Solvay (Formerly ACG) MTM45-1/CF0525-36%RW 3K PW AS4 Fabric Qualification Statistical Analysis Report

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Elizabeth Clarkson, Ph.D.
National Center for Advanced Materials Performance (NCAMP)
National Institute for Aviation Research
Wichita State University
Wichita, KS 67260-0093

Testing Facility:
Advanced Composites Group
5350 S 129th E. Ave
Tulsa, OK 74134

Test Panel Fabrication Facility:
Advanced Composites Group
5350 S 129th E. Ave
Tulsa, OK 74134

Prepared by: Dr. Elizabeth Clarkson

Digitally signed by Dr. Elizabeth Clarkson
DN: cn=Dr. Elizabeth Clarkson, o=Wichita State University, ou=NCAMP, email=bclarkson@niar.wichita.edu, c=US
Date: 2019.01.09 09:24:52 -06'00'

Elizabeth Clarkson, Ph.D

Reviewed by: Evelyn Lian

Digitally signed by Evelyn Lian
DN: cn=Evelyn Lian, o=NIAR/NCAMP, ou=NIAR/NCAMP, email=evelyn@niar.wichita.edu, c=US
Date: 2019.03.11 16:03:25 -05'00'

Evelyn Lian

Approved by: Royal Lovingfoss

Digitally signed by Royal Lovingfoss
DN: cn=Royal Lovingfoss, o=NIAR, ou=NCAMP, email=rlovingfoss@niar.wichita.edu, c=US
Date: 2019.01.09 09:08:43 -06'00'

Royal Lovingfoss

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1. Introduction

This report contains statistical analysis for Advanced Composites Group (ACG) MTM45-1/CF0525-36%RW 3K PW AS4 Fabric material properties data in "MTM45-1 CF0525 Data MH Cure Cycle Values Only 2-18-10.pdf". 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 along with A-estimates and B-estimates were computed using a variety of techniques that are detailed in section 2. The qualification material was procured to ACG Material Specification ACGM 1001-07 Revision Initial Release. An equivalent NCAMP Material Specification NMS 451/7 has been created. NMS 451/7 contains specification limits that are derived from the qualification dataset using guidelines in section 6 of DOT/FAA/AR-03/19 and CMH-17-1G section 8.4.1. The test panels were fabricated using ACG Process Specification ACGP 1001-02 using "MH" cure cycle. An equivalent NCAMP Process Specification NPS 81451 with "MH" cure cycle has been created. The panels were fabricated and mechanical testing were performed at Advanced Composites Group, 5350 S 129th E. Ave, Tulsa, OK 74134. The ACG Test Plan AI/TR/1392 Revision E was used for this qualification program.

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 along with the specific requirement(s) the data fails to meet. 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 are 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 451/7. NMS 451/7 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 451/7*. NMS 451/7 is a free, publicly available, non-proprietary aerospace industry material specification.

This report is intended for general distribution to the public, either freely or at a price that does not exceed the cost of reproduction (e.g. printing) and distribution (e.g. postage).

1.1 Symbols and Abbreviations

Test Property	**Abbreviation**
Warp Compression	WC
Warp Tension	WT
Fill Compression	FC
Fill Tension	FT
In-Plane Shear	IPS
Short Beam Strength	SBS
Unnotched Tension	UNT
Unnotched Compression	UNC
Open Hole Tension	OHT
Open Hole Compression	OHC
Filled Hole Tension	FHT
Filled Hole Compression	FHC
Laminate Short Beam Strength	SBS1
Pin Bearing Strength	PB
Interlaminar Tension Strength	ILT
Curved Beam Strength	CBS
Compression After Impact	CAI

Table 1-1: Test Property Abbreviations

Test Property	Symbol
Warp Compression Strength	F_1^{cu}
Warp Compression Modulus	E_1^{c}
Warp Compression Poisson's Ratio	ν_{12}^{c}
Warp Tension Strength	F_1^{tu}
Warp Tension Modulus	E_1^{t}
Fill Compression Strength	F_2^{cu}
Fill Compression Modulus	E_2^{c}
Fill Compression Poisson's Ratio	ν_{21}^{c}
Fill Tension Strength	F_2^{tu}
Fill 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 advisable because the data was not eligible for pooling and engineering judgment indicated there was not justification for overriding the result, then B-Basis values were computed for each environmental condition separately using STAT17 version 5.

1.3 Basis Value Computational Process

The general form to compute engineering basis values is: basis value = $\bar{X} - kS$ 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 presented 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 as-measured CV is greater than 8%, the modified CV method does not change the basis value. NCAMP recommended values make use of 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 will 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 STAT17 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. $$S_p = \sqrt{\frac{\sum_{i=1}^{k} (n_i - 1) S_i^2}{\sum_{i=1}^{k} (n_i - 1)}}$$ **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.

$$\text{Pooled Coefficient of Variation} = \frac{S_p}{1} = S_p \qquad \textbf{Equation 5}$$

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.

$$\text{Basis Values:} \quad \begin{aligned} A-basis &= \bar{X} - K_a S \\ B-basis &= \bar{X} - K_b S \end{aligned} \qquad \textbf{Equation 6}$$

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:

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

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

Where

r = the number of environments being pooled together

n_j= number of data values for environment j

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

$$f = N - r$$

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

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

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

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

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.

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

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

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

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

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 CMH-17-1G.

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

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

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:

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

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:

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

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.

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

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:

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

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

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

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:

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

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:

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

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 and 5.

2.2 STAT17

This section contains the details of the specific formulas STAT17 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); STAT17 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

STAT17 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-factors 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 11). 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:

$$\hat{\alpha}\hat{\beta}\mathrm{n} - \frac{\hat{\beta}}{\hat{\alpha}^{\hat{\beta}-1}}\sum_{i=1}^{n} x_i^{\hat{\beta}} = 0$$ **Equation 36**

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

STAT17 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

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

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 6.

2.2.2.3.3 Basis value calculations for the Weibull distribution

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

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

where

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

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

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

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

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

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

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 $(0 < a < b < \infty)$ 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:

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

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 6.

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 7.

2.2.4 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

The A-basis value is:

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

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

The Hanson-Koopmans method can be used to calculate A-basis values for n less than 299. Find the value k_A corresponding to the sample size n in Table 2-4. For an A-basis value that meets the requirements of CMH-17-1G, 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 10.

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:

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

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

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

$$SSE = SST - SSB \quad \textbf{Equation 54}$$

Next, the mean sums of squares are computed:

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

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

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

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

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

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

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

$$u = \frac{MSB}{MSE}$$ **Equation 59**

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

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

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

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

2.3 Single Batch and Two Batch estimates using modified CV

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

Estimated B-Basis = $\bar{X} - k_b S_{adj} = \bar{X} - k_b \cdot 0.08 \cdot \bar{X}$ **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 [12].

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

With:

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

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 for publication in 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. Caution is recommended with B-Basis values calculated from STAT17 when the B-basis value is 90% or more of the average value. Basis values of 90% or more of the mean value imply that the CV is unusually low and may not be conservative. Such values will be indicated.
6. If the data appear questionable (e.g. when the CTD-RTD-ETW trend of the basis values are not consistent with the CTD-RTD-ETW trend of the average values), then the B-basis values will not be recommended.

NCAMP Recommended B-basis Values for ACG MTM45-1/CF0525-36%RW 3K PW AS4 Fabric

All B-basis values in this table meet the standards for publication in CMH-17G Handbook

Values are for normalized data unless otherwise noted

Lamina Strength Tests

Environment	Statistic	WT	WC	FT	FC	SBS*	IPS* 0.2% Offset	IPS* 5% Strain
CTD (-65°F)	B-basis	112.76	NA:A	NA:A	NA:A	NA:A	6.61	NA:I
	Mean	129.48	102.24	124.00	93.13	11.67	7.85	13.25
	CV	9.86	10.73	8.05	10.45	5.64	8.46	2.38
RTD (75°F)	B-basis	115.85	84.01	109.23	NA:A	9.18	5.27	8.78
	Mean	132.49	95.29	124.79	87.52	10.41	6.00	9.95
	CV	6.32	6.00	6.32	11.50	6.00	6.56	6.03
ETD (200°F)	B-basis				NA:A	7.61		
	Mean				74.78	8.63		
	CV				11.65	6.00		
ETW (200°F)	B-basis	108.00	NA:A	NA:A	41.23	5.55	2.78	NA:I
	Mean	124.88	65.98	119.65	55.59	6.30	3.32	5.52
	CV	7.34	10.65	8.82	13.41	6.00	8.44	5.36
ETW2 (250°F)	B-basis	111.70	NA:A	NA:A	36.07	4.32	2.32	3.91
	Mean	128.67	52.05	112.92	47.57	4.96	2.63	4.47
	CV	6.00	12.57	13.15	12.40	6.55	10.15	6.37

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/CF0525-36% RW 3K PW AS4 Fabric

All B-basis values in this table meet the standards for publication in CMH-17G 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.	SBS1*
25/50/25	CTD (-65°)	B-basis	45.32		NA:A		NA:A				
		Mean	51.41		53.44		94.90				
		CV	6.00		5.55		5.53				
	RTD (75°F)	B-basis	NA:A	37.61	NA:I	NA:I	NA:A	65.02	69.44	117.89	8.53
		Mean	53.11	41.46	57.52	67.03	94.22	74.62	94.95	133.91	9.68
		CV	5.18	6.00	1.28	5.75	6.30	6.52	14.50	6.46	6.00
	ETW2 (250°F)	B-basis	NA:A	25.44		NA:I	NA:I	NA:A	NA:A	NA:A	NA:A
		Mean	52.53	29.29		41.32	85.84	44.11	70.98	104.36	4.70
		CV	5.54	6.00		7.80	3.72	8.58	17.32	6.81	4.34
10/80/10	CTD (-65°)	B-basis	40.40		NA:I		NA:I				
		Mean	45.83		48.34		59.59				
		CV	6.00		1.75		2.63				
	RTD (75°F)	B-basis	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	
		Mean	43.05	37.86	44.47	46.47	60.16	49.96	82.80	118.36	
		CV	1.46	1.86	0.70	3.74	1.23	3.18	6.17	4.52	
	ETW2 (250°F)	B-basis	NA:I	23.17	NA:I	28.36	NA:I	NA:I	NA:A	79.47	
		Mean	34.90	26.29	36.01	33.02	48.34	31.08	62.63	91.16	
		CV	1.57	6.00	1.08	7.33	3.20	4.24	16.84	6.92	
40/20/40	CTD (-65°)	B-basis	NA:A		NA:I		NA:I				
		Mean	63.85		69.55		114.35				
		CV	6.93		4.30		4.20				
	RTD (75°F)	B-basis	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	NA:I	
		Mean	69.71	45.66	69.18	55.88	116.82	82.94	70.67	111.78	
		CV	3.39	5.92	3.54	6.87	3.02	8.32	9.18	6.59	
	ETW2 (250°F)	B-basis	NA:I	27.11		34.75	NA:I	NA:I	43.65	79.06	
		Mean	73.09	31.76		42.94	109.02	48.31	54.42	91.30	
		CV	2.08	7.41		9.90	2.84	8.19	10.59	7.17	

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 : Recommended B-basis values for laminate test data

3.2 Lamina and Laminate Summary Tables

Prepreg Material:	ACG MTM45-1/CF0525-36%RW 3K PW AS4 Fabric	**ACG MTM45-1/CF0525-36%RW 3K PW AS4 Fabric Lamina Properties Summary**
Material Specification:	ACGM 1001-07 or NMS 451/7	
Process Specification:	ACGP 1001-02 or NPS 81451 "MH" Cure Cycle	

Fiber: Hexcel AS4 **Resin:** MTM45-1

Tg (dry): 375.11 °F **Tg (wet):** 313.38 °F **Tg METHOD:** DMA (SACMA SRM 18R-94)

Date of fiber manufacture	Dec 2004 - Sep 2005	**Date of testing**	Nov 2005-Sep 2006
Date of resin manufacture	Sep - Oct, 2005	**Date of data submittal**	Aug-07
Date of prepreg manufacture	Sep - Oct, 2005	**Date of analysis**	Oct-09
Date of composite manufacture	Sep - Oct, 2005		

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY

Data reported: As measured followed by normalized values in parentheses, normalizing tply: 0.0079 in

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

	CTD			RTD			ETD			ETW			ETW2		
	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^{tu}	102.55	NA	126.70	88.87	112.59	128.88				104.42	103.16	120.73	100.38	110.32	125.14
(ksi)	(105.43)	(112.76)	(129.48)	(102.30)	(115.85)	(132.49)				(108.60)	(108.00)	(124.88)	(104.55)	(111.70)	(128.67)
E_1^t			9.31			9.05						9.21			10.73
(Msi)			(9.52)			(9.31)						(9.53)			(11.03)
F_2^{tu}	69.81	NA	119.62	93.24	106.41	121.50				63.81	NA	115.00	18.62	NA	108.75
(ksi)	(81.20)	NA	(124.00)	(96.22)	(109.23)	(124.79)				(64.65)	NA	(119.65)	(16.54)	NA	(112.92)
E_2^t			8.84			8.62						8.58			9.71
(Msi)			(9.16)			(8.85)						(8.90)			(10.08)
F_1^{cu}	36.07	NA	100.06	84.94	81.64	93.03				25.07	NA	64.01	19.35	NA	50.62
(ksi)	(47.28)	NA	(102.24)	(88.19)	(84.01)	(95.29)				(28.12)	NA	(65.98)	(21.91)	NA	(52.05)
E_1^c			8.48			8.43						9.08			NA
(Msi)			(8.67)			(8.63)						(9.41)			NA
ν_{12}^c			0.046			0.045						0.066			NA
F_2^{cu}	37.68	NA	90.87	27.55	NA	85.76	30.23	NA	73.29	23.71	NA	54.32	35.94	NA	46.62
(ksi)	(44.61)	NA	(93.13)	(28.67)	NA	(87.52)	(30.17)	NA	(74.78)	(41.23)	NA	(55.59)	(36.07)	NA	(47.57)
E_2^c			7.56			7.87			8.16			8.50			NA
(Msi)			(7.75)			(8.05)			(8.32)			(8.69)			NA
ν_{21}^c			0.039			0.097			0.068			0.064			NA
$F_{12}^{s5\%}$ (ksi)	12.53	11.44	13.25	7.92	8.78	9.95				4.83	NA	5.52	4.05	3.91	4.47
$F_{12}^{s0.2\%}$ (ksi)	6.61	NA	7.85	5.43	5.27	6.00				2.78	NA	3.32	2.32	NA	2.63
G_{12}^s (Msi)			0.627			0.541						0.370			0.309
SBS (ksi)	7.89	10.10	11.67	8.33	9.18	10.41	8.27	7.61	8.63	5.30	5.55	6.30	4.46	4.32	4.96

No modulus values were available for compression tests at the ETW2 condition

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

Poissons ratio is not available for tension tests because a uniaxial strain measurement device was used.

