted]	3
[redacted]	19

4.6



Unnotched Compression (UNC0) Strength (msi)										
	Normalized					As Measured				
Env	CTD	RTD	ETD	ETW	ETW2	CTD	RTD	ETD	ETW	ETW2
Mean	9.26	9.71	9.27	9.47	9.05	9.12	9.57	9.12	9.29	8.95
Stdev	0.40	0.44	0.37	0.36	0.46	0.41	0.52	0.39	0.34	0.51
CV	4.27	4.57	4.03	3.82	5.14	4.49	5.39	4.22	3.70	5.67
Mod CV	6.13	6.29	6.02	6.00	6.57	6.24	6.70	6.11	6.00	6.84
Min	8.81	9.08	8.80	9.10	8.23	8.63	8.85	8.52	8.79	8.06
Max	10.22	10.51	10.17	10.26	9.88	10.01	10.58	10.00	10.05	9.78
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	19	19	22	20	22	19	19	22	20	22

Table 4-12: Statistics from UNC0 Modulus data

4.7 In-Plane Shear Properties (IPS)

In-Plane Shear data is not normalized. Pooling across environments was not a viable method for computing basis values for IPS. The pooled dataset failed the normality test for both the 0.2% offset strength and strength at 5% strain. After applying the modified CV transform, both datasets failed Levene's test.

The CTD 0.2% offset strength data did not adequately fit any of the tested distributions and required a non-parametric analysis. The RTD 0.2% offset strength data and the ETW strength at 5% strain data failed the Anderson Darling k-sample test (ADK) for batch-to-batch variation so an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. Using the ANOVA method to compute basis values with fewer than five batches may result in overly conservative estimates of the basis values.

The ETW strength at 5% strain passed the ADK test after the modified CV transform, so modified CV basis values are provided. In the ETW2 environment, there were only five specimens from a single batch that had measurements recorded for the strength at 5% strain. E result(specim)20d measurem

Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	8.34	6.07	3.65	2.64	12.01	10.18	5.84	4.48
Stdev	0.69	0.13	0.10	0.21	0.37	0.15	0.14	0.15

4.8 Short Beam Strength (SBS)

Pooling across environments was not a viable method for computing basis values for SBS. The pooled dataset failed Levene's test. The CTD, ETW and ETW2 environments failed the Anderson Darling k-sample test (ADK) for batch-to-batch variation which means that those datasets required the ANOVA method to compute basis values. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. Using the ANOVA method to compute basis values with fewer than five batches may result in overly conservative estimates of the basis values. However, all three datasets did pass the ADK test after the modified CV transform, so modified CV basis values are provided. There were no outliers.

Statistics, estimates and basis values are given for SBS data in Table 4-15. The data, B-basis values and B-estimates are shown graphically in Figure 4:9.

Short Beam (SBS) Strength (ksi) as measured					
Env	CTD	RTD	ETD	ETW	ETW2
Mean	19.55	14.52	10.74	8.47	6.98
Stdev	1.09	0.43	0.13	0.22	0.24
CV	5.57	2.99	1.24	2.62	3.37
Mod CV	6.79	6.00	6.00	6.00	6.00
Min	17.64	13.51	10.49	8.20	6.58
Max	21.38	15.17	10.94	8.91	7.39
No. Batches	3	3	3	3	3
No. Spec.	19	19	19	20	19
Basis Values and/or Estimates					
B-basis Value		13.68	10.48		
B-estimate	15.22			7.20	5.68
A-estimate	12.13	13.07	10.29	6.28	4.76
Method	ANOVA	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and/or Estimates					
B-basis Value	16.97	12.82	9.48	7.50	6.16
A-estimate	15.13	11.62	8.59	6.80	5.58
Method	Normal	Normal	Normal	Normal	Normal

Table 4-15: Statistics, Basis Values and Estimates for SBS data

5. Laminate Test Results, Statistics, Basis Values and Graph

Many of the laminate tests were performed with one batch only. In those cases, there was insufficient data to produce basis values meeting the requirements of CMH-17 Rev G, so only estimates are provided. When possible, estimates were prepared in the following ways and multiple estimates are provided.

1. Using the ASAP program to pool across the available environments. The modified CV values from this program are provided.
2. The Lamina Variability method detailed in section 2.4. For properties that use the CV of the LC CTD, LC ETW2 and TT ETW datasets, modified CV values are not available due to the large CV (over 8%) of the those datasets.

5.1 Open Hole Tension (OHT1, OHT2, OHT3) Properties

5.1.1 Quasi Isotropic Open Hole Tension (OHT1)

The OHT1 RTD data (both normalized and as measured) does not pass the ADK test but passes it after the transform for the modified CV method, so pooling was acceptable for the modified CV basis values. There was one outlier. It was on the low side of batch two in the CTD environment. It was an outlier after pooling only and was retained for this analysis. Statistics, estimates and basis values are given for OHT1 strength data in Table 5-1. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5:1.

Figure 5:1: Batch plot fo

5.1.2 "Soft" Open Hole Tension (OHT2)

The OHT2 CTD data (as measured only) failed the ADK test, so it required an ANOVA analysis. In order for B-basis values to be computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. However, it passed the ADK test after the transform for the modified CV method, so modified CV basis values are provided. There were no outliers.

Statistics, estimates and basis values are given for OHT2 strength data in Table 5-2. The normalized data, estimated B-basis values and B-estimates are shown graphically in Figure 5:2.

Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	45.99	42.06	38.26	45.09	41.50	37.64
Stdev	0.65	0.72	0.49	1.05	0.70	0.60
CV	1.41	1.71	1.28	2.34	1.69	1.60
Modified CV	6.00	8.00	8.00	6.00	8.00	8.00
Min	44.70	41.15	37.67	43.30	40.72	36.92
Max	47.08	42.96	38.93	46.41	42.49	38.58
No. Batches	3	1	1	3	1	1
No. Spec.	19	7	7	19	7	7
B-basis Value	44.73					

5.1.3 "Hard" Open Hole Tension (OHT3)

The OHT3 CTD data (both as measured and norm

Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	94.94	98.29	112.67	94.25	97.15	111.21
Stdev	4.67	3.89	5.88	4.85	3.70	5.81
CV	4.92	3.96	5.22	5.14	3.81	5.22
Modified CV	6.46	8.00	8.00	6.57	8.00	8.00
Min	86.31	92.86	107.53	84.52	91.63	106.44
Max	104.31	103.13	124.88	102.68	101.78	123.36
No. Batches	3	1	1	3	1	1
No. Spec.	19	7	7	19	7	7
B-estimate	78.19	90.15	100.38	77.30	88.93	99.05
A-estimate	66.26	NA	NA	65.23	NA	NA
Method	ANOVA	LVM	LVM	ANOVA	LVM	LVM
	Modified CV Basis Values and/or Estimnd0.89					92.59
B-basis Value	82.99			NA		
B-estimate		81.84	93.81		80.89	92.59
A-estimate	74.51	NA	NA	NA	NA	NA
Method	Normal	LVM	LVM	NA	LVM	LVM

5.2 Open Hole Compression (OHC1, OHC2, OHC3) Properties

5.2.1 Quasi Isotropic Open Hole Compression (OHC1)

The OHC1 RTD data (normalized only) and ETW2 data (both as measured and normalized) failed the ADK test, so they required an ANOVA analysis. In order for B-basis values to be computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. However, both datasets passed the ADK test after the transform for the modified CV method. The as measured ETW2 data does not pass the normality test, so modified CV basis values are not provided for that dataset, but they are provided for the normalized RTD dataset.

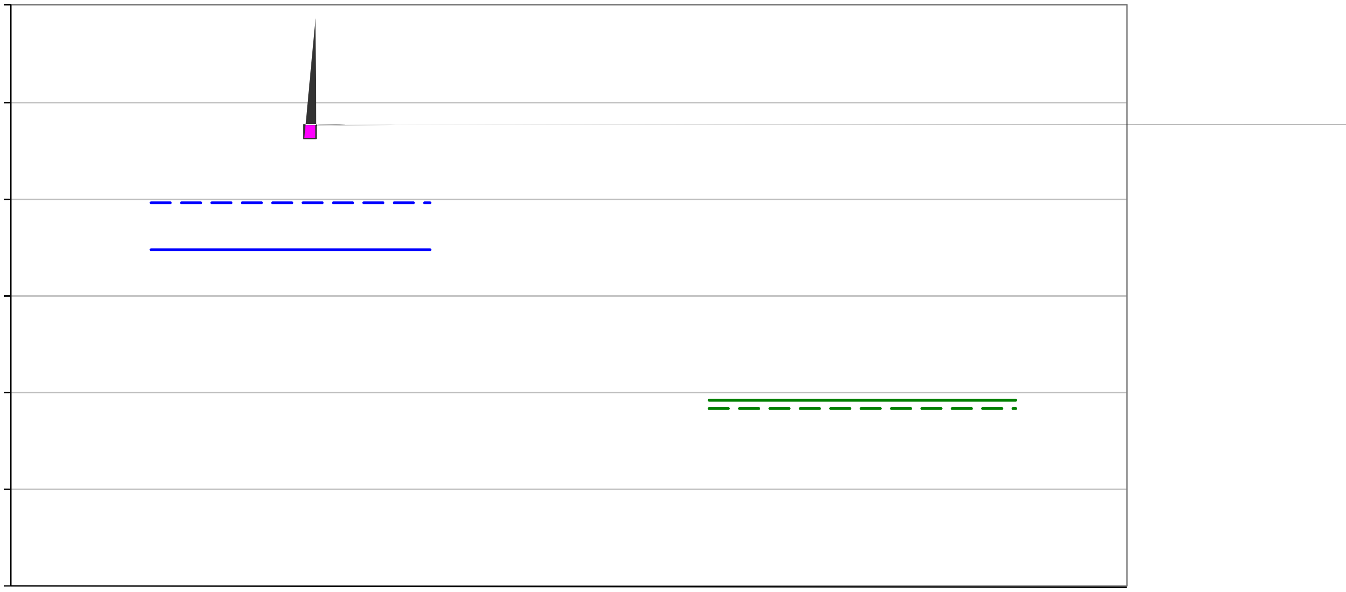
Pooling was appropriate for the normalized data when computing modified CV basis values. There were no outliers. Statistics, estimates and basis values are given for OHC1 strength data in Table 5-4. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5:4.

Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	47.44	41.77	38.28	46.51	41.20	37.40
Stdev	1.38	1.41	2.61	0.96	1.27	2.84
CV	2.90	3.39	6.81	2.06	3.09	7.58
Modified CV	6.00	6.00	7.41	6.00	8.00	7.79
Min	44.81	39.47	34.49	44.94	39.30	33.11
Max	49.67	43.74	44.94	48.80	42.78	44.11
No. Batches	3	1	3	3	1	3
No. Spec.	19	7	19	19	7	19
B-basis Value				44.64		

5.2.2 "Soft" Open Hole Compression (OHC2)

The OHC2 ETW2 data (both as measured and normalized) failed the ADK test, so they required an ANOVA analysis. In order for B-basis values to be computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. However, this dataset passed the ADK test after the transform for the modified CV method, so modified CV basis values are provided.

There was one outlier. It was on the high side of batch one in the as measured ETW2 data. It was an outlier only before pooling the three batches. The outlier was retained for this analysis. Statistics, estimates and basis values are given for OHC2 strength data in Table 5-5. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5:5.



