CYTEC (Formerly Advanced Composites Group) MTM45-1/ 12K AS4 145gsm 32%RW Unidirectional Qualification Statistical Analysis Report

FAA Special Project Number SP3505WI-Q

NCAMP Report No: NCP-RP-2008-004 Rev B

Report Date: October 20, 2023

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REVISIONS:

Rev	**By**	**Date**	**Rev App By**	**Pages Revised or Added**
N/C	Elizabeth Clarkson	3/25/2016	Royal Lovingfoss	Document Initial Release
A	Elizabeth Clarkson	10/5/2021	Royal Lovingfoss	Updated Table 3-4 page 37 with corrected value for “Hard” layup to 50/40/10. Updated DMA measurements in Tables 3-3 and 3-4 on pages 36 and 37.
B	Evelyn Lian	10/20/2023	Royal Lovingfoss	- Editorial changes - Updated reference of “CMH-17 Rev G” to “CMH-17-1G” - Updated IPS data for all conditions; affected sections also updated in Tables 3-1 (Pg. 33), 3-3 (Pg. 35), 4-11 (Pg. 52), 4-12 (Pg. 52), 4-13 (Pg. 53) and 6-1 (Pg. 103), Figures 4-7 (Pg. 51) and 4-8 (Pg. 51), and Section 4.7 (Pg. 50).

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1. Introduction

This report contains statistical analysis of ACG MTM45-1/AS4-145-32%RW material property data published in "MTM45-1 AS4 Data MH Cure Cycle.pdf", available on the NCAMP website. 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.

B-Basis values and A and B-basis estimates were computed using a variety of techniques that are detailed in section 2. Qualification material was procured in accordance with ACG material specification ACGM 1001-11. An equivalent NCAMP Material Specification NMS 451/11 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 "MH" cure cycle has been created. The panels were fabricated at Advanced Composites Group, 5350 E. 129th E. Ave. Tulsa, OK 74134 and Solvay, 1440 N Kraemer Blvd, Anaheim, CA 92806. The ACG Test Plan AI/TR/1392 was used for this qualification program. The mechanical testing was performed by ACG at their Tulsa, Oklahoma facility and National Institute for Aviation Research, Wichita State University, Wichita, KS 67260.

Basis numbers are labeled as 'values' when the data meets all the requirements of CMH-17-1G. When those requirements are not met, they will be labeled as 'estimates.' When the data does not meet all requirements, the failure to meet these requirements is reported and the specific requirement(s) the data fails to meet is identified. The method used to compute the basis value is noted for each basis value provided. When appropriate, in addition to the traditional computational methods, values computed using the modified coefficient of variation method is also provided.

The material property data acquisition process is designed to generate basic material property data with sufficient pedigree for submission to Complete Documentation sections of Composite Materials Handbook 17 (CMH-17-1G).

The NCAMP shared material property database contains material property data of common usefulness to a wide range of aerospace projects. However, the data may not fulfill all the needs of a project. Specific properties, environments, laminate architecture, and loading situations that individual projects need may require additional testing.

The use of NCAMP material and process specifications do not guarantee material or structural performance. Material users should be actively involved in evaluating material performance and quality including, but not limited to, performing regular purchaser quality control tests, performing periodic equivalency/additional testing, participating in material change management activities, conducting statistical process control, and conducting regular supplier audits.

The applicability and accuracy of NCAMP material property data, material allowables, and specifications must be evaluated on case-by-case basis by aircraft companies and certifying agencies. NCAMP assumes no liability whatsoever, expressed or implied, related to the use of the material property data, material allowables, and specifications.

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-17-1G. 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-17-1G are adequate for the given program.

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 451/11. NMS 451/11 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 451/11. NMS 451/11* is a free, publicly available, non-proprietary aerospace industry material specification.

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1.1 Symbols and Abbreviations

Test Property	Abbreviation
Longitudinal Compression	LC
Longitudinal Tension	LT
Transverse Compression	TC
Transverse Tension	TT
In Plane Shear	IPS
Unnotched Tension	UNT
Unnotched Compression	UNC
Short Beam Strength	SBS
Laminate Short Beam Strength	LSBS
Open Hole Tension	OHT
Open Hole Compression	OHC
Filled Hole Tension	FHT
Filled Hole Compression	FHC
Pin Bearing Strength	PB
Curved Beam Strength	CBS
Interlaminar Tension	ILT

Table 1-1: Test Property Abbreviations

Test Property	Symbol
Longitudinal Compression Strength	F_1^{cu}
Longitudinal Compression Modulus	E_1^c
Longitudinal Compression Poisson's Ratio	ν_{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	ν_{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	Temperature	Abbreviation
Cold Temperature Dry	−65°F	CTD
Room Temperature Dry	75°F	RTD
Elevated Temperature Dry	200°F	ETD
Elevated Temperature Wet	200°F	ETW
Elevated Temperature Wet	250°F	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.

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 allowable, (i.e. the data failed the Anderson-Darling test or normality tests and engineering judgment indicated there was no justification for overriding the result), B-Basis values were computed for each environment separately using Stat-17 version 5.

1.3 Basis Value Computational Process

The general form to compute engineering basis values is: basis value = $\bar{X} - kS$ 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.

1.4 Modified Coefficient of Variation (CV) Method

A common problem with new material qualifications is that the initial specimens produced and tested do not contain all of the variability that will be encountered when the material is being produced in larger amounts over a lengthy period of time. This can result in setting basis values that are unrealistically high. The variability as measured in the qualification program is often lower than the actual material variability because of several reasons. The materials used in the qualification programs are usually manufactured within a short period of time, typically 2-3 weeks only, which is not representative of the production material. Some raw ingredients that are used to manufacture the multi-batch qualification materials may actually be from the same production batches or manufactured within a short period of time so the qualification materials, although regarded as multiple batches, may not truly be multiple batches so they are not representative of the actual production material variability.

The modified Coefficient of Variation (CV) used in this report is in accordance with section 8.4.4 of CMH-17-1G. It is a method of adjusting the original basis values downward in anticipation of the expected additional variation. Composite materials are expected to have a CV of at least 6%. The modified coefficient of variation (CV) method increases the measured coefficient of variation when it is below 8% prior to computing basis values. A higher CV will result in lower or more conservative basis values and lower specification limits. The use of the modified CV method is intended for a temporary period of time when there is minimal data available. When a sufficient number of production batches (approximately 8 to 15) have been produced and tested, the as-measured CV may be used so that the basis values and specification limits may be adjusted higher.

The material allowables in this report are calculated using both the as-measured CV and modified CV, so users have the choice of using either one. When the measured CV is greater than 8%, the modified CV method does not change the basis value. NCAMP recommended values make use the modified CV method when it is appropriate for the data.

When the data fails the Anderson-Darling K-sample test for batch to batch variability or when the data fails the normality test, the modified CV method is not appropriate and no modified CV basis value will be provided. When the ANOVA method is used, it may produce excessively conservative basis values. When appropriate, a single batch or two batch estimate may be provided in addition to the ANOVA estimate.

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.

2. Background

Statistical computations are performed with AGATE Statistical Analysis Program (ASAP) when pooling across environments is permissible according to CMH-17-1G guidelines. If pooling is not permissible, a single point analysis using STAT-17 is performed for each environmental condition with sufficient test results. If the data does not meet the CMH-17-1G requirements for a single point analysis, estimates are created by a variety of methods depending on which is most appropriate for the dataset available. Specific procedures used are presented in the individual sections where the data is presented.

2.1 ASAP Statistical Formulas and Computations

This section contains the details of the specific formulas ASAP uses in its computations.

2.1.1 Basic Descriptive Statistics

The basic descriptive statistics shown are computed according to the usual formulas, which are shown below:

Mean: $$\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n}$$ **Equation 1**

Std. Dev.: $$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} \left(X_i - \bar{X} \right)^2}$$ **Equation 2**

% Co. Variation: $$\frac{S}{\bar{X}} \times 100$$ **Equation 3**

Where n refers to the number of specimens in the sample and X_i refers to the individual specimen measurements.

2.1.2 Statistics for Pooled Data

Prior to computing statistics for the pooled dataset, the data is normalized to a mean of one by dividing each value by the mean of all the data for that condition. This transformation does not affect the coefficients of variation for the individual conditions.

2.1.2.1 Pooled Standard Deviation

The formula to compute a pooled standard deviation is given below:

Pooled Std. Dev. $S_p = \sqrt{\dfrac{\sum_{i=1}^{k}(n_i - 1)S_i^2}{\sum_{i=1}^{k}(n_i - 1)}}$ **Equation 4**

Where k refers to the number of batches and n_i refers to the number of specimens in the i^{th} sample.

2.1.2.2 Pooled Coefficient of Variation

Since the mean for the normalized data is 1.0 for each condition, the pooled normalized data also has a mean of one. The coefficient of variation for the pooled normalized data is the pooled standard deviation divided by the pooled mean, as in equation 3. Since the mean for the pooled normalized data is one, the pooled coefficient of variation is equal to the pooled standard deviation of the normalized data.

Pooled Coefficient of Variation $= \dfrac{S_p}{1} = S_p$ **Equation 5**

2.1.3 Basis Value Computations

Basis values are computed using the mean and standard deviation for that environment, as follows: The mean is always the mean for the environment, but if the data meets all requirements for pooling, S_p can be used in place of the standard deviation for the environment, S.

Basis Values: $$A - basis = \overline{X} - K_a S$$ $$B - basis = \overline{X} - K_b S$$ **Equation 6**

2.1.3.1 K-factor computations

K_a and K_b are computed according to the methodology documented in section 8.3.5 of CMH-17-1G. The approximation formulas are given below:

$$K_a = \frac{2.3263}{\sqrt{q(f)}} + \sqrt{\frac{1}{c_A(f) \cdot n_j} + \left(\frac{b_A(f)}{2c_A(f)}\right)^2} - \frac{b_A(f)}{2c_A(f)}$$ **Equation 7**

$$K_b = \frac{1.2816}{\sqrt{q(f)}} + \sqrt{\frac{1}{c_B(f) \cdot n_j} + \left(\frac{b_B(f)}{2c_B(f)}\right)^2} - \frac{b_B(f)}{2c_B(f)}$$ **Equation 8**

Where

r = the number of environments being pooled together
n_j= number of data values for environment j

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

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

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

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

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

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

2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

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

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

$$C_i = \frac{S_i^*}{S_i} \quad \textbf{Equation 18}$$

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.

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

$$C' = \sqrt{\frac{SSE^*}{SSE'}} \quad \textbf{Equation 20}$$

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

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

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

All outliers are identified in text and graphics. If an outlier is removed from the dataset, it will be specified and the reason why will be documented in the text. Outliers are identified using the Maximum Normed Residual Test for Outliers as specified in section 8.3.3 of CMH-17-1G.

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

$$C = \frac{n-1}{\sqrt{n}} \sqrt{\frac{t^2}{n-2+t^2}} \qquad \text{Equation 24}$$

where t is the $1 - \frac{.05}{2n}$ quartile of a t distribution with n−2 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 from the dataset and the MNR procedure is applied again. This process is repeated until no outliers are detected. Additional information on this procedure can be found in references 1 and 2.

2.1.6 The k-Sample Anderson Darling Test for batch equivalency

The k-sample Anderson-Darling test is a nonparametric statistical procedure that tests the hypothesis that the populations from which two or more groups of data were drawn are identical. The distinct values in the combined data set are ordered from smallest to largest, denoted $z_{(1)}, z_{(2)}, \ldots z_{(L)}$, where L will be less than n if there are tied observations. These rankings are used to compute the test statistic.

The k-sample Anderson-Darling test statistic is:

$$ADK = \frac{n-1}{n^2(k-1)} \sum_{i=1}^{k} \left[\frac{1}{n_i} \sum_{j=1}^{L} h_j \frac{\left(nF_{ij} - n_i H_j \right)^2}{H_j \left(n - H_j \right) - \frac{nh_j}{4}} \right] \qquad \text{Equation 25}$$

Where

n_i = the number of test specimens in each batch
$n = n_1 + n_2 + \ldots + n_k$
h_j = the number of values in the combined samples equal to $z_{(j)}$
H_j = the number of values in the combined samples less than $z_{(j)}$ plus ½ the number of values in the combined samples equal to $z_{(j)}$
F_{ij} = the number of values in the i^{th} group which are less than $z_{(j)}$ plus ½ the number of values in this group which are equal to $z_{(j)}$.

The critical value for the test statistic at 1−α level is computed:

$$ADC = 1 + \sigma_n \left[z_\alpha + \frac{0.678}{\sqrt{k-1}} - \frac{0.362}{k-1} \right]. \qquad \text{Equation 26}$$

This formula is based on the formula in reference 3 at the end of section 5, using a Taylor's expansion to estimate the critical value via the normal distribution rather than using the t distribution with k-1 degrees of freedom.

$$\sigma_n^2 = VAR(ADK) = \frac{an^3 + bn^2 + cn + d}{(n-1)(n-2)(n-3)(k-1)^2} \quad \text{Equation 27}$$

With

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

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

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

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

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

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

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

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: A two parameter (μ, σ) family of probability distributions for which the probability that an observation will fall between *a* and *b* is given by the area under the curve between a and b:

$$F(x) = \int_a^b \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx \quad \text{Equation 28}$$

A normal distribution with parameters (μ, σ) has population mean μ and variance σ^2.

The normal distribution is considered by comparing the cumulative normal distribution function that best fits the data with the cumulative distribution function of the data. Let

$$z_{(i)} = \frac{x_{(i)} - \bar{x}}{s}, \quad \text{for i = 1,…,n} \quad \text{Equation 29}$$

where $x_{(i)}$ is the smallest sample observation, $\bar{x}$ is the sample average, and s is the sample standard deviation.

The Anderson Darling test statistic (AD) is:

$$AD = \sum_{i=1}^{n} \frac{1-2i}{n} \left\{ \ln\left[F_0(z_{(i)})\right] + \ln\left[1 - F_0\left(z_{(n+1-i)}\right)\right] \right\} - n \quad \text{Equation 30}$$

Where F_0 is the standard normal distribution function. The observed significance level (OSL) is

$$OSL = \frac{1}{1+e^{-0.48+0.78\ln(AD^*)+4.58AD^*}}, \quad AD^* = \left(1+\frac{0.2}{\sqrt{n}}\right)AD \qquad \textbf{Equation 31}$$

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:

$$F = \frac{\sum_{i=1}^{k} n_i \left(\bar{w}_i - \bar{w}\right)^2 /(k-1)}{\sum_{i=1}^{k}\sum_{j=1}^{n_i} {}_i\left(w_{ij} - \bar{w}_i\right)^2 /(n-k)} \qquad \textbf{Equation 32}$$

If this computed F statistic is less than the critical value for the F-distribution having k-1 numerator and n-k denominator degrees of freedom at the 1-α level of confidence, then the data is not rejected as being too different in terms of the co-efficient of variation. ASAP provides the appropriate critical values for F at α levels of 0.10, 0.05, 0.025, and 0.01. For more information on this procedure, see references 4, 5, and 6.

2.2 STAT-17

This section contains the details of the specific formulas STAT-17 uses in its computations.

The basic descriptive statistics, the maximum normed residual (MNR) test for outliers, and the Anderson Darling K-sample test for batch variability are the same as with ASAP – see sections 2.1.1, 2.1.3.1, and 2.1.5.

Outliers must be dispositioned before checking any other test results. The results of the Anderson Darling k-Sample (ADK) Test for batch equivalency must be checked. If the data passes the ADK test, then the appropriate distribution is determined. If it does not pass the ADK test, then the ANOVA procedure is the only approach remaining that will result in basis values that meet the requirements of CMH-17-1G.

2.2.1 Distribution tests

In addition to testing for normality using the Anderson-Darling test (see 2.1.7); Stat-17 also tests to see if the Weibull or Lognormal distribution is a good fit for the data.

Each distribution is considered using the Anderson-Darling test statistic which is sensitive to discrepancies in the tail regions. The Anderson-Darling test compares the cumulative distribution function for the distribution of interest with the cumulative distribution function of the data.

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

Stat-17 uses a table of values for the k-factors (shown in Table 2-1) when the sample size is less than 16 and a slightly different formula than ASAP to compute approximate k-values for the normal distribution when the sample size is 16 or larger.

Norm. Dist. k Factors for N<16		
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
12	2.211	3.747
13	2.156	3.659
14	2.109	3.585
15	2.069	3.520

Table 2-1: K factors for normal distribution

2.2.2.1 One-sided B-basis tolerance factors, k_B, for the normal distribution when sample size is greater than 15.

The exact computation of k_B values is $1/\sqrt{n}$ times the 0.95th quantile of the noncentral t-distribution with noncentrality parameter $1.282\sqrt{n}$ and $n-1$ degrees of freedom. Since this in not a calculation that Excel can handle, the following approximation to the k_B values is used:

$$k_B \approx 1.282 + \exp\{0.958 - 0.520\ln(n) + 3.19/n\}$$ **Equation 33**

This approximation is accurate to within 0.2% of the tabulated values for sample sizes greater than or equal to 16.

2.2.2.2 One-sided A-basis tolerance factors, k_A, for the normal distribution

The exact computation of k_B values is $1/\sqrt{n}$ times the 0.95th quantile of the noncentral t-distribution with noncentrality parameter $2.326\sqrt{n}$ and $n-1$ degrees of freedom (Reference 12). Since this is not a calculation that Excel can handle easily, the following approximation to the k_B values is used:

$$k_A \approx 2.326 + \exp\{1.34 - 0.522\ln(n) + 3.87/n\}$$ **Equation 34**

This approximation is accurate to within 0.2% of the tabulated values for sample sizes greater than or equal to 16.

2.2.2.3 Two-parameter Weibull Distribution

A probability distribution for which the probability that a randomly selected observation from this population lies between a and b $(0 < a < b < \infty)$ is given by

$$e^{-\left(a/\alpha\right)^{\beta}} - e^{-\left(b/\alpha\right)^{\beta}}$$ **Equation 35**

where α is called the scale parameter and β is called the shape parameter.

In order to compute a check of the fit of a data set to the Weibull distribution and compute basis values assuming Weibull, it is first necessary to obtain estimates of the population shape and scale parameters (Section 2.2.2.3.1). Calculations specific to the goodness-of-fit test for the Weibull distribution are provided in section 2.2.2.3.2.

2.2.2.3.1 Estimating Weibull Parameters

This section describes the *maximum likelihood* method for estimating the parameters of the two-parameter Weibull distribution. The maximum-likelihood estimates of the shape and scale parameters are denoted $\hat{\beta}$ and $\hat{\alpha}$. The estimates are the solution to the pair of equations:

$$\hat{\alpha}\hat{\beta}\mathrm{n} - \frac{\hat{\beta}}{\hat{\alpha}^{\hat{\beta}-1}}\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{x}_{\mathrm{i}}^{\hat{\beta}} = 0 \qquad \textbf{Equation 36}$$

$$\frac{n}{\hat{\beta}} - n\ln\hat{\alpha} + \sum_{i=1}^{n}\ln x_i - \sum_{i=1}^{n}\left[\frac{x_i}{\hat{\alpha}}\right]^{\hat{\beta}}\left(\ln x_i - \ln\hat{\alpha}\right) = 0 \qquad \textbf{Equation 37}$$

Stat-17 solves these equations numerically for $\hat{\beta}$ and $\hat{\alpha}$ in order to compute basis values.

2.2.2.3.2 Goodness-of-fit test for the Weibull distribution

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

$$z_{(i)} = \left[x_{(i)}/\hat{\alpha}\right]^{\hat{\beta}}, \quad \text{for } i = 1,\ldots,n \qquad \textbf{Equation 38}$$

The Anderson-Darling test statistic is

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

and the observed significance level is

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

where

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

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 ≤ 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 7.

2.2.2.3.3 Basis value calculations for the Weibull distribution

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

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

where

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

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

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

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.

$$V_B \approx 3.803 + \exp\left[1.79 - 0.516\ln(n) + \frac{5.1}{n-1}\right] \quad \textbf{Equation 45}$$

$$V_A \approx 6.649 + \exp\left[2.55 - 0.526\ln(n) + \frac{4.76}{n}\right] \quad \textbf{Equation 46}$$

This approximation is accurate within 0.5% of the tabulated values for n greater than or equal to 16.

Weibull Dist. K Factors for N<16		
N	B-basis	A-basis
2	690.804	1284.895
3	47.318	88.011
4	19.836	36.895
5	13.145	24.45
6	10.392	19.329
7	8.937	16.623
8	8.047	14.967
9	7.449	13.855
10	6.711	12.573
11	6.477	12.093
12	6.286	11.701
13	6.127	11.375
14	5.992	11.098
15	5.875	10.861

Table 2-2: Weibull Distribution Basis Value Factors

2.2.2.4 Lognormal Distribution

A probability distribution for which the probability that an observation selected at random from this population falls between a and b $\left(0 < a < b < \infty\right)$ is given by the area under the normal distribution between ln(a) and ln(b).

The lognormal distribution is a positively skewed distribution that is simply related to the normal distribution. If something is lognormally distributed, then its logarithm is normally distributed. The natural (base e) logarithm is used.

2.2.2.4.1 Goodness-of-fit test for the Lognormal distribution

In order to test the goodness-of-fit of the lognormal distribution, take the logarithm of the data and perform the Anderson-Darling test for normality from Section 2.1.7. Using the natural logarithm, replace the linked equation above with linked equation below:

$$z_{(i)} = \frac{\ln\left(x_{(i)}\right) - \bar{x}_L}{s_L}, \quad \text{for } i = 1, \ldots, n \qquad \textbf{Equation 47}$$

where $x_{(i)}$ is the i[th] smallest sample observation, $\bar{x}_L$ and s_L are the mean and standard deviation of the $\ln(x_i)$ values.

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 ≤ 0.05, one may conclude (at a five percent risk of being in error) that the population is not lognormally distributed. Otherwise, the hypothesis that the population is lognormally distributed is not rejected. For further information on these procedures, see reference 7.

2.2.2.4.2 Basis value calculations for the Lognormal distribution

If the data set is assumed to be from a population with a lognormal distribution, basis values are calculated using the equation above in section 2.1.3. However, the calculations are performed using the logarithms of the data rather than the original observations. The computed basis values are then transformed back to the original units by applying the inverse of the log transformation.

2.2.3 Non-parametric Basis Values

Non-parametric techniques do not assume any particularly underlying distribution for the population the sample comes from. It does require that the batches be similar enough to be grouped together, so the ADK test must have a positive result. While it can be used instead of assuming the normal, lognormal or Weibull distribution, it typically results in lower basis values. One of following two methods should be used, depending on the sample size.

2.2.3.1 Non-parametric Basis Values for large samples

The required sample sizes for this ranking method differ for A and B basis values. A sample size of at least 29 is needed for the B-basis value while a sample size of 299 is required for the A-basis.

To calculate a B-basis value for n > 28, the value of r is determined with the following formulas:

For B-basis values:

$$r_B = \frac{n}{10} - 1.645\sqrt{\frac{9n}{100}} + 0.23 \qquad \textbf{Equation 48}$$

For A-Basis values:

$$r_A = \frac{n}{100} - 1.645\sqrt{\frac{99n}{10,000}} + 0.29 + \frac{19.1}{n} \qquad \textbf{Equation 49}$$

The formula for the A-basis values should be rounded to the nearest integer. This approximation is exact for most values and for a small percentage of values (less than 0.2%), the approximation errs by one rank on the conservative side.

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 8.

2.2.4 Non-parametric Basis Values for small samples

The Hanson-Koopmans method (references 9 and 10) 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-17-1G, 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				

Table 2-4: A-Basis Hanson-Koopmans Table

2.2.5 Analysis of Variance (ANOVA) Basis Values

ANOVA is used to compute basis values when the batch to batch variability of the data does not pass the ADK test. Since ANOVA makes the assumption that the different batches have equal variances, the data is checked to make sure the assumption is valid. Levene's test for equality of variance is used (see section 2.1.8). If the dataset fails Levene's test, the basis values computed are likely to be conservative. Thus this method can still be used but the values produced will be listed as estimates.

2.2.5.1 Calculation of basis values using ANOVA

The following calculations address batch-to-batch variability. In other words, the only grouping is due to batches and the k-sample Anderson-Darling test (Section 2.1.6) indicates that the batch to batch variability is too large to pool the data. The method is based on the one-way analysis of variance random-effects model, and the procedure is documented in reference 11.

ANOVA separates the total variation (called the sum of squares) of the data into two sources: between batch variation and within batch variation.

First, statistics are computed for each batch, which are indicated with a subscript $\left(n_i, \overline{x}_i, s_i^2\right)$ while statistics that were computed with the entire dataset do not have a subscript. Individual data values are represented with a double subscript, the first number indicated the batch and the second distinguishing between the individual data values within the batch. *k* stands for the number of batches in the analysis. With these statistics, the Sum of Squares Between batches (SSB) and the Total Sum of Squares (SST) are computed:

$$SSB = \sum_{i=1}^{k} n_i \overline{x}_I^2 - n\overline{x}^2$$ **Equation 52**

$$SST = \sum_{i=1}^{k} \sum_{j=1}^{n_i} x_{ij}^2 - n\overline{x}^2$$ **Equation 53**

The within-batch, or error, sum of squares (SSE) is computed by subtraction

$$SSE = SST - SSB$$ **Equation 54**

Next, the mean sums of squares are computed:

$$MSB = \frac{SSB}{k-1}$$ **Equation 55**

$$MSE = \frac{SSE}{n-k}$$ **Equation 56**

Since the batches need not have equal numbers of specimens, an 'effective batch size,' is defined as

$$n' = \frac{n - \frac{1}{n}\sum_{i=1}^{k} n_i^2}{k-1}$$ **Equation 57**

Using the two mean squares and the effective batch size, an estimate of the population standard deviation is computed:

$$S = \sqrt{\frac{MSB}{n'} + \left(\frac{n'-1}{n'}\right) MSE}$$ **Equation 58**

Two k-factors are computed using the methodology of section 2.2.2 using a sample size of n (denoted k_0) and a sample size of k (denoted k_1). Whether this value is an A- or B-basis value depends only on whether k_0 and k_1 are computed for A or B-basis values.

Denote the ratio of mean squares by

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

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

$$T = \frac{k_0 - \frac{k_1}{\sqrt{n'}} + (k_1 - k_0)\sqrt{\frac{u}{u + n' - 1}}}{1 - \frac{1}{\sqrt{n'}}} \quad \textbf{Equation 60}$$

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 batchs 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 = $\bar{X} - k_b S_{adj} = \bar{X} - k_b \cdot 0.08 \cdot \bar{X}$ **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 Tomblin and Seneviratne [13].

To compute the estimate, the coefficients of variation (CVs) of laminate data are paired with lamina CV's for the same loading condition and environmental condition. For example, the 0º compression lamina CV CTD condition is used with open hole compression CTD condition. Bearing and in-plane shear laminate CV's are paired with 0º compression lamina CV's. However, if the laminate CV is larger than the corresponding lamina CV, the larger laminate CV value is used.