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

Prepreg Material:	ACG MTM45-1/CF0525-36%RW 3K PW AS4 Fabric	**ACG MTM45-1/CF0525-36%RW 3K PW AS4 Fabric Laminate Properties Summary**
Material Specification:	ACGM 1001-07 or NMS 451/7	
Process Specification:	ACGP 1001-02 or NPS 81451 "MH" Cure Cycle	
	Fiber: Hexcel AS4	**Resin:** MTM45-1
Tg (dry): 375.11 °F	**Tg (wet):** 313.38 °F	**Tg METHOD :** DMA (SACMA SRM 18R-94)

Date of fiber manufacture	Dec 2004 - Sep 2005	**Date of testing**	Nov 2005-Sep 2006
Date of resin manufacture	Sep - Oct, 2005	**Date of data submittal**	Aug-07
Date of prepreg manufacture	Sep - Oct, 2005	**Date of analysis**	Oct-09
Date of composite manufacture	Sep - Oct, 2005		

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY

Data reported as normalized used a normalizing t_{ply} of 0.0079 in

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	Test Condition	Unit	Quasi Isotropic 25/50/25 B-value	Quasi Isotropic 25/50/25 Mod. CV B-value	Quasi Isotropic 25/50/25 Mean	"Soft" 10/80/10 B-value	"Soft" 10/80/10 Mod. CV B-value	"Soft" 10/80/10 Mean	"Hard" 40/20/40 B-value	"Hard" 40/20/40 Mod. CV B-value	"Hard" 40/20/40 Mean
OHT (normalized)	Strength	CTD	ksi	38.78	45.32	51.41	41.70	40.40	45.83	38.55	54.44	63.85
		RTD	ksi	34.15	46.20	53.11	39.00	36.07	43.05	63.01	58.16	69.71
		ETW	ksi	47.89	46.32	55.93	---	---	---	---	---	---
		ETW2	ksi	33.16	45.60	52.53	32.01	28.88	34.90	67.03	60.48	73.09
OHC (normalized)	Strength	RTD	ksi	33.86	37.61	41.46	34.92	31.63	37.86	40.10	38.15	45.66
		ETW	ksi	25.81	29.01	33.42	---	---	---	---	---	---
		ETW2	ksi	27.09	25.44	29.29	23.76	23.17	26.29	27.48	27.11	31.76
UNT (normalized)	Strength	CTD	ksi	60.57	82.22	94.90	47.06	NA	59.59	90.31	NA	114.35
	Modulus		Msi	---	---	6.53	---	---	4.46	---	---	7.94
	Strength	RTD	ksi	54.01	81.09	94.22	54.23	49.93	60.16	105.84	97.88	116.82
	Modulus		Msi	---	---	6.29	---	---	4.12	---	---	7.69
	Strength	ETW2	ksi	78.73	71.03	85.84	44.33	40.00	48.34	99.98	90.20	109.02
	Modulus		Msi	---	---	6.45	---	---	3.96	---	---	8.65
UNC (normalized)	Strength	RTD	ksi	67.20	65.02	74.62	45.89	41.34	49.96	68.05	NA	82.94
	Modulus		Msi	---	---	5.66	---	---	3.95	---	---	7.89
	Poisson's Ratio			---	---	0.296	---	---	0.551	---	---	0.105
	Strength	ETW	ksi	43.43	NA	56.24	---	---	---	---	---	---
	Modulus		Msi	---	---	6.59	---	---	---	---	---	---
	Poisson's Ratio			---	---	0.325	---	---	---	---	---	---
	Strength	ETW2	ksi	19.81	NA	44.11	22.72	NA	31.08	35.32	NA	48.31
	Modulus		Msi	---	---	6.52	---	---	5.09	---	---	NA
	Poisson's Ratio			---	---	0.358	---	---	0.661	---	---	NA
FHT (normalized)	Strength	CTD	ksi	36.09	46.30	53.44	38.18	NA	48.34	54.93	NA	69.55
		RTD	ksi	51.85	47.74	57.52	40.09	36.91	44.47	62.36	57.42	69.18
		ETW2	ksi	---	---	---	33.03	29.80	36.01	---	---	---
FHC (normalized)	Strength	RTD	ksi	58.08	54.58	67.03	42.68	38.45	46.47	47.82	46.49	55.88
		ETW2	ksi	24.19	34.68	41.32	28.79	28.36	33.02	34.75	NA	42.94
Pin Bearing (normalized)	2% Offset Strength	RTD	ksi	69.44	NA	94.95	71.77	68.51	82.80	56.68	NA	70.67
		ETW2	ksi	1.21	NA	70.98	9.31	NA	62.63	43.65	NA	54.42
	Ultimate Strength	RTD	ksi	112.36	117.89	133.91	107.36	98.90	118.36	96.64	93.40	111.78
		ETW2	ksi	55.37	90.04	104.36	81.29	79.47	91.16	80.48	79.06	91.30
SBS1 (as meas)	Strength	RTD	ksi	9.39	8.53	9.68	---	---	---	---	---	---
		ETW	ksi	4.93	NA	6.43	---	---	---	---	---	---
		ETW2	ksi	3.33	4.12	4.70	---	---	---	---	---	---
ILT (as measured)	Strength	RTD	ksi	---	---	5.22	---	---	---	---	---	---
		ETW2	ksi	---	---	3.77	---	---	---	---	---	---
CBS (as measured)	Strength	RTD	lb	---	---	220.89	---	---	---	---	---	---
		ETW2	lb	---	---	159.24	---	---	---	---	---	---
CAI (normalized)	Strength	RTD	ksi	---	---	34.44	---	---	---	---	---	---

No modulus values were available for compression tests at the ETW2 condition

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 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 of CMH-17-1G Chapter 8 section 8.3.10.

4.1 Warp (0º) Compression Properties (WC)

The Warp Compression data is normalized, so both normalized and as-measured statistics are provided. Only the RTD data, both normalized and as measured, passed the ADK test for batch-to-batch variation. The CTD, ETW and ETW2 data did not pass the ADK, so an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. The modified CV method could not be applied because the coefficient of variation was above 8%. Instead, estimates of basis values for these conditions that were computed with an override of the ADK test results are provided.

There were no outliers.

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

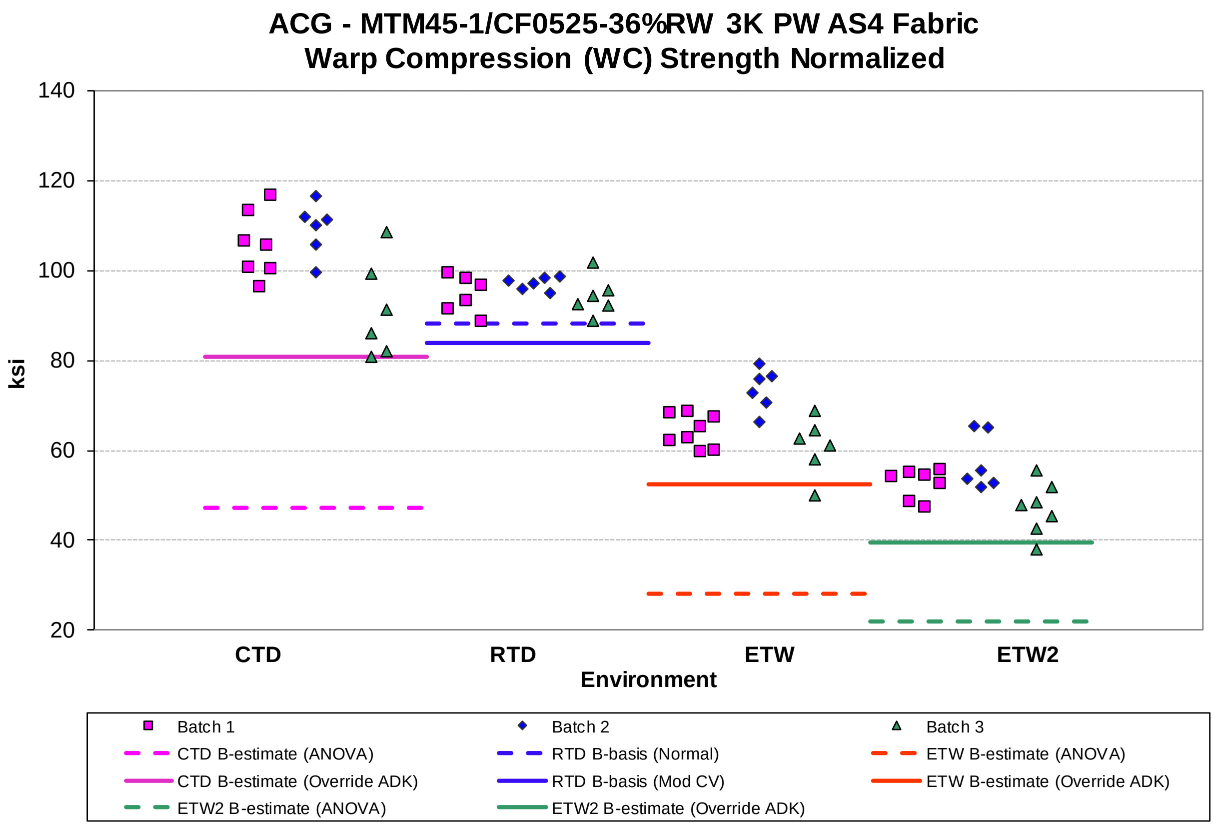

Figure 4-1: Batch Plot for WC Strength Normalized

Warp Compression (WC) Strength Basis Values and Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	102.24	95.29	65.98	52.05	100.06	93.03	64.01	50.62
Stdev	10.98	3.60	7.02	6.54	11.57	4.10	7.00	6.44
CV	10.73	3.78	10.65	12.57	11.56	4.40	10.93	12.72
Mod CV	10.73	6.00	10.65	12.57	11.56	6.20	10.93	12.72
Min	80.74	88.64	49.97	37.83	78.05	85.15	47.81	36.21
Max	116.64	101.77	79.38	65.37	114.38	98.58	76.79	63.28
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	19	18	20	20	19	18	20	20
Basis Values and/or Estimates								
B-basis Value		88.19				84.94		
B-estimate	47.28		28.12	21.91	36.07		25.07	19.35
A-estimate	8.07	83.15	1.11	0.40	0.00	79.21	0.00	0.00
Method	ANOVA	Normal	ANOVA	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and/or Estimates								
B-basis Value		84.01				81.64		
A-estimate		76.02				73.58		
Method		Normal				Normal		
Basis Value Estimates with override of ADK test result								
B-estimate	80.85		52.45	39.45	77.52		50.53	38.22
A-estimate	65.66		42.83	30.49	61.51		40.95	29.39
Method	Normal		Normal	Normal	Normal		Normal	Normal

Table 4-1: Statistics and Basis Values for WC Strength Data

Warp Compression (WC) Modulus Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	8.67	8.63	9.41		8.48	8.43	9.08	
Stdev	0.43	0.27	0.72		0.45	0.30	0.74	
CV	5.01	3.13	7.64		5.30	3.58	8.17	
Mod CV	6.51	6.00	7.82		6.65	6.00	8.17	
Min	7.81	8.02	7.95		7.72	7.60	7.69	
Max	9.22	9.01	10.59		9.20	8.77	10.27	
No. Batches	3	3	3		3	3	3	
No. Spec.	19	16	13		19	16	13	

Modulus values were not available for the ETW2 condition

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

Table 4-2: Statistics from WC Modulus Data

4.2 Warp (0º) Tension Properties (WT)

The Warp Tension data is normalized, so both normalized and as-measured statistics are provided. The RTD and ETW2 data (both normalized and as measured) did not pass the ADK test and required the ANOVA method to compute basis values which may result in overly conservative estimates of the basis values. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. The normalized data could be pooled across all four environments to compute modified CV basis values.

The as measured RTD data did not pass the ADK test under the modified CV transformation. A B-estimate computed using the modified CV method is provided, but is considered an estimate due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method. The as measured CTD dataset had a CV greater than 8%, so modified CV basis values could not be provided.

There was one outlier. The lowest values in batch three of the as-measured ETW2 dataset was an outlier for the batch three, but not for the ETW2 condition. It was retained for this analysis.

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

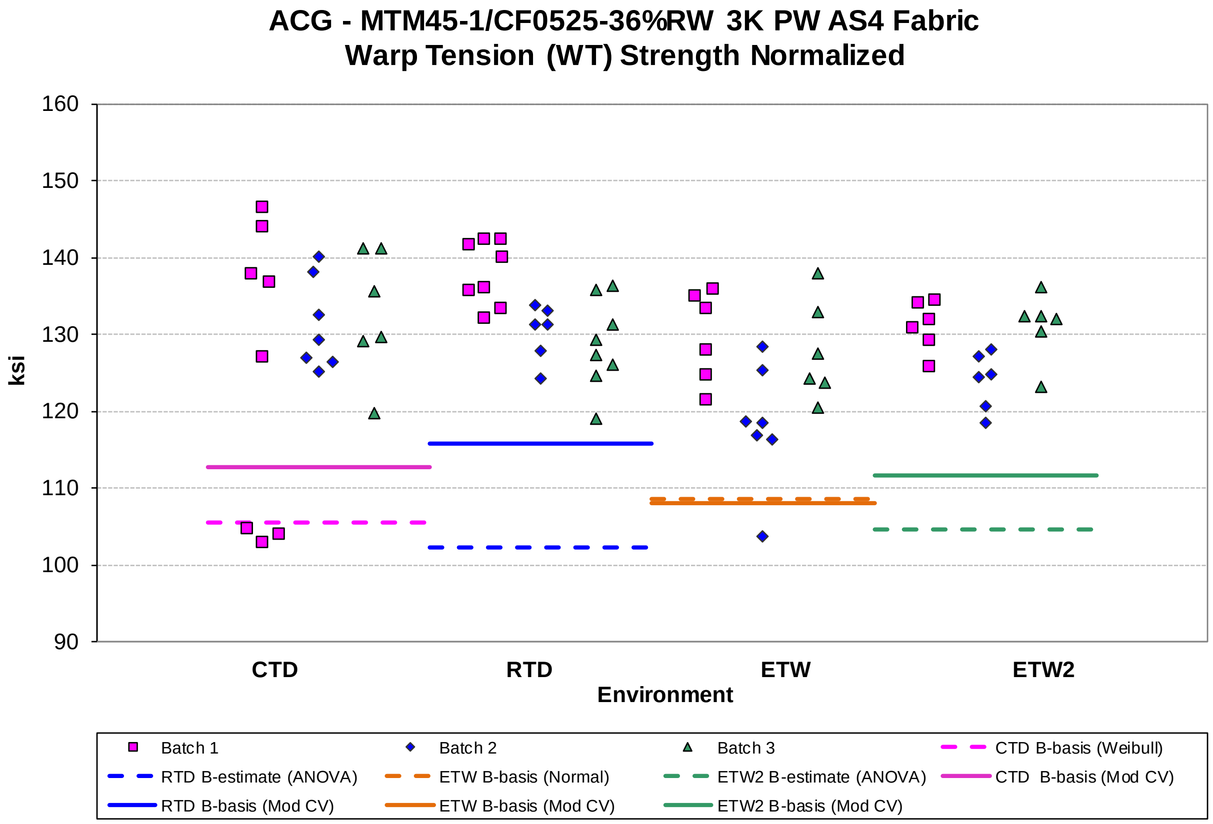

Figure 4-2: Batch Plot for WT Strength Normalized

Warp Tension (WT) Strength Basis Values and Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	129.48	132.49	124.88	128.67	126.70	128.88	120.73	125.14
Stdev	12.77	6.15	8.35	4.94	12.68	6.96	8.37	4.83
CV	9.86	4.64	6.69	3.84	10.01	5.40	6.93	3.86
Mod CV	9.86	6.32	7.34	6.00	10.01	6.70	7.47	6.00
Min	102.81	118.98	103.72	118.49	100.27	114.13	99.06	115.87
Max	146.56	142.33	138.06	136.27	146.96	140.93	134.03	133.27
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	22	19	18	21	22	19	18
Basis Values and/or Estimates								
B-basis Value	105.43		108.60		102.55		104.42	
B-estimate		102.30		104.55		88.87		100.38
A-estimate	83.13	80.74	97.04	87.35	85.33	60.31	92.83	82.72
Method	Weibull	ANOVA	Normal	ANOVA	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and/or Estimates								
B-basis Value	112.76	115.85	108.00	111.70	NA		103.16	110.32
B-estimate						112.59		
A-estimate	101.57	104.65	96.84	100.55	NA	100.96	90.70	99.83
Method	pooled	pooled	pooled	pooled	NA	Normal	Normal	Normal

Table 4-3: Statistics and Basis values for WT Strength Data

Warp Tension (WT) Modulus Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	9.52	9.31	9.53	11.03	9.31	9.05	9.21	10.73
Stdev	0.23	0.20	0.44	0.59	0.23	0.17	0.43	0.53
CV	2.37	2.11	4.65	5.31	2.43	1.87	4.64	4.90
Mod CV	6.00	6.00	6.32	6.65	6.00	6.00	6.32	6.45
Min	9.02	8.83	9.14	10.04	8.80	8.62	8.93	9.96
Max	10.03	9.67	11.18	12.37	9.64	9.38	10.88	11.81
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	22	19	18	21	22	19	18

Table 4-4: Statistics from WT Modulus Data

4.3 Fill (90°) Tension Properties (FT)

The Fill Tension data is normalized, so both normalized and as-measured statistics are provided. None of the conditions tested passed the ADK test, so all conditions required the ANOVA method to compute basis values which may result in overly conservative estimates of the basis values. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. Only the RTD condition passed the ADK test after the modified CV transformation, so modified CV basis values are provided only for that condition. For the CTD, ETW and ETW2 datasets, the modified CV method could not be applied because the coefficient of variation was above 8%. Instead, estimates of basis values for these conditions that were computed with an override of the ADK test results are provided.

There were two outliers. The lowest value in batch three of the CTD condition for both the normalized and as measured datasets. It was an outlier for the CTD condition, but not for batch three. The lowest value in batch two of the as measured RTD dataset was an outlier for batch two, but not for the RTD condition. It was not an outlier in the normalized RTD data. Both outliers were retained for this analysis.

Statistics, estimates and basis values are given for strength data in Table 4-5 and for the modulus data in Table 4-6. The normalized data, B-estimates and B-basis value are shown graphically in Figure 4-3.