Open Hole Compression Strength (OHC2)				
	Normalized		As Measured 2874652.781287532.284314 34 Tf74	
Env	RTD	ETW2	RTD	ETW2
Mean	38.93	27.87	38.49	27.56
Stdev	0.65	0.70	0.82	0.68
CV	1.67	2.52	2.13	2.47
Modified CV	8.00	6.00	8.00	6.00
Min	38.05	26.16	37.13	26.28
Max	39.93	29.03	39.64	28.65
No. Batches	1	3	1	3
No. Spec.	7	19	7	19
Basis Values and/or Estimates				
B-estimate	34.82	24.22	34.29	23.18
A-estimate	NA	21.62	NA	20.05
Method	LVM	ANOVA	LVM	ANOVA
Modified CV Basis Values and/or Estimates				
B-basis Value		24.61		24.33
B-estimate	32.41		32.05	
A-estimate	NA	22.30	NA	22.05
Method	LVM	Normal	LVM	Normal

5.2.3 "Hard" Open Hole Compression (OHC3)

There were no test failures or outliers. Statistics, estimates and basis values are given for OHC3 strength data in Table 5-6. The normalized data, B-basis values and B-estimates are shown

Env	RTD	ETW2	RTD	ETW2

Unnotched Tension Properties (UNT1) Strength						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	115.96	118.52	111.76	113.38	115.54	109.88
Stdev	4.32	3.33	2.18	4.25	2.79	2.05
CV	3.72	2.81	1.95	3.75	2.42	1.87
Modified CV	6.00	6.00	6.00	6.00	6.00	6.00
Min	104.46	113.21	109.29	104.14	110.71	106.60
Max	122.91	126.46	115.25	121.70	120.65	112.89
No. Batches	3	3	1	3	3	1
No. Spec.	19	19	7	19	19	7
Basis Values and/or Estimates						
B-basis Value	109.42	111.98		107.29	109.44	
B-estimate			104.39			103.01
A-estimate	104.99	107.55	100.09	103.15	105.31	98.99
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates						
B-basis Value	103.50	106.06		101.21	103.36	
B-estimate			97.71			96.15
A-estimate	95.05	97.61	89.51	92.95	95.11	88.14
Method	pooled	pooled	pooled	pooled	pooled	pooled

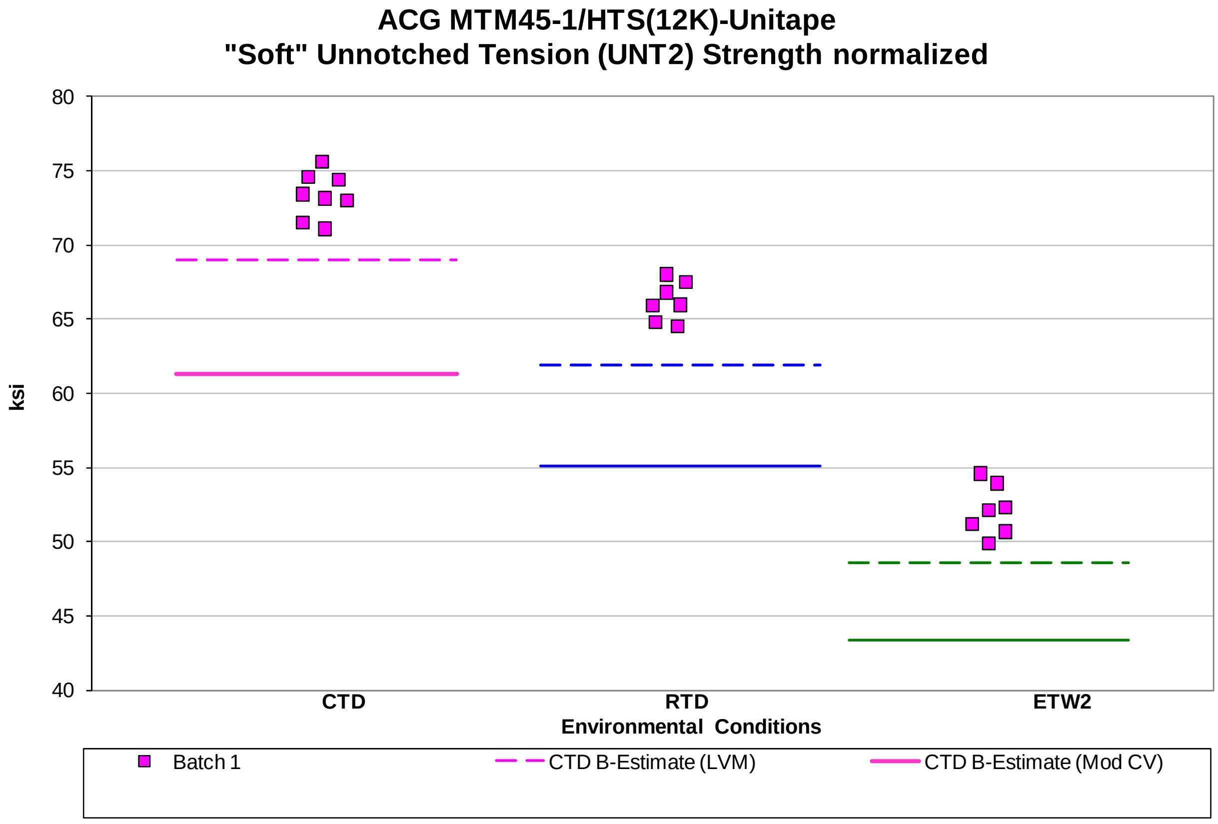
Table 5-7: Statistics, Basis Values and Estimates for UNT1 Strength data

Unnotched Tension Properties (UNT1) Modulus						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	7.26	7.12	7.18	7.10	6.94	7.06
Stdev	0.16	0.15	0.14	0.20	0.18	0.14
CV	2.17	2.18	1.96	2.76	2.63	2.04
Mod CV	6.00	6.00	6.00	6.00	6.00	6.00
Min	7.06	6.90	6.98	6.82	6.64	6.89
Max	7.60	7.43	7.42	7.46	7.27	7.33
No. Batches	3	3	1	3	3	1
No. Spec.	19	19	7	19	19	7

Table 5-8: Statistics from UNT1 Modulus Data

5.3.2 “Soft” Unnotched Tension Properties (UNT2)