The LVM B-basis value is then computed as:

LVM Estimated B-Basis = $\overline{X}_1 - K_{(N_1,N_2)} \cdot \overline{X}_1 \cdot \max\left(CV_1, CV_2\right)$ **Equation 62**

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 = $\overline{X}_1 - K_{(N_1,N_2)} \cdot \overline{X}_1 \cdot Max\left(8\%, CV_1, CV_2\right)$ **Equation 63**

With:

$\overline{X}_1$ 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_1 is the coefficient of variation of the laminate (small dataset)
CV_2 is the coefficient of variation of the lamina (large dataset)
$K_{(N_1,N_2)}$ is given in Table 2-5

	N1													
N1+N2-2	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	4.508	0	0	0	0	0	0	0	0	0	0	0	0	0
4	3.827	3.607	0	0	0	0	0	0	0	0	0	0	0	0
5	3.481	3.263	3.141	0	0	0	0	0	0	0	0	0	0	0
6	3.273	3.056	2.934	2.854	0	0	0	0	0	0	0	0	0	0
7	3.134	2.918	2.796	2.715	2.658	0	0	0	0	0	0	0	0	0
8	3.035	2.820	2.697	2.616	2.558	2.515	0	0	0	0	0	0	0	0
9	2.960	2.746	2.623	2.541	2.483	2.440	2.405	0	0	0	0	0	0	0
10	2.903	2.688	2.565	2.484	2.425	2.381	2.346	2.318	0	0	0	0	0	0
11	2.856	2.643	2.519	2.437	2.378	2.334	2.299	2.270	2.247	0	0	0	0	0
12	2.819	2.605	2.481	2.399	2.340	2.295	2.260	2.231	2.207	2.187	0	0	0	0
13	2.787	2.574	2.450	2.367	2.308	2.263	2.227	2.198	2.174	2.154	2.137	0	0	0
14	2.761	2.547	2.423	2.341	2.281	2.236	2.200	2.171	2.147	2.126	2.109	2.093	0	0
15	2.738	2.525	2.401	2.318	2.258	2.212	2.176	2.147	2.123	2.102	2.084	2.069	2.056	0
16	2.719	2.505	2.381	2.298	2.238	2.192	2.156	2.126	2.102	2.081	2.063	2.048	2.034	2.022
17	2.701	2.488	2.364	2.280	2.220	2.174	2.138	2.108	2.083	2.062	2.045	2.029	2.015	2.003
18	2.686	2.473	2.348	2.265	2.204	2.158	2.122	2.092	2.067	2.046	2.028	2.012	1.999	1.986
19	2.673	2.459	2.335	2.251	2.191	2.144	2.108	2.078	2.053	2.032	2.013	1.998	1.984	1.971
20	2.661	2.447	2.323	2.239	2.178	2.132	2.095	2.065	2.040	2.019	2.000	1.984	1.970	1.958
21	2.650	2.437	2.312	2.228	2.167	2.121	2.084	2.053	2.028	2.007	1.988	1.972	1.958	1.946
22	2.640	2.427	2.302	2.218	2.157	2.110	2.073	2.043	2.018	1.996	1.978	1.962	1.947	1.935
23	2.631	2.418	2.293	2.209	2.148	2.101	2.064	2.033	2.008	1.987	1.968	1.952	1.938	1.925
24	2.623	2.410	2.285	2.201	2.139	2.092	2.055	2.025	1.999	1.978	1.959	1.943	1.928	1.916
25	2.616	2.402	2.277	2.193	2.132	2.085	2.047	2.017	1.991	1.969	1.951	1.934	1.920	1.907
26	2.609	2.396	2.270	2.186	2.125	2.078	2.040	2.009	1.984	1.962	1.943	1.927	1.912	1.900
27	2.602	2.389	2.264	2.180	2.118	2.071	2.033	2.003	1.977	1.955	1.936	1.920	1.905	1.892
28	2.597	2.383	2.258	2.174	2.112	2.065	2.027	1.996	1.971	1.949	1.930	1.913	1.899	1.886
29	2.591	2.378	2.252	2.168	2.106	2.059	2.021	1.990	1.965	1.943	1.924	1.907	1.893	1.880
30	2.586	2.373	2.247	2.163	2.101	2.054	2.016	1.985	1.959	1.937	1.918	1.901	1.887	1.874
40	2.550	2.337	2.211	2.126	2.063	2.015	1.977	1.946	1.919	1.897	1.877	1.860	1.845	1.832
50	2.528	2.315	2.189	2.104	2.041	1.993	1.954	1.922	1.896	1.873	1.853	1.836	1.820	1.807
60	2.514	2.301	2.175	2.089	2.026	1.978	1.939	1.907	1.880	1.857	1.837	1.819	1.804	1.790
70	2.504	2.291	2.164	2.079	2.016	1.967	1.928	1.896	1.869	1.846	1.825	1.808	1.792	1.778
80	2.496	2.283	2.157	2.071	2.008	1.959	1.920	1.887	1.860	1.837	1.817	1.799	1.783	1.769
90	2.491	2.277	2.151	2.065	2.002	1.953	1.913	1.881	1.854	1.830	1.810	1.792	1.776	1.762
100	2.486	2.273	2.146	2.060	1.997	1.948	1.908	1.876	1.849	1.825	1.805	1.787	1.771	1.757
125	2.478	2.264	2.138	2.051	1.988	1.939	1.899	1.867	1.839	1.816	1.795	1.777	1.761	1.747
150	2.472	2.259	2.132	2.046	1.982	1.933	1.893	1.861	1.833	1.809	1.789	1.770	1.754	1.740
175	2.468	2.255	2.128	2.042	1.978	1.929	1.889	1.856	1.828	1.805	1.784	1.766	1.750	1.735
200	2.465	2.252	2.125	2.039	1.975	1.925	1.886	1.853	1.825	1.801	1.781	1.762	1.746	1.732

Table 2-5: B-Basis factors for small datasets using variability of corresponding large dataset

2.5 0º Lamina Strength Derivation

Lamina strength values in the 0º direction were not obtained directly for any conditions during compression tests. They are derived from the cross-ply lamina test results using a back out formula. Unless stated otherwise, the 0° lamina strength values were derived using the following formula:

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

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

$$BF = \frac{E_1\left[V_0E_2 + \left(1-V_0\right)E_1\right] - \left(\nu_{12}E_2\right)^2}{\left[V_0E_1 + \left(1-V_0\right)E_2\right]\left[V_0E_2 + \left(1-V_0\right)E_1\right] - \left(\nu_{12}E_2\right)^2} \quad \textbf{Equation 64}$$

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 section 2.4.2, equation 2.4.2.1(b) of CMH-17-1G.

In computing these strength values, the values for each environment are computed separately. The compression values are computed using only compression data, the tension values are computed using only tension data. Both normalized and as measured computations are done using the as measured and normalized strength values from the UNC0 and UNT0 strength values.

2.5.1 0º Lamina Strength Derivation (Alternate Formula)

In some cases, the previous formula cannot be used. For example, if there were no ETD tests run for transverse tension and compression, the value for E_2 would not be available. In that case, this alternative formula is used to compute the strength values for longitudinal tension and compression. It is similar to, but not quite the same as the formula detailed above. It requires the UNC0 and UNT0 strength and modulus data in addition to the LC and LT modulus data.

The 0° lamina strength values for the LC ETD condition were derived using the formula:

$$F^{cu}_{0^\circ} = F^{cu}_{0^\circ/90^\circ}\frac{E^c_1}{E^c_{0^\circ/90^\circ}}, \quad F^{tu}_{0^\circ} = F^{tu}_{0^\circ/90^\circ}\frac{E^t_1}{E^t_{0^\circ/90^\circ}} \quad \textbf{Equation 65}$$

with $F^{cu}_{0^\circ}, F^{tu}_{0^\circ}$ the derived mean lamina strength value for compression and tension respectively

$F^{cu}_{0^\circ/90^\circ}, \quad F^{tu}_{0^\circ/90^\circ}$ are the mean strength values for UNC0 and UNT0 respectively

$E^c_1, \quad E^t_1$ are the modulus values for LC and LT respectively

$E^c_{0^\circ/90^\circ}, \quad E^t_{0^\circ/90^\circ}$ are the modulus values for UNC0 and UNT0 respectively

This formula can also be found in section 2.4.2, equation 2.4.2.1(d) of CMH-17-1G.

3. Summary of Results

The basis values for all tests are summarized in the following tables. The NCAMP recommended B-basis values meet all requirements of CMH-17-1G. 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-17-1G 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-17-1G 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-17-1G recommends that no less than five batches be used when computing basis values with the ANOVA method.
5. Basis values of 90% or more of the mean value imply that the CV is unusually low and may not be conservative. Caution is recommended with B-Basis values calculated from STAT-17 when the B-basis value is 90% or more of the average value. 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.

NCAMP Recommended B-basis Values for
ACG - MTM45-1/AS4-145-32% RW Unidirectional

All B-basis values in this table meet the standards for publication in CMH-17-1G Handbook
Values are for normalized data unless otherwise noted

Lamina Strength Tests

Environment	Statistic	LT	LC	TT*	TC*	SBS*	IPS* 0.2% Offset	IPS* 5% Strain
CTD (-65°F)	B-basis	232.65	207.81	NA: A	33.04	14.41	7.61	12.17
	Mean	263.10	231.81	7.10	38.35	16.35	8.36	13.37
	CV	6.99	7.02	14.77	7.00	6.00	6.00	6.00
RTD (75°F)	B-basis	240.01	178.99	NA: A	24.26**	11.16	5.56	8.64
	Mean	270.76	202.80	6.92	26.81	12.66	6.31	9.83
	CV	6.64	7.68	17.47	4.93	6.00	6.00	6.00
ETD (200°F)	B-basis					8.70	NA:I	NA:I
	Mean					9.87	4.91	7.28
	CV					6.00	1.68	1.07
ETW (200°F)	B-basis	225.78	111.93	NA: A	13.15	7.32	3.71	5.44
	Mean	256.69	135.73	3.99	14.96	8.31	4.16	6.11
	CV	7.04	8.49	9.85	6.13	6.00	6.00	6.00
ETW2 (250°F)	B-basis	237.12	114.32	NA: A	10.90	5.96	2.89	NA:I
	Mean	268.04	138.12	3.26	12.30	6.83	3.24	4.79
	CV	6.13	9.44	13.32	6.16	6.45	6.00	6.00

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA implies that tests were run but data did not meet NCAMP recommended requirements.
"NA: A" indicates ANOVA with 3 batches, "NA: I" indicates insufficient data,
Shaded empty boxes indicate that no test data is available for that property and condition.
* Data is as measured rather than normalized
** indicates the Stat17 B-basis value is greater than 90% of the mean value.

Table 3-1 : NCAMP recommended B-basis values for lamina test data

NCAMP Recommended B-basis Values for
ACG - MTM45-1/AS4-145-32%RW Unidirectional
All B-basis values in this table meet the standards for publication in CMH-17-1G Handbook
Values are for normalized data unless otherwise noted

Laminate Strength Tests

Lay-up	ENV	Statistic	OHT	OHC	FHT	FHC	UNT	UNC	PB 2% Offset	PB Ult. Str.	LSBS*
"Quasi-Isotropic" 25/50/25	CTD (-65°F)	B-basis	51.52		51.76		101.08				
		Mean	57.49		58.71		113.13				
		CV	6.00		6.00		6.00				
	RTD (75°F)	B-basis	51.42	39.31	NA:I	NA:I	97.66	70.43	76.95	115.39	NA: A
		Mean	57.39	43.76	60.67	65.06	109.54	78.28	93.03	127.63	10.28
		CV	6.00	6.28	1.77	1.75	6.05	7.08	8.75	6.00	8.56
	ETW2 (250°F)	B-basis	48.99	30.12		38.72	NA:I	49.12	67.13	83.12	4.70
		Mean	54.96	34.57		45.13	99.38	56.84	77.77	95.19	5.34
		CV	6.00	6.37		7.28	5.87	6.26	7.18	6.21	6.00
"Soft" 10/80/10	CTD (-65°F)	B-basis	NA: A		NA:I		NA:I				
		Mean	43.22		44.88		69.62				
		CV	4.96		0.96		3.71				
	RTD (75°F)	B-basis	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	
		Mean	41.06	36.32	42.28	48.80	64.02	56.30	63.08	111.37	
		CV	0.91	2.53	2.52	4.69	2.76	7.83	6.49	3.41	
	ETW2 (250°F)	B-basis	NA:I	24.07	NA:I	31.22	NA:I	NA:I	66.17	81.84	
		Mean	34.93	27.31	35.87	35.42	47.37	44.27	75.04	92.78	
		CV	1.40	6.00	0.59	6.00	2.57	4.06	6.38	6.36	
"Hard" 50/40/10	CTD (-65°F)	B-basis	78.08		NA:I		NA:I				
		Mean	90.56		94.15		158.29				
		CV	6.98		4.50		4.82				
	RTD (75°F)	B-basis	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	
		Mean	93.57	56.05	90.20	83.49	161.63	95.48	68.40	107.16	
		CV	3.77	6.87	4.38	3.28	4.48	2.31	13.81	3.91	
	ETW2 (250°F)	B-basis	NA:I	40.53		46.41	NA:I	NA:I	57.35	82.18	
		Mean	96.13	46.06		56.83	148.41	65.89	74.88	92.69	
		CV	2.49	6.09		9.62	2.29	5.36	7.43	6.06	

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA implies that tests were run but data did not meet NCAMP recommended requirements.
"NA: A" indicates ANOVA with 3 batches, "NA: I" indicates insufficient data,
Shaded empty boxes indicate that no test data is available for that property and condition.
* Data is as measured rather than normalized
** indicates the Stat17 B-basis value is greater than 90% of the mean value.

Table 3-2 : NCAMP Recommended B-basis values for laminate test data

3.2 Lamina and Laminate Summary Tables

Material: Advanced Composites Group - MTM45-1 12K AS4-145 Unidirectional Tape
Material Specificaton: NMS 451/11 Material Specification
Process Specification: NPS 81451 Process Specification "MH" Cure Cycle

ACG - MTM45-1/AS4-145-32%RW
Lamina Properties Summary

Fabric: Hexcel AS4-GP Fiber 12K tow **Resin:** MTM45-1

Tg(dry): 397.33°F **Tg(wet):** 339.46°F **Tg METHOD:** SACMA SRM 18R-94

		IPS retest			IPS retest
Date of fiber manufacture	8/18/2005; 12/7/2005	3/2/2022 to 10/5/2022	**Date of testing**	8/2/2006 to 6/26/2007	7/25/2023 to 8/31/2023
Date of resin manufacture	12/6/2005 to 1/10/2006	5/31/2022 to 1/16/2023	**Date of data submittal**	7/1/2007	9/15/2023
Date of prepreg manufacture	12/6/2005 to 1/10/2006	6/8/2022 to 3/27/2023	**Date of Analysis**	7/18/2008 to 2/04/2011	9/21/2023
Date of composite manufacture	2/22/2006 to 7/7/2006	5/3/2023 to 5/16/2023			

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY

Data reported: As-measured with normalized values in parentheses, normalizing tply: 0.0055 inches

Values shown in shaded boxes do not meet CMH-17-1G requirements and are estimates only

These values may not be used for certification unless specifically allowed by the certifying agency

Property	CTD (-65°F)			RTD (75°F)			ETD (200°F)			ETW (200°F)			ETW2 (250°F)		
Test	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean
F_1^{cu}	211.95	209.91	233.19	182.47	180.44	203.53				115.15	113.12	136.21	117.40	115.37	138.46
(ksi)	(209.10)	(207.81)	(231.81)	(180.27)	(178.99)	(202.80)				(113.21)	(111.93)	(135.73)	(115.60)	(114.32)	(138.12)
$*E_1^c$			17.07			17.06						17.31			19.82
(Msi)			(16.83)			(17.02)						(17.24)			(19.63)
$*\nu_{12}^c$			0.30			0.31						0.32			0.35
F_1^{tu}	242.93	236.44	266.77	250.71	244.16	274.78				233.42	226.83	257.63	246.95	240.36	271.16
(ksi)	(238.38)	(232.65)	(263.10)	(245.79)	(240.01)	(270.76)				(231.59)	(225.78)	(256.69)	(242.94)	(237.12)	(268.04)
$*E_1^t$			18.96			18.79						18.74			22.21
(Msi)			(18.74)			(18.51)						(18.66)			(21.90)
F_2^{cu} (ksi)	33.80	33.04	38.35	24.26	NA	26.81				12.46	13.15	14.96	11.32	10.90	12.30
$*E_2^c$ (Msi)			1.42			1.25						1.18			1.27
$*\nu_{21}^c$			0.018			0.015						0.014			0.054
F_2^{tu} (ksi)	1.24	5.03	7.10	0.48	4.53	6.92				2.11	3.24	3.99	0.66	2.40	3.26
$*E_2^t$ (Msi)			1.25			1.15						0.99			0.94
UNC0 Strength	113.47	112.40	124.54	97.09	96.03	108.07	83.72	82.66	94.70	64.84	63.78	75.82	59.02	57.96	70.00
(ksi)	(112.63)	(111.61)	(123.72)	(96.57)	(95.56)	(107.57)	(83.40)	(82.39)	(94.40)	(65.18)	(64.17)	(76.18)	(59.05)	(58.03)	(70.05)
*UNC0 Modulus			9.12			9.06			9.50			9.64			10.02
(Msi)			(9.06)			(9.01)			(9.48)			(9.68)			(9.99)
*UNC0 Poisson's Ratio			0.039			0.034			0.031			0.034			0.058
UNT0 Strength	128.26	124.97	140.73	131.16	127.83	143.74				125.11	121.77	137.77	118.93	115.59	131.59
(ksi)	(129.51)	(125.75)	(141.41)	(132.67)	(128.88)	(144.69)				(127.46)	(123.64)	(139.54)	(121.65)	(117.84)	(133.73)
*UNT0 Modulus			10.00			9.83						10.02			10.78
(Msi)			(10.07)			(9.90)						(10.15)			(10.98)
$F_{12}^{s5\%strain}$ (ksi)	12.20	12.17	13.37	9.39	8.64	9.83	7.13	6.40	7.28	5.91	5.44	6.11	4.59	4.27	4.79
$F_{12}^{s0.2\%}$ (ksi)	8.10	7.61	8.36	5.88	5.56	6.31	4.74	4.31	4.91	4.03	3.71	4.16	3.10	2.89	3.24
G_{12}^s (Msi)			0.69			0.57			0.46			0.43			0.34
SBS (ksi)	15.09	14.41	16.35	10.38	11.16	12.66	9.50	8.70	9.87	6.69	7.32	8.31	4.73	5.96	6.83

F_1^{cu} and F_1^{tu} are derived from cross-ply laminates per AI/TR/1392 Table 3a, note (1).

*Strain data acquisition equipment calibrated by internal shunt method. Calibration traceable to NIST standard not available.

Table 3-3: Summary of Test Results for Lamina Data

ACG MTM45-1/AS4-145-32%RW Laminate Properties Summary

Material: Advanced Composites Group - MTM45-1 12K AS4-145 Unidirectional Tape
Material Specificaton: NMS 451/11 Material Specification
Process Specification: NPS 81451 Process Specification "MH" Cure Cycle

Fabric: Hexcel AS4-GP Fiber 12K tow **Resin:** MTM45-1

Tg(dry): 397.33°F **Tg(wet):** 339.46°F **Tg METHOD:** SACMA SRM 18R-94

Date of fiber manufacture	8/18/2005; 12/7/2005	**Date of testing**	8/2/2006 to 6/26/2007
Date of resin manufacture	12/6/2005 to 1/10/2006	**Date of data submittal**	7/1/2007
Date of prepreg manufacture	12/6/2005 to 1/10/2006	**Date of Analysis**	7/18/2008 to 2/04/2011
Date of composite manufacture	2/22/2006 to 7/7/2006		

LAMINATE MECHANICAL PROPERTY SUMMARY for MTM45-1/AS4-145-32%RW UNI

Data reported as normalized used a normalizing t_{ply} of 0.0055 inches

Values shown in shaded boxes do not meet CMH-17-1G requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test	Property	Layup:	"Quasi Isotropic" 25/50/25			"Soft" 10/80/10			"Hard" 50/40/10		
		Test Condition	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean
OHT (normalized)	Strength (ksi)	CTD (-65°F)	54.51	51.52	57.49	28.71	NA	43.22	62.46	78.08	90.56
		RTD (75°F)	51.36	51.42	57.39	36.41	34.00	41.06	82.97	77.49	93.57
		ETW (200°F)	47.79	48.13	55.01	---	---	---	---	---	---
		ETW2 (250°F)	51.82	48.99	54.96	31.73	28.91	34.93	87.31	79.54	96.13
OHC (normalized)	Strength (ksi)	RTD (75°F)	32.15	39.31	43.76	30.67	30.18	36.32	47.55	46.82	56.05
		ETW (200°F)	31.18	32.89	37.99	---	---	---	---	---	---
		ETW2 (250°F)	26.23	30.12	34.57	25.52	24.07	27.31	42.26	40.53	46.06
UNT (normalized)	Strength (ksi)	CTD (-65°F)	105.69	101.08	113.13	60.74	57.74	69.62	138.10	131.29	158.29
	* Modulus (Msi)		---	---	7.30	---	---	4.62	---	---	11.34
	Strength (ksi)	RTD (75°F)	102.20	97.66	109.54	56.77	53.02	64.02	144.17	135.16	161.63
	* Modulus (Msi)		---	---	7.00	---	---	4.35	---	---	10.82
	Strength (ksi)	ETW2 (250°F)	90.84	85.54	99.38	43.02	39.20	47.37	134.78	122.80	148.41
	* Modulus (Msi)		---	---	8.53	---	---	4.79	---	---	12.95
UNC (normalized)	Strength (ksi)	RTD (75°F)	59.57	70.43	78.28	46.98	46.78	56.30	80.63	79.35	95.48
	* Modulus (Msi)		---	---	6.29	---	---	4.06	---	---	9.78
	* Poisson's Ratio		---	---	0.2958	---	---	0.5413	---	---	0.3890
	Strength (ksi)	ETW (200°F)	53.00	55.21	63.94	---	---	---	---	---	---
	* Modulus (Msi)		---	---	6.86	---	---	---	---	---	---
	* Poisson's Ratio		---	---	0.35	---	---	---	---	---	---
	Strength (ksi)	ETW2 (250°F)	52.08	49.12	56.84	35.44	NA	44.27	53.35	NA	65.89
	* Modulus (Msi)		---	---	6.99	---	---	4.20	---	---	11.13
	* Poisson's Ratio		---	---	0.36	---	---	0.56	---	---	0.42
FHT (normalized)	Strength (ksi)	CTD (-65°F)	55.16	51.76	58.71	39.16	37.23	44.88	82.15	78.09	94.15
		RTD (75°F)	53.80	50.25	60.67	37.49	35.01	42.28	79.98	74.70	90.20
		ETW2 (250°F)	---	---	---	32.58	29.68	35.87	---	---	---
FHC (normalized)	Strength (ksi)	RTD (75°F)	54.94	54.07	65.06	41.21	40.55	48.80	70.50	69.38	83.49
		ETW2 (250°F)	39.36	38.72	45.13	32.72	31.22	35.42	46.41	NA	56.83
LSBS (as-measured)	Strength (ksi)	RTD (75°F)	5.40	8.54	10.28	---	---	---	---	---	---
		ETW (200°F)	5.41	5.40	6.50	---	---	---	---	---	---
		ETW2 (250°F)	4.96	4.70	5.34	---	---	---	---	---	---
Pin Bearing (normalized)	2% Offset Strength (ksi)	RTD (75°F)	76.95	NA	93.03	53.27	52.42	63.08	48.45	NA	68.40
		ETW2 (250°F)	68.34	67.13	77.77	68.43	66.17	75.04	57.35	NA	74.88
	Ultimate Strength (ksi)	RTD (75°F)	104.16	115.39	127.63	94.04	92.55	111.37	90.49	89.06	107.16
		ETW2 (250°F)	87.20	83.12	95.19	84.66	81.84	92.78	85.54	82.18	92.69
ILT (as-measured)	Strength (ksi)	RTD (75°F)	---	---	6.891	---	---	---	---	---	---
		ETW2 (250°F)	---	---	3.895	---	---	---	---	---	---
CBS (as-measured)	Strength (in-lb/in)	RTD (75°F)	---	---	287.34	---	---	---	---	---	---
		ETW2 (250°F)	---	---	163.19	---	---	---	---	---	---
CAI (normalized)	Strength (ksi)	RTD (75°F)	---	---	31.09	---	---	---	---	---	---
	*Modulus (Msi)		---	---	7.010	---	---	---	---	---	---

*** Strain data acquisition equipment calibrated by internal shunt method. Calibration traceable to NIST standard not available**

Table 3-4: Summary of Test Results for Laminate Data

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 2.1.4 for 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-17-1G section 8.3.10.

4.1 Longitudinal (0º) Tension Properties (LT)

The normalized LT data meets all CMH-17-1G requirements for B-basis values. The LT data met all requirements for pooling across all environments.

The as measured LT data could also be pooled across all environments. While the CTD and RTD environments failed the normality test, the pooled dataset passed.

There were four outliers in the LT data. There was one outlier in the RTD condition data. It was an outlier for both the as measured and normalized data. It was on the low side of batch two and was an outlier for the RTD condition but not for batch two. There were two outliers in the ETW condition data. One outlier was on the high side of batch two for the as measured data only. It was an outlier for batch two, but not for the ETW condition. The second outlier in the ETW data was on the low side of batch three. It was an outlier for both the normalized and as measured data. It was an outlier for the ETW condition, but not for batch three. The fourth outlier in the LT data was in the ETW2 condition. It was an outlier only for the as measured data. It was on the low side of batch two and was an outlier for both batch two and the ETW2 condition. All outliers were retained for this analysis.

Statistics and basis values are given for the LT strength data in Table 4-1. Statistics for the modulus data are given in Table 4-2. The normalized data and the B-basis values are shown graphically in Figure 4-1.

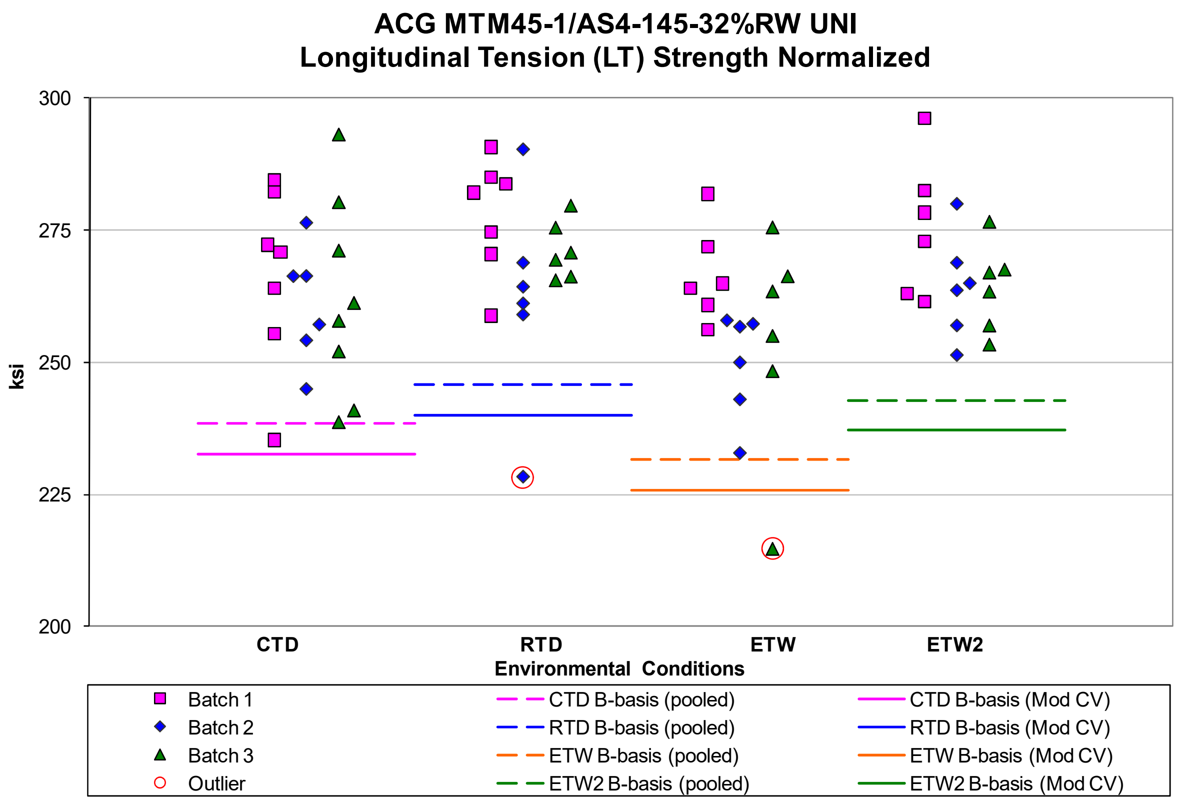

Figure 4-1: Batch Plot for LT Strength normalized

Longitudinal Tension Strength (ksi)								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	263.10	270.76	256.69	268.04	266.77	274.78	257.63	271.16
Stdev	15.74	14.28	15.61	11.41	17.56	14.87	11.43	9.57
CV	5.98	5.27	6.08	4.26	6.58	5.41	4.44	3.53
Mod CV	6.99	6.64	7.04	6.13	7.29	6.71	6.22	6.00
Min	235.33	228.30	214.72	251.32	229.34	226.92	224.77	243.03
Max	293.06	290.72	281.88	296.23	292.73	292.03	273.54	286.04
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	19	18	18	21	19	18	18
Basis Values and/or Estimates								
B-basis Value	238.38	245.79	231.59	242.94	242.93	250.71	233.42	246.95
A-estimate	221.79	229.25	215.07	226.42	226.94	234.76	217.49	231.02
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates								
B-basis Value	232.65	240.01	225.78	237.12	236.44	244.16	226.83	240.36
A-estimate	212.23	219.64	205.43	216.78	216.10	223.86	206.56	220.09
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-1: Statistics and Basis Values for LT Strength data

Longitudinal Tension Modulus (msi)								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	18.74	18.51	18.66	21.90	18.96	18.79	18.74	22.21
Stdev	0.78	0.62	0.61	1.12	0.76	0.56	0.70	1.16
CV	4.16	3.34	3.24	5.10	4.00	2.98	3.75	5.22
Mod CV	6.08	6.00	6.00	6.55	6.00	6.00	6.00	6.61
Min	17.55	17.53	17.54	19.51	17.43	18.20	17.87	19.70
Max	20.22	20.23	19.68	23.60	20.09	19.91	20.49	23.94
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	15	18	18	18	15

Table 4-2: Statistics from LT modulus data

4.2 Transverse (90º) Tension Properties (TT)

Transverse Tension data is not normalized because it is not a fiber dominated property for unidirectional tape. The strength data could not be pooled as all four conditions failed the ADK test. In addition, all environments have such a large coefficient of variation that the modified CV method would have no effect. This means those datasets require the ANOVA method and with data from less than five batches available it is an estimate only and may result in overly conservative basis values. An override of the ADK test results is not appropriate due to the batches showing trends across the environments; batch two has lowest mean for all four environments while batch three has the highest mean for all for environments. Estimates were also computed using the normal distribution method, but caution is advised with these estimates. There were no outliers.