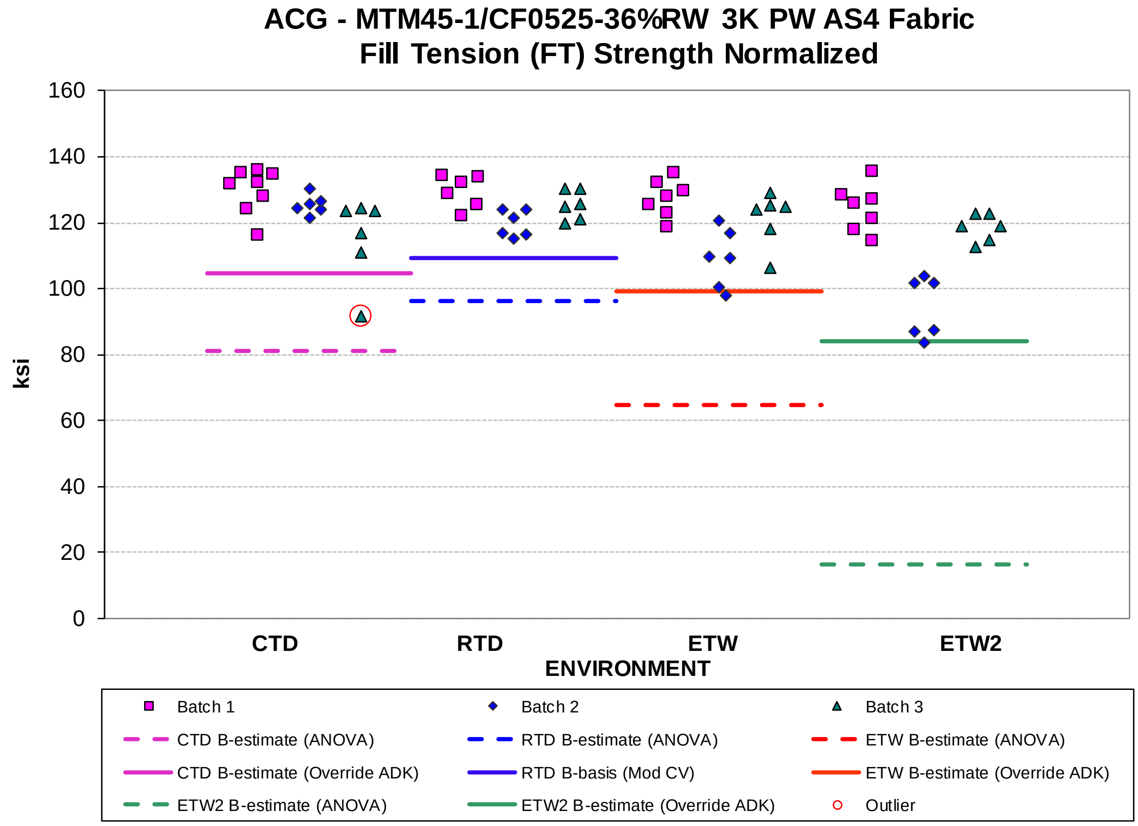

Figure 4-3: Batch Plot for FT Strength Normalized

Fill Tension (FT) Strength Basis Values and Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	124.00	124.79	119.65	112.92	119.62	121.50	115.00	108.75
Stdev	9.98	5.79	10.55	14.84	10.33	5.57	10.18	14.58
CV	8.05	4.64	8.82	13.15	8.63	4.58	8.85	13.40
Mod CV	8.05	6.32	8.82	13.15	8.63	6.29	8.85	13.40
Min	91.46	115.30	97.80	83.72	86.83	110.99	94.14	80.38
Max	135.86	134.16	135.04	135.19	132.85	132.43	131.02	135.48
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	20	18	19	19	20	18	19	19
Basis Values and/or Estimates								
B-estimate	81.20	96.22	64.65	16.54	69.81	93.24	63.81	18.62
A-estimate	50.67	75.84	25.42	0.00	34.27	73.08	27.29	0.00
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and/or Estimates								
B-basis Value		109.23				106.41		
A-estimate		98.22				95.73		
Method		Normal				Normal		
Basis Value Estimates with override of ADK test result								
B-estimate	104.77		99.09	83.99	100.63		95.16	80.34
A-estimate	91.10		84.51	63.47	82.44		81.10	60.19
Method	Normal		Normal	Normal	Weibull		Normal	Normal

Table 4-5: Statistics and Basis Values for FT Strength Data

Fill Tension (FT) Modulus Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	9.16	8.85	8.90	10.08	8.84	8.62	8.58	9.71
Stdev	0.45	0.14	0.31	0.31	0.41	0.26	0.30	0.35
CV	4.86	1.62	3.43	3.09	4.62	3.00	3.48	3.64
Mod CV	6.43	6.00	6.00	6.00	6.31	6.00	6.00	6.00
Min	8.29	8.59	8.47	9.28	8.04	8.22	8.11	8.84
Max	10.32	9.11	9.35	10.54	9.80	9.01	9.07	10.25
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	18	17	17	21	18	17	17

Table 4-6: Statistics from FT Modulus Data

4.4 Fill (90°) Compression Properties (FC)

The Fill Compression data is normalized, so both normalized and as-measured statistics are provided. The CTD, RTD and ETD data (both normalized and as measured) and the as measured ETW data did not pass the ADK test, so those conditions required the ANOVA method to compute basis values which may result in overly conservative estimates of the basis values. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. The modified CV method could not be applied to any of these datasets because the coefficient of variation was above 8% in all cases. Estimates of basis values for these conditions that were computed with an override of the ADK test results are provided for the CTD, RTD and ETD data (both normalized and as measured) and the as measured ETW data.

There was one outlier. The lowest value in batch three of the CTD condition for both normalized and as measured datasets. It was an outlier for batch three, but not for the CTD condition. It was retained for this analysis.

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

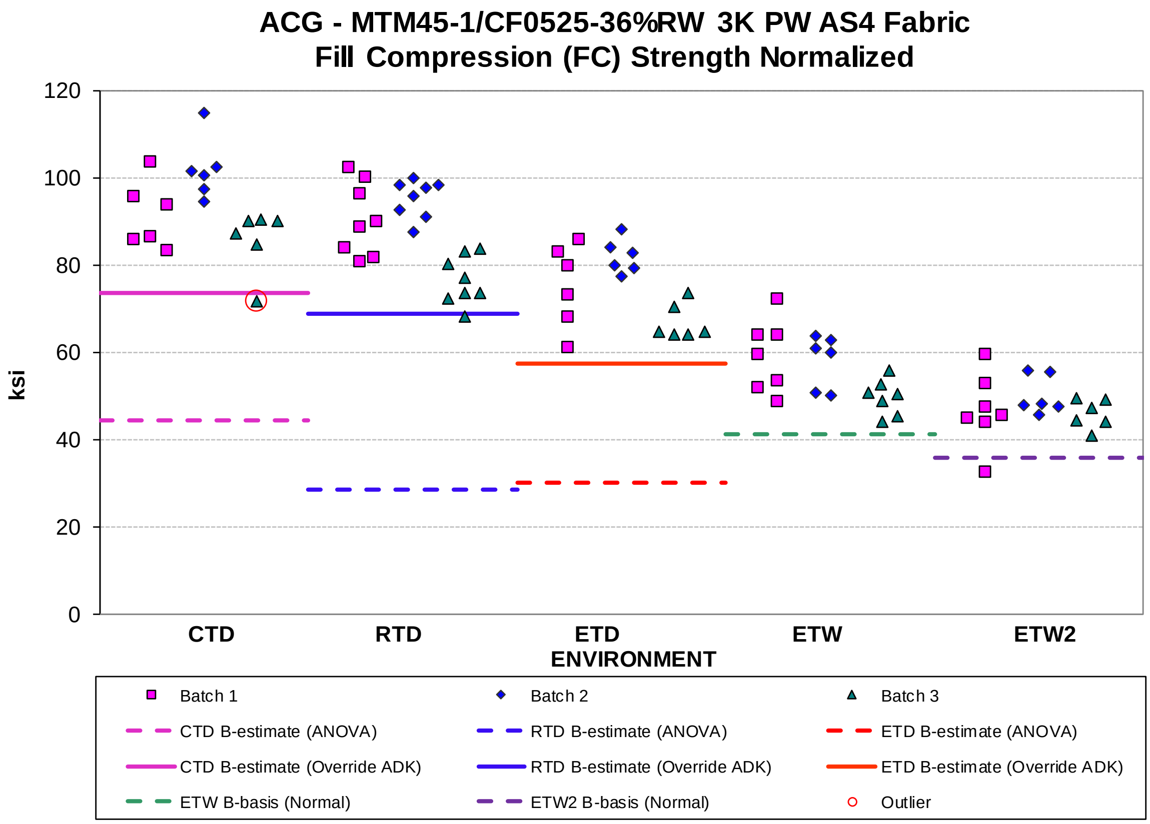

Figure 4-4: Batch Plot for FC strength normalized

Fill Compression (FC) Strength Basis Values and Statistics										
	Normalized					As Measured				
Env	CTD	RTD	ETD	ETW	ETW2	CTD	RTD	ETD	ETW	ETW2
Mean	93.13	87.52	74.78	55.59	47.57	90.87	85.76	73.29	54.32	46.62
Stdev	9.74	10.06	8.71	7.46	5.90	9.78	9.52	8.15	6.85	5.48
CV	10.45	11.50	11.65	13.41	12.40	10.76	11.10	11.12	12.61	11.76
Mod CV	10.45	11.50	11.65	13.41	12.40	10.76	11.10	11.12	12.61	11.76
Min	71.99	68.45	61.09	44.35	32.52	70.12	66.67	59.75	43.02	32.63
Max	115.17	102.29	88.26	72.24	59.36	111.95	98.55	85.44	69.22	57.38
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	24	18	20	19	18	24	18	20	19
Basis Values and/or Estimates										
B-basis Value				41.23	36.07					35.94
B-estimate	44.61	28.67	30.17			37.68	27.55	30.23	23.71	
A-estimate	10.02	0.00	0.00	31.01	27.91	0.00	0.00	0.00	1.86	28.35
Method	ANOVA	ANOVA	ANOVA	Normal	Normal	ANOVA	ANOVA	ANOVA	ANOVA	Normal
Basis Value Estimates with override of ADK test result										
B-estimate	73.91	68.87	57.58			71.57	68.12	57.20	41.12	
A-estimate	60.31	55.50	45.41			57.92	55.47	45.82	31.74	
Method	Normal	Normal	Normal			Normal	Normal	Normal	Normal	

Table 4-7: Statistics and Basis Values for FC Strength Data

Fill Compression (FC) Modulus Statistics										
	Normalized					As Measured				
Env	CTD	RTD	ETD	ETW	ETW2	CTD	RTD	ETD	ETW	ETW2
Mean	7.75	8.05	8.32	8.69		7.56	7.87	8.16	8.50	
Stdev	0.49	0.46	0.48	0.65		0.46	0.46	0.47	0.66	
CV	6.32	5.73	5.76	7.51		6.09	5.81	5.80	7.71	
Mod CV	7.16	6.86	6.88	7.76		7.05	6.91	6.90	7.85	
Min	6.94	7.41	7.41	7.45		6.81	7.22	7.23	7.28	
Max	8.87	8.99	9.24	10.53		8.67	8.75	9.04	10.10	
No. Batches	3	3	3	3		3	3	3	3	
No. Spec.	17	22	18	19		17	22	18	19	

Modulus values were not available for the ETW2 condition

Table 4-8: Statistics from FC Modulus Data

4.5 In-Plane Shear Properties (IPS)

The In-Plane Shear data is not normalized. The 0.2% offset strength data did not meet all requirements for pooling across the four environments. The data does not pass Levene's test for equality of variance. The ETW2 data did not fit any distribution adequately, so the non-parametric approach was used for this condition. Only the RTD environment had a CV below 8%, so modified CV basis values are provided only for that environment.

The strength at 5% strain data failed the ADK test for the RTD condition. This means that dataset required the ANOVA method to compute basis values which may result in overly conservative basis values. The RTD data did pass the normality test, and passes the ADK test under the modified CV transformation, so the modified CV values are provided. The CTD and ETW datasets had insufficient specimens to meet the requirements of CMH-17-1G for publishable basis values, so B-estimates only are provided. The 5% strain strength ETW data did not pass the normality test, so modified CV basis values and estimates are not provided for that dataset.

There were three outliers in the 0.2% offset strength data and a fourth in the 5% strain strength data. In the 0.2% offset strength data, the ETW data had two outliers; both were outliers only for their respective batches, but not for the ETW condition. One outlier was on the low side of batch two and the second on the high side of batch three. The third outlier was in the ETW2 condition on the high side of batch one. It was an outlier both for batch one and for the ETW2 condition. The outlier in the 5% strain strength data was in the RTD condition. It was on the high side of batch three. It was an outlier for batch three only, but not for the RTD condition. All four outliers were retained for this analysis.

Statistics, estimates and basis values are given for strength data in Table 4-9 and for the modulus data in Table 4-10. The as measured data, B-estimates and B-basis values are shown graphically in Figure 4-5 and Figure 4-6.

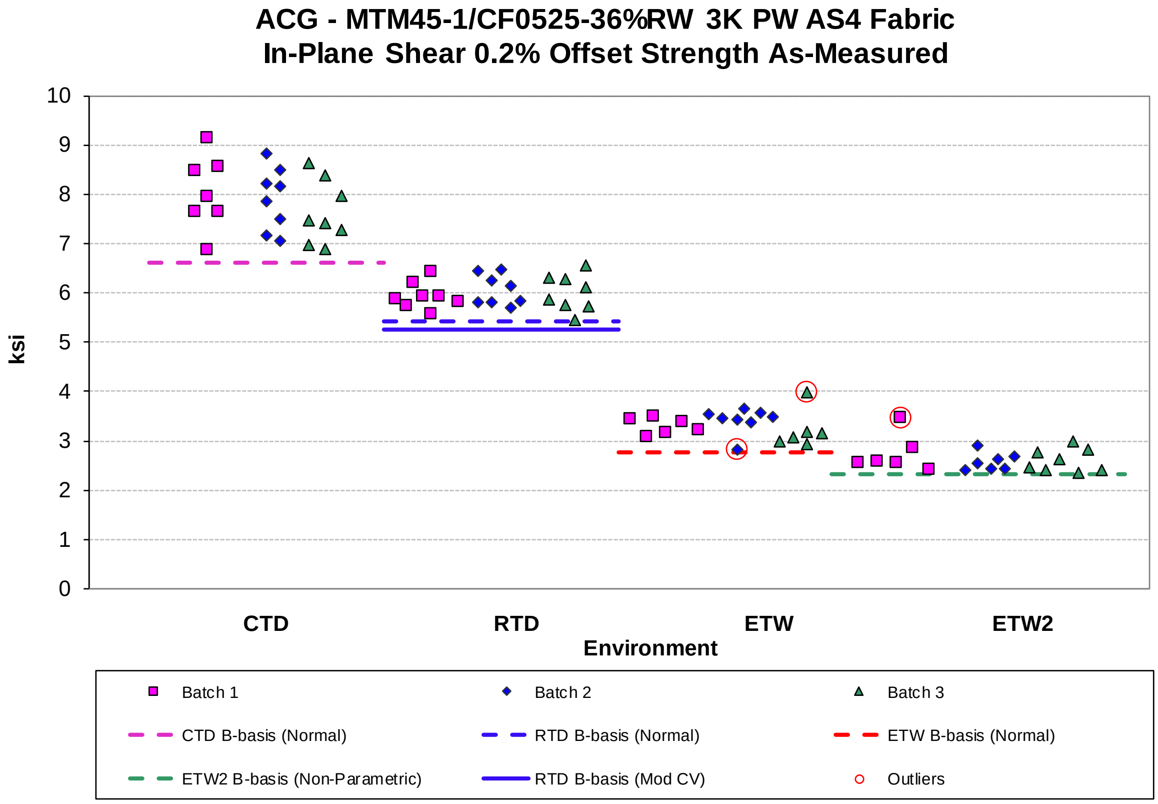

Figure 4-5: Batch Plot for IPS Strength at 0.2% Offset As-Measured

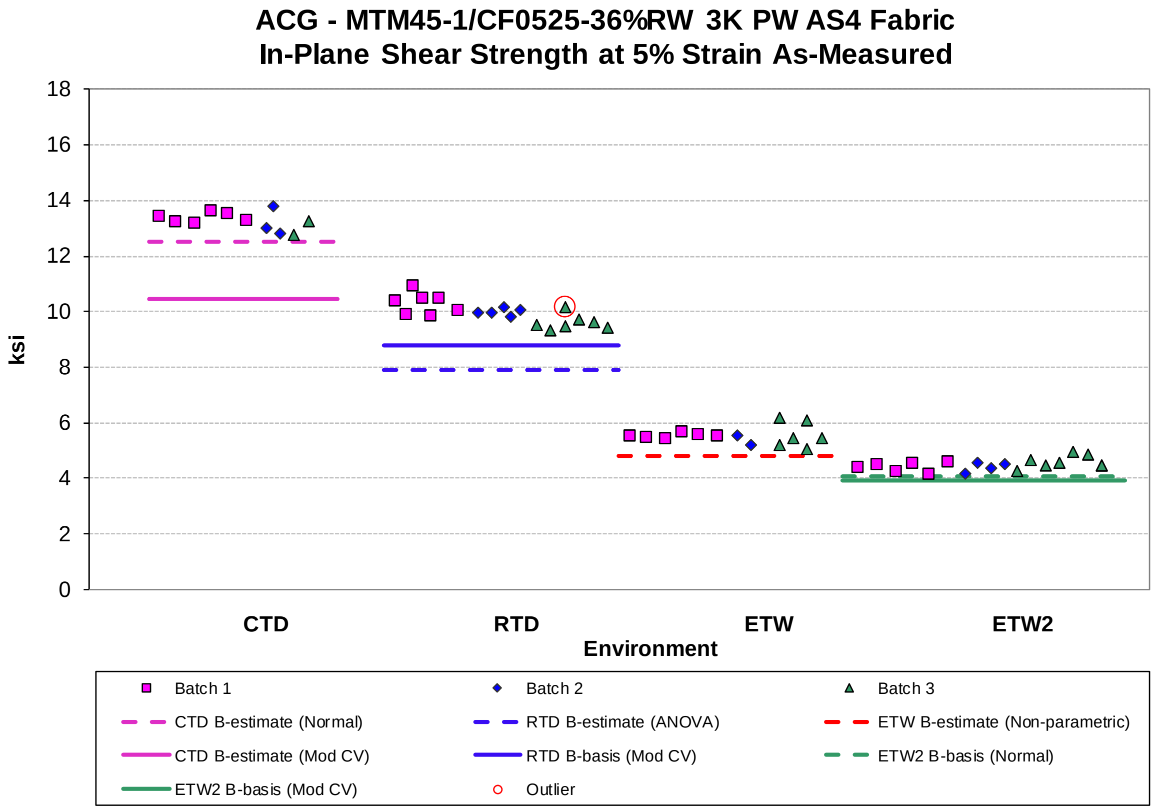

Figure 4-6: Batch Plot for IPS Strength at 5% Strain As-Measured

In-Plane Shear (IPS) Strength As-Measured Basis Values and Statistics								
	Strength at 5% Strain				0.2% Offset Strength			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	13.25	9.95	5.52	4.47	7.85	6.00	3.32	2.63
Stdev	0.32	0.40	0.30	0.21	0.66	0.31	0.28	0.27
CV	2.38	4.05	5.36	4.74	8.46	5.12	8.44	10.15
Mod CV	6.00	6.03	6.68	6.37	8.46	6.56	8.44	10.15
Min	12.75	9.35	5.07	4.14	6.86	5.46	2.84	2.35
Max	13.79	10.91	6.16	4.95	9.14	6.55	3.98	3.47
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	11	19	14	18	23	24	20	21
Basis Values and/or Estimates								
B-basis Value				4.05	6.61	5.43	2.78	2.32
B-estimate	12.53	7.92	4.83					
A-estimate	12.03	6.47	3.52	3.76	5.72	5.02	2.40	1.41
Method	Normal	ANOVA	Non-Parametric	Normal	Normal	Normal	Normal	Non-Parametric
Modified CV Basis Values and/or Estimates								
B-basis Value		8.78		3.91	NA	5.27	NA	NA
B-estimate	11.44		NA					
A-estimate	10.19	7.95	NA	3.51	NA	4.75	NA	NA
Method	Normal	Normal	NA	Normal	NA	Normal	NA	NA