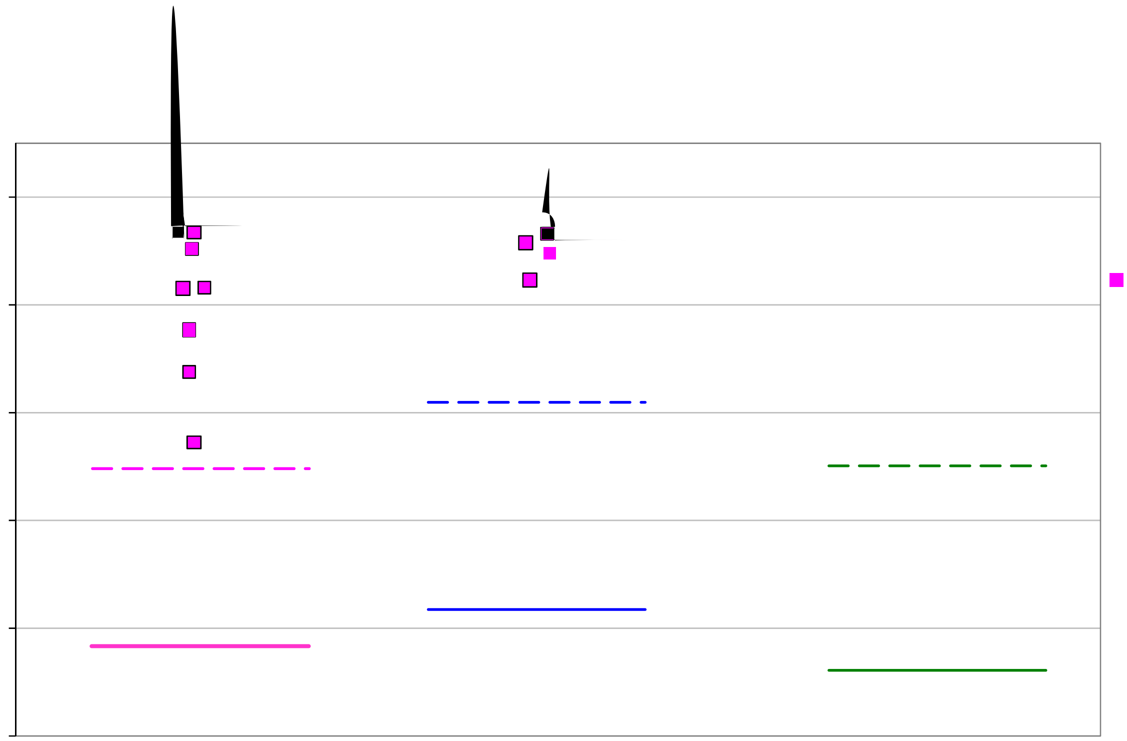
There were no outliers. Statistics and estimated basis values are given for UNT2 normalized strength data in Table 5-9. Modulus statistics are given in Table 5-10. The normalized data and B-estimates are shown graphically in Figure 5:8.



Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	4.69	4.65	3.95	4.64	4.59	3.89

5.3.3 "Hard" Unnotched Tension Properties (UNT3)

There were no outliers. Statistics and B-estimates are given for UNT3 strength data in Table 5-11. Modulus statistics are given in Table 5-12. The normalized data and the B-estimates are shown graphically in Figure 5:9.



Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	11.68	11.29	11.24	11.56	11.18	11.13
Stdev	0.22	0.19	0.35	0.20	0.22	0.29
CV	1.92	1.64	3.08	1.74	1.95	2.62
Mod CV	6.00	6.00	6.00	6.00	6.00	6.00
Min	11.45	11.01	10.58	11.24	10.93	10.57
Max	12.00	11.59	11.66	11.78	11.59	11.53

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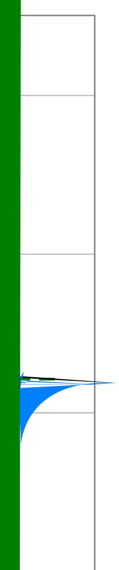


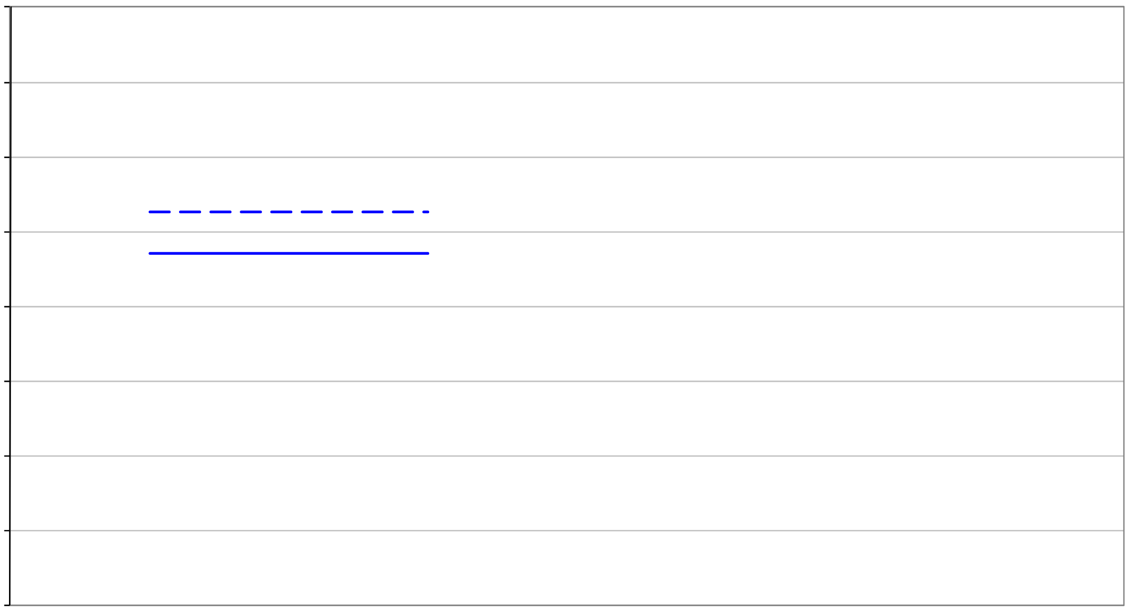
Unnotched Compression Properties (UNC1) Strength						
	Normalized			As Measured		
Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	88.02	74.68	61.81	86.60	74.13	60.97
Stdev	3.10	3.71	5.32	3.28	3.54	5.54
CV	3.52	4.96	8.61	3.79	4.77	9.09
Modified CV	6.00	6.48	8.61	6.00	6.38	9.09
Min	81.72	69.84	52.11	80.75	69.20	50.24
Max	93.16	79.79	71.78	92.64	79.00	71.83
No. Batches	3	1	3	3	1	3
No. Spec.	19	7	22	19	7	22
Basis Values and/or Estimates						
B-basis Value	80.31		54.20	78.61		53.08
B-estimate		65.98			65.11	
A-estimate	75.10	60.92	48.96	73.20	59.86	47.66
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates						
B-basis Value	78.72		52.63	77.19		51.69
B-estimate		64.19			63.52	
A-estimate	72.43	58.07	46.31	70.83	57.34	45.30
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 5-13: Statistics, Basis Values and Estimates for UNC1 Strength data

Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	6.64	6.72	6.42	6.54	6.67	6.33
Stdev	0.15	0.15	0.22	0.17	0.13	0.24
CV	2.22	2.28	3.37	2.65	1.95	3.82
Mod CV	6.00	6.00	6.00	6.00	6.00	6.00
Min	6.35	6.41	6.02	6.15	6.40	5.88
Max	6.91	6.84	6.80	6.87	6.77	6.77

5.4.2 "Soft" Unnotched Compression Properties (UNC2)

There were no outliers. Statistics and B-estimates are given for UNC2 normalized strength data in Table 5-15. Modulus statistics are given in Table 5-16. The normalized data and the B-estimates are shown graphically in Figure 5:11.



Unnotched Compression Properties (UNC2) Modulus				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	4.29	3.88	4.30	3.86
Stdev	0.08	0.07	0.11	0.07
CV	1.87	1.93	2.59	1.91
Mod CV	6.00	6.00	6.00	6.00
Min	4.12	3.80	4.12	3.78
Max	4.38	4.02	4.45	4.00
No. Batches	1	1	1	1
No. Spec.	7	7	7	7

Table 5-16: Statistics from UNC2 Modulus data

5.5 Laminate Short Beam Strength Properties (LSBS)

The LSBS data is not normalized. The RTD and ETW2 data failed the ADK test, so they required an ANOVA analysis. In order for B-basis values to be computed using the ANOVA method, data from five batches is required. Since these datasets have only three batches, the basis values computed using ANOVA are considered estimates. However, both datasets passed the ADK test after the transform for the modified CV method, so modified CV basis values are

Laminate Short Beam Strength (LSBS) as measured			
Env	RTD	ETW	ETW2
Mean	11.22	6.74	5.91
Stdev	0.61	0.23	0.20
CV	5.48	3.37	3.30
Mod CV	6.74	8.00	6.00
Min	10.18	6.45	5.41
Max	12.24	7.03	6.24
No. Batches	3	1	3
No. Spec.	19	7	19
Basis Values and/or Estimates			
B-estimate	8.19	5.64	5.19
A-estimate	6.04	NA	4.67
Method	ANOVA	LVM	ANOVA
Modified CV Basis Values and/or Estimates			
B-basis Value	9.74		5.22
B-estimate		5.61	
A-estimate	8.70	NA	4.73
Method	Normal	LVM	Normal

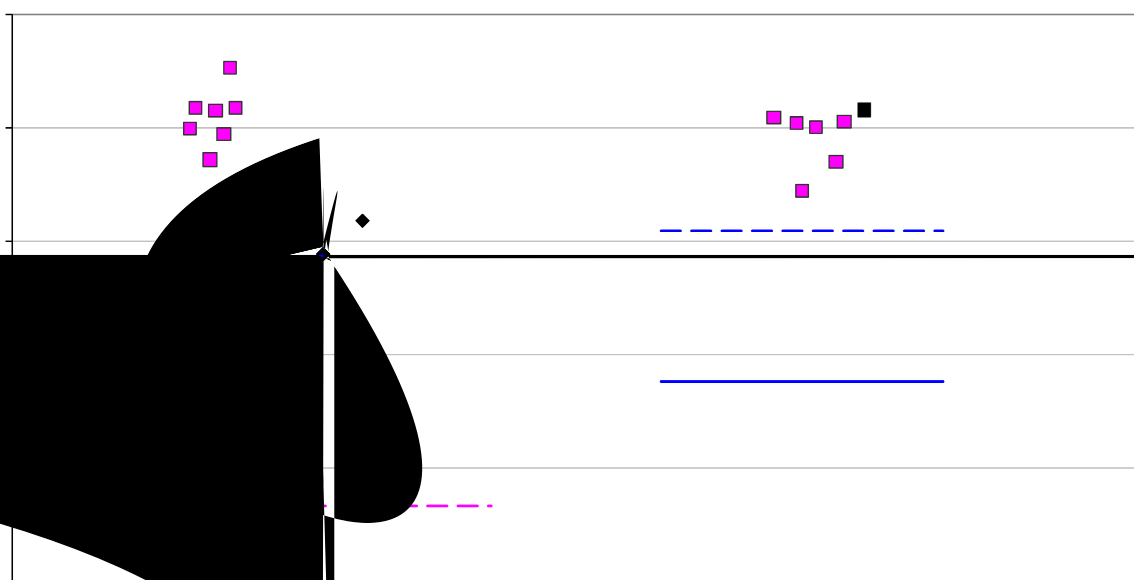
Table 5-19: Statistics, Basis Values and Estimates for LSBS Strength data

5.6 Filled Hole Tension (FHT1, FHT2, FHT3) Properties

5.6.1 Quasi Isotropic Filled Hole Tension (FHT1) Properties

The FHT1 CTD data failed the ADK test, so it required an ANOVA analysis. In order for B-basis values to be computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. The dataset passed the ADK test after the transform for the modified CV method, but failed the normality test. The lack of normality means that modified CV basis values are not appropriate. There was one outlier. It was in the normalized CTD data on the high side of batch two. It was an outlier only before pooling the three batches. The outlier was retained for this analysis.