Statistics and A- and B-estimates of basis values are given for the as measured TT strength and modulus data in Table 4-3. The data and B-estimates are shown graphically in Figure 4-2.

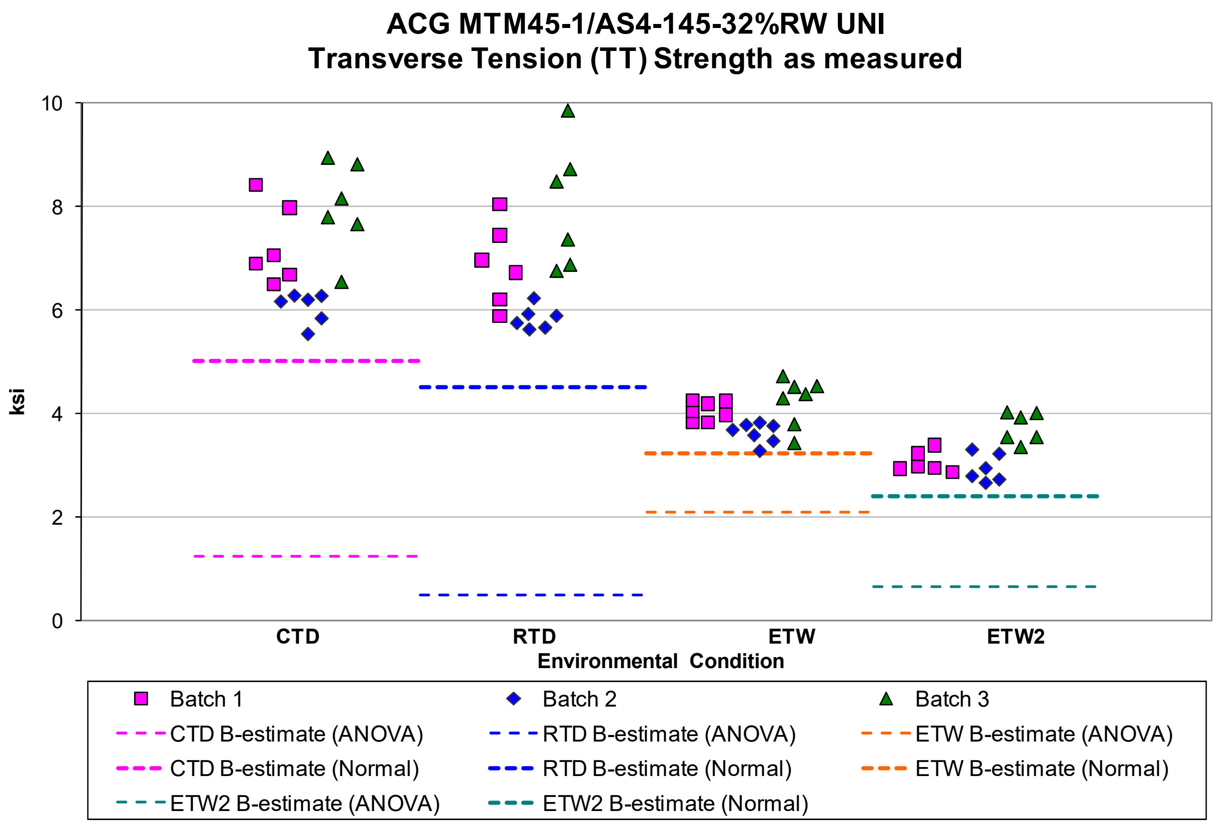

Figure 4-2: Batch Plot for TT Strength as measured

Transverse Tension								
Strength (ksi) as measured					Modulus (msi) as measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	7.10	6.92	3.99	3.26	1.25	1.15	0.99	0.94
Stdev	1.05	1.21	0.39	0.43	0.13	0.04	0.07	0.10
CV	14.77	17.47	9.85	13.32	10.73	3.08	7.01	10.78
Mod CV	14.77	17.47	9.85	13.32	10.73	6.00	7.51	10.78
Min	5.54	5.63	3.29	2.68	1.08	1.10	0.89	0.80
Max	8.94	9.85	4.74	4.04	1.54	1.22	1.22	1.21
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	21	18	17	18	20	15
Basis Values and/or Estimates								
B-estimate	1.24	0.48	2.11	0.66				
A-estimate	0.00	0.00	0.77	0.00				
Method	ANOVA	ANOVA	ANOVA	ANOVA				
Estimates computed ignoring the ADK test results								
B-estimate	5.03	4.53	3.24	2.40				
A-estimate	3.56	2.84	2.70	1.80				
Method	normal	normal	normal	normal				

Table 4-3: Statistics and Basis Values for TT Strength and Modulus data

4.3 Longitudinal (0º) Compression Properties (LC)

This data meets all CMH-17-1G requirements for publication of the B-basis values. The LC data met all requirements for pooling across all environments.

There was one outlier in batch one on the high side in the ETW environment. It was an outlier for the LC condition, but not batch one. It was an outlier for both the normalized and as measured data. This outlier was retained for this analysis.

Statistics and basis values are given for the LC strength data in Table 4-4. Statistics for the modulus data are given in Table 4-5. The normalized data and B-basis values are shown graphically in Figure 4-3.

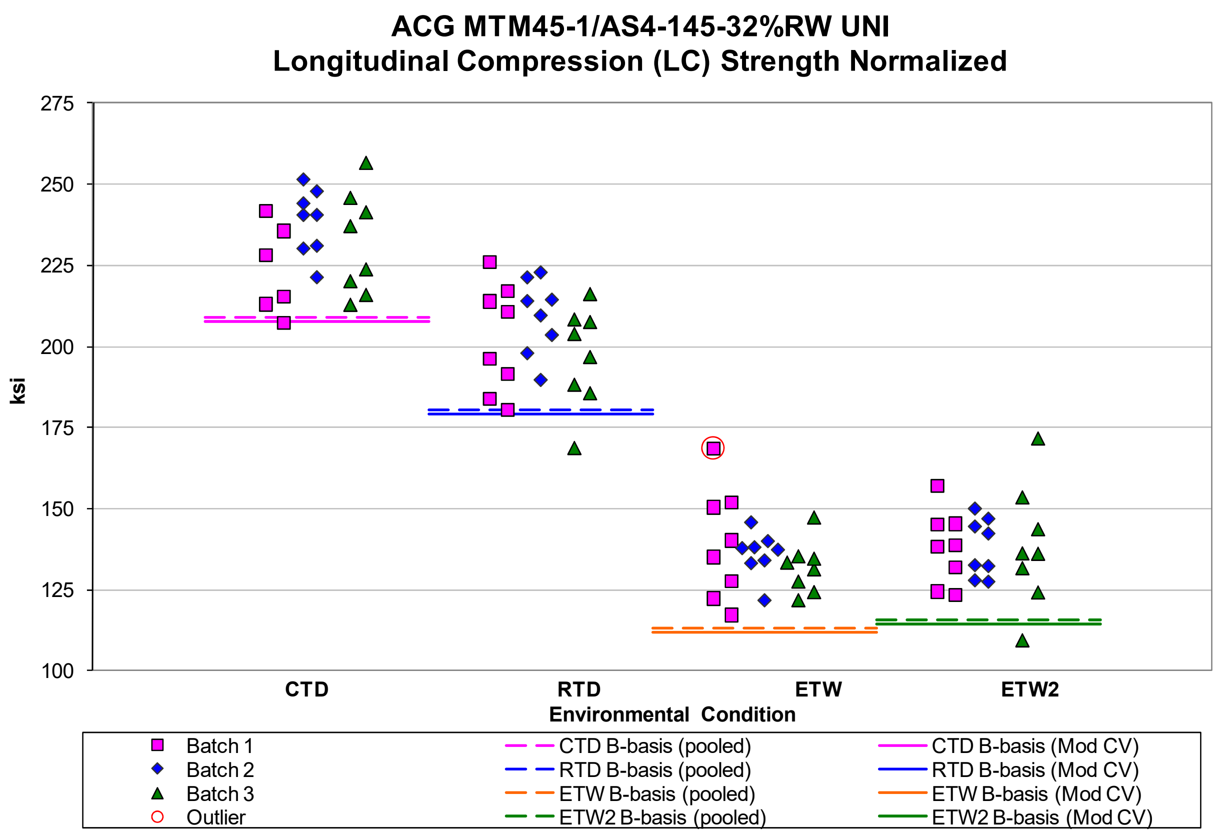

Figure 4-3: Batch Plot for LC Strength normalized

Longitudinal Compression Strength (ksi)								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	231.81	202.80	135.73	138.12	233.19	203.53	136.21	138.46
Stdev	14.01	14.94	11.52	13.04	15.05	10.22	10.86	13.70
CV	6.05	7.37	8.49	9.44	6.45	5.02	7.97	9.90
Mod CV	7.02	7.68	8.49	9.44	7.23	6.51	7.99	9.90
Min	207.41	168.68	117.18	109.48	201.16	181.16	115.00	113.93
Max	256.44	225.95	168.65	171.61	259.49	221.01	167.89	175.60
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	22	24	24	24	22	24	24	24
Basis Values and/or Estimates								
B-basis Value	209.10	180.27	113.21	115.60	211.95	182.47	115.15	117.40
A-estimate	193.90	165.04	97.98	100.37	197.74	168.23	100.91	103.16
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates								
B-basis Value	207.81	178.99	111.93	114.32	209.91	180.44	113.12	115.37
A-estimate	191.75	162.90	95.84	98.23	194.33	164.84	97.52	99.77
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-4: Statistics and B-Basis values for LC Strength data

Longitudinal Compression Modulus (msi)								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	16.83	17.02	17.24	19.63	17.07	17.06	17.31	19.82
Stdev	0.85	0.86	0.88	1.08	0.62	0.65	0.66	0.52
CV	5.07	5.06	5.10	5.49	3.62	3.81	3.82	2.64
Mod CV	6.54	6.53	6.55	6.74	6.00	6.00	6.00	6.00
Min	14.31	14.39	14.54	17.82	15.82	16.06	15.67	19.12
Max	17.85	18.89	18.37	20.78	18.08	18.59	18.34	20.45
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	17	6	18	18	17	6

Table 4-5: Statistics from LC modulus data

4.4 Transverse (90º) Compression Properties (TC)

Transverse Compression strength is not normalized because it is not a fiber dominated property for unidirectional tape. This data meets all CMH-17-1G requirements for publication of the B-basis values. The as measured TC strength data could not be pooled because the ETW data failed the Anderson-Darling k-sample test for batch to batch variability and the RTD data failed the normality test. The data was then analyzed for each condition individually using Stat-17. Since the ETW data failed the ADK test it requires the ANOVA method to compute basis values, but with data from only three batches, these values are considered estimates and may result in overly conservative basis values. The ETW data does pass the normality test and passed the ADK test under the modified CV transformation, so the modified CV values are provided for all but the RTD dataset.

There was one outlier in the TC data. It was on the low side of batch one in the RTD environment. It was an outlier only for batch one, not for the RTD condition. It was retained for this analysis. Statistics and basis values are given for the as measured TC data in Table 4-6. The data, B-basis values and B-estimates are shown graphically Figure 4-4.

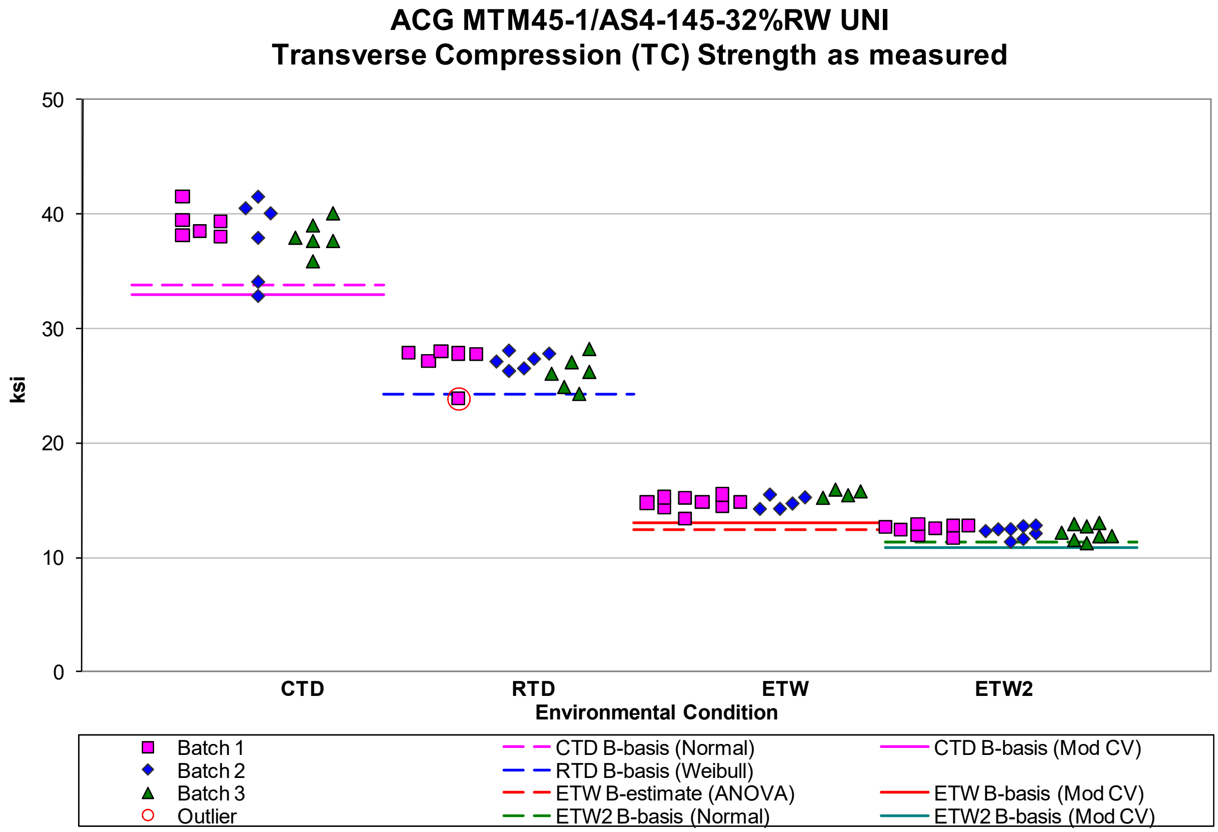

Figure 4-4: Batch Plot for TC Strength data

Transverse Compression								
	Strength (ksi) as measured				Modulus (msi) as measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	38.35	26.81	14.96	12.30	1.42	1.25	1.18	1.27
Stdev	2.30	1.32	0.64	0.53	0.05	0.04	0.05	0.16
CV	6.01	4.93	4.26	4.32	3.44	2.95	3.91	12.40
Mod CV	7.00	6.46	6.13	6.16	6.00	6.00	6.00	12.40
Min	32.86	23.89	13.44	11.29	1.32	1.20	1.11	1.09
Max	41.58	28.20	15.96	13.05	1.49	1.33	1.28	1.45
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	24	18	18	18	7
Basis Values and/or Estimates								
B-basis Value	33.80	24.26		11.32				
B-estimate			12.46					
A-estimate	30.58	21.61	10.67	10.61				
Method	Normal	Weibull	ANOVA	Normal				
Modified CV Basis Values and/or Estimates								
B-basis Value	33.04		13.15	10.90				
A-estimate	29.29		11.87	9.89				
Method	Normal		Normal	Normal				

Table 4-6: Statistics and Basis Values for TC Strength and Modulus data

4.5 Unnotched Tension Properties (UNT0)

Pooling across the environments was acceptable for both the normalized and the as measured data. The normalized and the as measured RTD data and the as measured CTD data did not pass the normality test, but the pooled dataset for both the normalized and the as measured data did pass the normality test.

There were four outliers in the LT data. There was one outlier in the RTD condition data. It was an outlier for both the as measured and normalized data. It was on the low side of batch two and was an outlier for both batch and condition in the normalized data. It was an outlier for the condition, but not the batch in the as measured data. There were two outliers in the ETW condition data. One outlier was on the high side of batch two for the as measured data only. It was an outlier for batch two, but not for the ETW condition. The second outlier in the ETW data was on the low side of batch three. It was an outlier for both the normalized and as measured data. It was an outlier for the ETW condition, but not for batch three. The fourth outlier in the LT data was in the ETW2 condition. It was an outlier only for the as measured data. It was on the low side of batch two and was an outlier for both batch two and the ETW2 condition. All four outliers were retained for this analysis.

Statistics and basis values are given for the UNT0 strength data in Table 4-7 and for the modulus data in Table 4-8. The normalized data and the B-basis values are shown graphically in Figure 4-5.

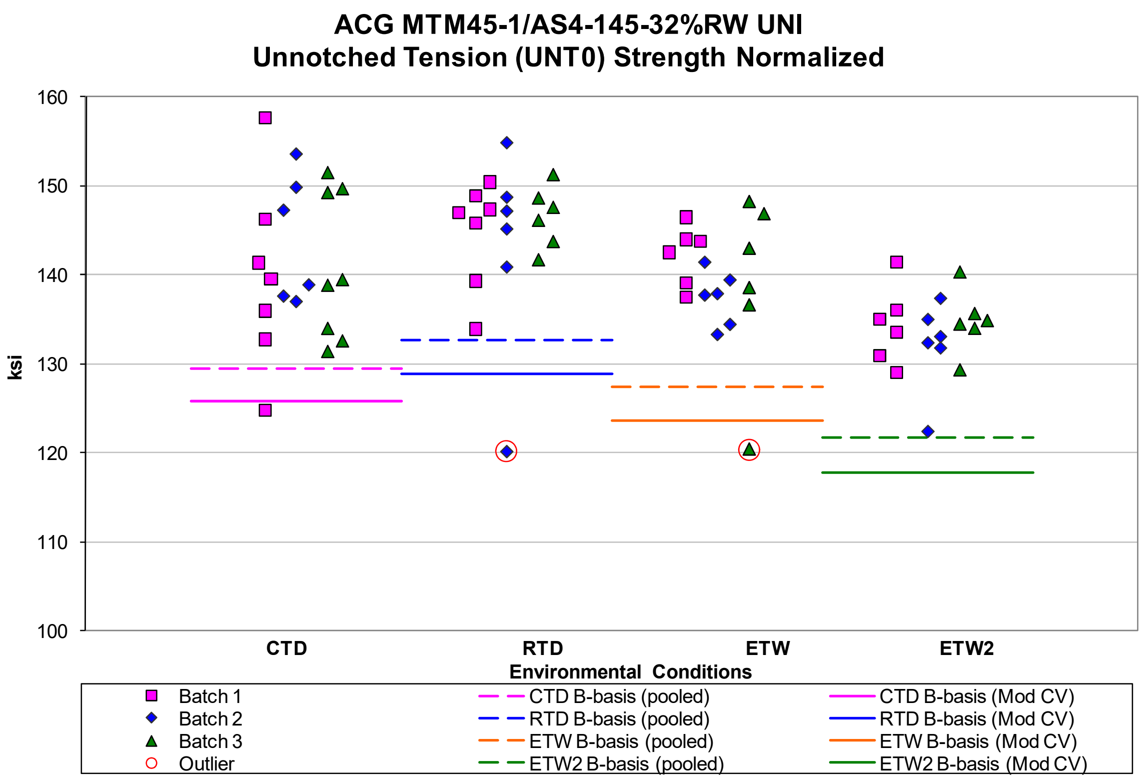

Figure 4-5: Batch plot for UNT0 Strength normalized

Unnotched Tension (UNT0) Strength (ksi)								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	141.41	144.69	139.54	133.73	140.73	143.74	137.77	131.59
Stdev	8.49	7.55	6.36	4.29	9.26	7.78	6.11	4.64
CV	6.00	5.22	4.56	3.20	6.58	5.41	4.44	3.53
Modified CV	7.00	6.61	6.28	6.00	7.29	6.71	6.22	6.00
Min	124.83	120.23	120.43	122.50	120.98	118.71	120.20	117.94
Max	157.67	154.91	148.22	141.49	154.42	152.77	146.28	138.81
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	19	18	18	21	19	18	18
Basis Values and/or Estimates								
B-basis Value	129.51	132.67	127.46	121.65	128.26	131.16	125.11	118.93
A-estimate	121.53	124.71	119.51	113.70	119.90	122.82	116.78	110.60
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates								
B-basis Value	125.75	128.88	123.64	117.84	124.97	127.83	121.77	115.59
A-estimate	115.25	118.40	113.18	107.37	114.40	117.28	111.23	105.05
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-7: Statistics and Basis Values for UNT0 Strength data

Unnotched Tension (UNT0) Modulus (msi)								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	10.07	9.90	10.15	10.98	10.00	9.83	10.02	10.78
Stdev	0.54	0.22	0.40	0.39	0.50	0.20	0.38	0.35
CV	5.32	2.21	3.95	3.53	5.01	2.07	3.83	3.25
Mod CV	6.66	6.00	6.00	6.00	6.51	6.00	6.00	6.00
Min	9.17	9.53	9.51	10.36	9.19	9.40	9.40	10.30
Max	11.20	10.40	11.28	11.39	10.89	10.24	11.06	11.19
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	20	23	18	9	20	23	18	9

Table 4-8: Statistics from UNT0 Modulus data

4.6 Unnotched Compression Properties (UNC0)

The UNC0 normalized strength data meets all CMH-17-1G requirements for pooling. There was one outlier in batch one on the high side in the ETW environment. It was an outlier after pooling for the ETW condition, but not batch one. It was an outlier in both the normalized and as measured data. It was retained for this analysis.

Statistics and basis values are given for the UNC0 strength data in Table 4-9. Statistics for the modulus data are given in Table 4-10. The normalized data and the B-basis values are shown graphically in Figure 4-6.

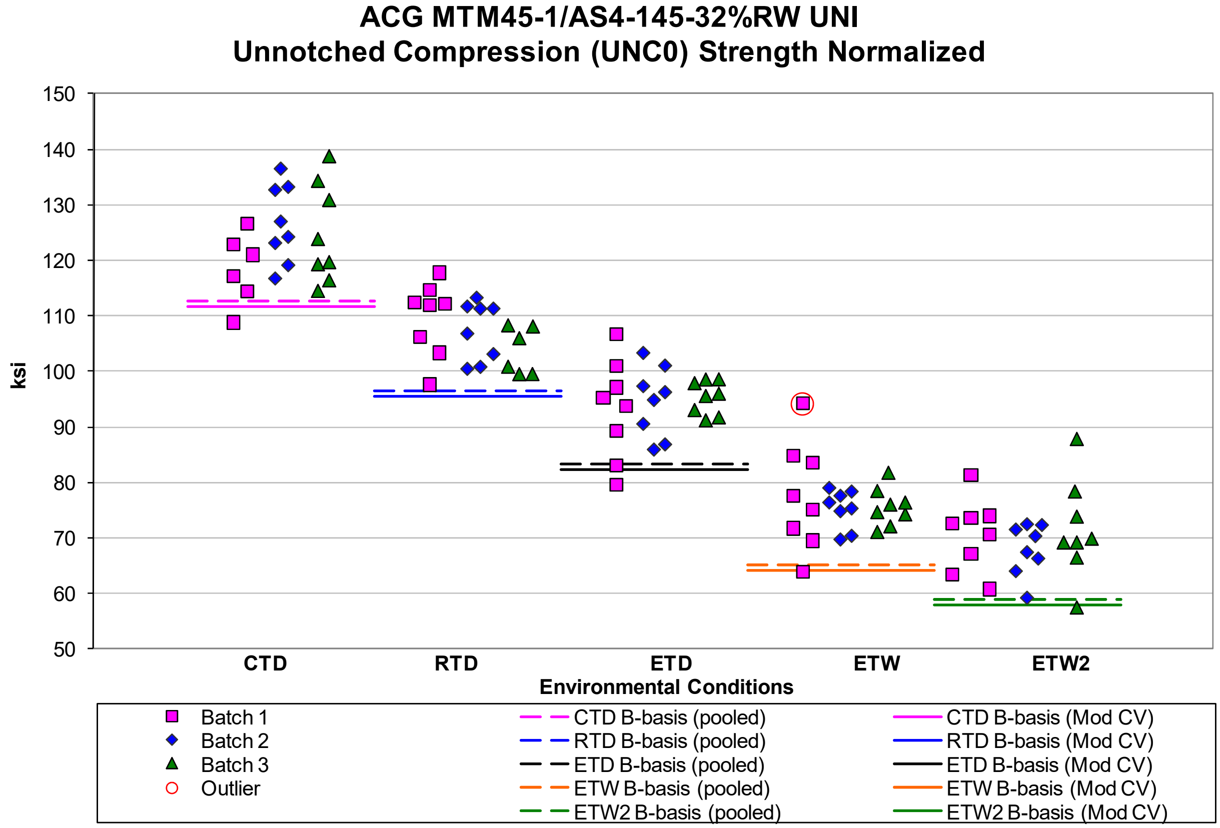

Figure 4-6: Batch plot for UNC0 Strength normalized

Unnotched Compression (UNC0) Strength (ksi)										
	Normalized					As Measured				
Env	CTD	RTD	ETD	ETW	ETW2	CTD	RTD	ETD	ETW	ETW2
Mean	123.72	107.57	94.40	76.18	70.05	124.54	108.07	94.70	75.82	70.00
Stdev	8.01	5.72	6.34	6.09	6.77	8.04	5.43	6.39	6.04	6.93
CV	6.47	5.31	6.72	7.99	9.67	6.45	5.02	6.75	7.97	9.90
Modified CV	7.24	6.66	7.36	7.99	9.67	7.23	6.51	7.38	7.99	9.90
Min	108.80	97.65	79.66	63.87	57.62	107.44	96.20	78.05	64.02	57.60
Max	138.72	117.80	106.70	94.27	87.90	138.59	117.35	106.47	93.45	88.78
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	22	24	24	24	24	22	24	24	24	24
Basis Values and/or Estimates										
B-basis Value	112.63	96.57	83.40	65.18	59.05	113.47	97.09	83.72	64.84	59.02
A-estimate	105.26	89.19	76.02	57.80	51.67	106.10	89.71	76.34	57.46	51.64
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates										
B-basis Value	111.61	95.56	82.39	64.17	58.03	112.40	96.03	82.66	63.78	57.96
A-estimate	103.56	87.50	74.33	56.11	49.97	104.33	87.95	74.58	55.70	49.88
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-9: Statistics and Basis Values for UNC0 Strength data

Unnotched Compression (UNC0) Modulus (msi)										
	Normalized					As Measured				
Env	CTD	RTD	ETD	ETW	ETW2	CTD	RTD	ETD	ETW	ETW2
Mean	9.06	9.01	9.48	9.68	9.99	9.12	9.06	9.50	9.64	10.02
Stdev	0.39	0.56	0.72	0.55	0.47	0.38	0.54	0.64	0.53	0.36
CV	4.31	6.16	7.56	5.67	4.72	4.18	5.98	6.74	5.53	3.64
Mod CV	6.16	7.08	7.78	6.83	8.00	6.09	6.99	7.37	6.76	8.00
Min	8.27	8.21	8.14	8.70	9.52	8.51	8.29	8.20	8.61	9.67
Max	9.86	10.72	11.69	10.60	10.71	9.95	10.59	11.33	10.77	10.56
No. Batches	3	3	3	3	2	3	3	3	3	2
No. Spec.	22	24	24	20	5	22	24	24	20	5

Table 4-10: Statistics from UNC0 Modulus data

4.7 In-Plane Shear Properties (IPS)

The In-Plane Shear data is not normalized. Data is reported on three properties: 0.2% Offset Strength, Strength at 5% Strain and Modulus. The ETD condition lacks sufficient specimens to compute B-basis values so only B-estimates are provided for that condition.