Table 4-9: Statistics and Basis Values for IPS Strength Data

In-Plane Shear (IPS) Modulus As-Measured Statistics				
Env	CTD	RTD	ETW	ETW2
Mean	0.63	0.54	0.37	0.31
Stdev	0.03	0.04	0.03	0.03
CV	5.41	7.52	9.23	10.61
Mod CV	6.71	7.76	9.23	10.61
Min	0.56	0.47	0.31	0.25
Max	0.71	0.60	0.44	0.38
No. Batches	3	3	3	3
No. Spec.	23	24	20	21

Table 4-10: Statistics from IPS Modulus Data

4.6 Lamina Short Beam Strength (SBS)

The Short Beam Strength data is not normalized. Pooling across the environments was not acceptable due to the data failing Levene's test for equality of variance. The CTD, RTD and ETW conditions did not pass the ADK test. This means those datasets required the ANOVA method to compute basis values which may result in overly conservative basis values. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. The RTD and ETW conditions data did pass the normality test, and passed the ADK test under the modified CV transformation, so the modified CV values are provided. B-estimates computed using the modified CV method are provided for the CTD condition, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method.

There were two outliers, both in the ETW2 condition. The highest value in batch two and the lowest value in batch three, both were outliers only for their respective batches, but not for the ETW2 condition. Both outliers were retained for this analysis.

Statistics, basis values and estimates are given for SBS strength data in Table 4-11. The as measured data, B-estimates and B-basis values are shown graphically in Figure 4-7.

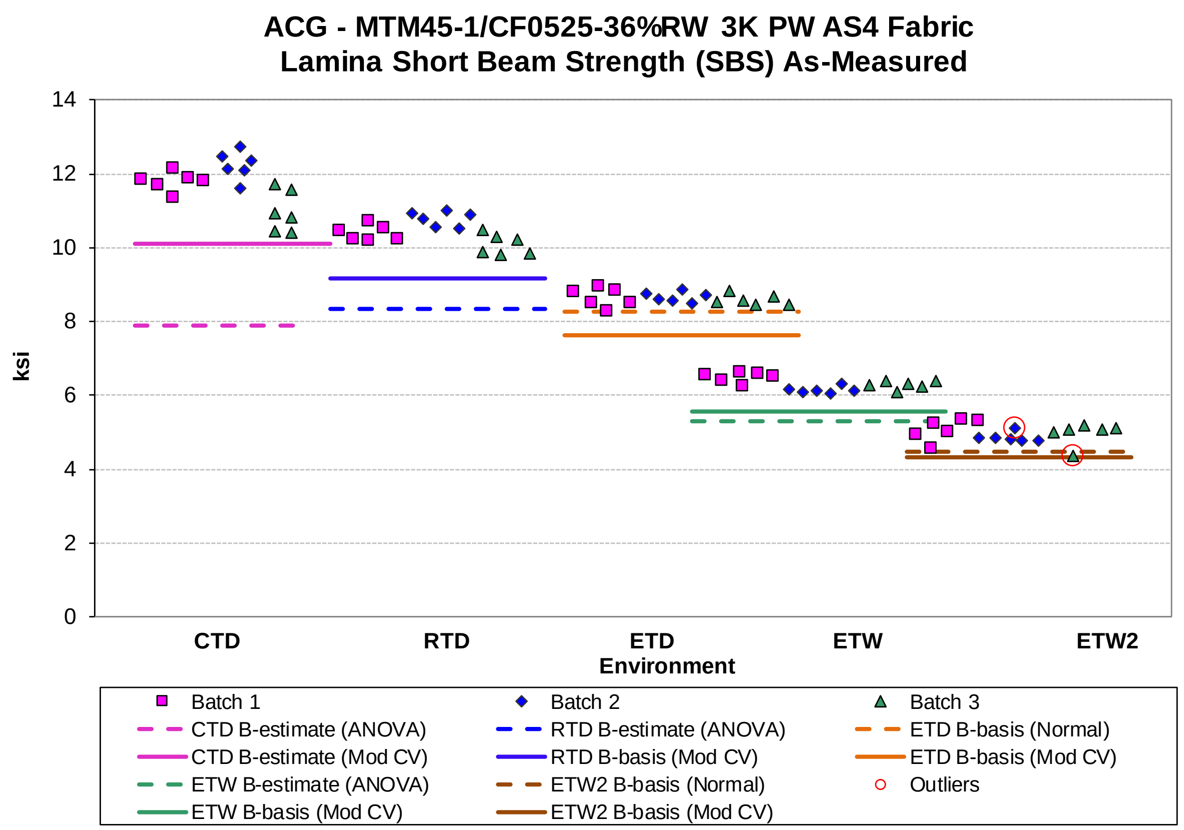

Figure 4-7: Batch Plot for SBS As-Measured

Short Beam Strength (SBS) As-Measured Basis Values and Statistics					
Env	CTD	RTD	ETD	ETW	ETW2
Mean	11.67	10.41	8.63	6.30	4.96
Stdev	0.66	0.36	0.18	0.18	0.25
CV	5.64	3.50	2.13	2.83	5.09
Mod CV	6.82	6.00	6.00	6.00	6.55
Min	10.42	9.81	8.25	6.07	4.37
Max	12.72	10.99	8.95	6.62	5.32
No. Batches	3	3	3	3	3
No. Spec.	18	18	18	18	18
Basis Values and/or Estimates					
B-basis Value			8.27		4.46
B-estimate	7.89	8.33		5.30	
A-estimate	5.19	6.84	8.01	4.60	4.11
Method	ANOVA	ANOVA	Normal	ANOVA	Normal
Modified CV Basis Values and/or Estimates					
B-basis Value		9.18	7.61	5.55	4.32
B-estimate	10.10				
A-estimate	8.99	8.31	6.88	5.02	3.86
Method	Normal	Normal	Normal	Normal	Normal

Table 4-11: Statistics and Basis Values for SBS Data

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

Many of the laminate tests were performed with one batch only. In those cases, there was insufficient data to produce basis values meeting the requirements of CMH-17-1G, so only estimates are provided. When possible, estimates were prepared in the following ways and multiple estimates are provided.

1. Using the ASAP program to pool across the available environments. The modified CV values from this program are provided.
2. The Lamina Variability method detailed in section 2.4. LVM Mod CV values are not available for laminate test properties that use the CV from the following lamina tests and conditions due to their CV's being greater than 8%.
    a. WC CTD
    b. WC ETW
    c. WC ETW2
    d. WT CTD
    e. FC all conditions
    f. FT CTD
    g. FT ETW
    h. FT ETW2

5.1 Unnotched Tension Properties

5.1.1 Quasi Isotropic Unnotched Tension (UNT1)

The UNT1 data is normalized. The CTD and RTD conditions did not pass the ADK test for either the as measured or normalized datasets. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. This means those datasets required the ANOVA method to compute basis values may result in overly conservative basis values. They did not pass the ADK test under the modified CV transformation. B-estimates computed using the modified CV method are provided, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method. The as measured CTD data failed the normality test, so modified CV B-estimates are not appropriate for that dataset. The ETW2 condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were two outliers, both were outliers only for their respective batches, but not for their respective conditions. The lowest value in batch one of the normalized CTD dataset. The highest value in batch one of the RTD condition was an outlier for both the normalized and as measured datasets. Both outliers were retained for this analysis.

Statistics and A- and B-estimates are given for strength data in Table 5-1 and for the modulus data in Table 5-2. The normalized data and the B-estimates are shown graphically in Figure 5-1.

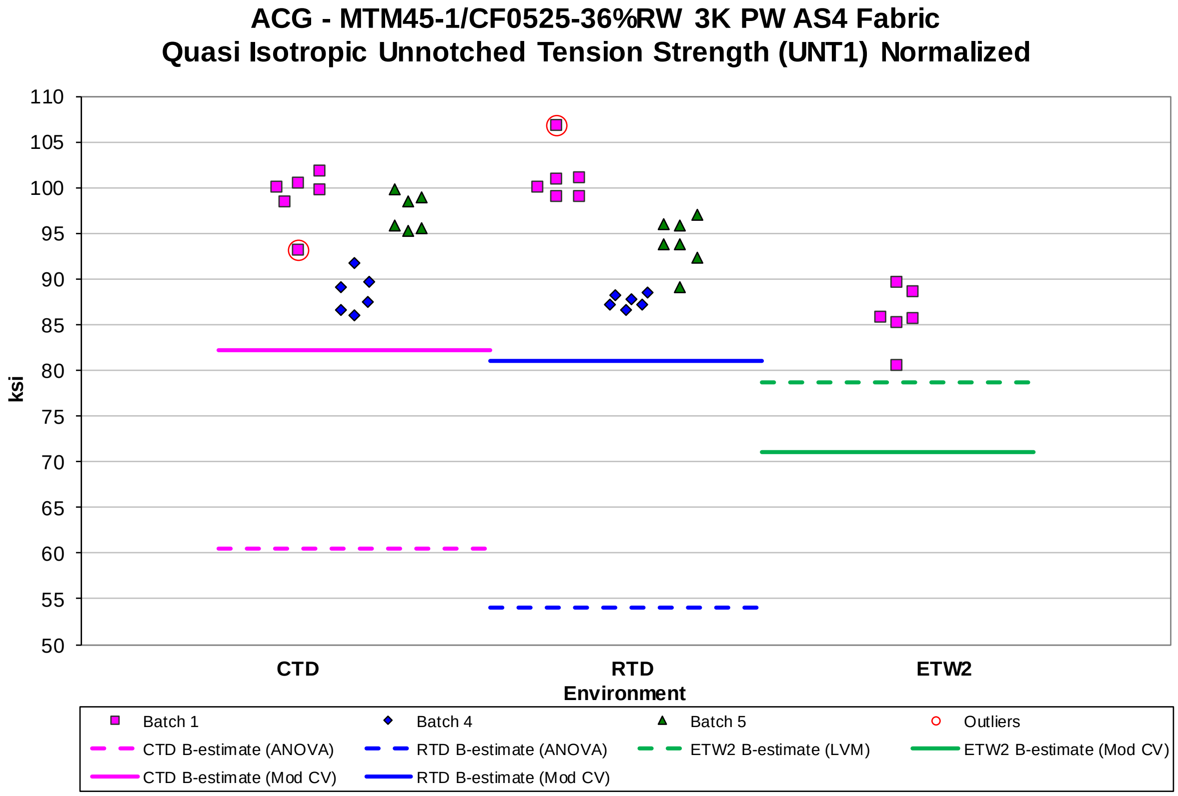

Figure 5-1: Batch Plot for UNT1 Strength Normalized

Quasi Isotropic Unnotched Tension (UNT1) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	94.90	94.22	85.84	90.67	90.47	80.98
Stdev	5.25	5.94	3.19	4.86	5.37	3.66
CV	5.53	6.30	3.72	5.36	5.93	4.52
Modified CV	6.77	7.15	8.00	6.68	6.97	8.00
Min	86.08	86.69	80.45	83.06	82.57	75.33
Max	101.69	106.70	89.61	96.72	102.88	85.70
No. Batches	3	3	1	3	3	1
No. Spec.	18	19	6	18	19	6
Basis Values and/or Estimates						
B-estimate	60.57	54.01	78.73	59.78	56.93	73.09
A-estimate	36.07	25.31	NA	37.74	33.00	NA
Method	ANOVA	ANOVA	LVM	ANOVA	ANOVA	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	82.22	81.09	71.03	NA	78.18	67.01
A-estimate	73.25	71.78	NA	NA	69.47	NA
Method	Normal	Normal	LVM	NA	Normal	LVM

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

Quasi Isotropic Unnotched Tension (UNT1) Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	6.53	6.29	6.45	6.24	6.03	6.09
Stdev	0.60	0.39	0.15	0.59	0.36	0.14
CV	9.13	6.13	2.27	9.41	5.94	2.32
Modified CV	9.13	7.07	6.00	9.41	6.97	6.00
Min	5.68	4.81	6.29	5.42	4.68	5.89
Max	8.30	6.67	6.68	7.96	6.38	6.26
No. Batches	3	3	1	3	3	1
No. Spec.	18	18	5	18	18	5

Table 5-2: Statistics from UNT1 Modulus Data

5.1.2 "Soft" Unnotched Tension Properties (UNT2)

The UNT2 data is normalized. This property had data from only one batch available. There was insufficient data to meet the requirements of CMH-17-1G, so only estimates are provided. B-estimates were prepared using the laminate variability method (LVM) detailed in section 2.4. Modified CV values are not available for the CTD condition due to the large CV of the warp tension lamina data for the CTD condition which was used to compute the LVM B-estimate.

There were no outliers.

Statistics and A- and B-estimates are given for strength data in Table 5-3 and for the modulus data in Table 5-4. The normalized data and the B-estimates are shown graphically in Figure 5-2.