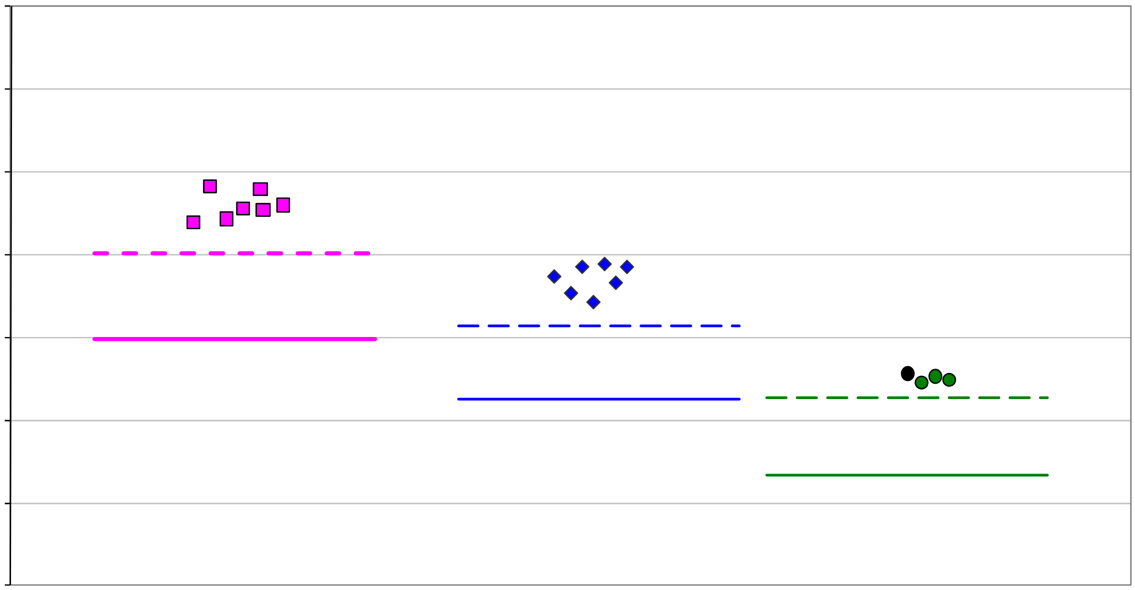
Statistics, basis values and estimates are given for FHT1 normalized strength data in Table 5-20. The normalized data and B-estimates are shown graphically in Figure 5:14.



Env	CTD	RTD	CTD	RTD
Mean	64.25	64.63	63.51	64.44
Stdev	2.53	1.28	2.86	1.37
CV	3.94	1.99	4.50	2.13
Modified CV	6.00	8.00	6.25	8.00

5.6.2 "Soft" Filled Hole Tension (FHT2)

There were no outliers. Statistics and B-estimates are given for FHT2 strength data in Table 5-21. The normalized data and B-estimates are shown graphically in Figure 5:15.



5.6.3 "Hard" Filled Hole Tension (FHT3)

There were no outliers. Statistics and B-estimates are given for FHT3 strength data in Table 5-22. The normalized data and B-estimates are shown graphically in Figure 5:16.

Env	RTD	ETW2	RTD	ETW2

5.7.2 "Soft" Filled Hole Compression (FHC2)

There were no test failures or outliers. Statistics, estimates and basis values are given for FHC2 strength data in Table 5-24. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5:18.

Env	RTD	ETW2	RTD	ETW2
Mean	86.68	61.40	85.21	60.80
Stdev	0.87	2.87	0.96	3.44
CV	1.00	4.67	1.12	5.66
Modified CV	8.00	6.33	8.00	6.83
Min	85.17	55.74	83.81	54.19
Max	87.79	66.39	86.69	66.37

5.8 Pin Bearing (PB1, PB2, PB3) Properties

5.8.1 Quasi Isotropic Pin Bearing (PB1)

The PB1 RTD 2% strength data, both normalized and as measured, failed the ADK test, so they required an ANOVA analysis. In order for B-basis values to be computed using the ANOVA method, data from five batches is required. Since these datasets have only three batches, the basis values computed using ANOVA are considered estimates. However, both datasets passed the ADK test after the transform for the modified CV method, so modified CV basis values are provided. Pooling the two environments was appropriate for computing the modified CV basis values. There were no outliers.

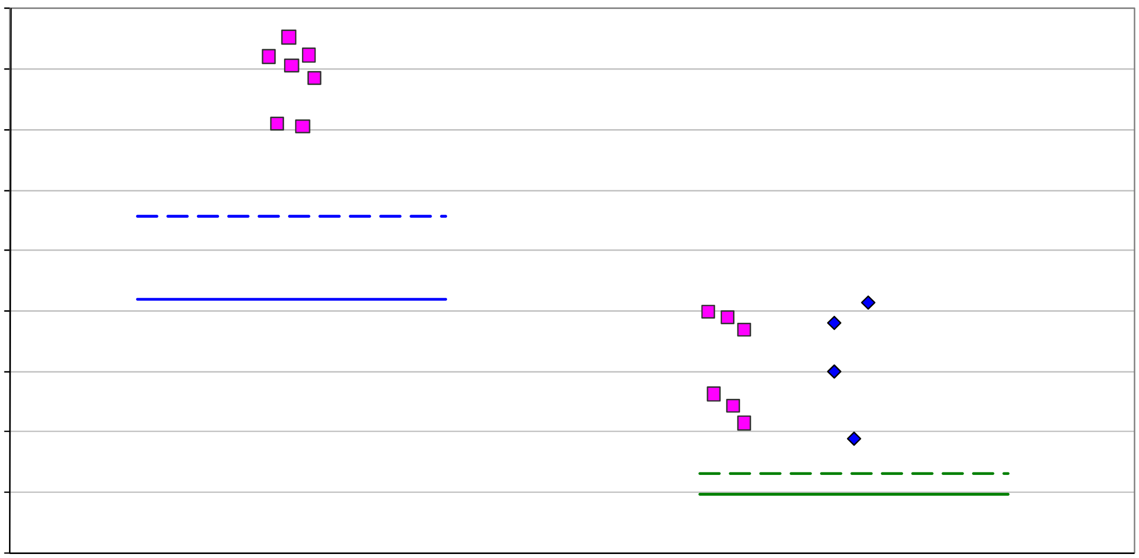
Statistics, estimates and basis values are given for the 2% offset strength data in Table 5-26. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5:20.