The 0.2% Offset Strength (RTD) and Strength at 5% Strain (CTD and RTD) datasets, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17-1G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. All three datasets passed the ADK test after the modified CV approach was applied, so modified CV basis values are provided.

The CTD and RTD conditions for both strength (0.2% Offset and 5% Strain) properties met all requirements for pooling after modified CV approach.

There was one outlier. The largest value in batch two of the ETD 0.2% Offset Strength dataset was an outlier for batch two, but not for the ETD condition. The outlier was retained for this analysis.

Statistics and basis values are given for the IPS Strength at 5% Strain data as-measured in Table 4-11 and for the 0.2% Offset Strength data as-measured in Table 4-12. Statistics for the as-measured modulus data are given in Table 4-13. The as-measured data, B-estimates and B-basis values are shown graphically for the Strength at 5% Strain data in Figure 4-7 and for the 0.2% Offset Strength data in Figure 4-8.

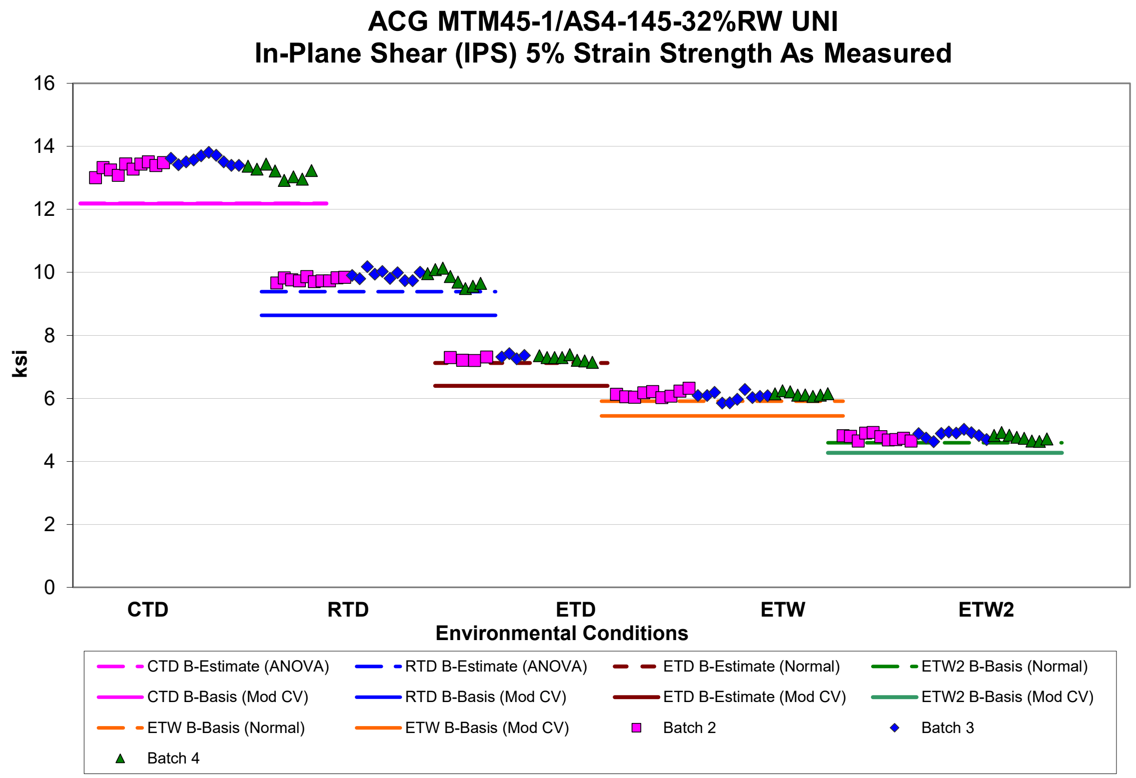

Figure 4-7: Batch plot for IPS Strength at 5% Strain as measured

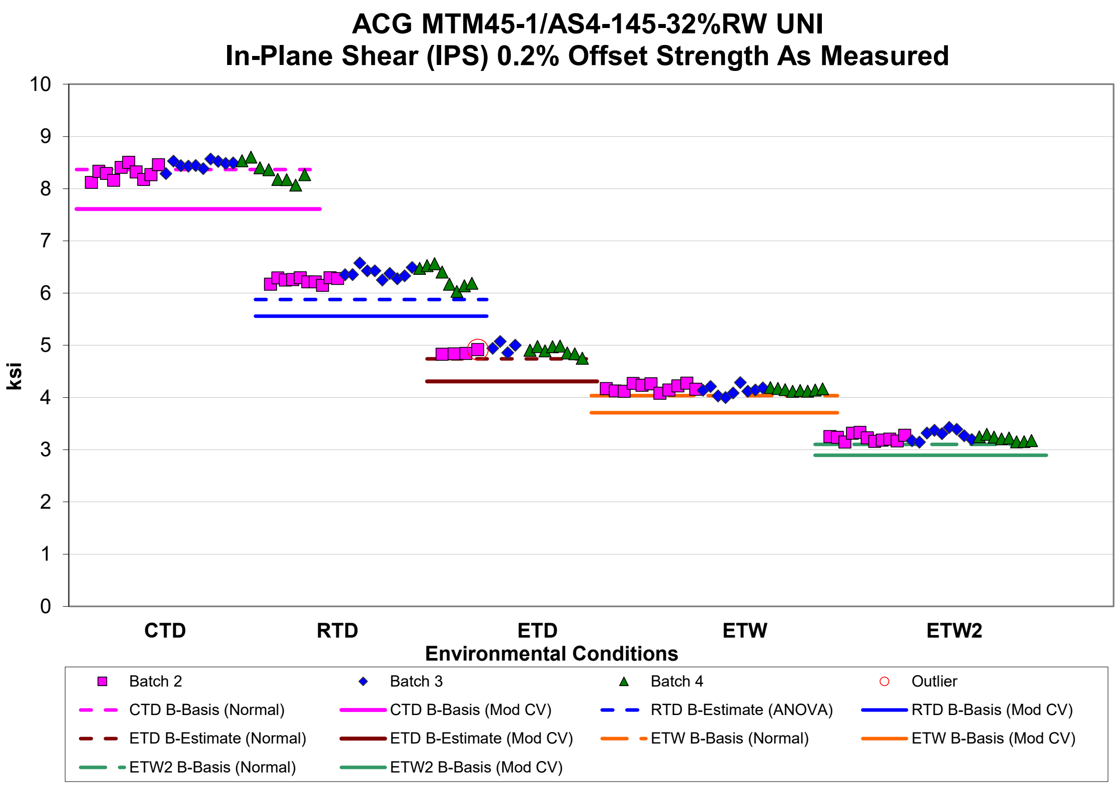

Figure 4-8: Batch plot for IPS 0.2% Offset Strength as measured

In-Plane Shear (IPS) - Strength at 5% Strain (ksi)					
Env	CTD	RTD	ETD	ETW	ETW2
Mean	13.37	9.83	7.28	6.11	4.79
Stdev	0.23	0.17	0.078	0.11	0.11
CV	1.70	1.70	1.07	1.82	2.29
Mod CV	6.00	6.00	6.00	6.00	6.00
Min	12.92	9.49	7.14	5.85	4.63
Max	13.81	10.18	7.42	6.32	5.02
No. Batches	3	3	3	3	3
No. Spec.	28	28	16	27	28
Basis Values and/or Estimates					
B-basis Value				5.91	4.59
B-estimate	12.20	9.39	7.13		
A-estimate	11.36	9.07	7.01	5.76	4.45
Method	ANOVA	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and/or Estimates					
B-basis Value	12.17	8.64		5.44	4.27
B-estimate			6.40		
A-estimate	11.34	7.80	5.77	4.97	3.90
Method	pooled	pooled	Normal	Normal	Normal

Table 4-11: Statistics and Basis Values for IPS Strength at 5% Strain data

In-Plane Shear (IPS) - 0.2% Offset Strength (ksi)					
Env	CTD	RTD	ETD	ETW	ETW2
Mean	8.36	6.31	4.91	4.16	3.24
Stdev	0.15	0.14	0.08	0.07	0.08
CV	1.77	2.16	1.68	1.66	2.42
Mod CV	6.00	6.00	6.00	6.00	6.00
Min	8.07	6.03	4.75	4.00	3.14
Max	8.60	6.57	5.07	4.29	3.43
No. Batches	3	3	3	3	3
No. Spec.	28	28	16	28	28
Basis Values and/or Estimates					
B-basis Value	8.10			4.03	3.10
B-estimate		5.88	4.74		
A-estimate	7.91	5.56	4.62	3.94	3.00
Method	Normal	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and/or Estimates					
B-basis Value	7.61	5.56		3.71	2.89
B-estimate			4.31		
A-estimate	7.08	5.03	3.89	3.39	2.64
Method	pooled	pooled	Normal	Normal	Normal

Table 4-12: Statistics and Basis Values for IPS 0.2% Offset Strength data

In-Plane Shear (IPS) - Modulus (Msi)					
Env	CTD	RTD	ETD	ETW	ETW2
Mean	0.69	0.57	0.46	0.43	0.34
Stdev	0.014	0.015	0.012	0.0083	0.0092
CV	2.06	2.57	2.59	1.94	2.71
Mod CV	6.00	6.00	6.00	6.00	6.00
Min	0.67	0.54	0.45	0.41	0.33
Max	0.71	0.60	0.48	0.44	0.36
No. Batches	3	3	3	3	3
No. Spec.	28	28	16	28	28

Table 4-13: Statistics from IPS Modulus data

4.8 Short Beam Strength (SBS)

The Short Beam Strength data is not normalized. The SBS data could not be pooled as three of the five environmental conditions (RTD, ETW and ETW2) failed the ADK test and the pooled dataset failed Levene's test for equality of variance after the transform to match the assumptions of the modified CV method. In addition, the ETW environment failed the normality test.

The RTD, ETW and ETW2 environments required an ANOVA analysis. Since ANOVA is not recommended for samples with fewer than 5 batches, these values are considered estimates and may be overly conservative. All three of these environments passed the ADK test, so modified CV basis values are provided. The data from the ETW environment did not pass the normality test, but after the transform to match the assumptions of the modified CV method, the ETW data did pass the normality test.

The SBS strength data had one outlier. It was on the high side of batch two in the data from the RTD condition. It was an outlier only for batch two, not for the RTD condition.

Statistics and basis values are given in Table 4-14. The data, B-basis values and B-estimates are shown graphically in Figure 4-9.

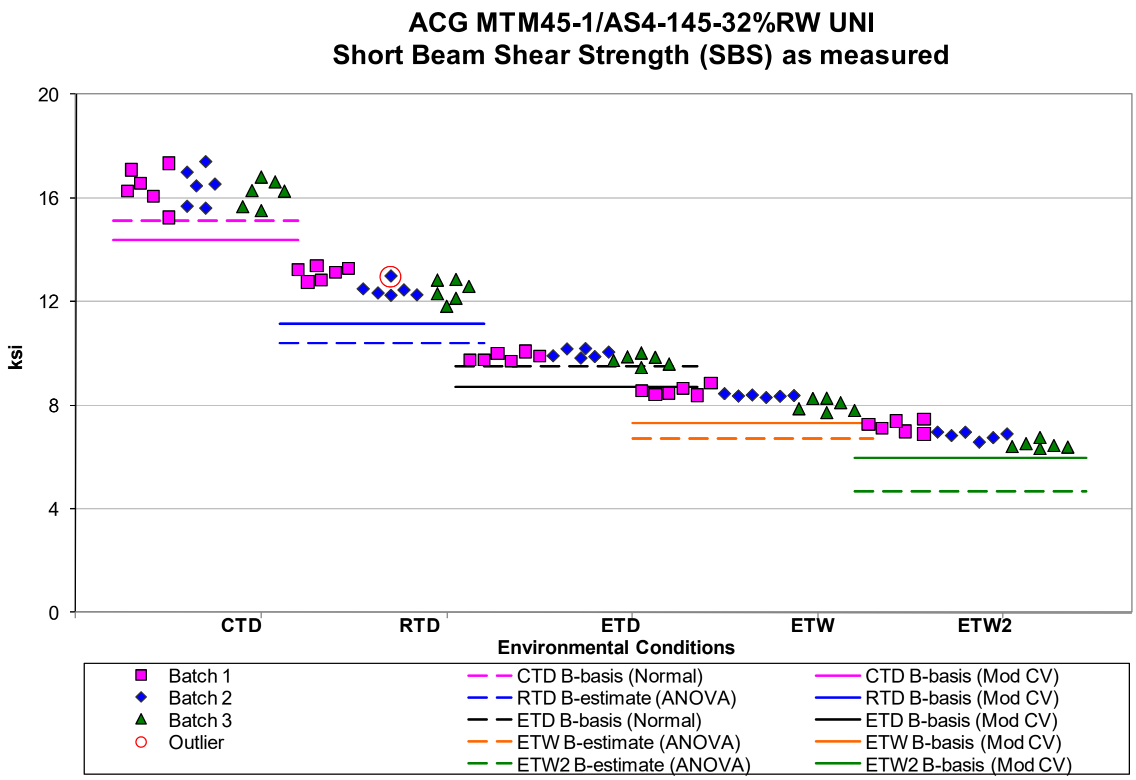

Figure 4-9: Batch plot for SBS as measured

Short Beam Strength (SBS) as measured (ksi)					
Env	CTD	RTD	ETD	ETW	ETW2
Mean	16.35	12.66	9.87	8.31	6.83
Stdev	0.64	0.44	0.19	0.28	0.34
CV	3.89	3.50	1.90	3.37	4.91
Mod CV	6.00	6.00	6.00	6.00	6.45
Min	15.25	11.83	9.47	7.73	6.35
Max	17.39	13.38	10.18	8.85	7.46
No. Batches	3	3	3	3	3
No. Spec.	18	18	18	18	18
Basis Values and/or Estimates					
B-basis Value	15.09		9.50		
B-estimate		10.38		6.69	4.73
A-estimate	14.20	8.75	9.24	5.53	3.24
Method	Normal	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and/or Estimates					
B-basis Value	14.41	11.16	8.70	7.32	5.96
A-estimate	13.04	10.10	7.88	6.63	5.34
Method	Normal	Normal	Normal	Normal	Normal

Table 4-14: Statistics and Basis Values for SBS data

5. Laminate Test Results, Statistics and Basis Values

Many of the laminate tests were performed with one batch only. This is insufficient data to produce basis values that meet the requirements of CMH-17-1G, so only estimates are provided. Estimates were prepared using the lamina variability method documented in section 2.4 or by pooling with the other environments when appropriate.

5.1 Unnotched Tension Properties

5.1.1 Quasi Isotropic Unnotched Tension (UNT1)

The UNT1 data meets all CMH-17 requirements for pooling, but the ETW2 environment only had data from one batch available and thus is an estimate. There was one outlier in the UNT1 dataset. It was on the low side of batch one in the RTD environment. It was an outlier for both the normalized and as measured data. It was an outlier for the RTD condition, but not for batch one. It was retained for this analysis. Statistics and basis values are given for the strength data in Table 5-1 and the modulus data in Table 5-2. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-1.

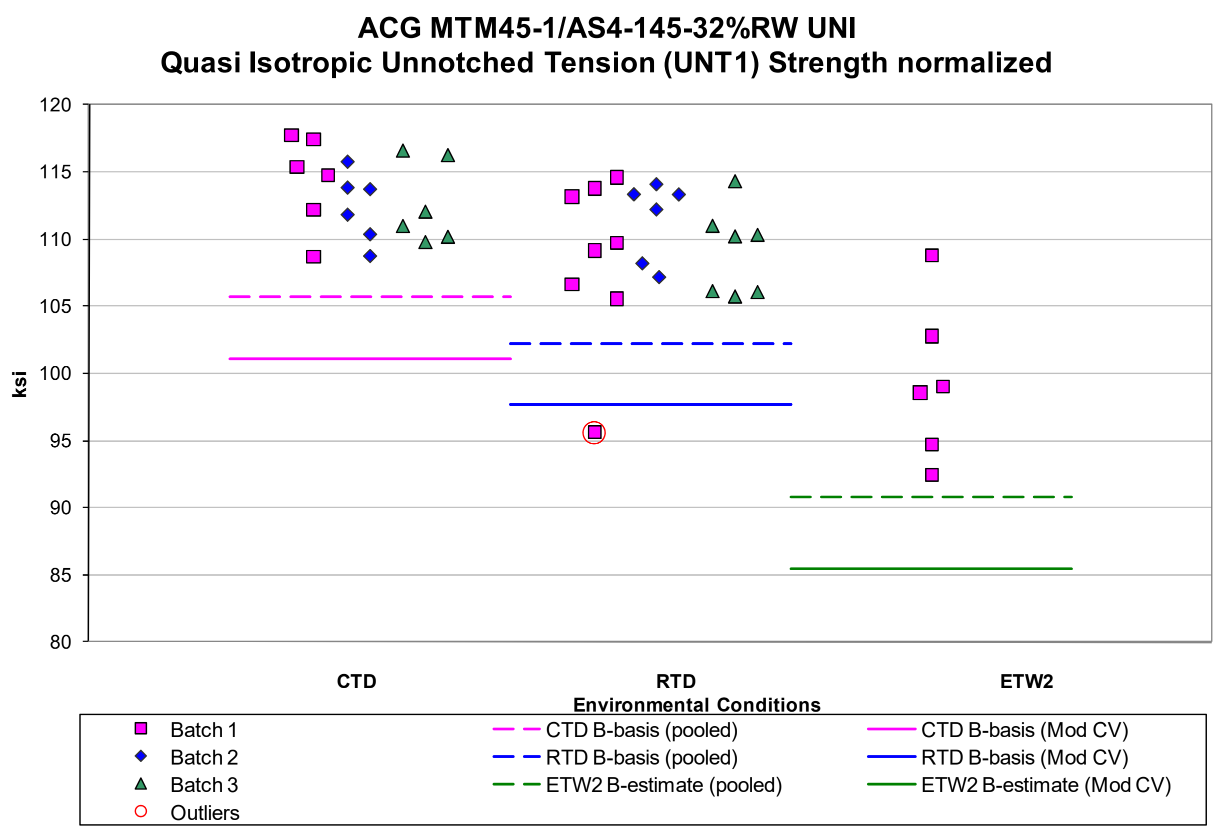

Figure 5-1: Batch plot for UNT1 Strength normalized

Laminate Unnotched Tension (UNT1) Strength (ksi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	113.13	109.54	99.38	112.20	108.82	95.92
Stdev	2.98	4.49	5.83	3.75	4.68	6.01
CV	2.64	4.10	5.87	3.34	4.31	6.26
Modified CV	6.00	6.05	6.93	6.00	6.15	7.13
Min	108.72	95.61	92.46	105.15	94.04	88.44
Max	117.74	114.59	108.77	118.21	116.65	105.39
No. Batches	3	3	1	3	3	1
No. Spec.	18	21	6	18	21	6
Basis Values and/or Estimates						
B-basis Value	105.69	102.20		104.09	100.83	
B-estimate			90.84			86.62
A-estimate	100.68	97.17	85.98	98.64	95.34	81.33
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates						
B-basis Value	101.08	97.66		100.14	96.93	
B-estimate			85.54			82.08
A-estimate	92.97	89.51	77.69	92.02	88.77	74.22
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 5-1: Statistics and Basis Values for UNT1 Strength data

Laminate Unnotched Tension (UNT1) Modulus (msi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	7.30	7.00	8.53	7.24	6.95	8.22
Stdev	0.42	0.12	0.46	0.49	0.15	0.47
CV	5.78	1.69	5.37	6.72	2.20	5.68
Mod CV	6.89	6.00	6.69	7.36	6.00	6.84
Min	6.43	6.82	7.85	6.36	6.64	7.55
Max	8.13	7.24	9.03	8.34	7.23	8.75
No. Batches	3	3	1	3	3	1
No. Spec.	18	23	5	18	23	5

Table 5-2: Statistics from UNT1 Modulus Data

5.1.2 "Soft" Unnotched Tension (UNT2)

This property had data from only one batch available, thus all basis values are estimates. Statistics and B-estimates are given for the strength data in Table 5-3 and the modulus data in Table 5-4. The normalized strength data and B-estimates are shown graphically in Figure 5-2.

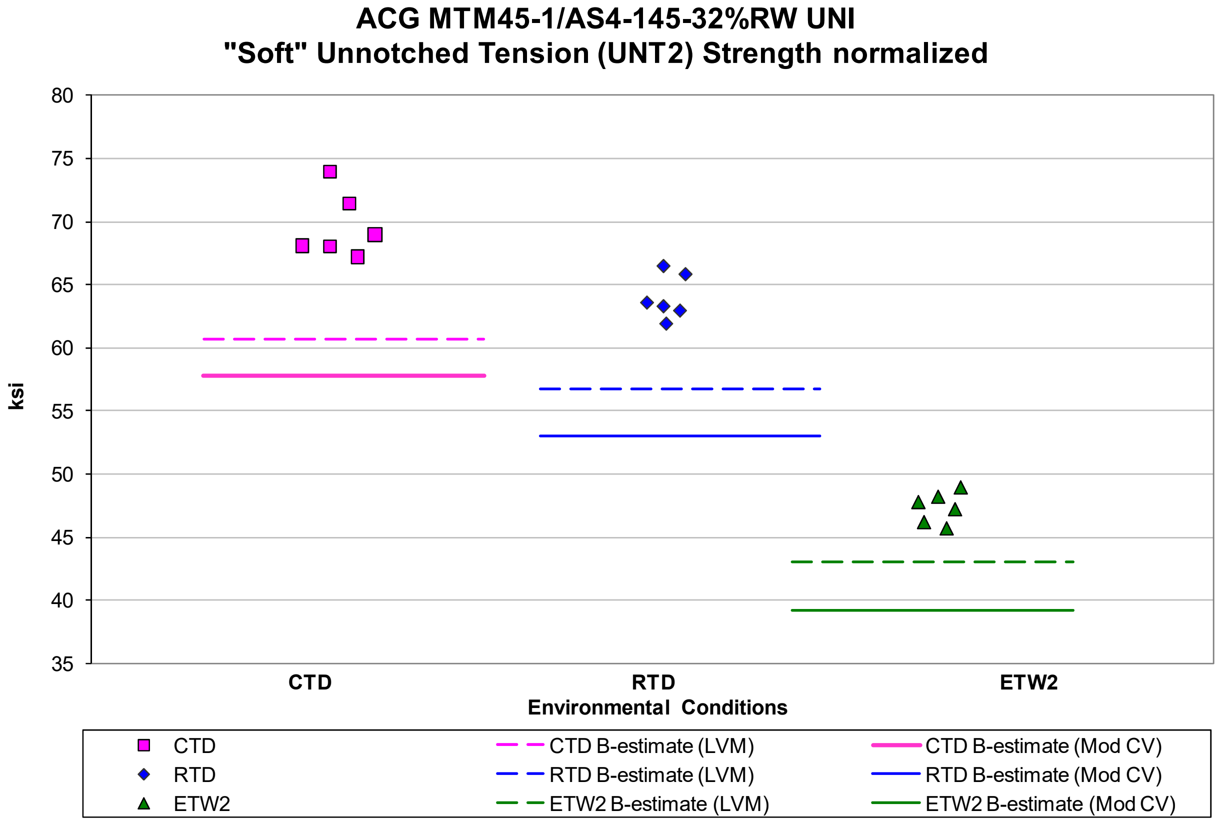

Figure 5-2: Batch plot for UNT2 Strength normalized

Laminate Unnotched Tension (UNT2) Strength (ksi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	69.62	64.02	47.37	67.84	62.46	46.12
Stdev	2.59	1.77	1.22	2.93	2.28	0.92
CV	3.71	2.76	2.57	4.32	3.65	2.00
Modified CV	8.00	8.00	8.00	8.00	8.00	8.00
Min	67.20	61.93	45.74	64.65	59.84	45.02
Max	73.98	66.49	48.96	72.83	65.48	47.29
No. Batches	1	1	1	1	1	1
No. Spec.	6	6	6	6	6	6
Basis Values and/or Estimates						
B-estimate	60.74	56.77	43.02	58.32	55.20	42.61
Method	LVM	LVM	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	57.74	53.02	39.20	56.27	51.72	38.16
Method	LVM	LVM	LVM	LVM	LVM	LVM

Table 5-3: Statistics and Basis Values for UNT2 Strength data

Laminate Unnotched Tension (UNT2) Modulus (msi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	4.62	4.35	4.79	4.50	4.24	4.69
Stdev	0.43	0.07	0.26	0.40	0.12	0.23
CV	9.36	1.62	5.39	8.78	2.85	4.95
Mod CV	9.36	6.00	6.70	8.78	6.00	6.48
Min	3.80	4.26	4.41	3.75	4.10	4.34
Max	4.94	4.43	4.96	4.84	4.37	4.82
No. Batches	1	1	1	1	1	1
No. Spec.	6	6	4	6	6	4

Table 5-4: Statistics from UNT2 Modulus Data

5.1.3 "Hard" Unnotched Tension (UNT3)

This property had data from only one batch available, thus all basis values are estimates. Statistics and B-estimates are given for the strength data in Table 5-5 and the modulus data in Table 5-6. The normalized strength data and B-estimates are shown graphically in Figure 5-3.

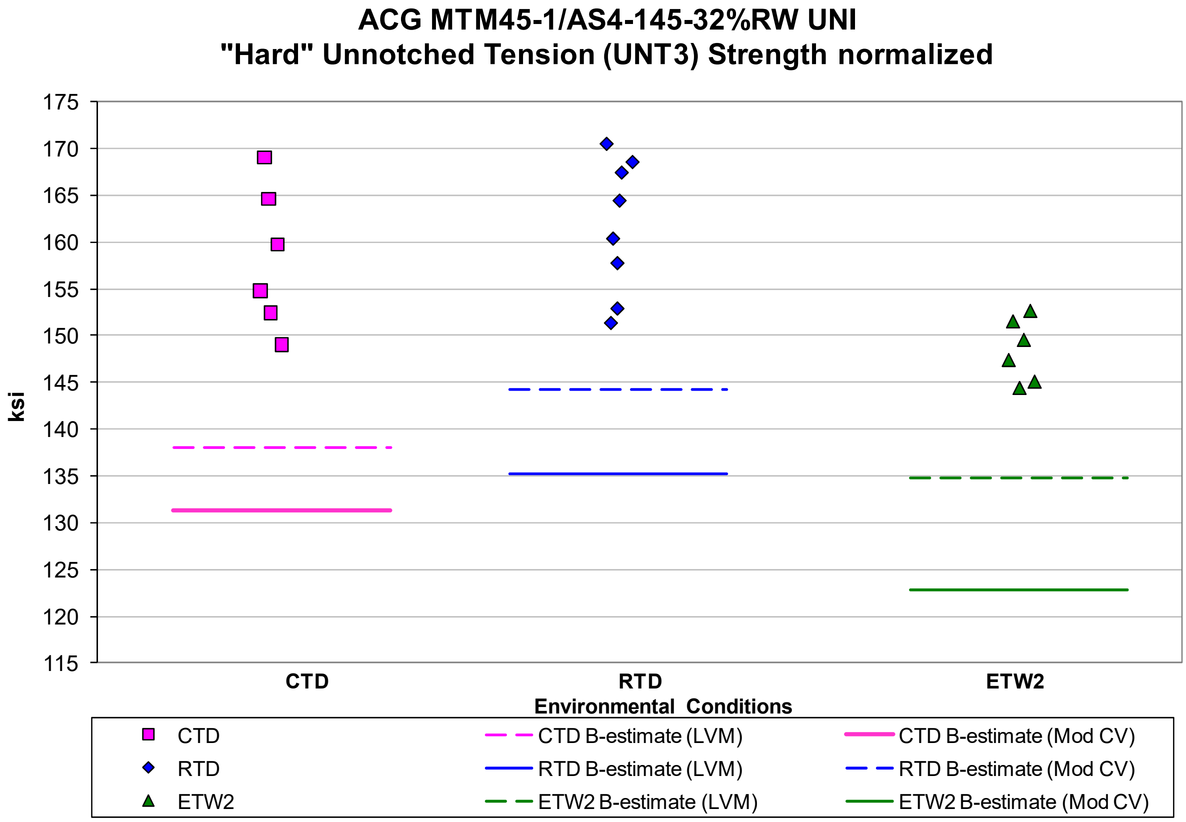

Figure 5-3: Batch plot for UNT3 Strength normalized

Laminate Unnotched Tension (UNT3) Strength (ksi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	158.29	161.63	148.41	155.74	158.63	144.47
Stdev	7.63	7.24	3.40	8.21	7.21	4.30
CV	4.82	4.48	2.29	5.27	4.54	2.98
Modified CV	8.00	8.00	8.00	8.00	8.00	8.00
Min	149.04	151.32	144.35	146.38	150.09	139.66
Max	169.08	170.47	152.65	168.47	167.92	149.53
No. Batches	1	1	1	1	1	1
No. Spec.	6	8	6	6	8	6
Basis Values and/or Estimates						
B-estimate	138.10	144.17	134.78	133.89	141.06	133.48
Method	LVM	LVM	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	131.29	135.16	122.80	129.18	132.65	119.54
Method	LVM	LVM	LVM	LVM	LVM	LVM

Table 5-5: Statistics and Basis Values for UNT3 Strength data

Laminate Unnotched Tension (UNT3) Modulus (msi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	11.34	10.82	12.95	11.16	10.62	12.55
Stdev	0.66	0.18	0.21	0.71	0.19	0.22
CV	5.79	1.66	1.60	6.37	1.80	1.76
Mod CV	6.90	6.00	6.00	7.19	6.00	6.00
Min	10.64	10.60	12.77	10.43	10.30	12.35
Max	12.46	11.13	13.23	12.42	10.96	12.86
No. Batches	1	1	1	1	1	1
No. Spec.	6	8	4	6	8	4

Table 5-6: Statistics for UNT3 Modulus data

5.2 Unnotched Compression Properties

5.2.1 Quasi Isotropic Unnotched Compression (UNC1)

The UNC1 as measured strength data could be pooled, but the UNC1 normalized strength data could not be pooled because the normalized data from the RTD environment did not pass the ADK test and required an ANOVA analysis. Since ANOVA is not recommended for samples with fewer than 5 batches, these values are considered estimates and may be overly conservative. However, under the assumptions of the modified CV, the data from the RTD environment passed the ADK test and pooling was permissible. The ETW environment only had data from one batch available and thus is an estimate.