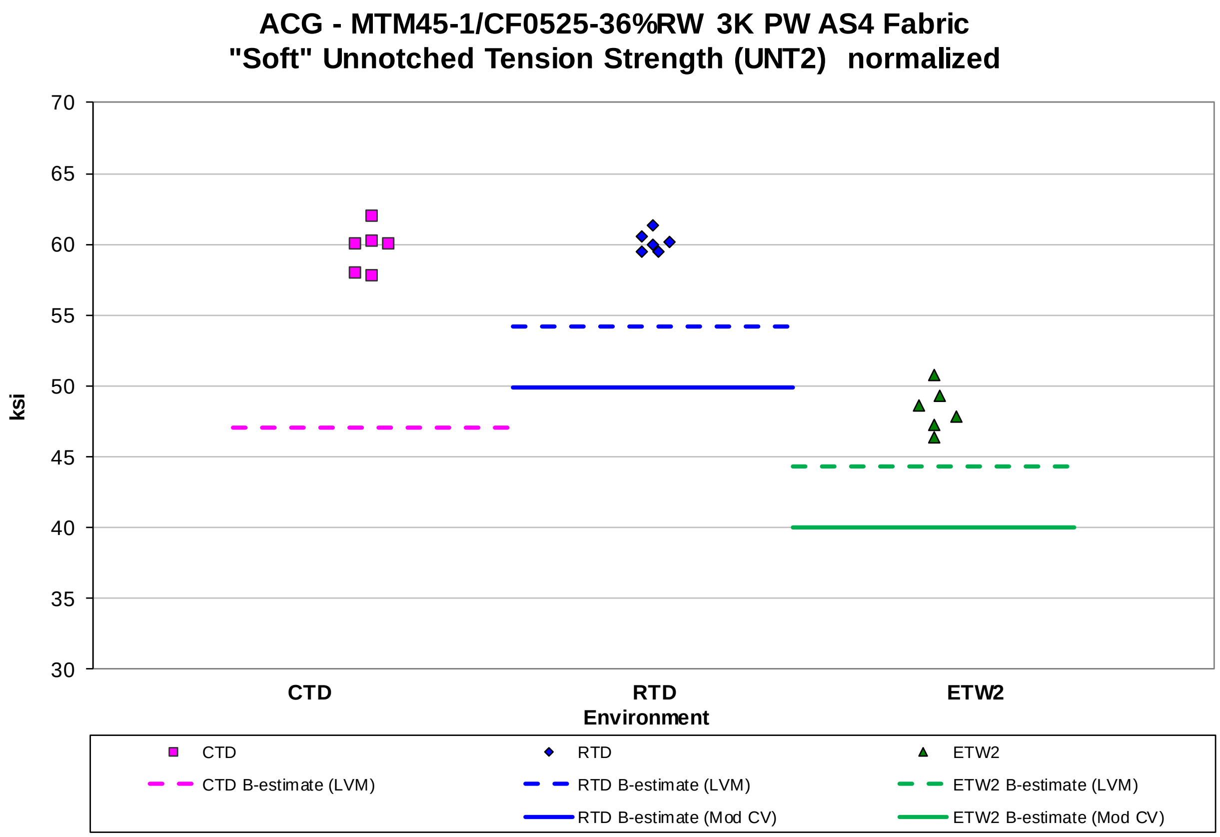

Figure 5-2: Batch Plot for UNT2 Strength Normalized

"Soft" Unnotched Tension (UNT2) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	59.59	60.16	48.34	57.42	57.95	46.35
Stdev	1.57	0.74	1.55	1.93	0.67	1.33
CV	2.63	1.23	3.20	3.36	1.15	2.87
Modified CV	8.00	8.00	8.00	8.00	8.00	8.00
Min	57.69	59.42	46.38	55.19	57.18	44.77
Max	61.90	61.37	50.76	59.93	58.88	48.74
No. Batches	1	1	1	1	1	1
No. Spec.	6	6	6	6	6	6
Basis Values and/or Estimates						
B-estimate	47.06	54.23	44.33	45.17	51.31	42.49
A-estimate	NA	NA	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	NA	49.93	40.00	NA	48.10	38.35
A-estimate	NA	NA	NA	NA	NA	NA
Method	NA	LVM	LVM	NA	LVM	LVM

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

"Soft" Unnotched Tension (UNT2) Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	4.46	4.12	3.96	4.30	3.97	3.80
Stdev	0.11	0.10	0.20	0.13	0.09	0.21
CV	2.41	2.38	4.95	3.06	2.33	5.40
Modified CV	6.00	6.00	6.47	6.00	6.00	6.70
Min	4.33	4.01	3.74	4.12	3.88	3.53
Max	4.63	4.23	4.25	4.48	4.07	4.10
No. Batches	1	1	1	1	1	1
No. Spec.	6	5	6	6	5	6

Table 5-4: Statistics from UNT2 Modulus Data

5.1.3 "Hard" Unnotched Tension Properties (UNT3)

The UNT3 data is normalized. This property had data from only one batch available. There was insufficient data to meet the requirements of CMH-17-1G, so only estimates are provided. B-estimates were prepared using the laminate variability method (LVM) detailed in section 2.4. Modified CV values are not available for the CTD condition due to the large CV of the warp tension lamina data for the CTD condition which was used to compute the LVM B-estimate.

There were no outliers.

Statistics and A- and B-estimates are given for strength data in Table 5-5 and for the modulus data in Table 5-6. The normalized data and B-estimates are shown graphically in Figure 5-3.

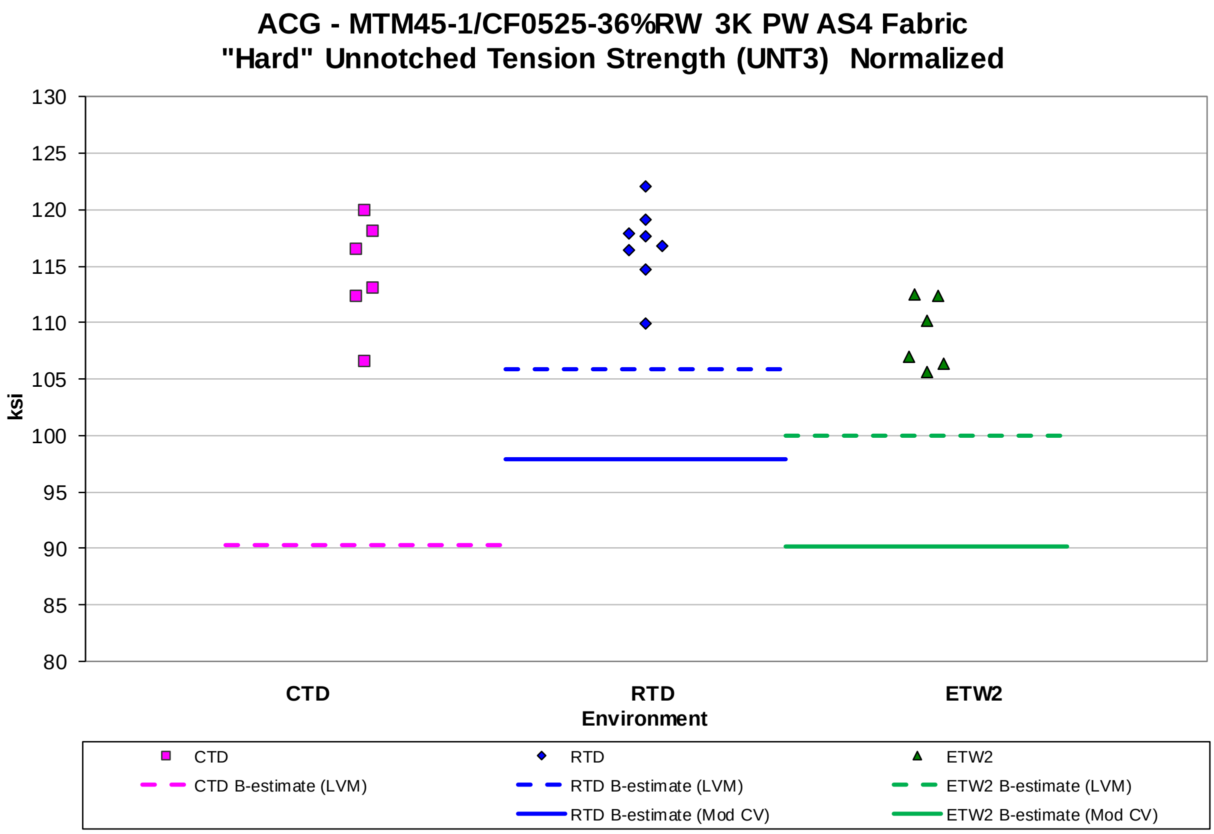

Figure 5-3: Batch Plot for UNT3 Strength Normalized

"Hard" Unnotched Tension (UNT3) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	114.35	116.82	109.02	119.01	122.09	113.02
Stdev	4.80	3.53	3.10	4.62	3.58	3.35
CV	4.20	3.02	2.84	3.88	2.93	2.97
Modified CV	8.00	8.00	8.00	8.00	8.00	8.00
Min	106.54	109.94	105.58	111.33	114.68	109.04
Max	119.93	122.12	112.56	124.66	126.50	117.38
No. Batches	1	1	1	1	1	1
No. Spec.	6	8	6	6	8	6
Basis Values and/or Estimates						
B-estimate	90.31	105.84	99.98	93.62	108.73	103.60
A-estimate	NA	NA	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	NA	97.88	90.20	NA	102.29	93.52
A-estimate	NA	NA	NA	NA	NA	NA
Method	NA	LVM	LVM	NA	LVM	LVM

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

"Hard" Unnotched Tension (UNT3) Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	7.94	7.69	8.65	8.27	8.02	8.95
Stdev	0.45	0.06	0.30	0.47	0.07	0.34
CV	5.70	0.82	3.43	5.71	0.91	3.75
Modified CV	6.85	6.00	6.00	6.86	6.00	6.00
Min	7.47	7.58	8.38	7.71	7.92	8.65
Max	8.63	7.75	9.02	8.97	8.10	9.33
No. Batches	1	1	1	1	1	1
No. Spec.	6	6	5	6	6	5

Table 5-6: Statistics from UNT3 Modulus Data

5.2 Unnotched Compression Properties

5.2.1 Quasi Isotropic Unnotched Compression (UNC1)

The UNC1 data is normalized. The data for the ETW2 condition, both normalized and as measured, did not pass the Anderson-Darling k-sample test for batch-to-batch variation, so an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates and may be overly conservative.

Modified CV basis values are not provided for the normalized and as measured ETW2 datasets due to the failuires of ADK after the modified CV method is applied and had a CV greater than 8%.. The ETW condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4. A modified CV basis value is not available due to the large variation of the corresponding lamina (WC) data.

There was one outlier. The lowest value in batch four of the RTD condition for both the normalized and as measured datasets. It was an outlier only for batch four, but not for the RTD condition. It was retained for this analysis.

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

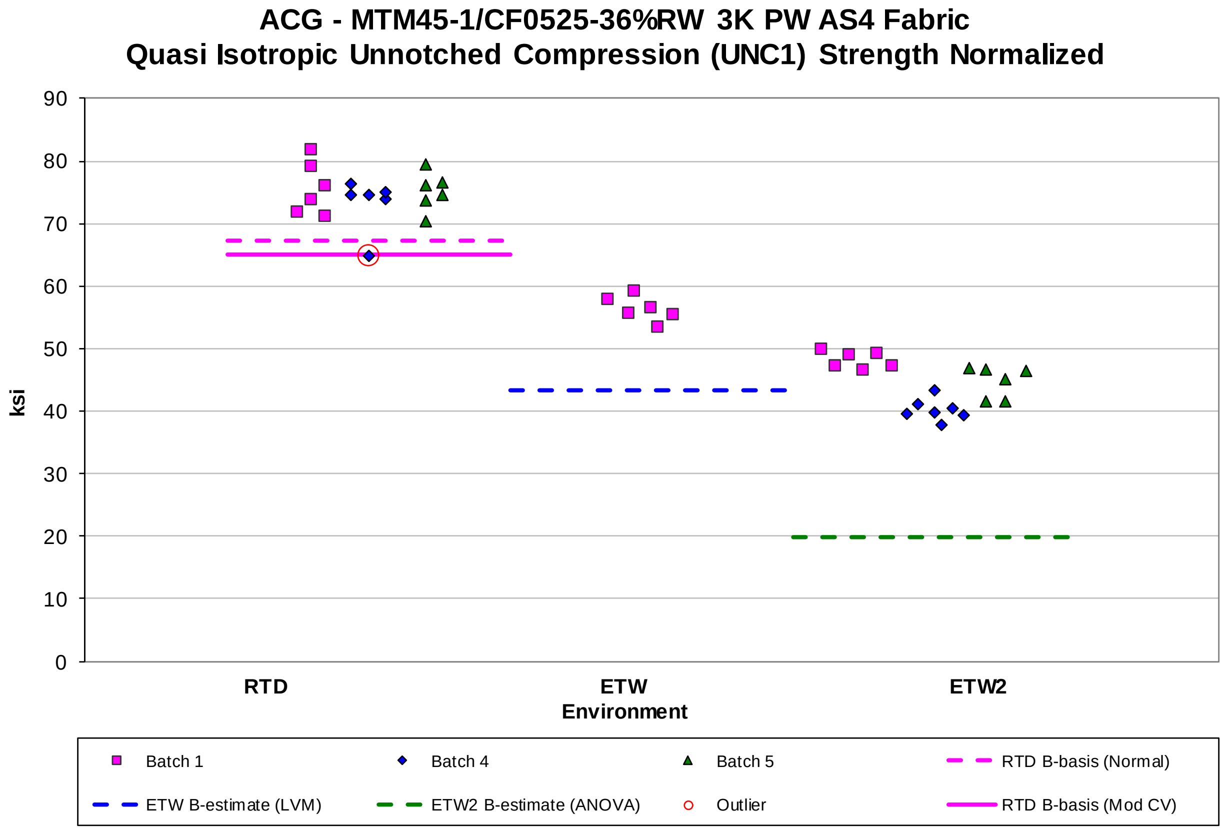

Figure 5-4: Batch Plot for UNC1 Strength Normalized

Quasi Isotropic Unnotched Compression (UNC1) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	74.62	56.24	44.11	72.47	55.00	42.90
Stdev	3.76	1.96	3.79	3.88	2.05	4.11
CV	5.04	3.48	8.58	5.35	3.73	9.58
Modified CV	6.52	8.00	8.58	6.68	8.00	9.58
Min	64.87	53.40	37.90	62.75	52.08	37.04
Max	81.56	58.99	49.73	80.54	57.77	49.17
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	19	18	6	19
Basis Values and/or Estimates						
B-basis Value	67.20			64.81		
B-estimate		43.43	19.81		42.14	15.66
A-estimate	61.94	NA	2.47	59.39	NA	NA
Method	Normal	LVM	ANOVA	Normal	LVM	ANOVA
Modified CV Basis Values and/or Estimates						
B-basis Value	65.02			62.92		
B-estimate		NA	NA		NA	NA
A-estimate	58.22	NA	NA	56.16	NA	NA
Method	Normal	NA	NA	Normal	NA	NA

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

Quasi Isotropic Unnotched Compression (UNC1) Modulus Statistics						
	Normalized			As Measured		
Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	5.66	6.59	6.52	5.50	6.44	6.40
Stdev	0.30	0.34	0.49	0.31	0.34	0.46
CV	5.24	5.17	7.49	5.63	5.32	7.16
Modified CV	6.62	6.59	7.75	6.81	6.66	7.58
Min	5.03	6.07	5.68	4.84	5.94	5.62
Max	6.50	6.94	6.87	6.29	6.82	6.73
No. Batches	3	1	2	3	1	2
No. Spec.	18	6	7	18	6	7

Table 5-8: Statistics from UNC1 Modulus Data

5.2.2 "Soft" Unnotched Compression Properties (UNC2)

The UNC2 data is normalized. This property had data from only one batch available. There was insufficient data to meet the requirements of CMH-17-1G, so only estimates are provided. B-estimates were prepared using the laminate variability method (LVM) detailed in section 2.4. Modified CV values are not available for the ETW2 condition due to the large CV of the warp compression lamina data for the ETW2 condition which was used to compute the LVM B-estimate.

There were no outliers.

Statistics and A- and B-estimates are given for strength data in Table 5-9 and for the modulus data in Table 5-10. The normalized data and the B-estimates are shown graphically in Figure 5-5.

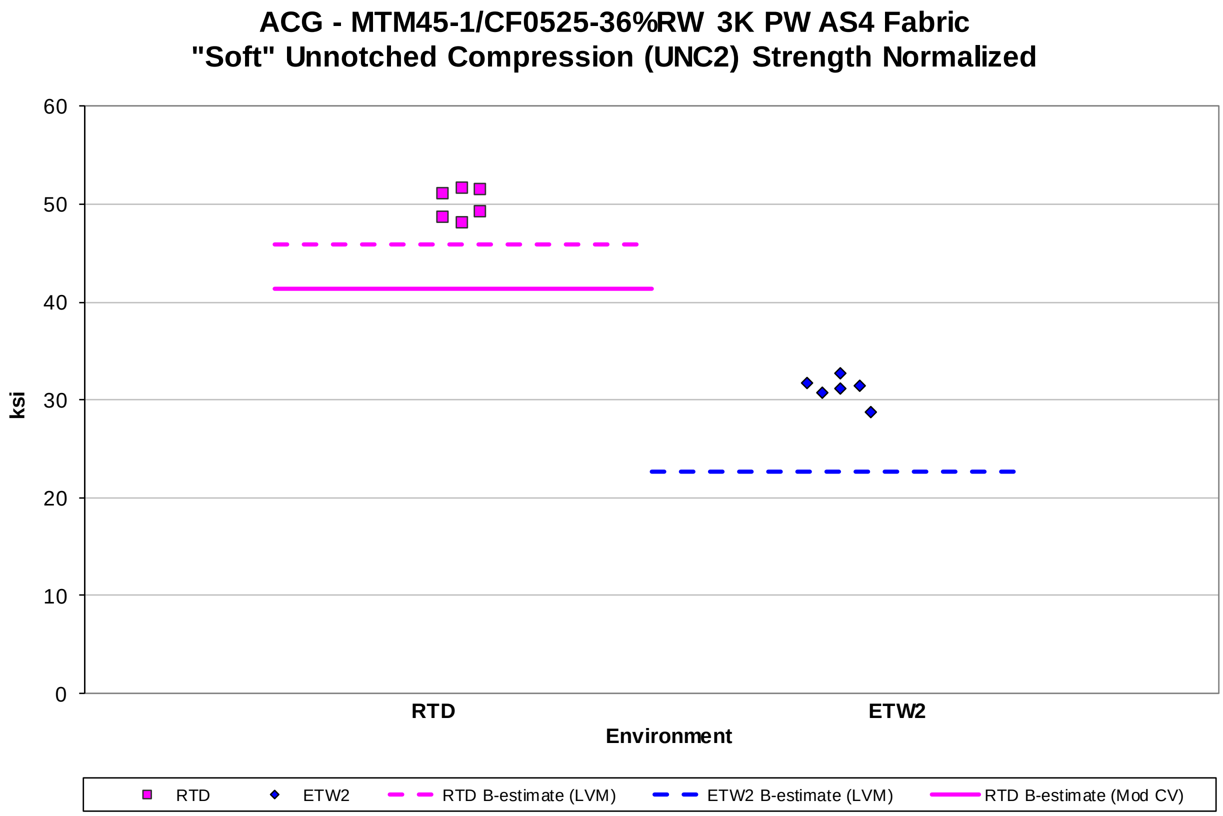

Figure 5-5: Batch Plot for UNC2 Strength Normalized

"Soft" Unnotched Compression (UNC2) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	49.96	31.08	49.55	29.96
Stdev	1.59	1.32	1.73	1.34
CV	3.18	4.24	3.49	4.48
Modified CV	8.00	8.00	8.00	8.00
Min	48.01	28.75	47.41	27.99
Max	51.62	32.68	51.68	32.07
No. Batches	1	1	1	1
No. Spec.	6	6	6	6
Basis Values and/or Estimates				
B-estimate	45.89	22.72	44.84	21.81
A-estimate	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates				
B-estimate	41.34	NA	41.00	NA
A-estimate	NA	NA	NA	NA
Method	LVM	NA	LVM	NA

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

"Soft" Unnotched Compression (UNC2) Modulus Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	3.95	5.09	3.92	4.89
Stdev	0.32	0.74	0.30	0.67
CV	8.16	14.56	7.54	13.71
Modified CV	8.16	14.56	7.77	13.71
Min	3.61	3.77	3.63	3.70
Max	4.50	5.52	4.42	5.26
No. Batches	1	1	1	1
No. Spec.	6	5	6	5

Table 5-10: Statistics from UNC2 Modulus Data

5.2.3 "Hard" Unnotched Compression Properties (UNC3)

The UNC3 data is normalized. This property had data from only one batch available. There was insufficient data to meet the requirements of CMH-17-1G, so only estimates are provided. B-estimates were prepared using the laminate variability method (LVM) detailed in section 2.4. Modified CV values were not provided due to the large CV of both the RTD and ETW2 data for this test.