Pin Bearing (PB1) 2% Offset Strength				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	102.47	91.67	100.54	90.10
Stdev	4.38	3.51	4.48	3.58
CV	4.27	3.83	4.46	3.98
Modified CV	6.14	6.00	6.23	6.00
Min	94.97	85.88	93.70	84.02
Max	112.00	97.81	111.54	95.96
No. Batches	3	3	3	3
No. Spec.	19	19	19	19
Basis Values and/or Estimates				
B-basis Value		84.84		83.11
B-estimate	78.64		76.64	
A-estimate	61.63	79.98	59.58	78.15
Method	ANOVA	Normal	ANOVA	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value	91.81	81.01	89.99	79.55
A-estimate	84.53	73.74	82.78	72.34
Method	pooled	pooled	pooled	pooled

5.8.2 "Soft" Pin Bearing (PB2)

The PB2 ETW2 data had one outlier. It was an outlier in both the normalized and as measured data. It was on the high side of batch three. It was an outlier only after pooling the three batches. The outlier was retained for this analysis.

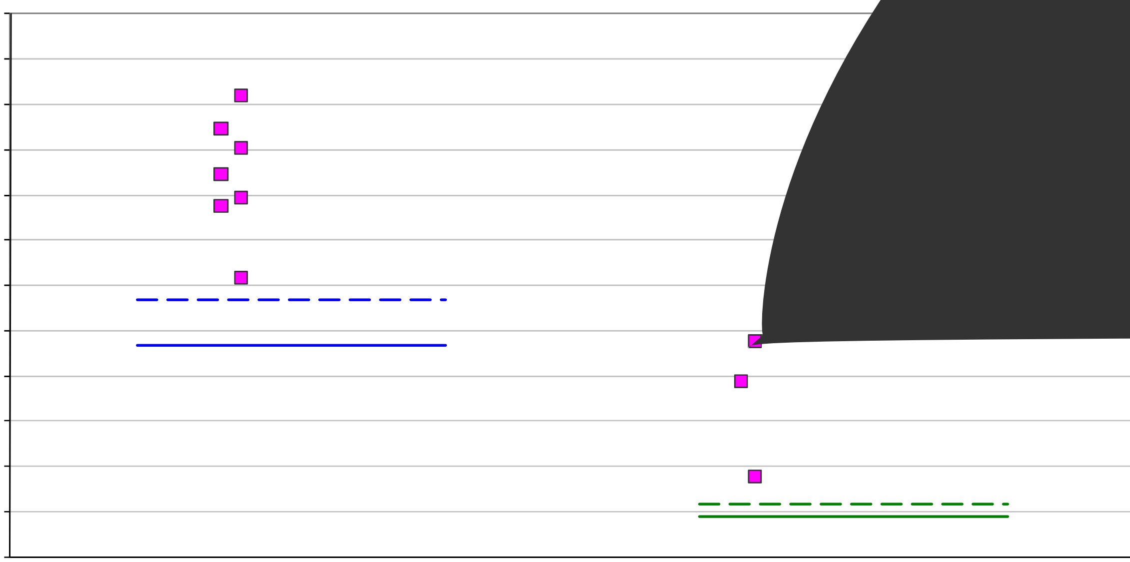
Statistics, estimates and basis values are given for the 2% offset strength data in Table 5-27. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5:21.



Env	RTD	ETW2	RTD	ETW2
Mean	109.32	86.68	107.47	85.59
Stdev	2.88	5.18	3.00	5.20
CV	2.63	5.98	2.79	6.08
Modified CV	8.00	6.99	8.00	7.04
Min	105.26	79.40	102.30	77.82
Max	112.65	101.62	111.07	100.66

5.8.3 "Hard" Pin Bearing (PB3)

There were no test failures or outliers. Statistics, estimates and basis values and estimates are given for the 2% offset strength data in Table 5-28. The normalized data, B-basis values and [illegible] estimates for the strength data are shown graphically in Figure 5:22.



Pin Bearing (PB3) 2% Offset Strength				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	112.19	86.37	110.62	85.46
Stdev	6.57	5.39	6.64	5.34
CV	5.86	6.24	6.01	6.24
Modified CV	8.00	7.12	8.00	7.12
Min	100.89	77.70	99.31	76.74
Max	120.99	96.91	119.79	95.77
No. Batches	1	3	1	3
No. Spec.	7	19	7	19
Basis Values and/or Estimates				
B-basis Value		75.87		75.06
B-estimate	98.43		96.72	
A-estimate	NA	68.41	NA	67.68
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		74.39		73.60
B-estimate	93.41		92.11	
A-estimate	NA	65.89	NA	65.19
Method	LVM	Normal	LVM	Normal

Table 5-28: Statistics, Basis Values and Estimates for PB3 2% Offset Strength data

5.9 Compression After Impact (CAI) Properties

Basis values are not computed for this property. Test results only are presented here. It was tested at only one environmental condition (RTD). Statistics are given for the Compression After Impact (CAI) strength data in Table 5-29. The normalized data are shown graphically in Figure 5:23.