There were no outliers. Statistics and basis values are given for the strength data in Table 5-7 and the modulus data in Table 5-8. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-4.

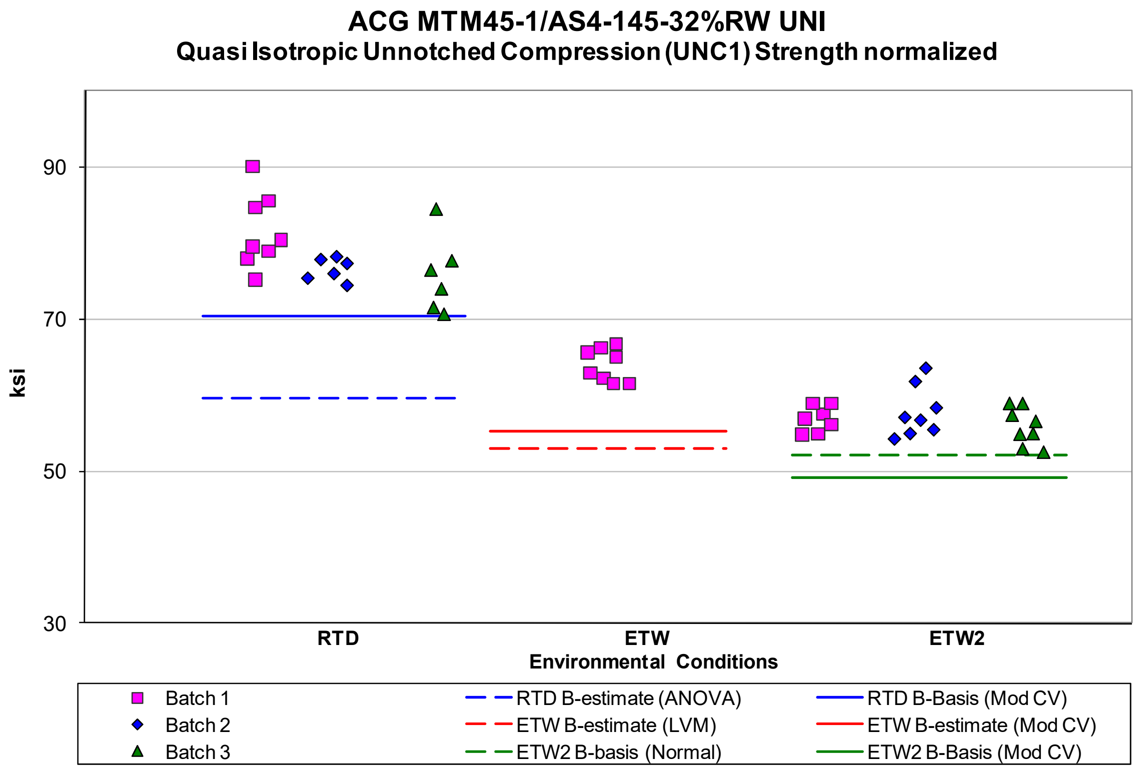

Figure 5-4: Batch plot for UNC1 Strength normalized

Laminate Unnotched Compression (UNC1) Strength (ksi)						
	Normalized			As Measured		
Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	78.28	63.94	56.84	78.71	62.69	57.04
Stdev	4.83	2.15	2.57	4.41	2.05	2.86
CV	6.17	3.35	4.52	5.60	3.27	5.02
Modified CV	7.08	6.00	6.26	6.80	6.00	6.51
Min	70.58	61.49	52.48	71.83	60.28	52.94
Max	90.07	66.69	63.58	88.77	65.40	64.72
No. Batches	3	1	3	3	1	3
No. Spec.	20	8	24	20	8	24
Basis Values and/or Estimates						
B-basis Value			52.08	72.63		51.05
B-estimate	59.57	53.00			55.92	
A-estimate	46.23	NA	48.66	68.51	51.90	46.91
Method	ANOVA	LVM	Normal	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates						
B-basis Value	70.43		49.12	70.93		49.39
B-estimate		55.21			54.03	
A-estimate	65.11	50.02	43.77	65.66	48.90	44.09
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 5-7: Statistics and Basis Values for UNC1 Strength data

Laminate Unnotched Compression (UNC1) Modulus (msi)						
	Normalized			As Measured		
Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	6.29	6.86	6.99	6.33	6.72	6.98
Stdev	0.18	0.25	0.33	0.17	0.25	0.29
CV	2.83	3.63	4.75	2.61	3.74	4.20
Mod CV	6.00	6.00	6.37	6.00	6.00	6.10
Min	5.86	6.61	6.34	6.04	6.45	6.45
Max	6.61	7.36	7.39	6.57	7.22	7.31
No. Batches	3	1	3	3	1	3
No. Spec.	19	7	7	19	7	7

Table 5-8: Statistics from UNC1 Modulus data

5.2.2 "Soft" Unnotched Compression (UNC2)

This property had data from only one batch available, thus all basis values are estimates. Modified CV values are not available for the ETW2 condition due to the large CV of the LC lamina data for the ETW2 condition which was used to compute the LVM B-estimate. Statistics and B-estimates are given for the strength data in Table 5-9 and the modulus data in Table 5-10. The normalized strength data and B-estimates are shown graphically in Figure 5-5.

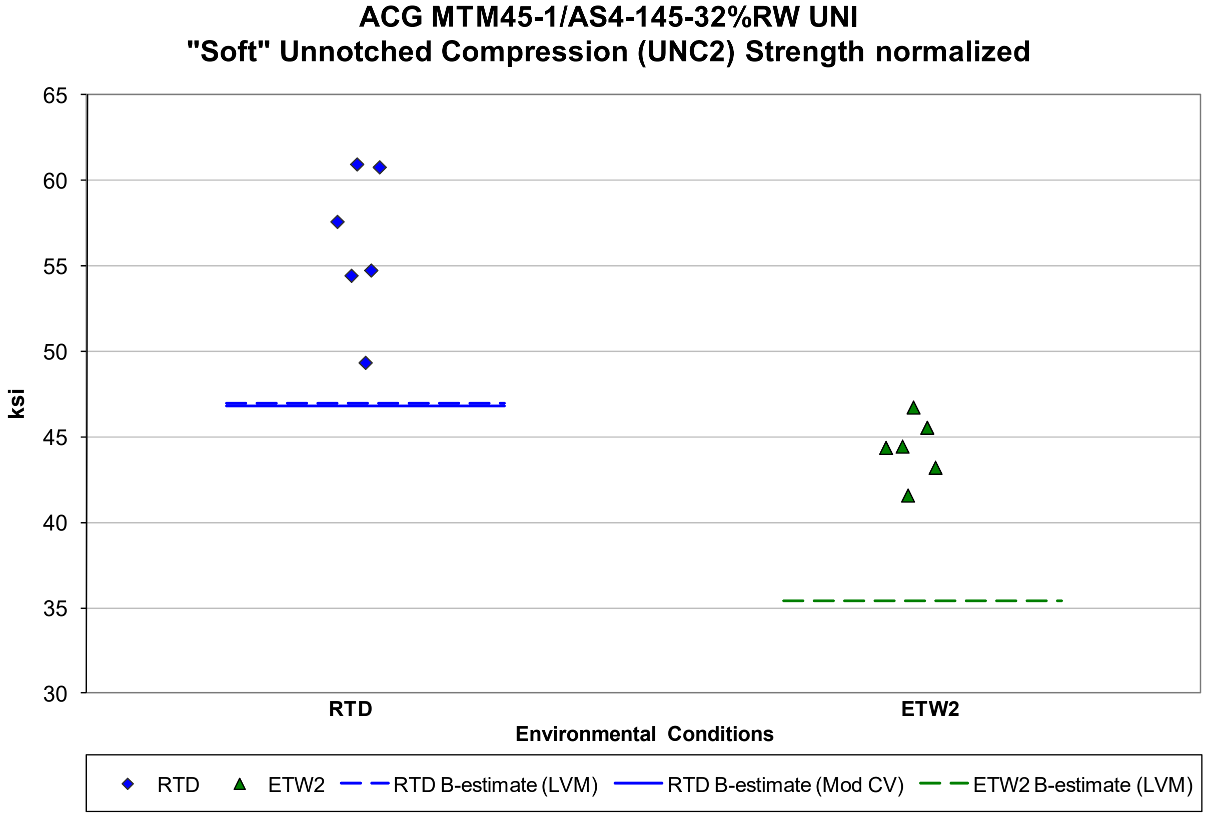

Figure 5-5: Batch plot for UNC2 Strength normalized

Laminate Unnotched Compression (UNC2) Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	56.30	44.27	55.20	43.00
Stdev	4.41	1.80	4.30	1.62
CV	7.83	4.06	7.80	3.78
Modified CV	8.00	8.00	8.00	8.00
Min	49.35	41.53	48.40	40.34
Max	60.93	46.69	59.88	44.68
No. Batches	1	1	1	1
No. Spec.	6	6	6	6
Basis Values and/or Estimates				
B-estimate	46.98	35.44	46.11	34.01
Method	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates				
B-estimate	46.78	NA	45.88	NA
Method	LVM	NA	LVM	NA

Table 5-9: Statistics and Basis Values for UNC2 Strength data

Laminate Unnotched Compression (UNC2) Modulus (msi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	4.06	4.20	3.99	4.08
Stdev	0.11	0.23	0.12	0.19
CV	2.60	5.57	3.01	4.68
Mod CV	6.00	6.79	6.00	6.34
Min	3.88	3.96	3.78	3.87
Max	4.17	4.53	4.11	4.33
No. Batches	1	1	1	1
No. Spec.	6	6	6	6

Table 5-10: Statistics from UNC2 Modulus data

5.2.3 "Hard" Unnotched Compression (UNC3)

This property had data from only one batch available, thus all basis values are estimates. Modified CV values are not available for the ETW2 condition due to the large CV of the LC lamina data for the ETW2 condition which was used to compute the LVM B-estimate. Statistics and B-estimates are given for the strength data in Table 5-11 and the modulus data in Table 5-12. The normalized strength data and B-estimates are shown graphically in Figure 5-6.

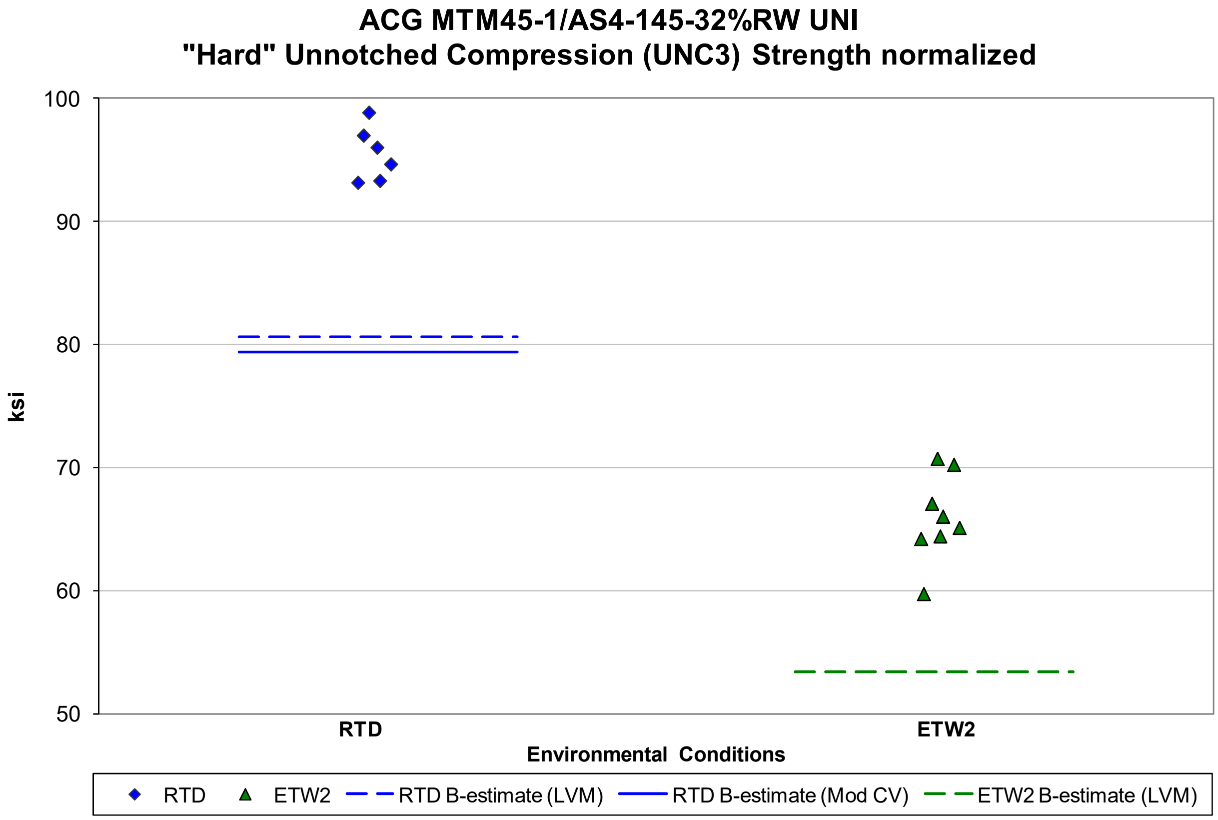

Figure 5-6: Batch plot for UNC3 Strength normalized

Laminate Unnotched Compression (UNC3) Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	95.48	65.89	95.32	64.60
Stdev	2.21	3.53	1.55	3.19
CV	2.31	5.36	1.63	4.93
Modified CV	8.00	8.00	8.00	8.00
Min	93.16	59.67	93.09	58.52
Max	98.81	70.68	97.63	69.23
No. Batches	1	1	1	1
No. Spec.	6	8	6	8
Basis Values and/or Estimates				
B-estimate	80.63	53.35	85.21	51.71
Method	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates				
B-estimate	79.35	NA	79.22	NA
Method	LVM	NA	LVM	NA

Table 5-11: Statistics and Basis Values for UNC3 Strength data

Laminate Unnotched Compression (UNC3) Modulus (msi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	9.78	11.13	9.77	10.88
Stdev	0.38	0.70	0.31	0.71
CV	3.92	6.30	3.14	6.52
Mod CV	6.00	7.15	6.00	7.26
Min	9.20	10.17	9.34	9.77
Max	10.27	12.16	10.18	11.82
No. Batches	1	1	1	1
No. Spec.	6	6	6	6

Table 5-12: Statistics from UNC3 Modulus Data

5.3 Laminate Short Beam Shear Properties (LSBS)

The LSBS data is not normalized. Only the data for the ETW2 condition meets all requirements of CMH-17-1G. The RTD data does not pass the ADK test, even after the transformation to fit the assumptions of the modified CV approach. It required an ANOVA analysis and since ANOVA is not recommended for samples with fewer than 5 batches, these values are considered estimates and may be overly conservative. B-estimates computed using the modified CV method are provided for the RTD environment.

There was insufficient data for the ETW condition. There were no outliers. Statistics, basis values and estimates are given for the LSBS data in Table 5-13. The strength data, B-basis values and B-estimates are shown graphically in Figure 5-7.

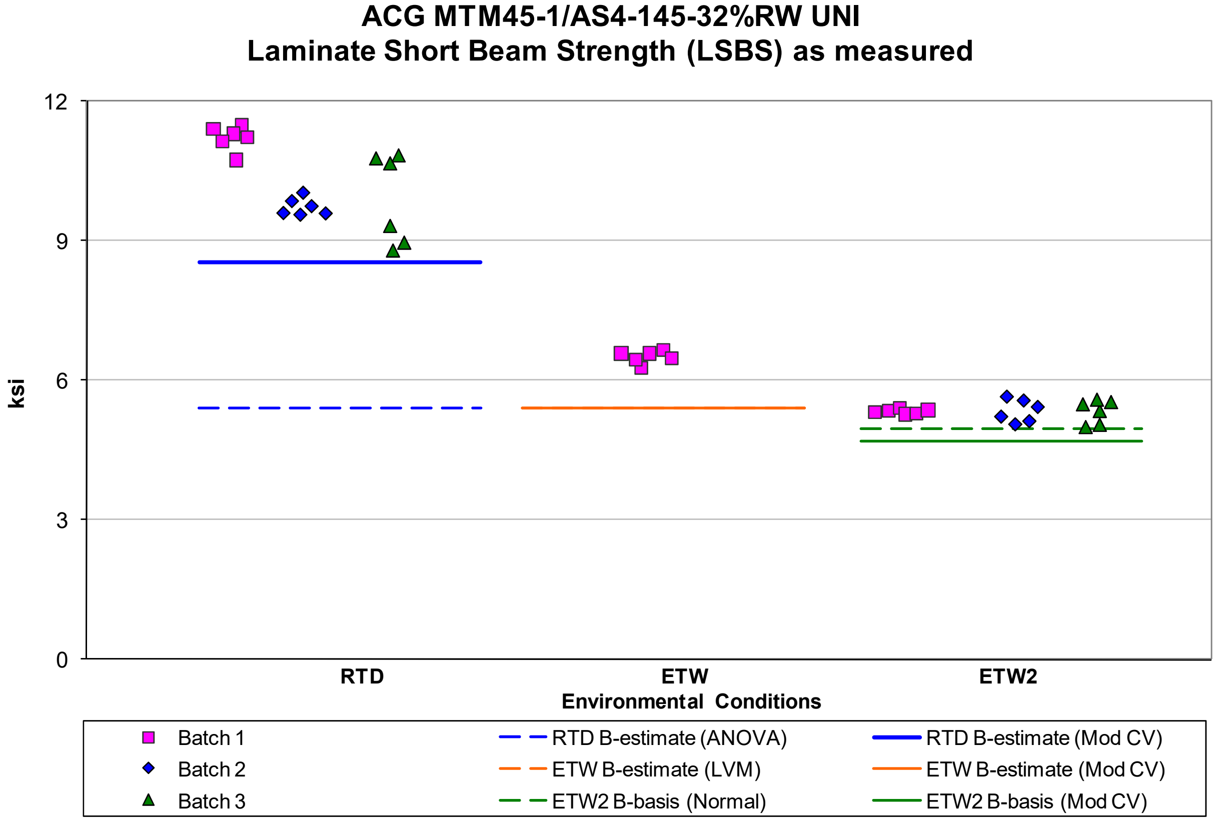

Figure 5-7: Batch plot for LSBS as measured

Laminate Short Beam (LSBS) Strength (ksi)			
Env	RTD	ETW	ETW2
Mean	10.28	6.50	5.34
Stdev	0.88	0.14	0.19
CV	8.56	2.14	3.62
Mod CV	8.56	8.00	6.00
Min	8.78	6.26	4.99
Max	11.48	6.65	5.66
No. Batches	3	1	3
No. Spec.	18	6	18
Basis Values and/or Estimates			
B-basis Value			4.96
B-estimate	5.40	5.41	
A-estimate	1.93	NA	4.69
Method	ANOVA	LVM	Normal
Modified CV Basis Values and/or Estimates			
B-basis Value			4.70
B-estimate	8.54	5.40	
A-estimate	7.31	NA	4.26
Method	Normal	LVM	Normal

Table 5-13: Statistics and Basis Values for LSBS data

5.4 Open Hole Tension Properties

5.4.1 Quasi Isotropic Open Hole Tension (OHT1)

The as measured OHT1 strength data met all requirements for pooling across environments, but the normalized OHT1 strength data could not be pooled because the RTD data failed the Anderson-Darling k-sample test for batch to batch variability. Since the RTD data failed the ADK test it requires the ANOVA method to compute basis values, but with data from only three batches, these values are considered estimates and may result in overly conservative basis values. The normalized RTD data does pass the normality test and passed the ADK test under the modified CV transformation, so the modified CV values are provided. There was insufficient data for the ETW condition so only estimates are provided.

There was an outlier on the high side of batch one of the ETW2 data. The normalized value was an outlier both for batch one and for the ETW2 condition while the as measured value was only an outlier for batch one. There was an outlier on the high side of batch two of the as measured RTD data. It was an outlier only for batch two and not for the RTD condition.

Statistics, basis values and estimates are given for the strength data in Table 5-14. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-8.

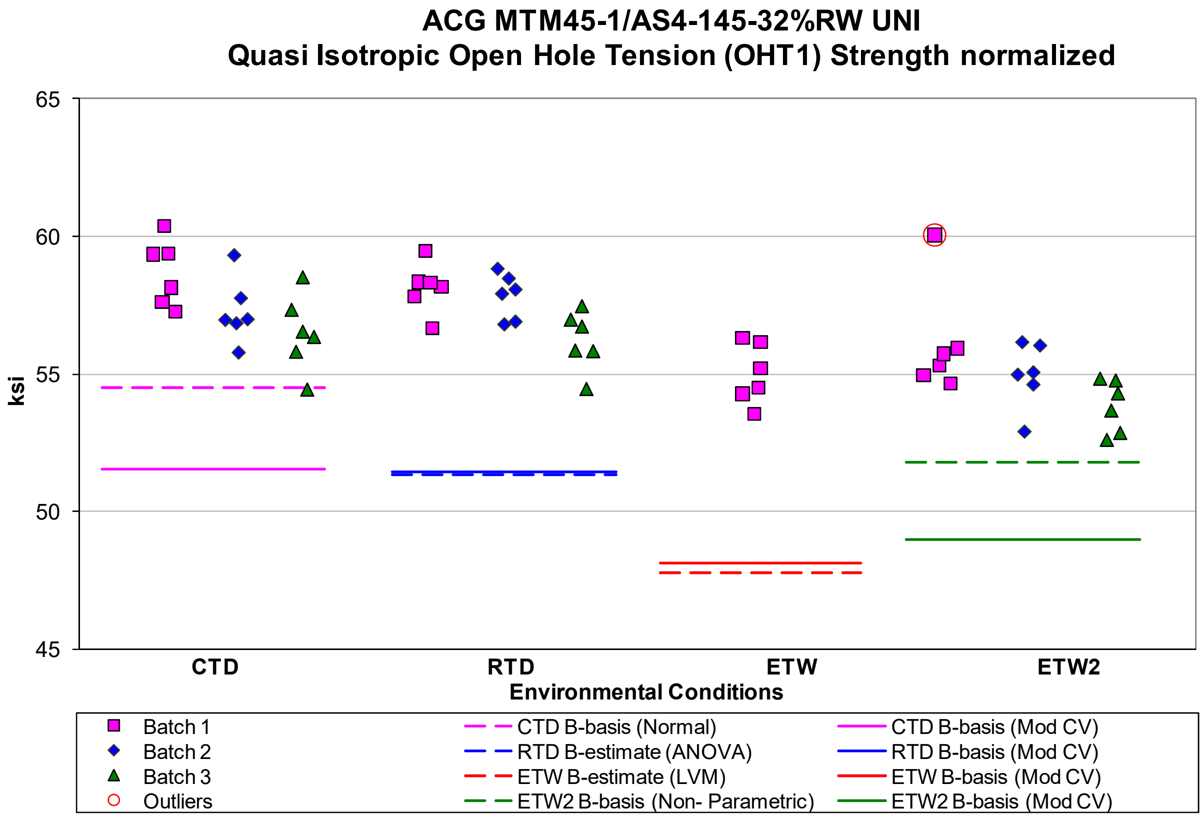

Figure 5-8: Batch plot for OHT1 Strength normalized

Laminate Open Hole Tension (OHT1) Strength (ksi)								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	57.49	57.39	55.01	54.96	57.65	57.72	53.56	54.54
Stdev	1.51	1.24	1.09	1.66	1.39	1.51	1.16	1.31
CV	2.63	2.15	1.98	3.02	2.41	2.62	2.16	2.40
Modified CV	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Min	54.43	54.45	53.57	52.59	55.11	53.96	52.43	52.67
Max	60.40	59.48	56.31	60.05	59.51	60.59	55.38	57.90
No. Batches	3	3	1	3	3	3	1	3
No. Spec.	18	18	6	18	18	18	6	18
Basis Values and/or Estimates								
B-basis Value	54.51			51.82	55.21	55.29		52.10
B-estimate		51.36	47.79				50.75	
A-estimate	52.39	47.07	NA	43.12	53.59	53.66	49.17	50.48
Method	Normal	ANOVA	LVM	Non-Parametric	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates								
B-basis Value	51.52	51.42		48.99	51.69	51.77		48.58
B-estimate			48.13				46.69	
A-estimate	47.55	47.45	44.27	45.02	47.73	47.80	42.84	44.62
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 5-14: Statistics and Basis Values for OHT1 Strength data

5.4.2 "Soft" Open Hole Tension (OHT2)

The data from the CTD condition, both normalized and as measured, did not pass the ADK test or the normality test. Since the CTD data failed the ADK test it requires the ANOVA method to compute basis values, but with data from only three batches, these values are considered estimates and may result in overly conservative basis values. Since the CTD data fails the normality test, modified CV estimates of basis values cannot be provided. The RTD and ETW2 environments had insufficient data for publication in the handbook, so only estimates are provided.

There was one outlier on the low side of batch one in the normalized CTD data. It was an outlier only for batch one, not for the CTD condition. Statistics, A- and B-estimates are given for the strength data in Table 5-15. The normalized strength data and B-estimates are shown graphically in Figure 5-9.