There were no outliers.

Statistics and A- and B-estimates are given for strength data in Table 5-11 and for the modulus data in Table 5-12. The normalized data and the B-estimates are shown graphically in Figure 5-6.

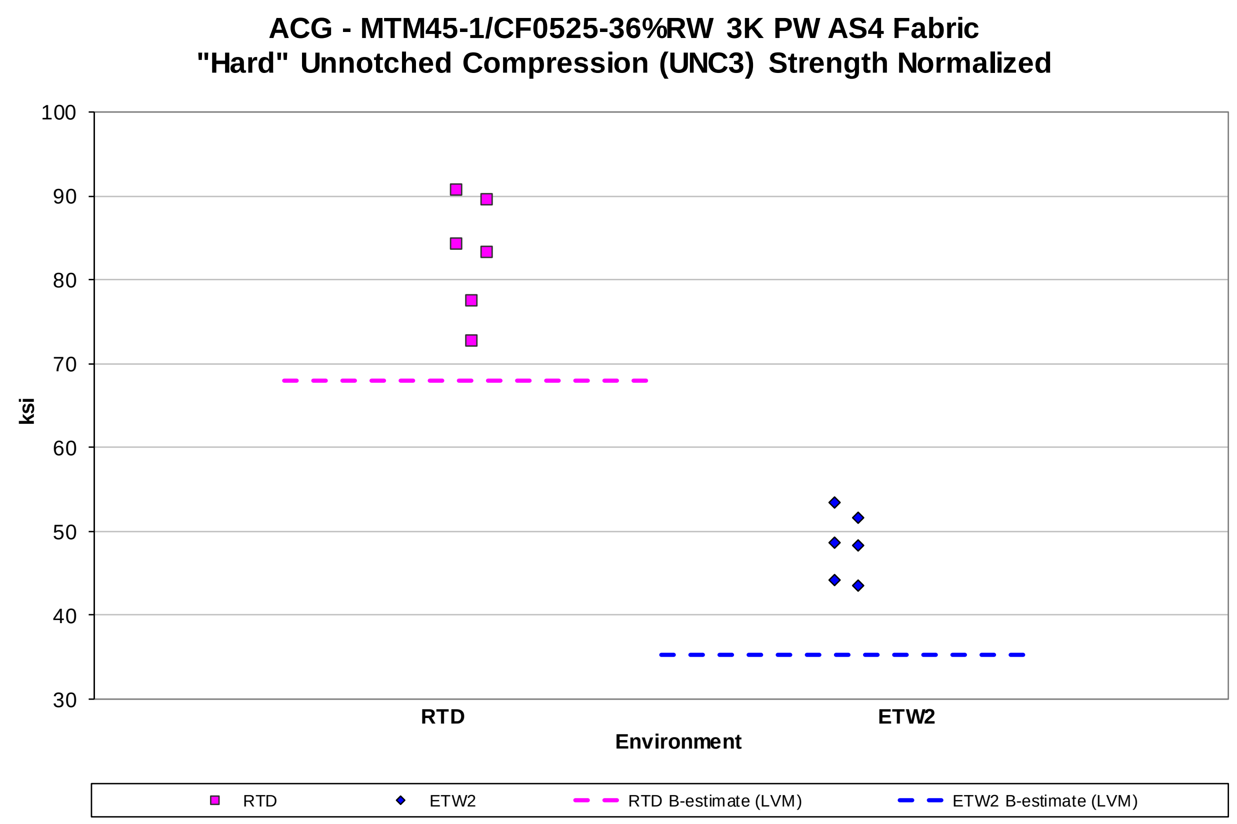

Figure 5-6: Batch Plot for UNC3 Strength Normalized

"Hard" Unnotched Compression (UNC3) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	82.94	48.31	80.18	47.26
Stdev	6.90	3.96	6.54	3.87
CV	8.32	8.19	8.16	8.18
Modified CV	8.32	8.19	8.16	8.18
Min	72.67	43.51	70.01	42.89
Max	90.66	53.51	87.34	52.26
No. Batches	1	1	1	1
No. Spec.	6	6	6	6
Basis Values and/or Estimates				
B-estimate	68.05	35.32	66.07	34.40
A-estimate	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates				
B-estimate	NA	NA	66.07	NA
A-estimate	NA	NA	NA	NA
Method	NA	NA	NA	NA

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

"Hard" Unnotched Compression (UNC3) Modulus Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	7.89		7.63	
Stdev	0.29		0.28	
CV	3.64		3.61	
Modified CV	6.00		6.00	
Min	7.45		7.18	
Max	8.21		7.98	
No. Batches	1		1	
No. Spec.	6		6	

No modulus values were available for compression tests at the ETW2 condition

Table 5-12: Statistics from UNC3 Modulus Data

5.3 Open Hole Tension Properties

5.3.1 Quasi Isotropic Open Hole Tension Properties (OHT1)

The OHT1 data is normalized. None of the conditions tested with multiple batches passed the Anderson-Darling k-sample test for batch-to-batch variation, so an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates and may be overly conservative. The data from the CTD condition, both normalized and as measured passed the ADK test under the modified CV transformation. The normalized CTD dataset failed the normality test, but passed the normality test after the transformation to meet the assumptions of the modified CV method. So modified CV basis values are provided for that dataset.

The RTD and ETW2 datasets, both normalized and as measured, did not pass the ADK test under the modified CV transformation. B-estimates computed using the modified CV method are provided, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method.

The ETW condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were no outliers.

Statistics, estimates and basis values are given for strength data in Table 5-13. The normalized data, B-estimates and B-basis values are shown graphically in Figure 5-7

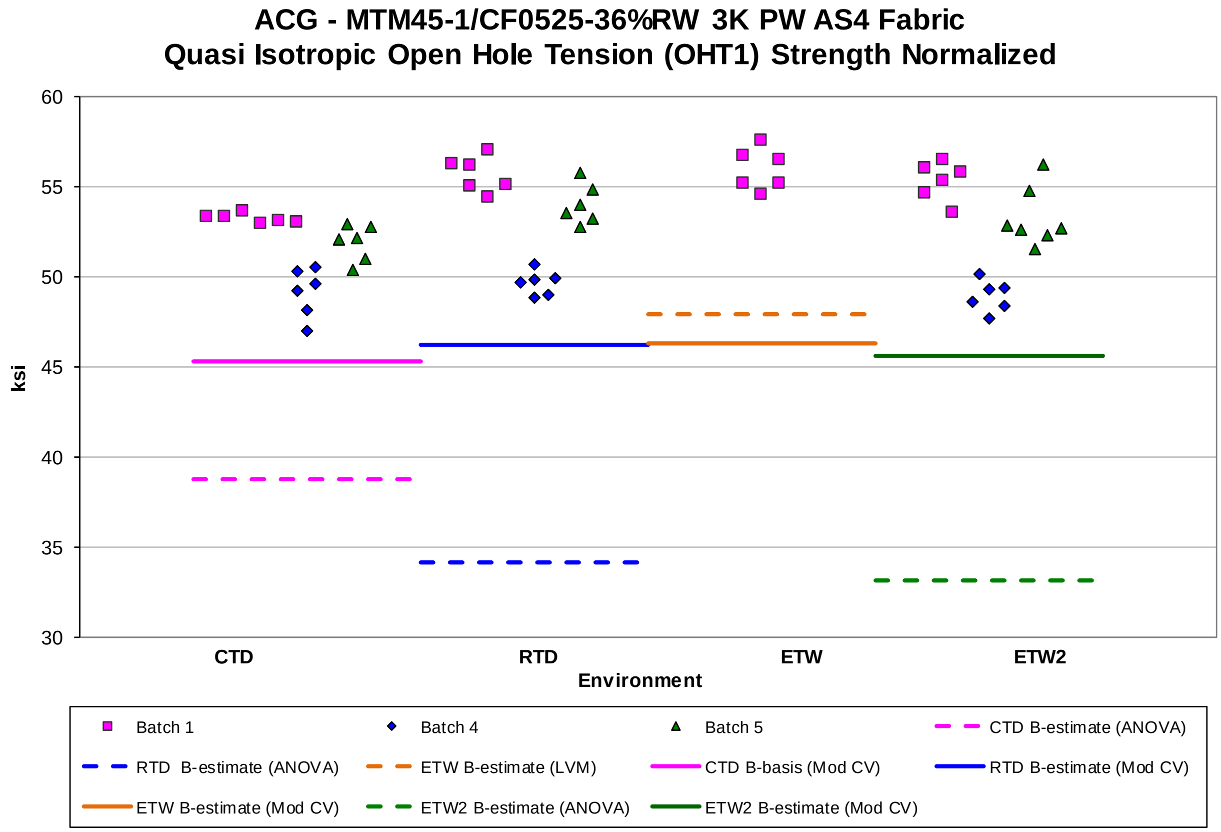

Figure 5-7: Batch Plot for OHT1 Strength Normalized

Quasi Isotropic Open Hole Tension (OHT1) Strength Basis Values and Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETW	ETW2	CTD	RTD	ETW	ETW2
Mean	51.41	53.11	55.93	52.53	49.60	51.56	53.92	50.69
Stdev	1.97	2.75	1.15	2.91	1.93	2.77	1.12	3.00
CV	3.84	5.18	2.05	5.54	3.90	5.37	2.07	5.93
Modified CV	6.00	6.59	8.00	6.77	6.00	6.68	8.00	6.96
Min	47.03	48.87	54.57	47.71	45.03	47.30	52.70	45.82
Max	53.62	57.02	57.55	56.45	51.78	55.87	55.67	55.27
No. Batches	3	3	1	3	3	3	1	3
No. Spec.	18	18	6	19	18	18	6	19
Basis Values and/or Estimates								
B-estimate	38.78	34.15	47.89	33.16	37.97	33.52	45.89	30.79
A-estimate	29.76	20.61	NA	19.32	29.67	20.64	NA	16.57
Method	ANOVA	ANOVA	LVM	ANOVA	ANOVA	ANOVA	LVM	ANOVA
Modified CV Basis Values and/or Estimates								
B-basis Value	45.32				43.73			
B-estimate		46.20	46.32	45.60		44.76	44.66	43.81
A-estimate	41.01	41.32	NA	40.69	39.57	39.95	NA	38.93
Method	Normal	Normal	LVM	Normal	Normal	Normal	LVM	Normal

Table 5-13: Statistics and Basis Values for OHT1 Strength Data

5.3.2 "Soft" Open Hole Tension Properties (OHT2)

The OHT2 data is normalized. The normalized data for the CTD condition did not pass the Anderson-Darling k-sample test for batch-to-batch variation. This means that dataset required the ANOVA method to compute basis values which may result in overly conservative basis values. However, the CTD data did pass the normality test, and passed the ADK test under the modified CV transformation, so the modified CV values are provided for that dataset.

The RTD and ETW2 conditions had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were no outliers.

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

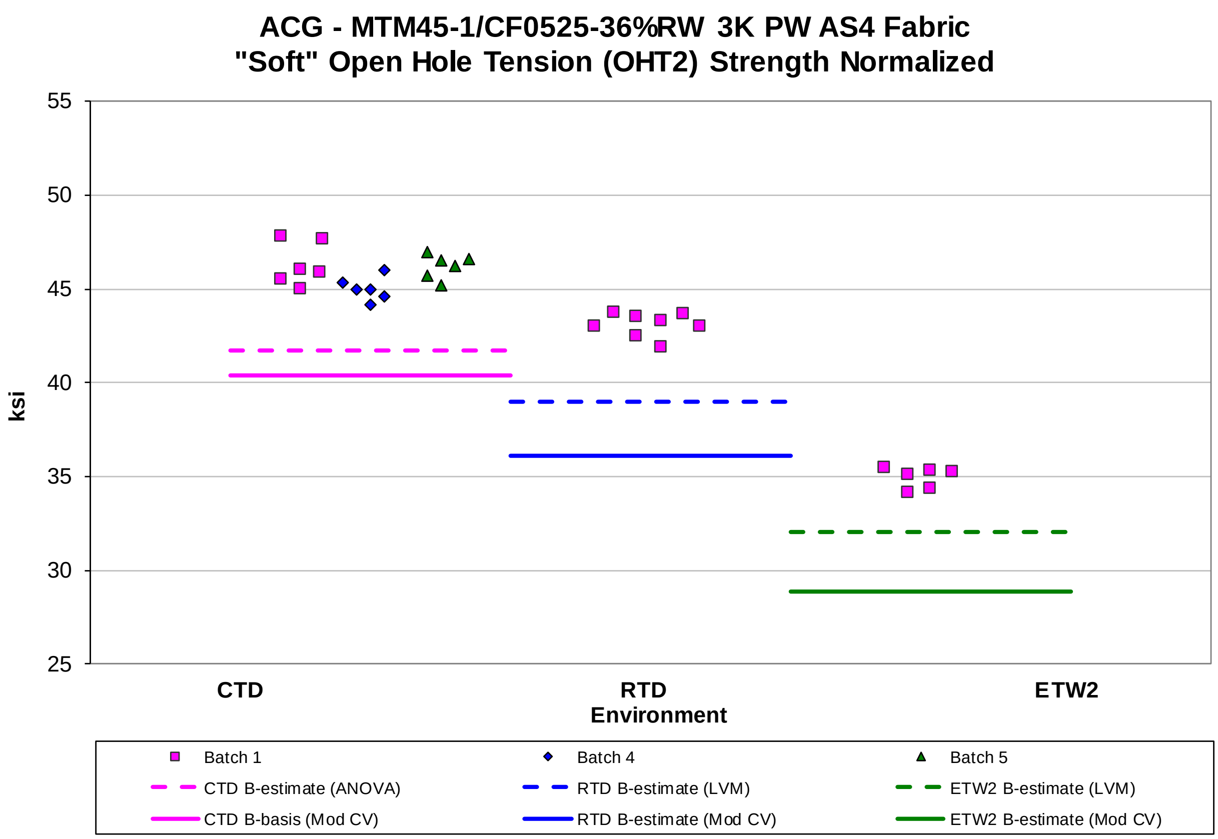

Figure 5-8: Batch Plot for OHT2 Strength Normalized

	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	45.83	43.05	34.90	44.07	41.80	22.22
Stdev	0.99	0.63	0.55	0.97	0.68	0.33
CV	2.17	1.46	1.57	2.20	1.63	1.50
Modified CV	6.00	8.00	8.00	6.00	8.00	8.00
Min	44.15	41.90	34.11	42.28	40.61	21.71
Max	47.75	43.74	35.44	46.27	42.80	22.49
No. Batches	3	1	1	3	1	1
No. Spec.	18	8	6	18	8	6
Basis Values and/or Estimates						
B-basis Value				42.16		
B-estimate	41.70	39.00	32.01		37.22	20.36
A-estimate	38.76	NA	NA	40.80	NA	NA
Method	ANOVA	LVM	LVM	Normal	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-basis Value	40.40			38.85		
B-estimate		36.07	28.88		35.02	18.38
A-estimate	36.56	NA	NA	35.16	NA	NA
Method	Normal	LVM	LVM	Normal	LVM	LVM

Table 5-14: Statistics and Basis Values for OTH2 Strength Data

5.3.3 "Hard" Open Hole Tension Properties (OHT3)

The OHT3 data is normalized. The data for the CTD condition, both as measured and normalized, did not pass the Anderson-Darling k-sample test for batch-to-batch variation. This means that data from that condition required the ANOVA method to compute basis values which may result in overly conservative basis values. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. The CTD data did not pass the ADK test under the modified CV transformation, so B-estimates computed using the modified CV method are provided for that condition, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method.