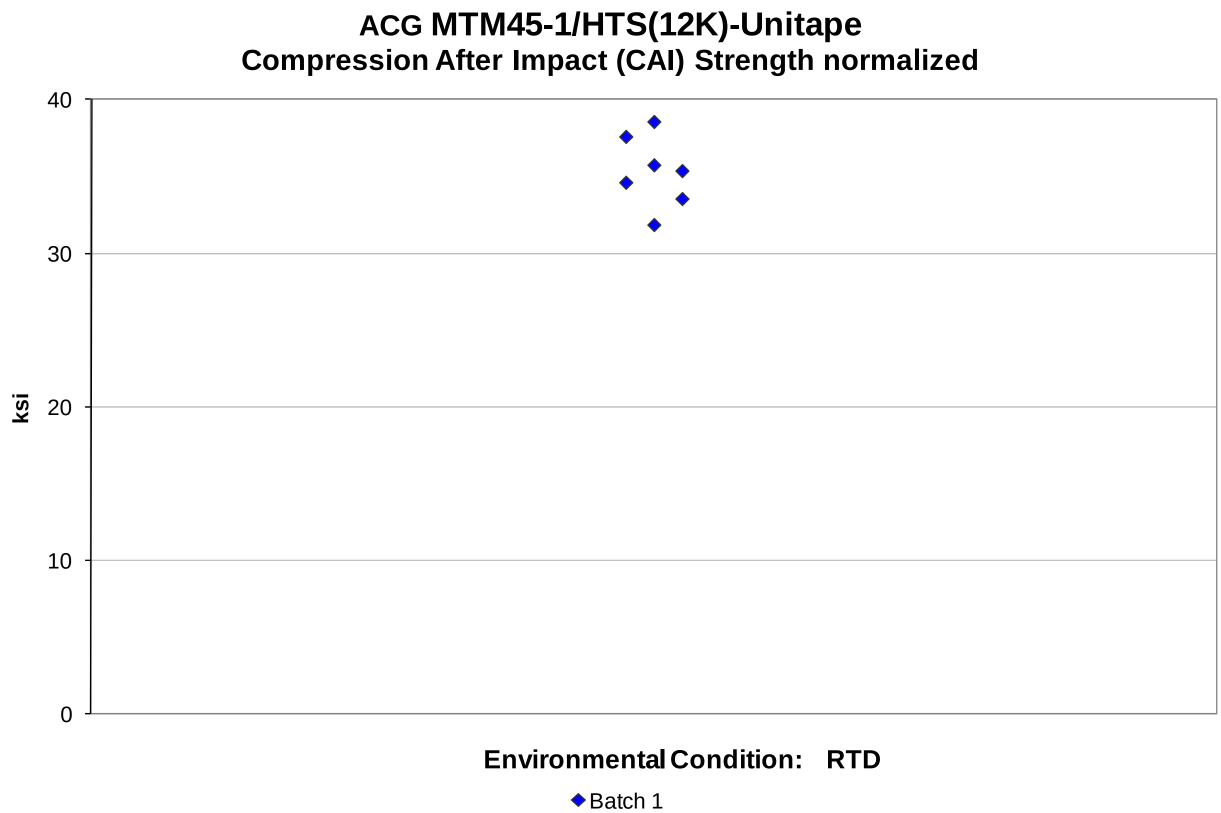
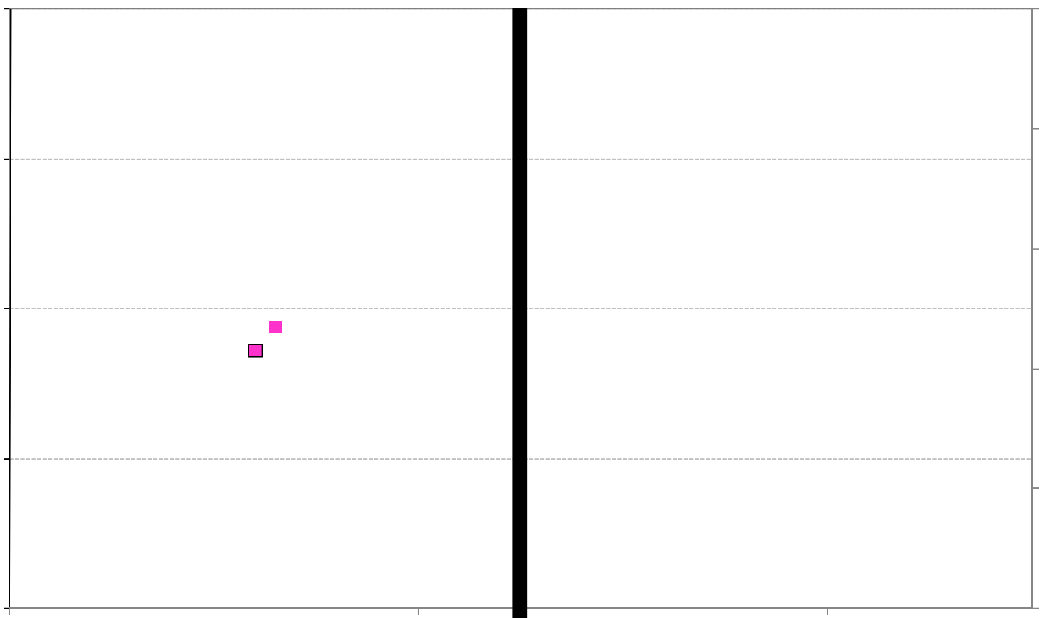


Figure 5:23: Plot of CAI strength data normalized

Compression After Impact Strength (ksi)		
RTD Env.	Normalized	As measured
Mean	35.30	34.79
Stdev	2.28	2.34
CV	6.47	6.74
Modified CV	7.24	7.37
Min	31.84	31.37
Max	38.53	38.12
No. Batches	1	1
No. Spec.	7	7

5.10 Interlaminar Tension (ILT) and Curved Beam Strength (CBS)

The ILT and CBS data is not normalized. Basis values are not computed for the Interlaminar tension or curved beam strength data. Test results only are presented here.   ILT tests were performed at both RTD and ETW2 environmental conditions. Statistics are given for the Interlaminar Tension (ILT) and Curved Beam strength (CBS) data in Table 5-30. The normalized data are shown graphically in Figure 5:24.



6. Outliers

Outliers were identified according to the standards documented in section 2.1.4, which are in accordance with the guidelines developed in CMH-17 Rev G section 8.3.3. An outlier may be an outlier in the normalized data, the as measured data, or both. A specimen may be an outlier for the batch only (before pooling the three batches within a condition together) or for the condition (after pooling the three batches within a condition together) or both.

Approximately 5 out of 100 specimens will be identified as outliers due to the expected random variation of the data. This test is used only to identify specimens to be investigated for a cause of the extreme observation. Outliers that have an identifiable cause are removed from the dataset as they inject bias into the computation of statistics and basis values. Specimens that are outliers for the condition and in both the normalized and as measured data are typically more extreme and more likely to have a specific cause and be removed from the dataset than other outliers.