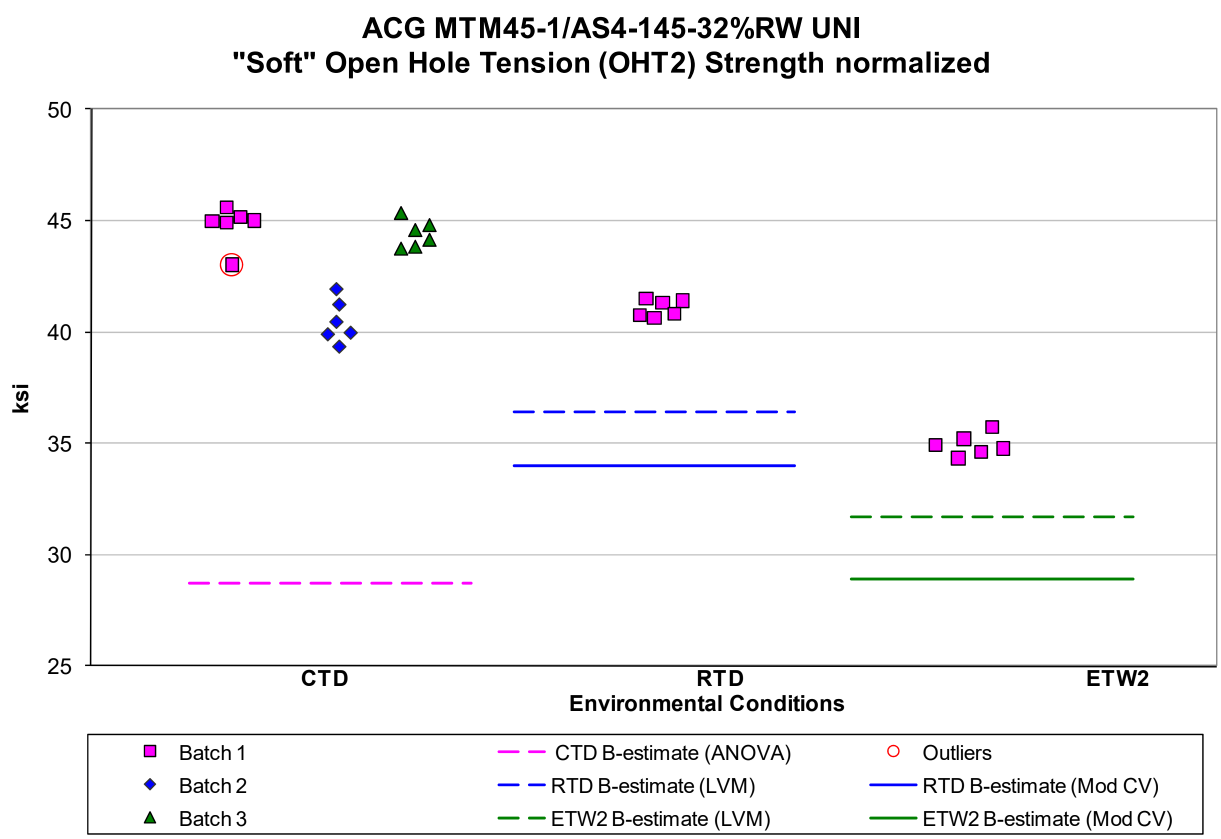

Figure 5-9: Batch plot for OHT2 Strength normalized

Laminate Open Hole Tension (OHT2) Strength (ksi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	43.22	41.06	34.93	44.02	41.34	34.61
Stdev	2.14	0.37	0.49	1.78	0.88	0.48
CV	4.96	0.91	1.40	4.04	2.12	1.39
Modified CV	6.48	8.00	8.00	6.02	8.00	8.00
Min	39.36	40.63	34.35	40.77	40.35	34.14
Max	45.61	41.49	35.74	46.20	42.71	35.45
No. Batches	3	1	1	3	1	1
No. Spec.	18	6	6	18	6	6
Basis Values and/or Estimates						
B-estimate	28.71	36.41	31.73	32.93	36.54	31.98
A-estimate	18.36	NA	NA	25.01	NA	NA
Method	ANOVA	LVM	LVM	ANOVA	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	NA	34.00	28.91	NA	34.24	28.64
A-estimate	NA	NA	NA	NA	NA	NA
Method	NA	LVM	LVM	NA	LVM	LVM

Table 5-15: Statistics and Basis Values for OHT2 Strength data

5.4.3 "Hard" Open Hole Tension (OHT3)

Only the CTD data meets the requirements of CMH-17-1G. The normalized CTD data did not pass the ADK test so it requires the ANOVA method to compute basis values, but with data from only three batches, these values are considered estimates and may result in overly conservative basis values. However, the normalized CTD data did pass the ADK test after the modified CV transform and modified CV basis values are provided.

The RTD and ETW2 environments had insufficient data for publication in the handbook, so only estimates are provided. There were no outliers. Statistics, basis values and estimates are given for the strength data in Table 5-16. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-10.

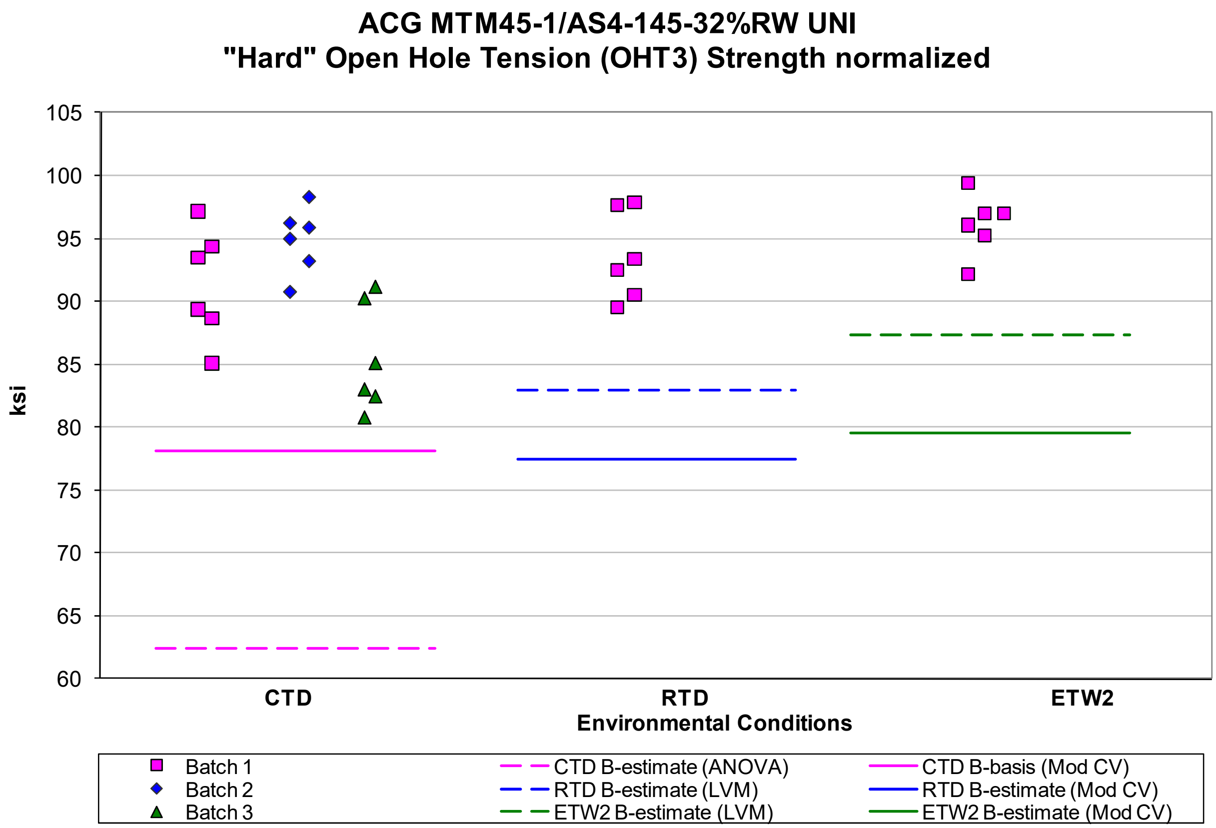

Figure 5-10: Batch plot for OHT3 Strength normalized

Laminate Open Hole Tension (OHT3) Strength (ksi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	90.56	93.57	96.13	90.38	91.81	94.04
Stdev	5.39	3.53	2.39	4.59	3.00	2.19
CV	5.96	3.77	2.49	5.08	3.26	2.33
Modified CV	6.98	8.00	8.00	6.54	8.00	8.00
Min	80.79	89.53	92.19	83.12	88.43	90.74
Max	98.28	97.89	99.42	98.22	95.69	96.58
No. Batches	3	1	1	3	1	1
No. Spec.	18	6	6	18	6	6
Basis Values and/or Estimates						
B-basis Value				81.32		
B-estimate	62.46	82.97	87.31		81.14	86.88
A-estimate	42.43	NA	NA	74.90	NA	NA
Method	ANOVA	LVM	LVM	Normal	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-basis Value	78.08			78.71		
B-estimate		77.49	79.54		76.03	77.81
A-estimate	69.26	NA	NA	70.46	NA	NA
Method	Normal	LVM	LVM	Normal	LVM	LVM

Table 5-16: Statistics and Basis Values for OHT3 Strength data

5.5 Open Hole Compression Properties

5.5.1 Quasi Isotropic Open Hole Compression (OHC1)

The normalized RTD and ETW2 data did not pass the ADK test and required an ANOVA analysis to compute basis values, but with data from only three batches, these values are considered estimates and may result in overly conservative basis values.. However, those datasets did pass the ADK test after the modified CV transform and modified CV basis values are provided. Pooling was acceptable for the modified CV approach. The ETW condition has insufficient data for publishable basis values. Estimates only are provided.

There were no outliers. Statistics, basis values and estimates are given for the strength data in Table 5-17 . The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-11.

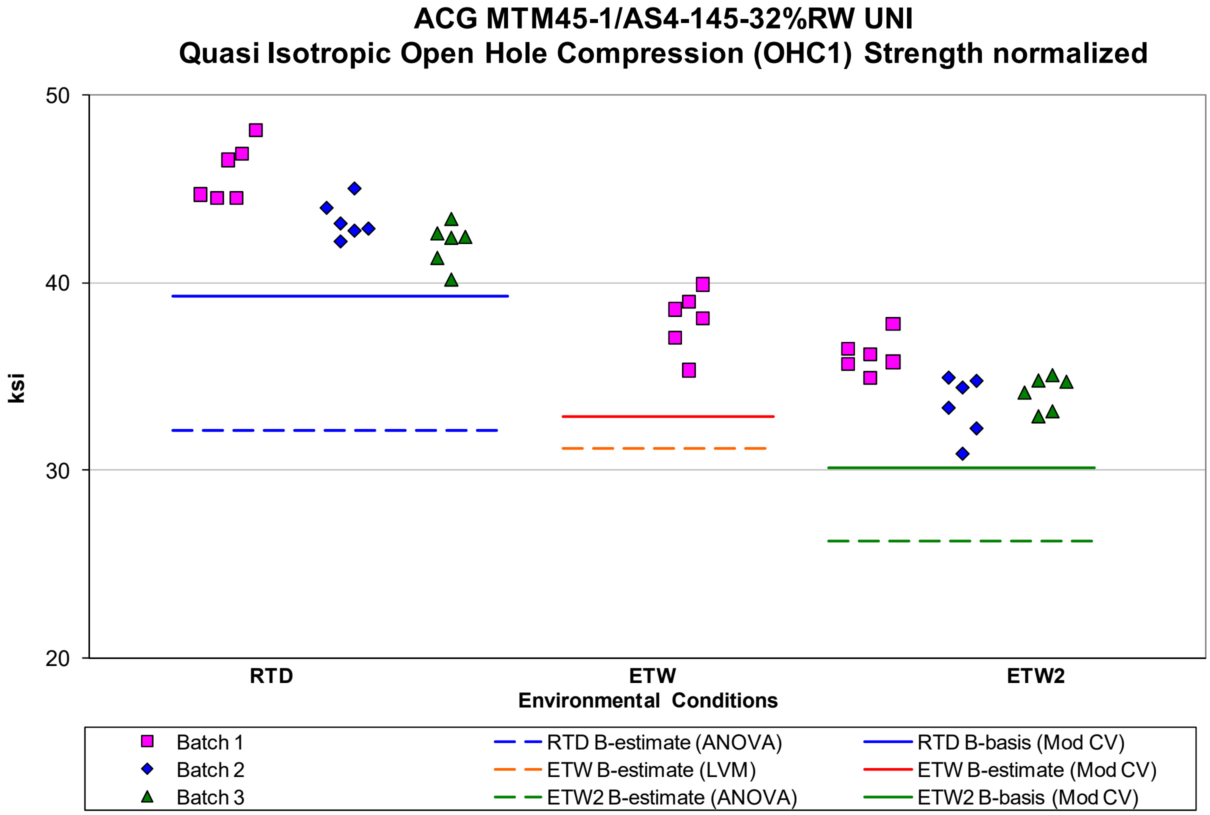

Figure 5-11: Batch plot for OHC1 Strength normalized

Laminate Open Hole Compression (OHC1) Strength (ksi)						
	Normalized			As Measured		
Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	43.76	37.99	34.57	43.75	37.39	34.49
Stdev	2.00	1.61	1.64	1.59	1.62	1.66
CV	4.57	4.24	4.74	3.63	4.33	4.82
Modified CV	6.28	6.12	6.37	6.00	6.17	6.41
Min	40.19	35.32	30.88	40.60	34.67	30.10
Max	48.11	39.90	37.80	46.78	39.31	37.25
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and/or Estimates						
B-basis Value				40.82		31.56
B-estimate	32.15	31.18	26.23		34.04	
A-estimate	23.87	NA	20.28	38.84	32.12	29.58
Method	ANOVA	LVM	ANOVA	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates						
B-basis Value	39.31		30.12	39.40		30.14
B-estimate		32.89			32.41	
A-estimate	36.30	29.98	27.11	36.47	29.57	27.20
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 5-17: Statistics and Basis Values for OHC1 Strength data

5.5.2 "Soft" Open Hole Compression (OHC2)

There were no outliers or test failures. The RTD data is insufficient to generate basis values that meet the requirements of CMH-17-1G so only estimates are provided for that condition. Statistics, basis values and estimates are given for the strength data in Table 5-18. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-12.

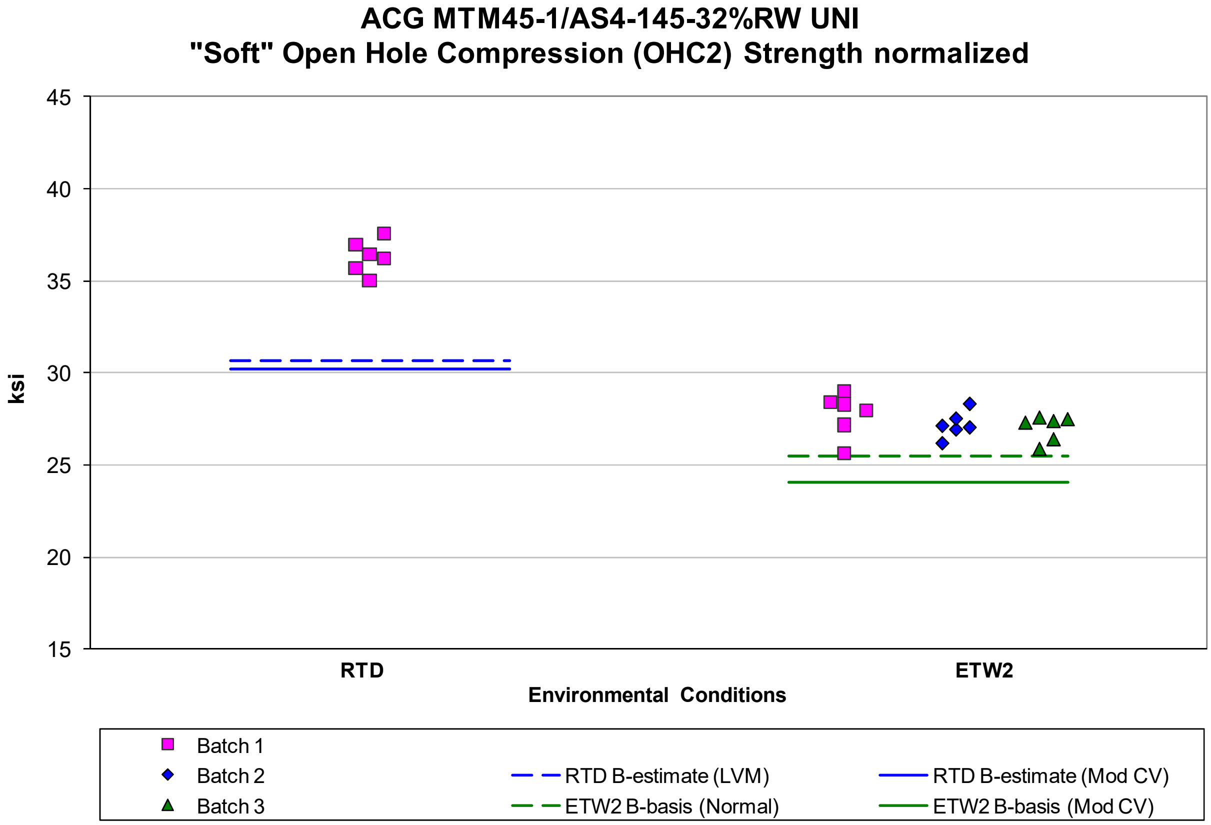

Figure 5-12: Batch plot for OHC2 Strength normalized

Laminate Open Hole Compression (OHC2) Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	36.32	27.31	35.75	27.45
Stdev	0.92	0.90	0.93	0.90
CV	2.53	3.31	2.60	3.27
Modified CV	8.00	6.00	8.00	6.00
Min	34.99	25.62	34.42	25.32
Max	37.59	29.01	37.18	28.67
No. Batches	1	3	1	3
No. Spec.	6	18	6	18
Basis Values and/or Estimates				
B-basis Value		25.52		25.68
B-estimate	30.67		31.96	
A-estimate	NA	24.26	NA	24.42
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		24.07		24.20
B-estimate	30.18		29.71	
A-estimate	NA	21.78	NA	21.90
Method	LVM	Normal	LVM	Normal

Table 5-18: Statistics and Basis Values for OHC2 Strength data

5.5.3 "Hard" Open Hole Compression (OHC3)

There were no outliers or test failures. The RTD data is insufficient to generate basis values that meet the requirements of CMH-17-1G so only estimates are provided for that condition. The ETW2 as measured data does not fit a normal distribution, so no modified CV basis values are provided for that dataset. Statistics, basis values and estimates are given for the strength data in Table 5-19. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-13.

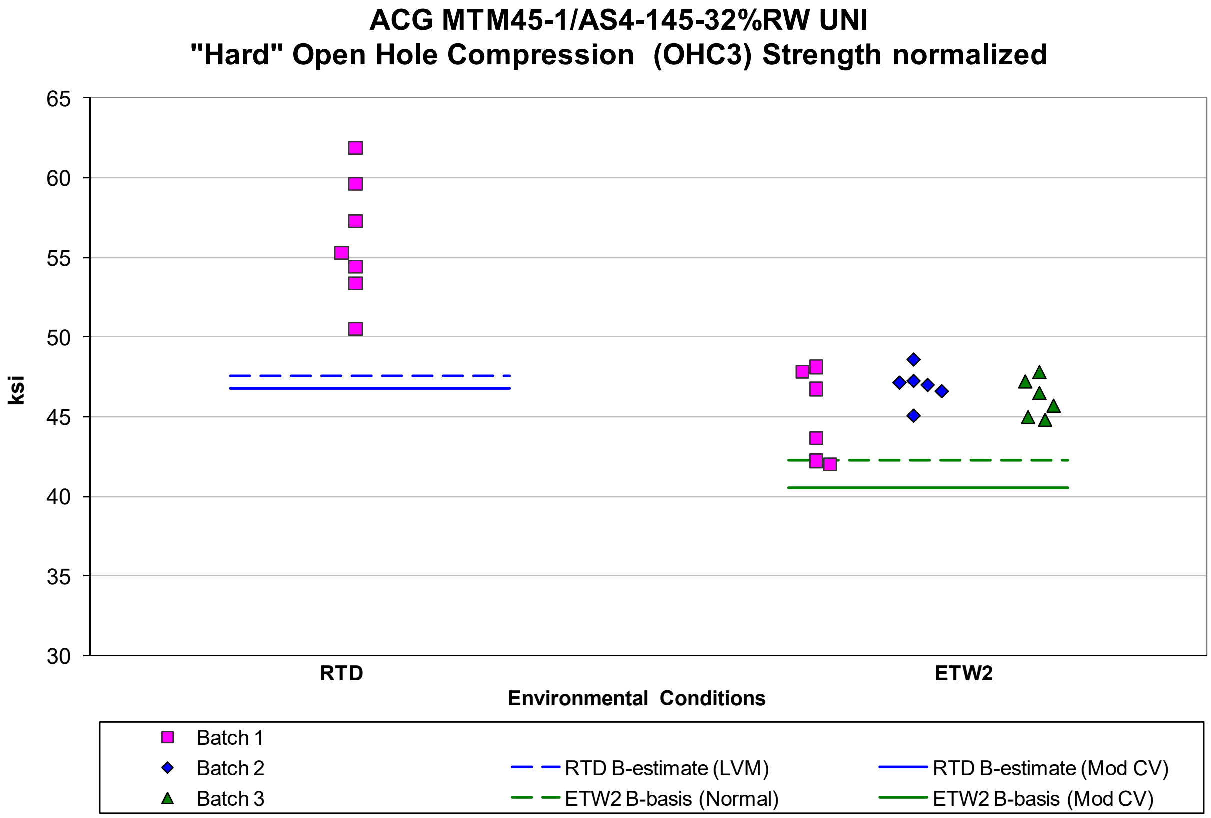

Figure 5-13: Batch plot for OHC3 Strength normalized

Laminate Open Hole Compression (OHC3) Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	56.05	46.06	55.63	46.86
Stdev	3.85	1.92	4.24	2.42
CV	6.87	4.18	7.62	5.16
Modified CV	8.00	6.09	8.00	6.58
Min	50.53	42.04	49.92	41.50
Max	61.87	48.58	61.83	50.06
No. Batches	1	3	1	3
No. Spec.	7	18	7	18
Basis Values and/or Estimates				
B-basis Value		42.26		41.90
B-estimate	47.55		46.90	
A-estimate	NA	39.57	NA	36.85
Method	LVM	Normal	LVM	Weibull
Modified CV Basis Values and/or Estimates				
B-basis Value		40.53		NA
B-estimate	46.82		46.47	
A-estimate	NA	36.61	NA	NA
Method	LVM	Normal	LVM	NA

Table 5-19: Statistics and Basis Values for OHC3 Strength data

5.6 Filled Hole Tension Properties

5.6.1 Quasi Isotropic Filled Hole Tension (FHT1)

The data from the CTD environment meets all requirements of CMH-17-1G. The RTD data is insufficient to generate basis values that meet the requirements of CMH-17-1G so only estimates are provided for that condition.

There was one outlier on the high side of batch two in the CTD data. It was an outlier only for the normalized data and only for batch two, not for the as measured data or for the CTD environment. Statistics, basis values and estimates are given for the strength data in Table 5-20. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-14.

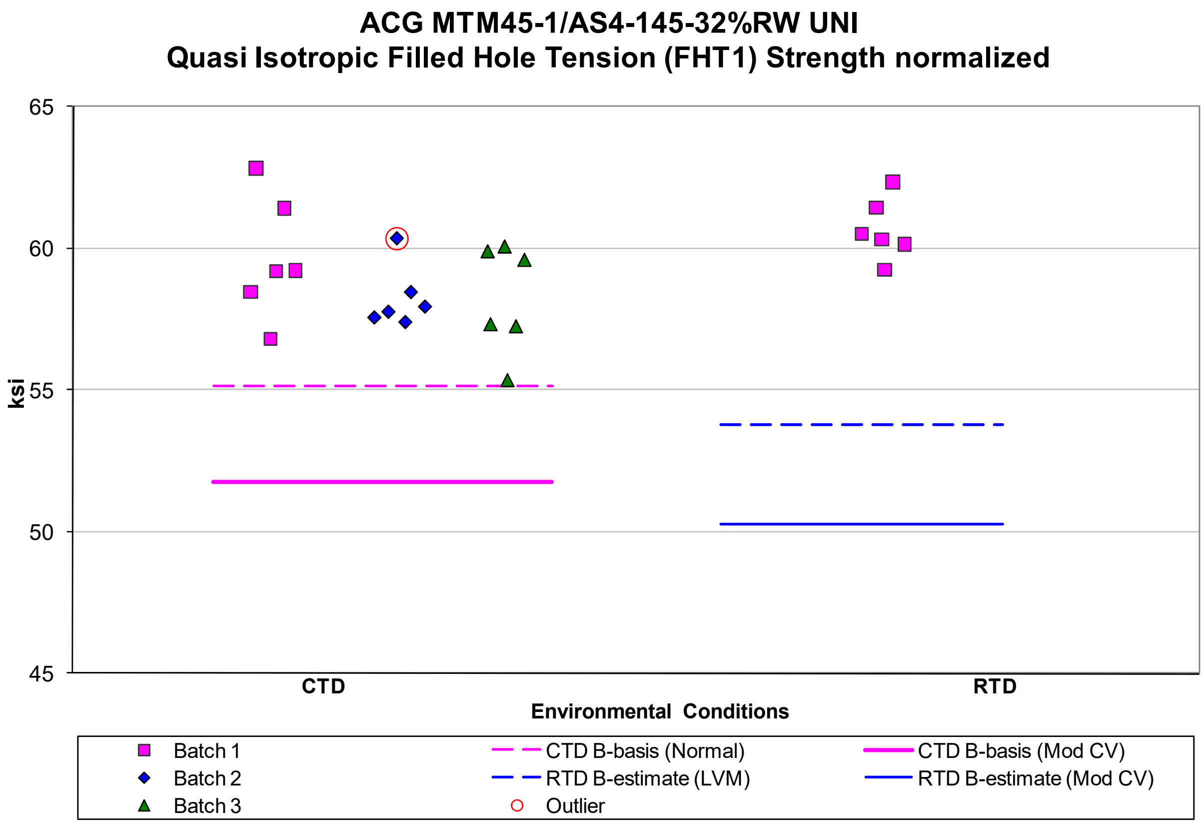

Figure 5-14: Batch plot for FHT1 Strength normalized

Laminate Filled-Hole Tension (FHT1) Strength (ksi)				
	Normalized		As Measured	
Env	CTD	RTD	CTD	RTD
Mean	58.71	60.67	58.51	59.77
Stdev	1.80	1.08	1.82	0.87
CV	3.07	1.77	3.12	1.46
Modified CV	6.00	8.00	6.00	8.00
Min	55.33	59.26	55.73	58.63
Max	62.83	62.34	61.34	61.30
No. Batches	3	1	3	1
No. Spec.	18	6	18	6
Basis Values and/or Estimates				
B-basis Value	55.16		54.91	
B-estimate		53.80		52.82
A-estimate	52.64	NA	52.36	NA
Method	Normal	LVM	Normal	LVM
Modified CV Basis Values and/or Estimates				
B-basis Value	51.76		51.58	
B-estimate		50.25		49.50
A-estimate	46.84	NA	46.68	NA
Method	Normal	LVM	Normal	LVM

Table 5-20: Statistics and Basis Values for FHT1 Strength data

5.6.2 "Soft" Filled Hole Tension (FHT2)

This property had data from only one batch available, thus all basis values are estimates. Statistics and B-estimates are given for the strength data in Table 5-21. The normalized strength data and B-estimates are shown graphically in Figure 5-15.

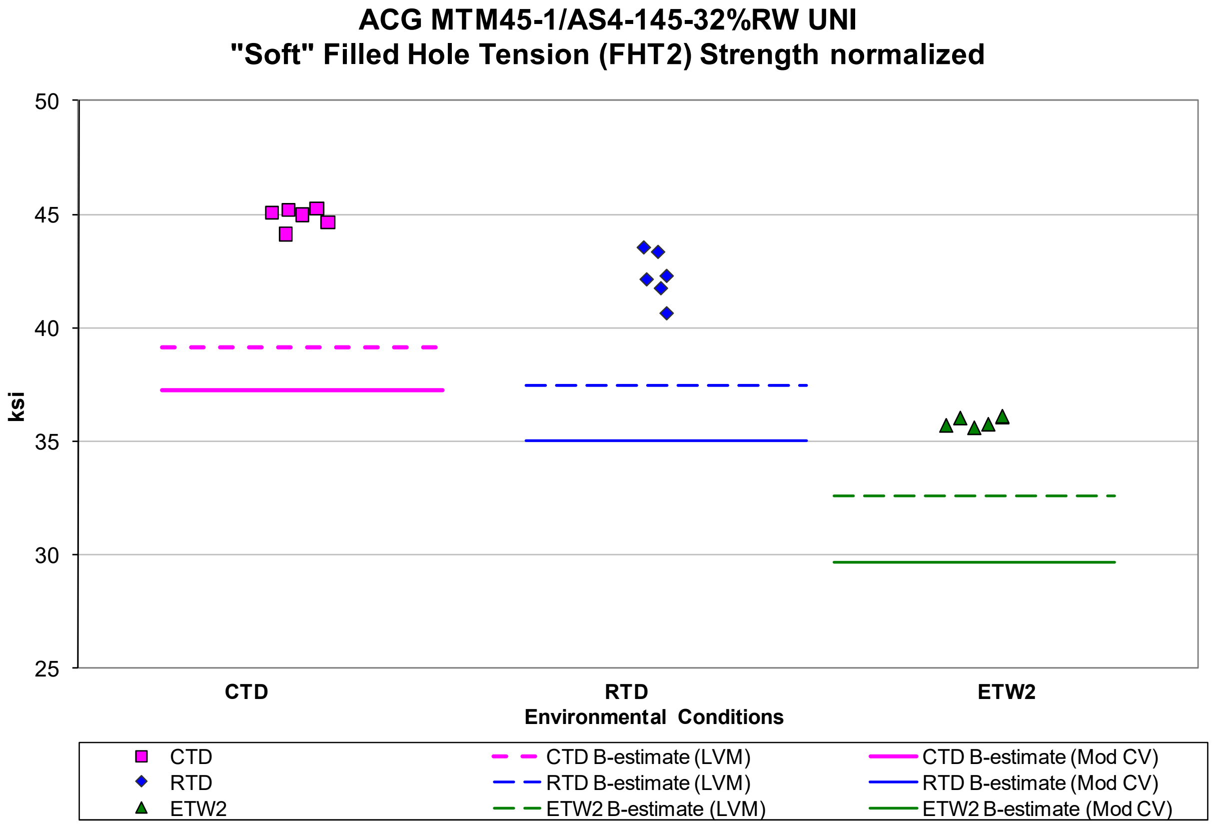

Figure 5-15: Batch plot for FHT2 Strength normalized

Laminate Filled-Hole Tension (FHT2) Strength (ksi)						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	44.88	42.28	35.87	44.55	41.99	35.38
Stdev	0.43	1.06	0.21	0.35	1.36	0.38
CV	0.96	2.52	0.59	0.79	3.25	1.08
Modified CV	8.00	8.00	8.00	8.00	8.00	8.00
Min	44.13	40.64	35.60	43.91	40.36	34.73
Max	45.27	43.53	36.09	44.98	44.07	35.79
No. Batches	1	1	1	1	1	1
No. Spec.	6	6	6	6	6	6
Basis Values and/or Estimates						
B-estimate	39.16	37.49	32.58	38.29	37.11	32.68
Method	LVM	LVM	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	37.23	35.01	29.68	36.95	34.78	29.27
Method	LVM	LVM	LVM	LVM	LVM	LVM

Table 5-21: Statistics and Basis Values for FHT2 Strength data

5.6.3 "Hard" Filled Hole Tension (FHT3)

This property had data from only one batch available, thus all basis values are estimates. Statistics and B-estimates are given for the strength data in Table 5-22. The normalized strength data and B-estimates are shown graphically in Figure 5-16.