The RTD and ETW2 conditions had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were no outliers.

Statistics and A- and B-estimates are given for strength data in Table 5-15. The normalized data and B-estimates are shown graphically in Figure 5-9.

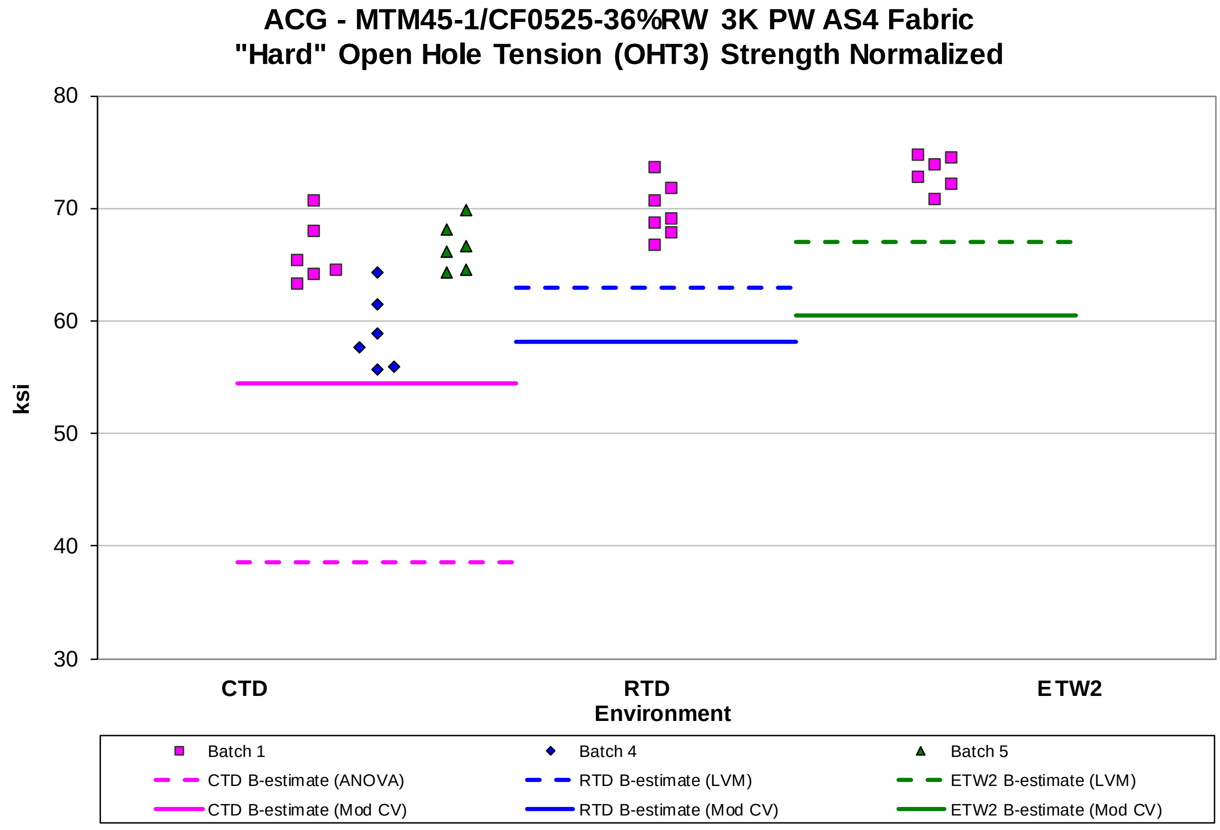

Figure 5-9: Batch Plot for OHT3 Strength Normalized

"Hard" Open Hole Tension (OHT3) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	63.85	69.71	73.09	61.98	67.97	70.50
Stdev	4.42	2.37	1.52	4.04	2.11	1.25
CV	6.93	3.39	2.08	6.52	3.10	1.77
Modified CV	7.46	8.00	8.00	7.26	8.00	8.00
Min	55.69	66.69	70.74	54.33	65.80	68.71
Max	70.64	73.50	74.70	67.95	71.39	72.26
No. Batches	3	1	1	3	1	1
No. Spec.	18	7	6	18	7	6
Basis Values and/or Estimates						
B-estimate	38.55	63.01	67.03	38.22	60.37	64.63
A-estimate	20.49	NA	NA	21.27	NA	NA
Method	ANOVA	LVM	LVM	ANOVA	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	54.44	58.16	60.48	53.09	56.70	58.34
A-estimate	47.79	NA	NA	46.81	NA	NA
Method	Normal	LVM	LVM	Normal	LVM	LVM

Table 5-15: Statistics and Basis Values for OHT3 Strength Data

5.4 Open Hole Compression

5.4.1 Quasi Isotropic Open Hole Compression 1 (OHC1)

The OHC1 data is normalized. Both the normalized and the as measured data for the RTD condition did not pass the Anderson-Darling k-sample test for batch-to-batch variation. This means those datasets required the ANOVA method to compute basis values which may result in overly conservative basis values. However, the RTD data did pass the normality test, and passed the ADK test under the modified CV transformation, so the pooled modified CV values are provided. Pooling was acceptable for the modified CV basis values.

The ETW conditions had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4. The ETW data was included in the pooled dataset for the modified CV basis values.

There was one outlier. The highest value in batch one of the as measured RTD data. It was an outlier only for batch one, but not for the RTD condition. It was retained for this analysis.

Statistics, estimates and basis values are given for OHC1 strength data in Table 5-16. The normalized data, B-estimates and B-basis values are shown graphically in Figure 5-10.

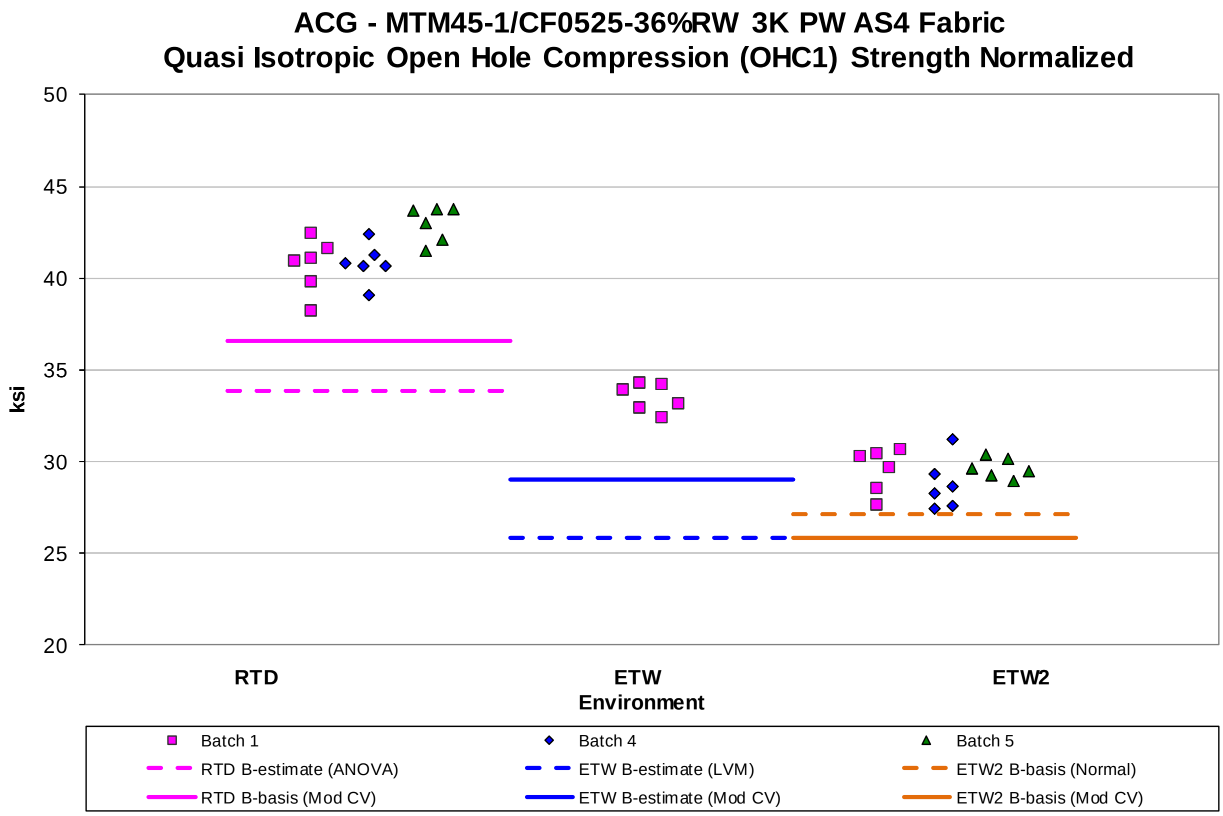

Figure 5-10: Batch Plot for OHC1 Strength Normalized

Quasi Isotropic Open Hole Compression (OHC1) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	RTD	ETW	ETW2	RTD	ETW	ETW2
Mean	41.46	33.42	29.29	40.30	31.81	28.16
Stdev	1.56	0.77	1.11	1.59	0.81	1.25
CV	3.76	2.31	3.80	3.94	2.54	4.43
Modified CV	6.00	6.00	6.00	6.00	6.00	6.22
Min	38.15	32.33	27.43	37.42	30.59	26.08
Max	43.73	34.25	31.20	43.13	32.95	30.13
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and/or Estimates						
B-basis Value			27.09			25.70
B-estimate	33.86	25.81		31.65	24.37	
A-estimate	28.44	NA	25.53	25.49	NA	23.95
Method	ANOVA	LVM	Normal	ANOVA	LVM	Normal
Modified CV Basis Values and/or Estimates						
B-basis Value	37.61		25.44	36.54		24.41
B-estimate		29.01			27.50	
A-estimate	35.01	26.49	22.84	34.00	25.04	21.87
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 5-16: Statistics and Basis Values for OHC1 Strength Data

5.4.2 "Soft" Open Hole Compression (OHC2)

The OHC2 data is normalized. The normalized data for the ETW2 condition did not pass the Anderson-Darling k-sample test for batch-to-batch variation. This means that dataset required the ANOVA method to compute basis values which may result in overly conservative basis values. However, the normalized ETW2 data did pass the normality test, and passed the ADK test under the modified CV transformation, so the modified CV values are provided for those dataset. There was insufficient data for the two environments to be pooled.

The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There was one outlier. The lowest value in batch five of the ETW2 condition for both the normalized and as measured datasets. It was an outlier only for batch five, but not for the ETW2 condition. It was retained for this analysis.

Statistics, estimates and basis values are given for OHC2 strength data in Table 5-17. The normalized data, B-estimates and B-basis values are shown graphically in Figure 5-11.

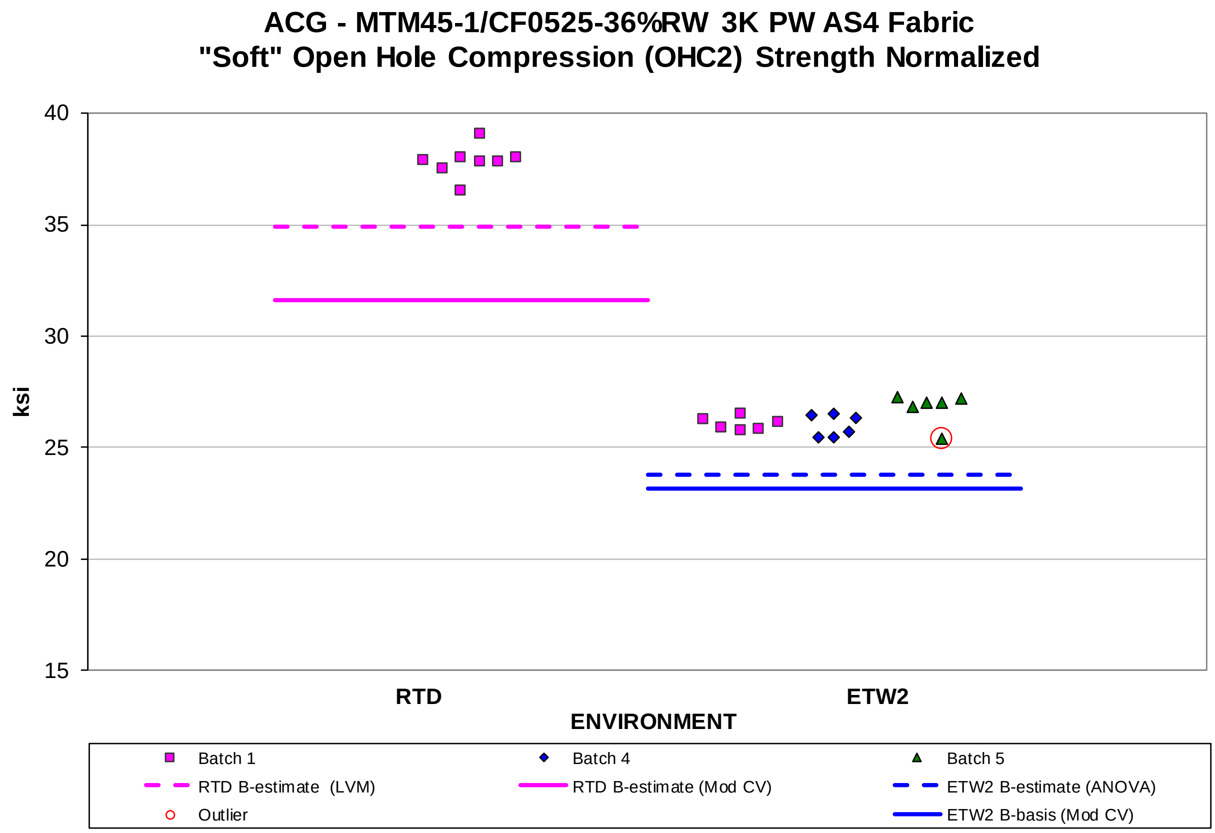

Figure 5-11: Batch Plot for OHC2 Strength Normalized

"Soft" Open-Hole Compression (OHC2) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	37.86	26.29	37.30	25.52
Stdev	0.70	0.61	0.86	0.53
CV	1.86	2.34	2.31	2.06
Modified CV	8.00	6.00	8.00	6.00
Min	36.52	25.42	35.62	24.76
Max	39.09	27.30	38.48	26.38
No. Batches	1	3	1	3
No. Spec.	8	18	8	18
Basis Values and/or Estimates				
B-basis Value				24.48
B-estimate	34.92	23.76	33.93	
A-estimate	NA	21.96	NA	23.75
Method	LVM	ANOVA	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		23.17		22.50
B-estimate	31.63		31.17	
A-estimate	NA	20.97	NA	20.36
Method	LVM	Normal	LVM	Normal

Table 5-17: Statistics and Basis Values for OHC2 Strength Data

5.4.3 “Hard” Open Hole Compression (OHC3)

The OHC3 data is normalized. The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were no outliers.

Statistics, estimates and basis values are given for OHC3 strength data in Table 5-18. The normalized data, B-estimates and B-basis values are shown graphically in Figure 5-12.