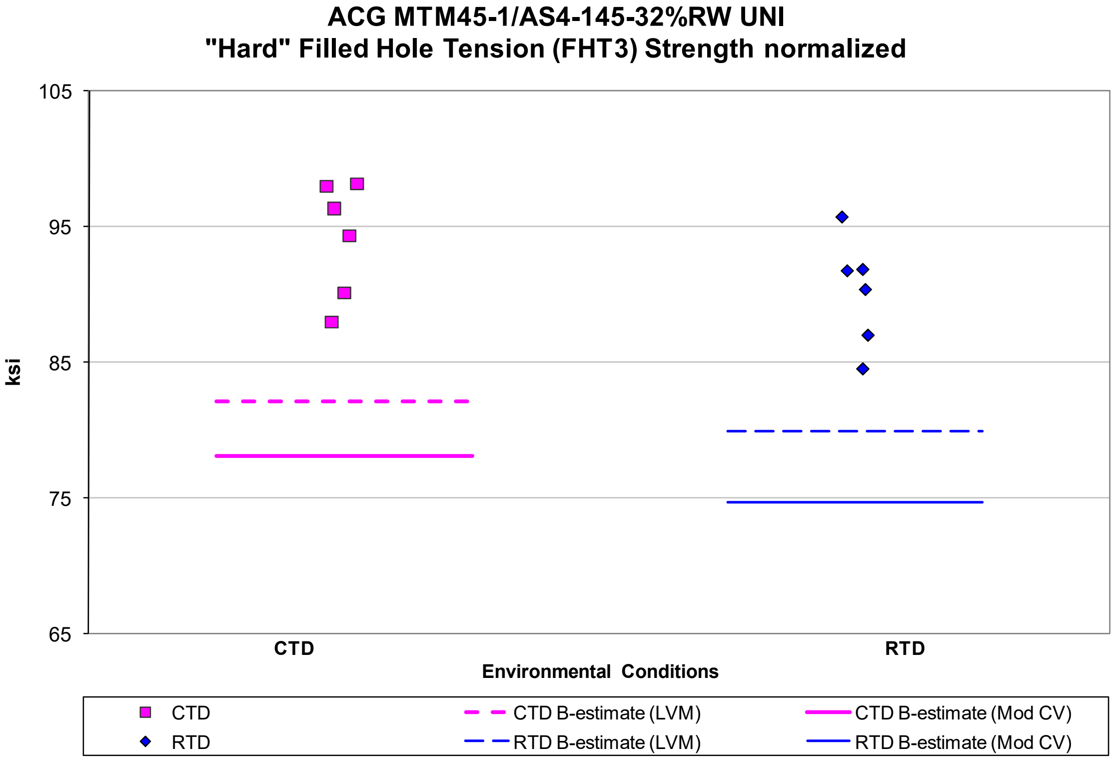

Figure 5-16: Batch plot for FHT3 Strength normalized

Laminate Filled-Hole Tension (FHT3) Strength (ksi)				
	Normalized		As Measured	
Env	CTD	RTD	CTD	RTD
Mean	94.15	90.20	92.65	88.99
Stdev	4.24	3.95	3.51	4.26
CV	4.50	4.38	3.79	4.79
Modified CV	8.00	8.00	8.00	8.00
Min	87.98	84.53	87.77	83.14
Max	98.17	95.71	97.49	95.80
No. Batches	1	1	1	1
No. Spec.	6	6	6	6
Basis Values and/or Estimates				
B-estimate	82.15	79.98	79.65	78.65
Method	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates				
B-estimate	78.09	74.70	76.85	73.70
Method	LVM	LVM	LVM	LVM

Table 5-22: Statistics and Basis Values for FHT3 Strength data

5.7 Filled Hole Compression Properties

5.7.1 Quasi Isotropic Filled Hole Compression (FHC1)

The as measured ETW2 data did not pass the ADK test and requires the ANOVA method to compute basis values, but with data from only three batches, these values are considered estimates and may result in overly conservative basis values. The as measured ETW2 data also fails the normality test, so modified CV basis values cannot be provided. The RTD environment had data from only one batch available. Only estimates are provided for that environmental condition.

There were no outliers. Statistic, basis values and estimates are given for the strength data in Table 5-23. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-17.

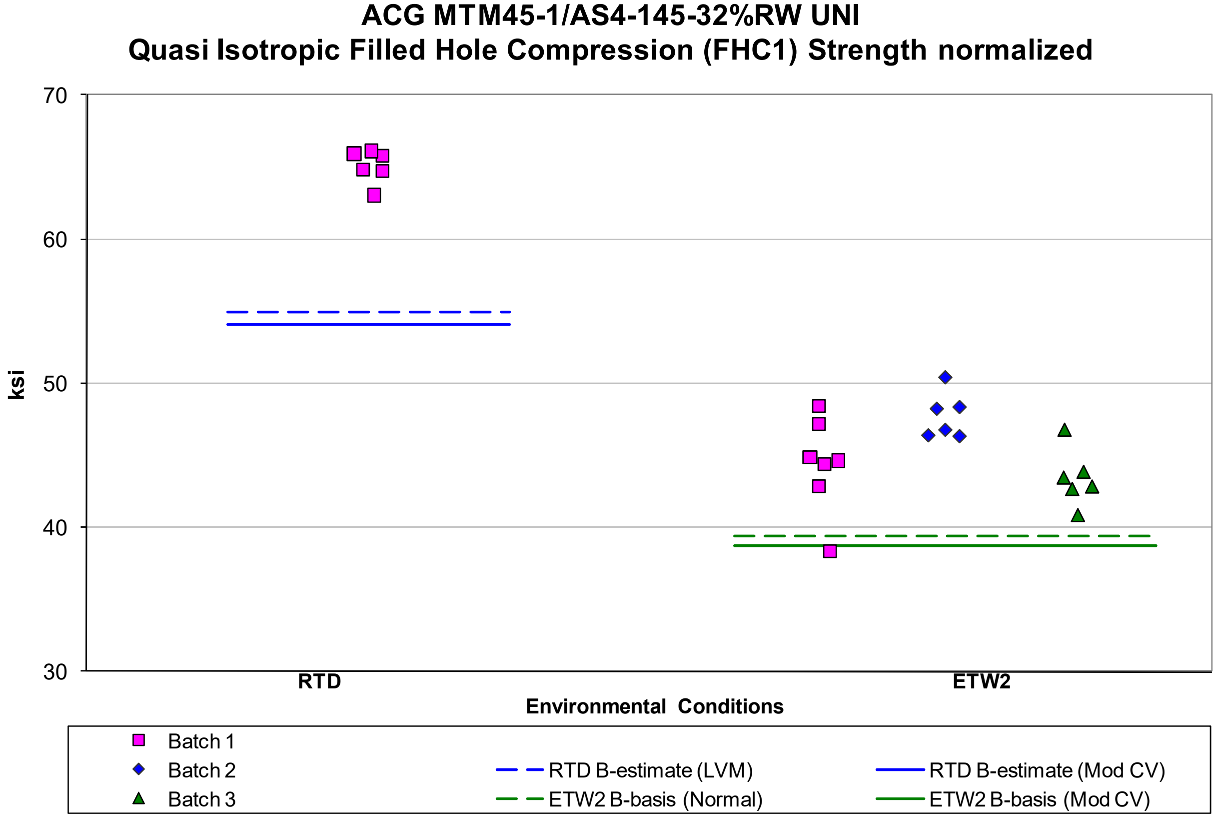

Figure 5-17: Batch plot for FHC1 Strength normalized

Laminate Filled-Hole Compression (FHC1) Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	65.06	45.13	64.14	46.70
Stdev	1.14	2.96	1.03	5.26
CV	1.75	6.56	1.61	11.27
Modified CV	8.00	7.28	8.00	11.27
Min	63.06	38.33	62.40	37.58
Max	66.11	50.39	65.18	58.12
No. Batches	1	3	1	3
No. Spec.	6	19	6	19
Basis Values and/or Estimates				
B-basis Value		39.36		
B-estimate	54.94		57.34	17.20
A-estimate	NA	35.26	NA	0.00
Method	LVM	Normal	LVM	ANOVA
Modified CV Basis Values and/or Estimates				
B-basis Value		38.72		
B-estimate	54.07		53.31	NA
A-estimate	NA	34.18	NA	NA
Method	LVM	Normal	LVM	NA

Table 5-23: Statistics and Basis Values for FHC1 Strength data

5.7.2 "Soft" Filled Hole Compression (FHC2)

The data for the ETW2 environment meets all requirements of CMH-17-1G. The as measured ETW2 data did not fit a normal distribution, so modified CV basis values are not provided for that condition. The RTD data is insufficient to generate basis values that meet the requirements of CMH-17-1G so only estimates are provided for that condition.

There was one outlier on the low side of batch two in the as measured ETW2 dataset. It was an outlier only for batch two, not the ETW2 condition. It was retained for this analysis.

Statistics, basis values and estimates are given for the strength data in Table 5-24. The normalized strength data and B-basis values and B-estimates are shown graphically in Figure 5-18.

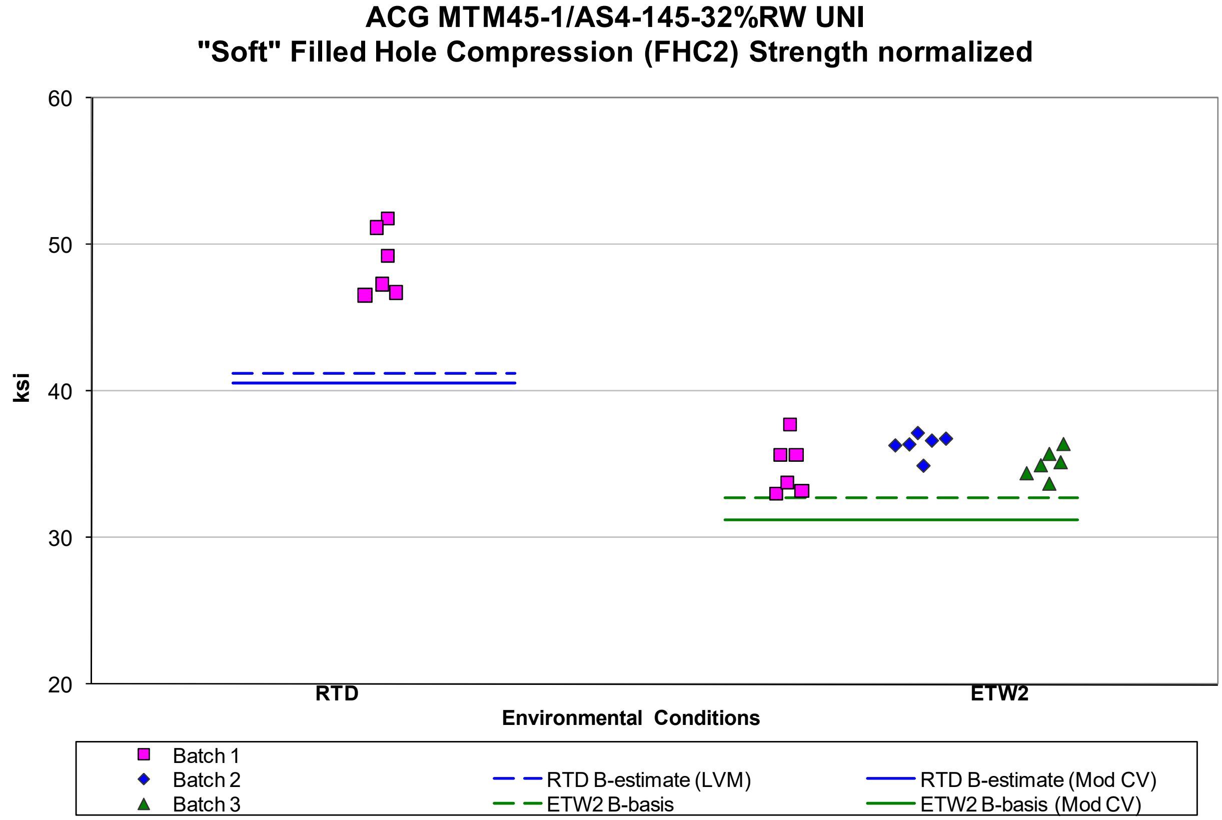

Figure 5-18: Batch plot for FHC2 Strength normalized

Laminate Filled-Hole Compression (FHC2) Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	48.80	35.42	48.10	35.60
Stdev	2.29	1.37	2.28	1.55
CV	4.69	3.86	4.73	4.36
Modified CV	8.00	6.00	8.00	6.18
Min	46.55	33.04	45.97	32.41
Max	51.79	37.71	51.11	37.79
No. Batches	1	3	1	3
No. Spec.	6	18	6	18
Basis Values and/or Estimates				
B-basis Value		32.72		32.38
B-estimate	41.21		43.00	
A-estimate	NA	30.81	NA	29.03
Method	LVM	Normal	LVM	Weibull
Modified CV Basis Values and/or Estimates				
B-basis Value		31.22		NA
B-estimate	40.55		39.98	
A-estimate	NA	28.26	NA	NA
Method	LVM	Normal	LVM	NA

Table 5-24: Statistics and Basis Values for FHC2 Strength data

5.7.3 "Hard" Filled Hole Compression (FHC3)

The data for the ETW2 environments meets all requirements of CMH-17-1G. There is no change in basis values with the modified CV approach for the ETW2 environment due to the large CV of the measured data. The RTD environment had data from only one batch available. Only estimates are provided for that environmental condition.

There were two outliers in the FHC3 data. One outlier was the highest value in the RTD data. Since there was only one batch of data for the RTD condition, it can only be stated that it was an outlier for that batch. The other outlier was on the high side of batch two in the ETW2 dataset. It was an outlier only for the as measured data and only for batch two, not for the ETW2 condition. Both outliers were retained for this analysis.

Statistics, basis values and estimates are given for the strength data in Table 5-25. The normalized strength data, B-basis values and B-estimates are shown graphically in Figure 5-19.

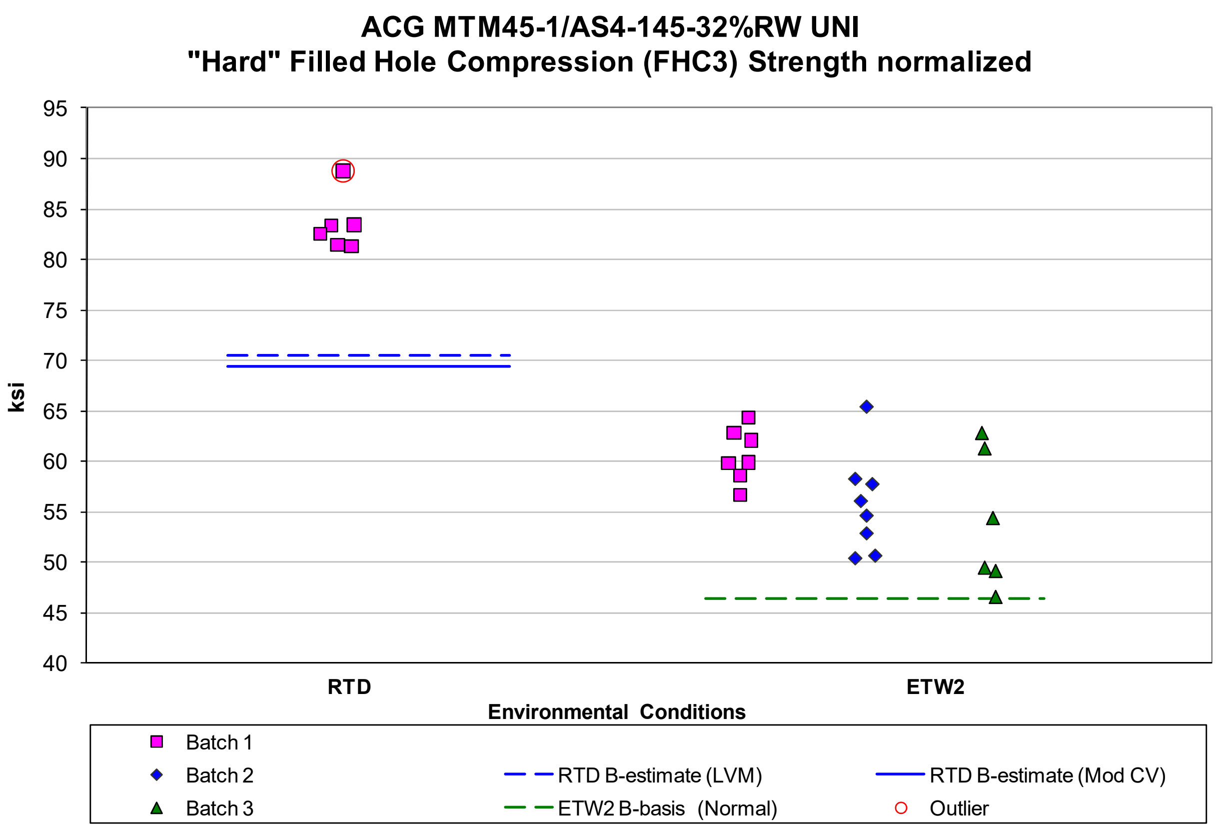

Figure 5-19: Batch plot for FHC3 Strength normalized

Laminate Filled-Hole Compression (FHC3) Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	83.49	56.83	81.58	56.57
Stdev	2.74	5.47	3.34	5.01
CV	3.28	9.62	4.09	8.86
Modified CV	8.00	9.62	8.00	8.86
Min	81.35	46.60	78.41	48.20
Max	88.76	65.34	87.90	64.21
No. Batches	1	3	1	3
No. Spec.	6	21	6	21
Basis Values and/or Estimates				
B-basis Value		46.41		47.02
B-estimate	70.50		72.93	
A-estimate	NA	38.99	NA	40.21
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		NA		NA
B-estimate	69.38		67.80	
A-estimate	NA	NA	NA	NA
Method	LVM	NA	LVM	NA

Table 5-25: Statistics and Basis Values for FHC3 Strength data

5.8 Pin Bearing Properties

5.8.1 Quasi Isotropic Pin Bearing (PB1)

Pooling the two environments was not acceptable for the 2% offset strength because the pooled dataset, for both the normalized and as measured data, failed the Anderson-Darling test for normality. Modified CV basis values are not available for the RTD condition due to the large CV of that data.

Pooling the two environments was acceptable for the as measured ultimate strength data, but the normalized RTD data failed the ADK test and could not be pooled. The RTD data required the ANOVA method to compute basis values, but with data from only three batches, these values are considered estimates and may result in overly conservative basis values. The normalized RTD data did pass the ADK test with the modified CV transform, so modified CV values are provided and pooling was appropriate for the modified CV basis values.

There was one outlier. It was in the as measured 2% offset strength data. It was on the low side of batch one in the as measured RTD dataset. It was an outlier for the RTD condition but not for batch one. It was retained for this analysis.

Statistics, basis values and estimates are given for the 2% offset strength data in Table 5-26 and the ultimate strength data in Table 5-27. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5-20 for the 2% offset strength data and in Figure 5-21 for the ultimate strength data.

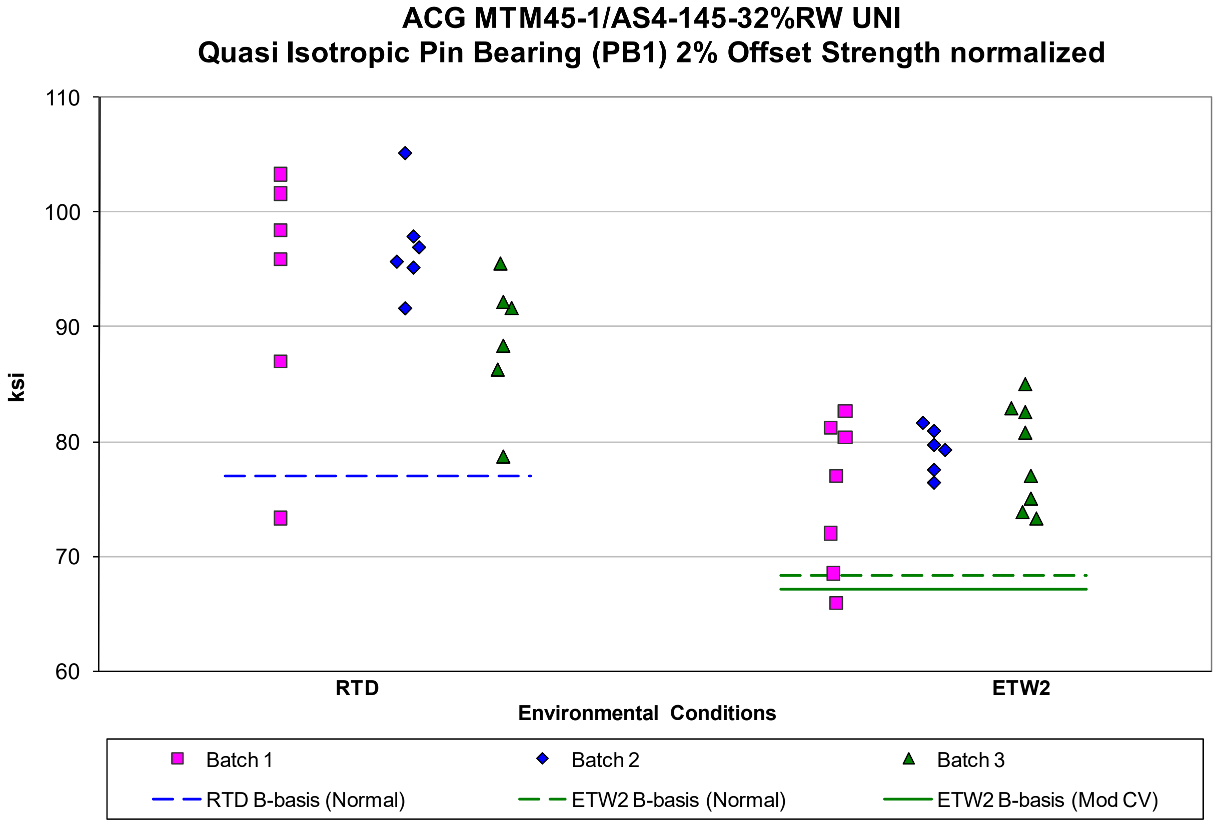

Figure 5-20: Batch plot for PB1 2% Offset Strength normalized

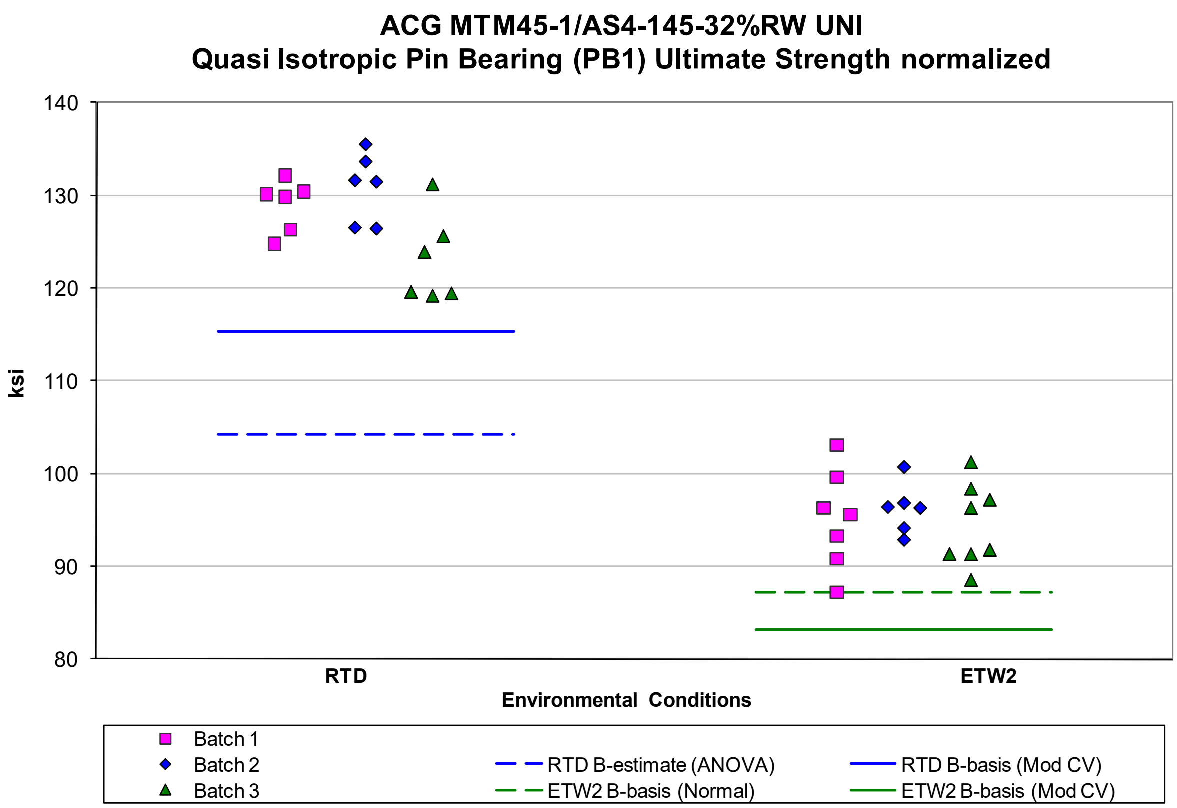

Figure 5-21: Batch plot for PB1 Ultimate Strength normalized

Pin Bearing Properties (PB1) 2% Offset Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	93.03	77.77	93.03	77.43
Stdev	8.14	4.95	7.66	5.26
CV	8.75	6.36	8.23	6.80
Modified CV	8.75	7.18	8.23	7.40
Min	73.31	65.88	71.79	64.16
Max	105.16	84.95	103.79	86.23
No. Batches	3	3	3	3
No. Spec.	18	21	18	21
Basis Values and/or Estimates				
B-basis Value	76.95	68.34	78.18	67.41
A-estimate	65.56	61.62	64.07	60.26
Method	Normal	Normal	Weibull	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value	NA	67.13	NA	66.52
A-estimate	NA	59.55	NA	58.74
Method	NA	normal	NA	normal

Table 5-26: Statistics and Basis Values for PB1 2% Offset Strength data

Pin Bearing (PB1) Ultimate Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	127.63	95.19	127.67	94.75
Stdev	4.93	4.20	4.41	4.02
CV	3.86	4.41	3.46	4.25
Modified CV	6.00	6.21	6.00	6.12
Min	119.16	87.19	122.20	86.10
Max	135.46	103.12	136.34	102.00
No. Batches	3	3	3	3
No. Spec.	18	21	18	21
Basis Values and/or Estimates				
B-basis Value		87.20	120.06	87.24
B-estimate	104.16			
A-estimate	87.43	81.49	114.90	82.06
Method	ANOVA	Normal	pooled	pooled
Modified CV Basis Values and/or Estimates				
B-basis Value	115.39	83.12	115.51	82.76
A-estimate	107.10	74.79	107.27	74.48
Method	pooled	pooled	pooled	pooled

Table 5-27: Statistics and Basis Values for PB1 Ultimate Strength data

5.8.2 "Soft" Pin Bearing (PB2)

The ETW2 data meets all requirements of CMH-17-1G. The RTD data is insufficient to generate basis values that meet the requirements of CMH-17-1G so only estimates are provided for that condition.

There were no outliers. Statistics, basis values and estimates are given for the 2% offset strength data in Table 5-28 and the ultimate strength data in Table 5-29. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5-22 for the 2% offset strength and Figure 5-23 for the ultimate strength data.

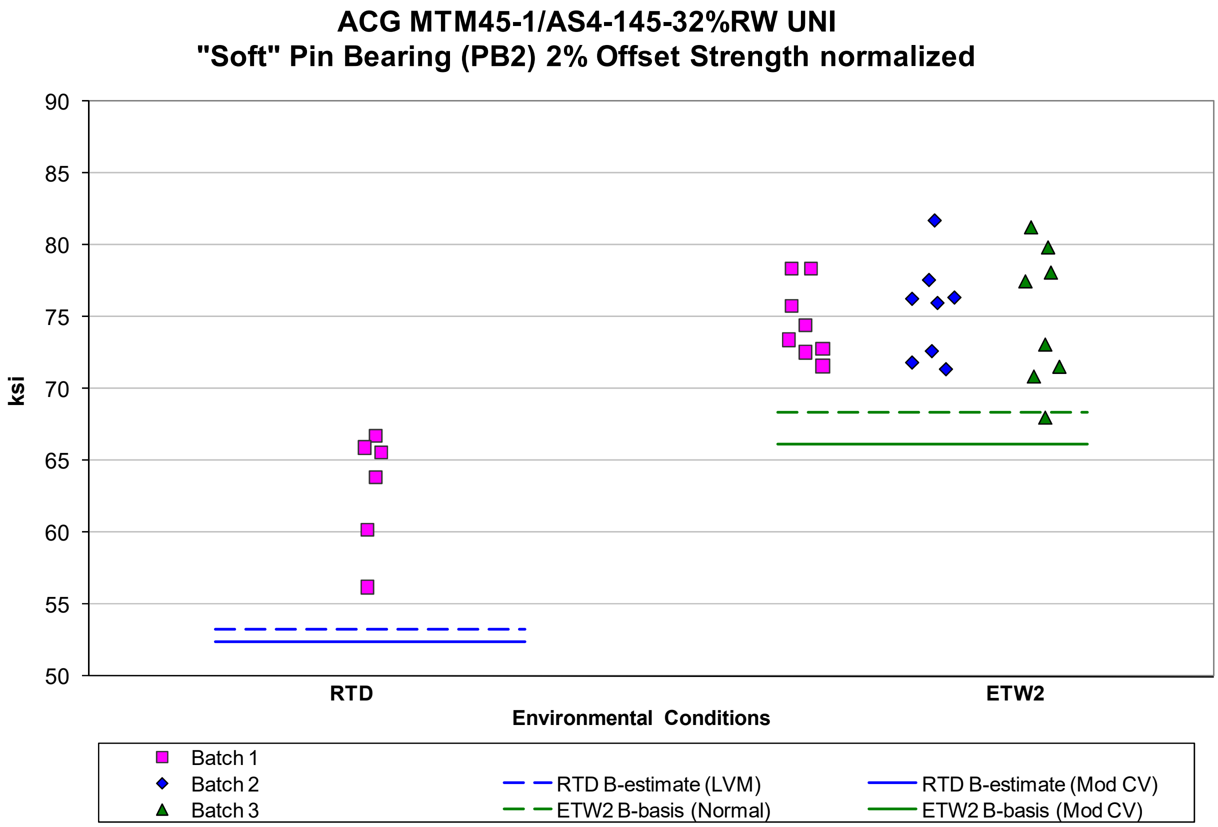

Figure 5-22: Batch plot for PB2 2% Offset Strength normalized

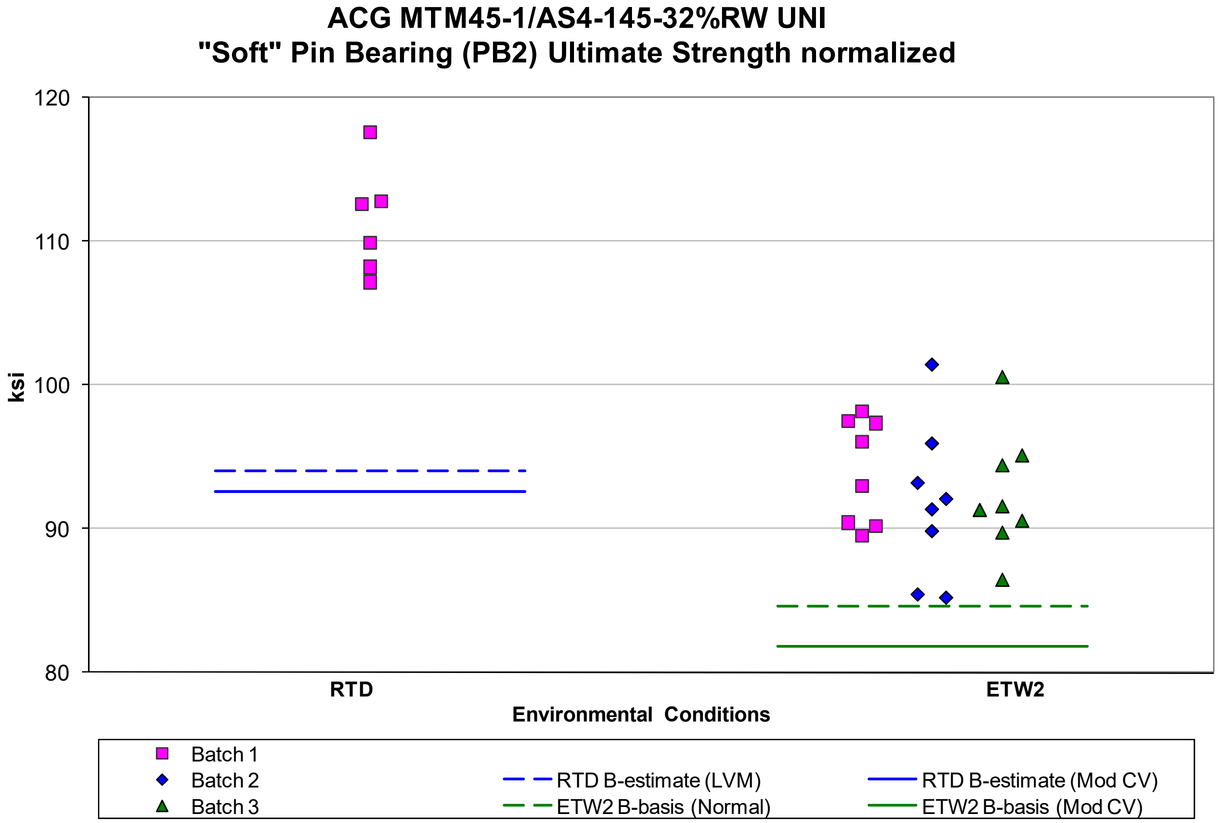

Figure 5-23: Batch plot for PB2 Ultimate Strength normalized

Pin Bearing Properties (PB2) 2% Offset Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	63.08	75.04	62.68	75.71
Stdev	4.10	3.57	4.25	4.44
CV	6.49	4.76	6.79	5.86
Modified CV	8.00	6.38	8.00	6.93
Min	56.19	67.97	55.41	69.93
Max	66.75	81.67	66.41	85.06
No. Batches	1	3	1	3
No. Spec.	6	24	6	24
Basis Values and/or Estimates				
B-basis Value		68.43		67.49
B-estimate	53.27		53.70	
A-estimate	NA	63.68	NA	61.60
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		66.17		65.99
B-estimate	52.42		52.09	
A-estimate	NA	59.81	NA	59.02
Method	LVM	Normal	LVM	Normal

Table 5-28: Statistics and Basis Values for PB2 2% Offset Strength data

Pin Bearing Properties (PB2) Ultimate Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	111.37	92.78	110.65	93.57
Stdev	3.80	4.38	3.96	4.88
CV	3.41	4.72	3.58	5.22
Modified CV	8.00	6.36	8.00	6.61
Min	107.16	85.23	106.62	83.76
Max	117.60	101.46	116.98	105.67
No. Batches	1	3	1	3
No. Spec.	6	24	6	24
Basis Values and/or Estimates				
B-basis Value		84.66		84.53
B-estimate	94.04		98.91	
A-estimate	NA	78.85	NA	78.05
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		81.84		82.11
B-estimate	92.55		91.95	
A-estimate	NA	74.00	NA	73.90
Method	LVM	Normal	LVM	Normal

Table 5-29: Statistics and Basis Values for PB2 Ultimate Strength data

5.8.3 "Hard" Pin Bearing (PB3)

The ETW2 data meets all requirements of CMH-17-1G. The RTD data is insufficient to generate basis values that meet the requirements of CMH-17-1G so only estimates are provided for that condition. Modified CV basis values are not available for the 2% offset strength. The data from the RTD condition has a large CV and the modified CV method would not make any change to it, while the data from the ETW2 condition fails the normality test.

There were three outliers, two in the 2% offset strength data and one in the ultimate strength data. The outliers in the 2% offset strength data were both on the low side of batch two in the normalized ETW2 dataset. In the ultimate strength data, the outlier was on the high side of batch three in the as measured ETW2 dataset. All three outliers were outliers for the ETW2 condition, not for their respective batches. All outliers were retained for this analysis.

Statistics, basis values and estimates are given for the 2% offset strength data in Table 5-30 and the ultimate strength data in Table 5-31. The normalized data, B-basis values and B-estimates are shown graphically in Figure 5-24 for the 2% offset strength data and in Figure 5-25 for the ultimate strength data.

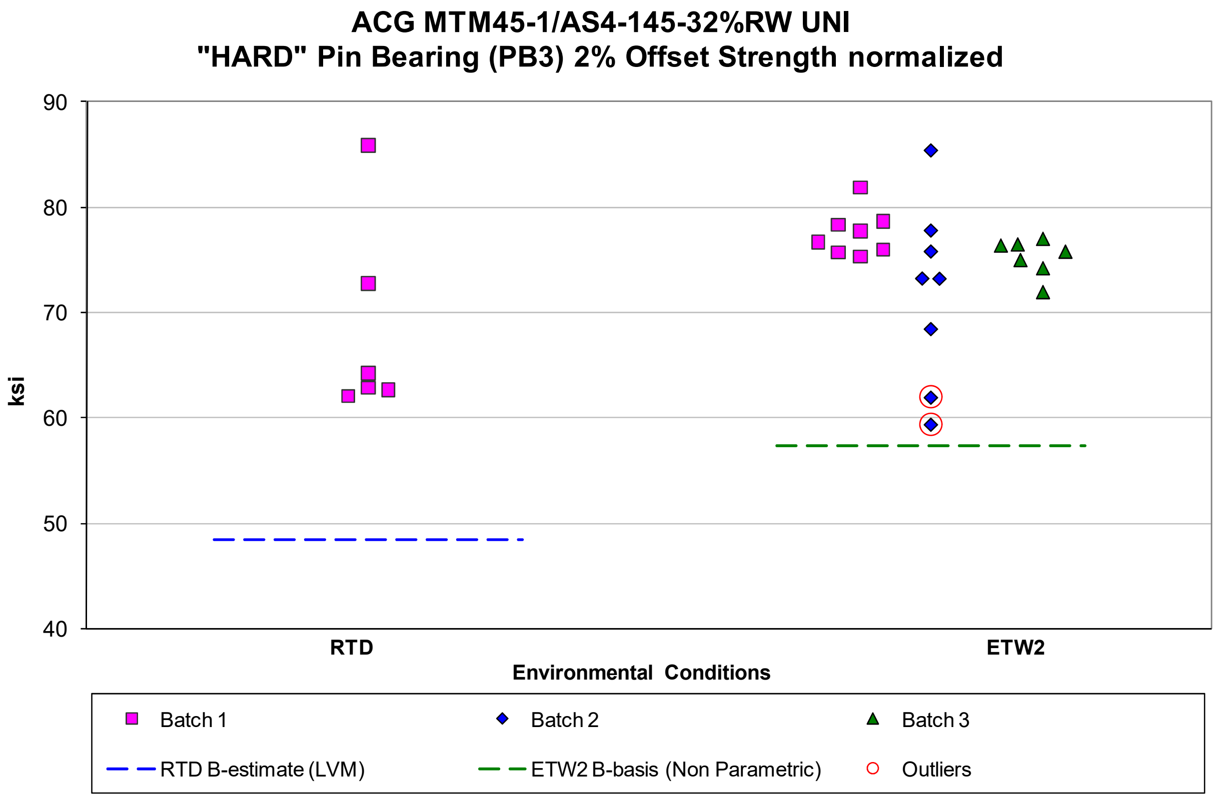

Figure 5-24: Batch plot for PB3 2% Offset Strength normalized

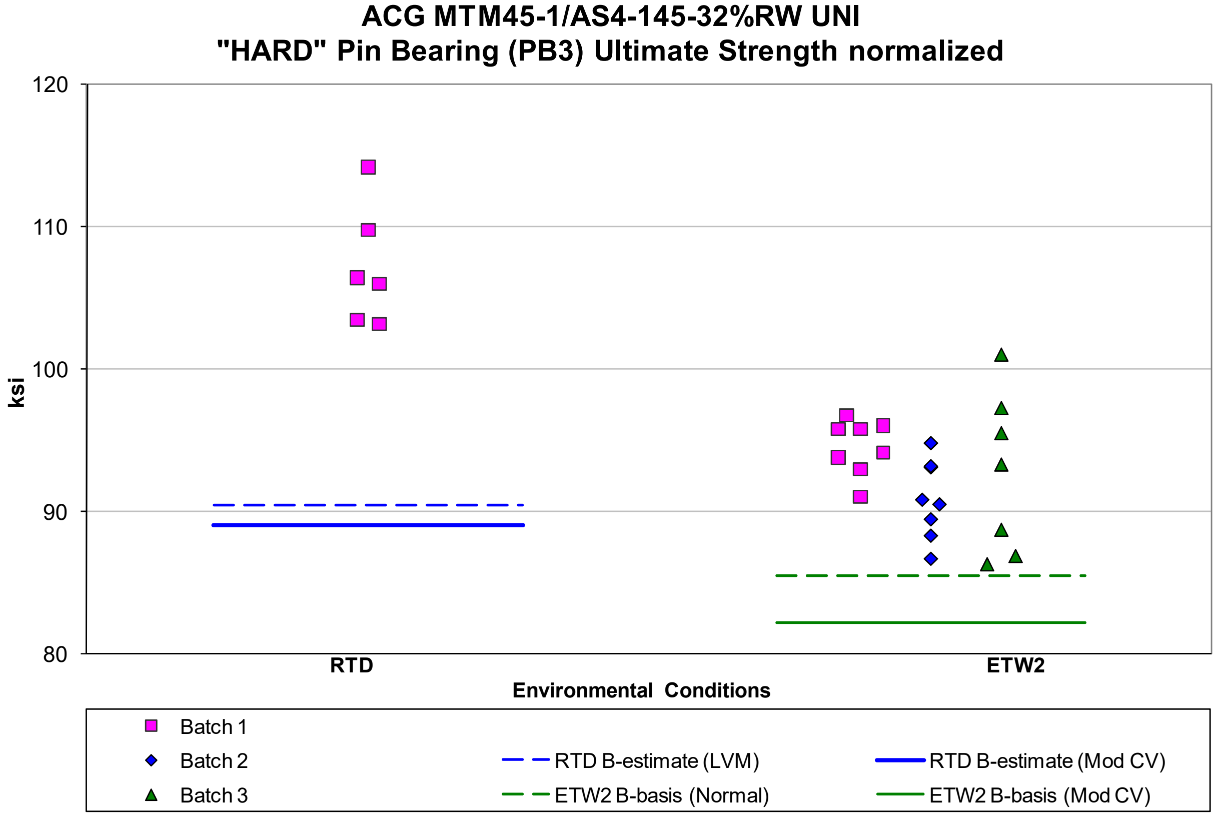

Figure 5-25: Batch plot for PB3 Ultimate Strength normalized

Pin Bearing Properties (PB3) 2% Offset Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	68.40	74.88	67.88	75.42
Stdev	9.45	5.56	9.38	4.86
CV	13.81	7.43	13.82	6.45
Modified CV	13.81	7.71	13.82	7.22
Min	62.03	59.39	61.07	62.12
Max	85.88	85.37	85.22	84.76
No. Batches	1	3	1	3
No. Spec.	6	23	6	23
Basis Values and/or Estimates				
B-basis Value		57.35		64.64
B-estimate	48.45		48.06	
A-estimate	NA	38.23	NA	54.19
Method	LVM	Non-Parametric	LVM	Weibull

Table 5-30: Statistics and Basis Values for PB3 2% Offset Strength data

Pin Bearing Properties (PB3) Ultimate Strength (ksi)				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	107.16	92.69	106.34	93.42
Stdev	4.19	3.83	4.12	3.87
CV	3.91	4.13	3.87	4.14
Modified CV	8.00	6.06	8.00	6.07
Min	103.16	86.28	102.64	87.99
Max	114.18	101.02	113.30	104.42
No. Batches	1	3	1	3
No. Spec.	6	23	6	23
Basis Values and/or Estimates				
B-basis Value		85.54		86.20
B-estimate	90.49		95.07	
A-estimate	NA	80.42	NA	81.03
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		82.18		82.82
B-estimate	89.06		88.38	
A-estimate	NA	74.67	NA	75.24
Method	LVM	Normal	LVM	Normal

Table 5-31: Statistics and Basis Values for PB3 Ultimate Strength data

5.9 Compression After Impact Properties (CAI)

Basis values are not computed for this property. However the summary statistics are presented in Table 5-32. The normalized strength data are shown graphically in Figure 5-26.

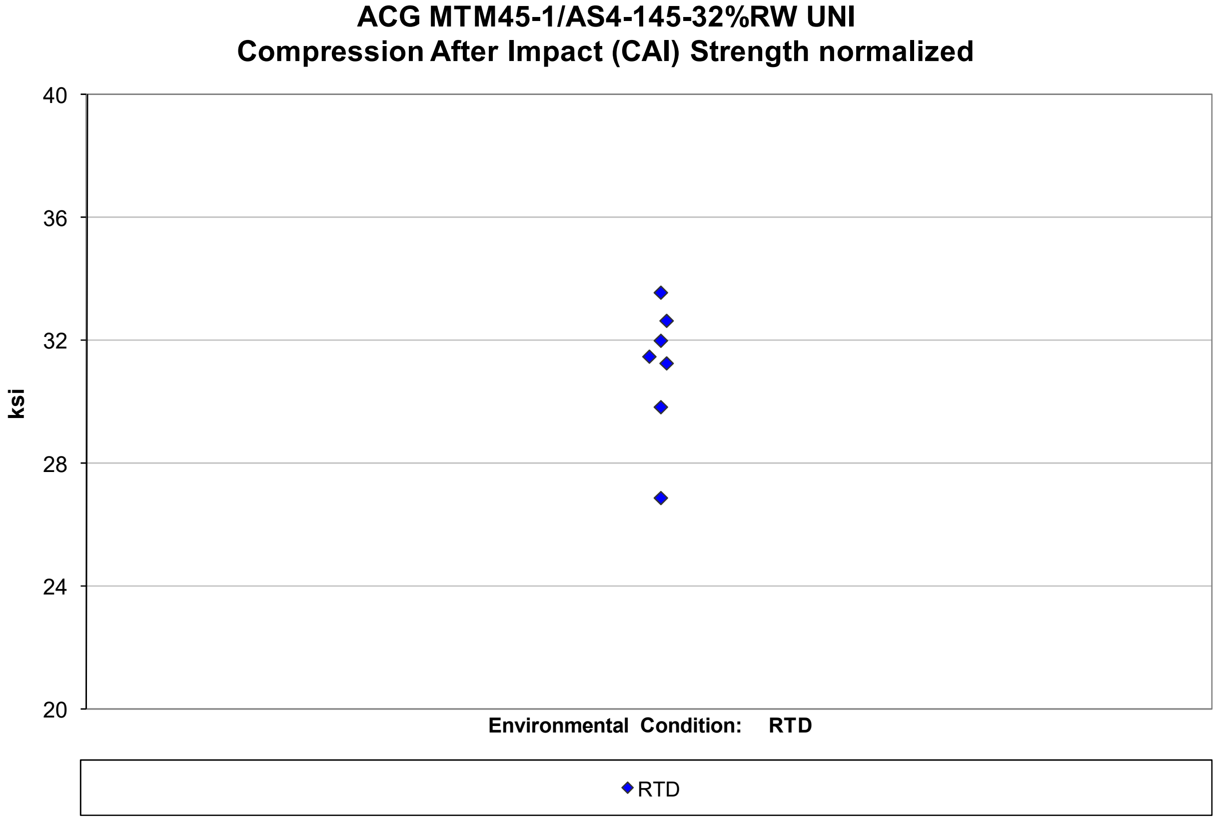

Figure 5-26: Batch plot for CAI Strength normalized

Compression After Impact (CAI)				
	Strength (ksi)		Modulus (msi)	
RTD Env.	Normalized	As measured	Normalized	As measured
Mean	31.09	30.25	7.01	6.82
Stdev	2.18	2.19	0.03	0.04
CV	7.02	7.25	0.42	0.58
Modified CV	7.51	7.63	6.00	6.00
Min	26.90	26.11	6.97	6.77
Max	33.55	32.81	7.05	6.88
No. Batches	1	1	1	1
No. Spec.	7	7	7	7

Table 5-32: Statistics and Basis Values for CAI data

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

The Interlaminar Tension and Curved Beam Strength data is not normalized. Basis values are not computed for the ILT and CBS data. Test results only are presented here. Statistics are given for the Interlaminar Tension (ILT) and Curved Beam strength (CBS) data in Table 5-33. ILT tests were performed at both RTD and ETW2 environmental conditions.

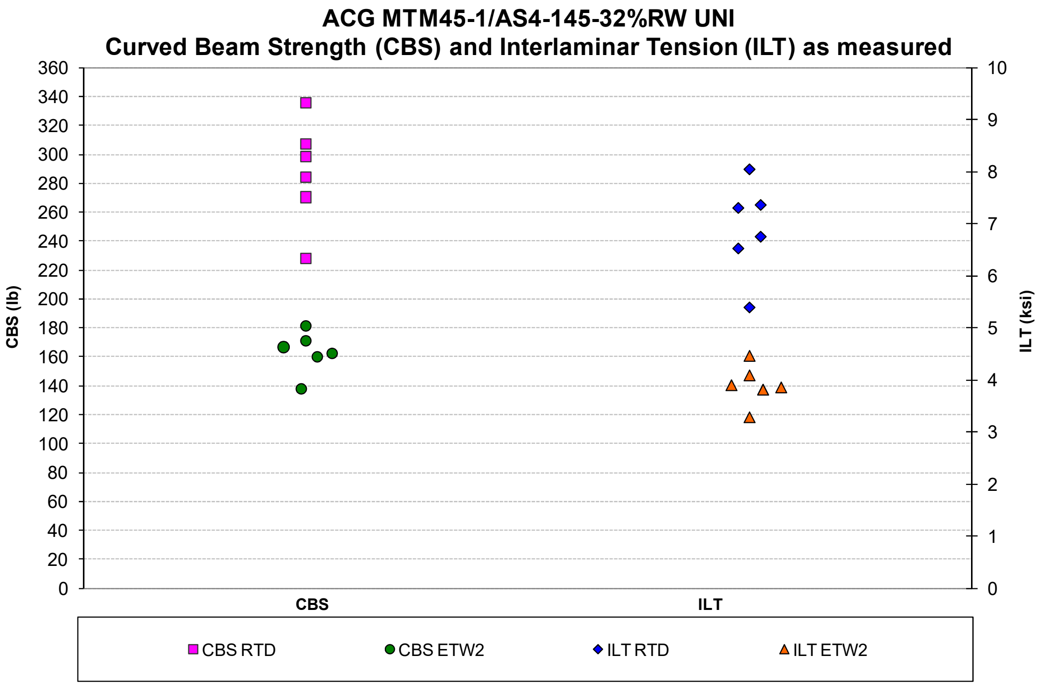

Figure 5-27: Plot for ILT and CBS Data as measured

Property	ILT (ksi)		CBS (lb)	
Env	RTD	ETW2	RTD	ETW2
Mean	6.89	3.90	287.34	163.19
Stdev	0.91	0.39	36.59	14.48
CV	13.19	9.90	12.74	8.87
Mod CV	13.19	9.90	12.74	8.87
Min	5.39	3.28	227.96	137.84
Max	8.04	4.46	335.80	181.14
No. Batches	1	1	1	1
No. Spec.	6	6	6	6

Table 5-33: Statistics for ILT and CBS data

6. Outliers

Outliers were identified according to the standards documented in section 2.1.5, which are in accordance with the guidelines developed in CMH-17-1G 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. Specimens that are outliers only for the batch, but not the condition and specimens that are identified as outliers only for the normalized data or the as measured data but not both, are typical of normal random variation.

All outliers identified were investigated to determine if a cause could be found. Outliers with causes were removed from the dataset and the remaining specimens were analyzed for this report. Information about specimens that were removed from the dataset along with the cause for removal is documented in the "MTM45-1 AS4 Data MH Cure Cycle.pdf".

Outliers for which no causes could be identified are listed in Table 6-1. These outliers were included in the analysis for their respective test properties.

Test	Condition	Batch	Specimen Number	Normalized Strength	As-Measured Strength	High/ Low	Batch Outlier	Condition Outlier
LT	RTD	2	AITR1392-ASU1-UNT0-B-MH1-RTD-3	228.30	226.92	Low	No	Yes
UNT0				120.23	118.71		Norm only	
LT	ETW	2	AITR1392-ASU1-UNT0-B-MH2-ETW-3	Not an Outlier	264.69	High	Yes	No
UNT0					141.54			
LT	ETW	3	AITR1392-ASU1-UNT0-C-MH1-ETW-2	214.72	224.77	Low	No	Yes
UNT0				120.43	120.20			
LT	ETW2	2	AITR1392-ASU1-UNT0-B-MH1-ETW2-3	Not an Outlier	243.03	Low	Yes	Yes
UNT0					117.94			
LC	ETW	1	AITR1392-ASU1-UNC0-A-MH2-ETW-4	168.65	167.89	High	No	Yes
UNC0				94.27	93.45			
TC	RTD	1	AITR1392-ASU1-TC-A-MH1-RTD-1	NA	23.89	Low	Yes	No
IPS 0.2% Offset	ETD	2	AITR1392-ASU1-IPS-B-MH3-1-ETD-4	NA	4.92	High	Yes	No
SBS	RTD	2	AITR1392-ASU1-SBS-B-MH1-RTD-3	NA	12.98	High	Yes	No
UNT1	RTD	1	AITR1392-ASU1-UNT1-A-MH1-RTD-2	95.61	94.04	Low	No	Yes
OHT1	RTD	2	AITR1392-ASU1-OHT1-B-MH1-RTD-2	Not an Outlier	60.59	High	Yes	No
OHT1	ETW2	1	AITR1392-ASU1-OHT1-A-MH2-ETW2-1	60.05	57.90	High	Yes	Norm only
OHT2	CTD	1	AITR1392-ASU1-OHT2-A-MH2-CTD-1	43.02	Not an Outlier	Low	Yes	No
FHT1	CTD	2	AITR1392-ASU1-FHT1-B-MH1-CTD-1	60.34	Not an Outlier	High	Yes	No
FHC2	ETW2	2	AITR1392-ASU1-FHC2-B-MH2-ETW2-2	Not an Outlier	34.84	Low	Yes	No
FHC3	RTD	1	AITR1392-ASU1-FHC3-A-MH1-RTD-4	88.76	87.90	High	Yes	NA
FHC3	ETW2	2	AITR1392-ASU1-FHC3-B-MH2-ETW2-4	Not an Outlier	62.61	High	Yes	No
PB1 - 2% Offset	RTD	1	AITR1392-ASU1-PB1-A-MH2-RTD-3	Not an Outlier	71.79	Low	No	Yes
PB3 - 2% Offset	ETW2	2	AITR1392-ASU1-PB3-B-MH2-ETW2-2	59.39	Not an Outlier	Low	No	Yes
PB3 - 2% Offset	ETW2	2	AITR1392-ASU1-PB3-B-MH2-ETW2-4	61.95	Not an Outlier	Low	No	Yes
PB3 - Ult. Str.	ETW2	3	AITR1392-ASU1-PB3-C-MH2-ETW2-2	Not an Outlier	104.42	High	No	Yes

Table 6-1: List of outliers

7. References

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