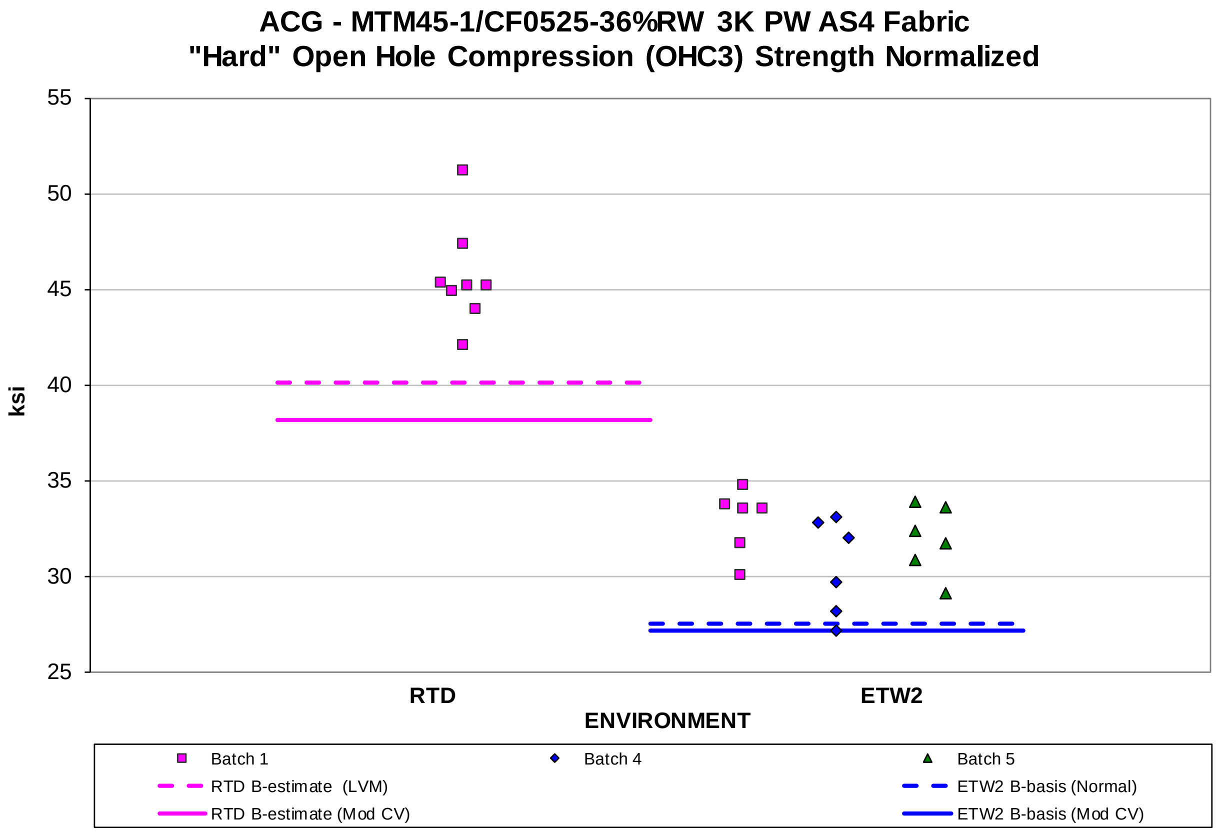

Figure 5-12: Batch Plot for OHC3 Strength Normalized

"Hard" Open-Hole Compression (OHC3) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	45.66	31.76	44.76	30.81
Stdev	2.70	2.17	2.56	2.12
CV	5.92	6.83	5.72	6.87
Modified CV	8.00	7.41	8.00	7.44
Min	42.05	27.16	41.35	26.27
Max	51.24	34.78	50.18	33.72
No. Batches	1	3	1	3
No. Spec.	8	18	8	18
Basis Values and/or Estimates				
B-basis Value		27.48		26.63
B-estimate	40.10		39.50	
A-estimate	NA	24.45	NA	23.67
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		27.11		26.29
B-estimate	38.15		37.40	
A-estimate	NA	23.83	NA	23.09
Method	LVM	Normal	LVM	Normal

Table 5-18: Statistics and Basis Values for OHC3 Strength Data

5.5 Filled Hole Tension

5.5.1 Quasi Isotropic Filled Hole Tension (FHT1)

The FHT1 data is normalized. The data for the CTD condition, both normalized and as measured, did not pass the Anderson-Darling k-sample test for batch-to-batch variation. This means the ANOVA method to compute basis values is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimate and may result in overly conservative basis values. The CTD data did not pass the ADK test under the modified CV transformation, so B-estimates computed using the modified CV method are provided, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method.

The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were no outliers.

Statistics and A- and B-estimates are given for FHT1 strength data in Table 5-19. The normalized data and B-estimates are shown graphically in Figure 5-13.

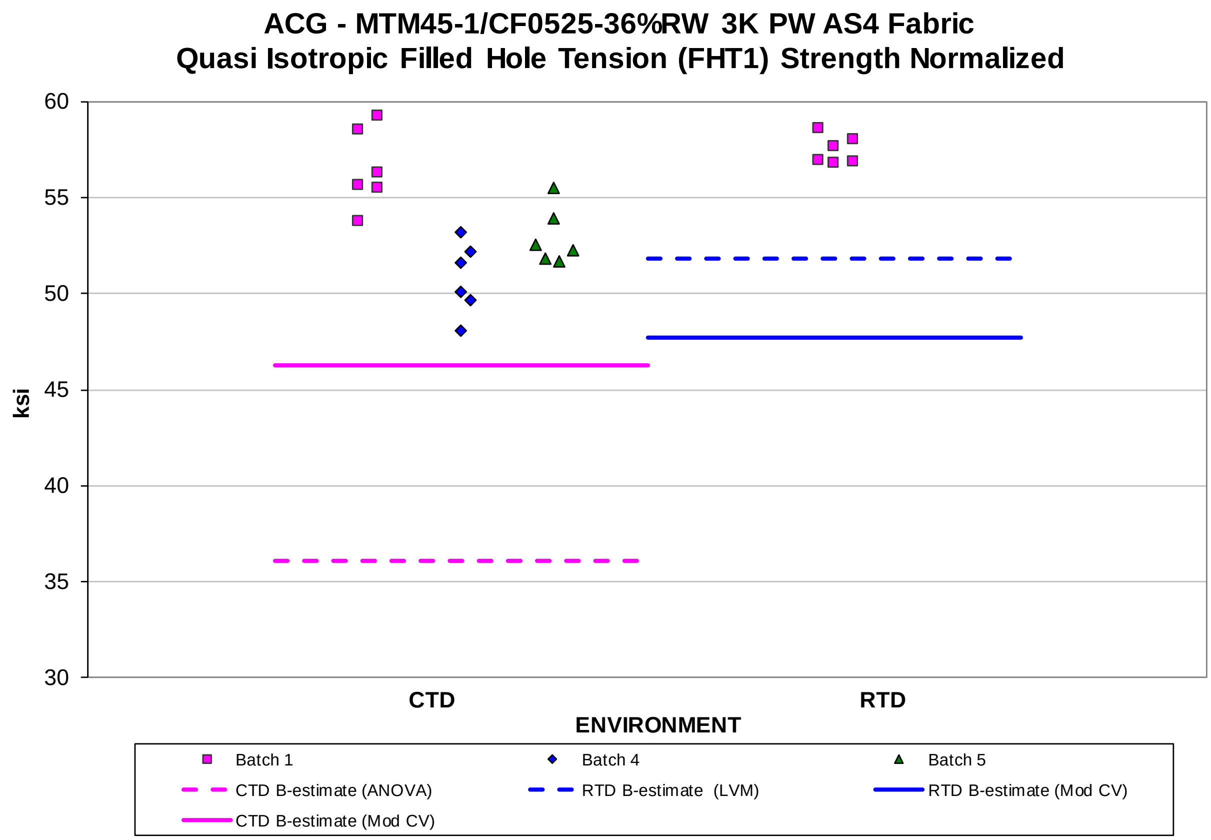

Figure 5-13: Batch Plot for FHT1 Strength Normalized

Quasi Isotropic Filled-Hole Tension (FHT1) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	CTD	RTD	CTD	RTD
Mean	53.44	57.52	51.11	55.05
Stdev	2.96	0.74	2.92	0.81
CV	5.55	1.28	5.72	1.47
Modified CV	6.77	8.00	6.86	8.00
Min	48.06	56.79	46.02	53.98
Max	59.27	58.61	56.45	56.30
No. Batches	3	1	3	1
No. Spec.	18	6	18	6
Basis Values and/or Estimates				
B-estimate	36.09	51.85	33.37	48.73
A-estimate	23.70	NA	20.72	NA
Method	ANOVA	LVM	ANOVA	LVM
Modified CV Basis Values and/or Estimates				
B-estimate	46.30	47.74	44.19	45.69
A-estimate	41.24	NA	39.29	NA
Method	Normal	LVM	Normal	LVM

Table 5-19: Statistics and Basis Values for FHT1 Strength Data

5.5.2 "Soft" Filled Hole Tension (FHT2)

The FHT2 data is normalized. This property had data from only one batch available. There was insufficient data to meet the requirements of CMH-17-1G, so only estimates are provided. B-estimates were prepared using the laminate variability method (LVM) detailed in section 2.4. Modified CV values are not provided for the CTD data due to large CV of the warp tension lamina data for the CTD condition which was used to compute the LVM B-estimate.

There were no outliers.

Statistics and B-estimates are given for FHT2 strength data in Table 5-20. The normalized data and B-estimates are shown graphically in Figure 5-14.

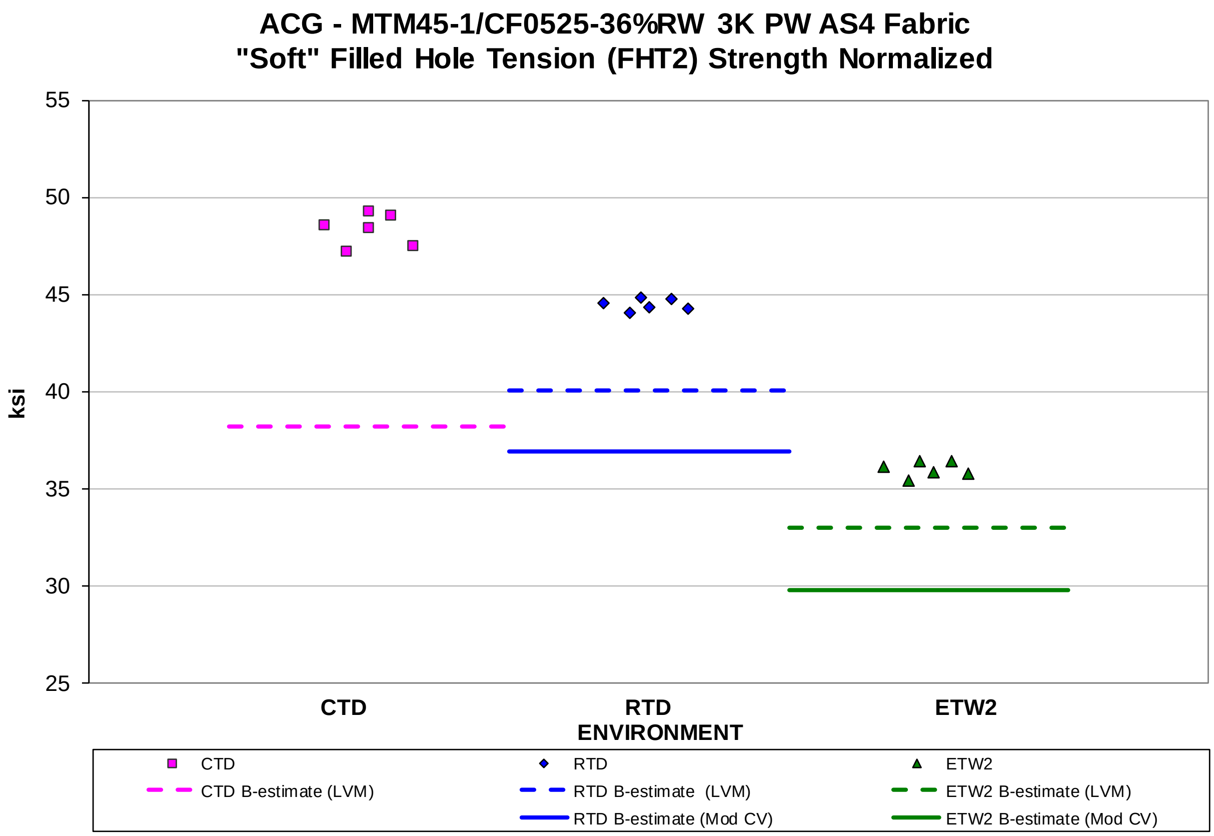

Figure 5-14: Batch Plot for FHT2 Strength Normalized

"Soft" Filled Hole Tension (FHT2) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW2	CTD	RTD	ETW2
Mean	48.34	44.47	36.01	46.48	42.97	34.79
Stdev	0.85	0.31	0.39	0.86	0.24	0.41
CV	1.75	0.70	1.08	1.84	0.55	1.19
Modified CV	8.00	8.00	8.00	8.00	8.00	8.00
Min	47.18	44.07	35.45	45.01	42.61	34.08
Max	49.30	44.84	36.44	47.35	43.26	35.32
No. Batches	1	1	1	1	1	1
No. Spec.	6	6	6	6	6	6
Basis Values and/or Estimates						
B-estimate	38.18	40.09	33.03	36.57	38.04	31.89
A-estimate	NA	NA	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates						
B-estimate	NA	36.91	29.80	NA	35.67	28.79
A-estimate	NA	NA	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM	LVM	LVM

Table 5-20: Statistics and Basis Values for FHT2 Strength Data

5.5.3 "Hard" Filled Hole Tension (FHT3)

The FHT3 data is normalized. This property had data from only one batch available. There was insufficient data to meet the requirements of CMH-17-1G, so only estimates are provided. B-estimates were prepared using the laminate variability method (LVM) detailed in section 2.4. Modified CV values are not provided for the CTD data due to large CV of the warp tension lamina data for the CTD condition which was used to compute the LVM B-estimate.

There were no outliers.

Statistics and B-estimates are given for FHT3 strength data in Table 5-21. The normalized data and B-estimates are shown graphically in Figure 5-15.

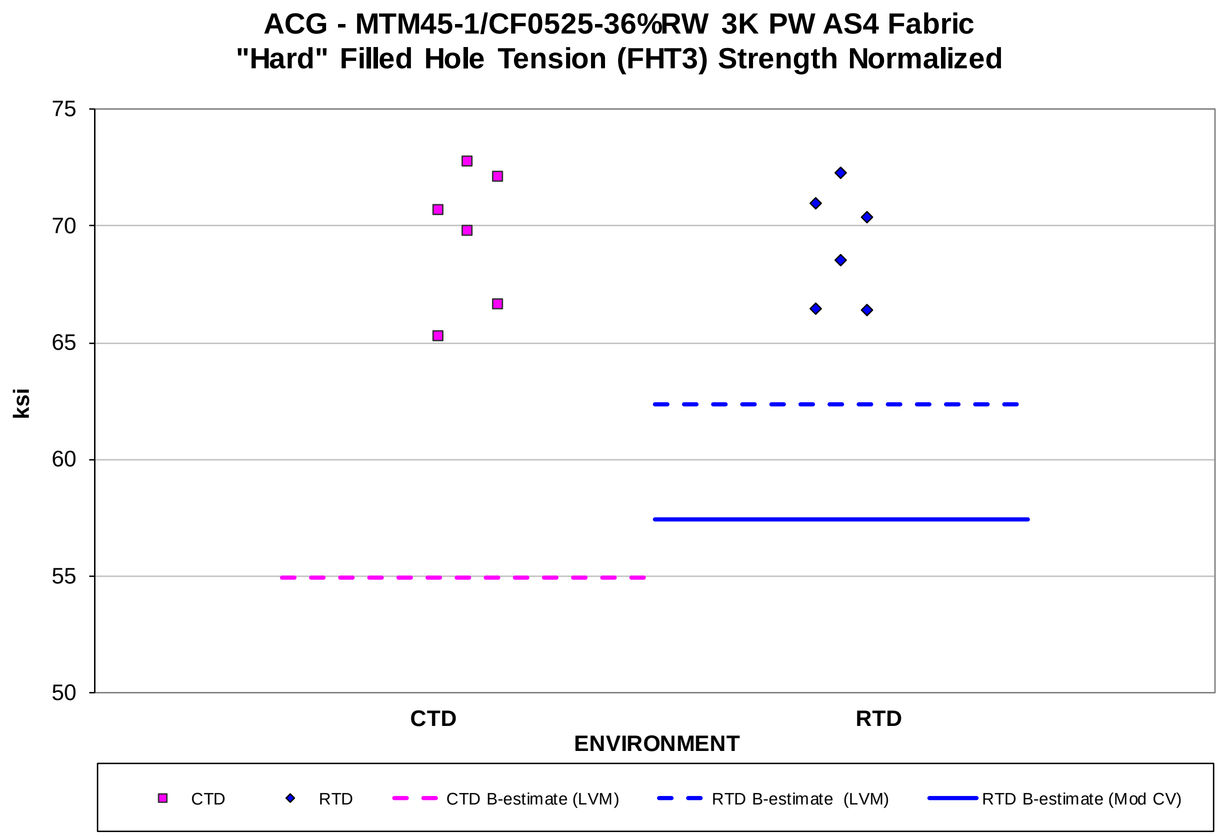

Figure 5-15: Batch Plot for FHT3 Strength Normalized

"Hard" Filled-Hole Tension (FHT3) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	CTD	RTD	CTD	RTD
Mean	69.55	69.18	67.25	67.20
Stdev	2.99	2.45	2.86	2.69
CV	4.30	3.54	4.25	4.00
Modified CV	8.00	8.00	8.00	8.00
Min	65.28	66.42	63.36	64.20
Max	72.75	72.29	70.49	70.33
No. Batches	1	1	1	1
No. Spec.	6	6	6	6
Basis Values and/or Estimates				
B-estimate	54.93	62.36	52.90	59.49
A-estimate	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM
Modified CV Basis Values and/or Estimates				
B-estimate	NA	57.42	NA	55.78
A-estimate	NA	NA	NA	NA
Method	LVM	LVM	LVM	LVM

Table 5-21: Statistics and Basis Values for FHT3 Strength Data

5.6 Filled Hole Compression

5.6.1 Quasi Isotropic Filled Hole Compression (FHC1)

The FHC1 data is normalized. The data for the ETW2 condition, both normalized and as measured, did not pass the Anderson-Darling k-sample test for batch-to-batch variation. This means the ANOVA method to compute basis values is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimate and may result in overly conservative basis values. The ETW2 data did not pass the ADK test under the modified CV transformation, so B-estimates computed using the modified CV method are provided, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method.

The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There was one outlier. The highest value in batch five of the ETW2 condition for both the normalized and as measured datasets. It was an outlier only for the ETW2 condition, but not for the batch five. It was retained for this analysis.

Statistics and A- and B-estimates are given for FHC1 strength data in Table 5-22. The normalized data and B-estimates are shown graphically in Figure 5-16.

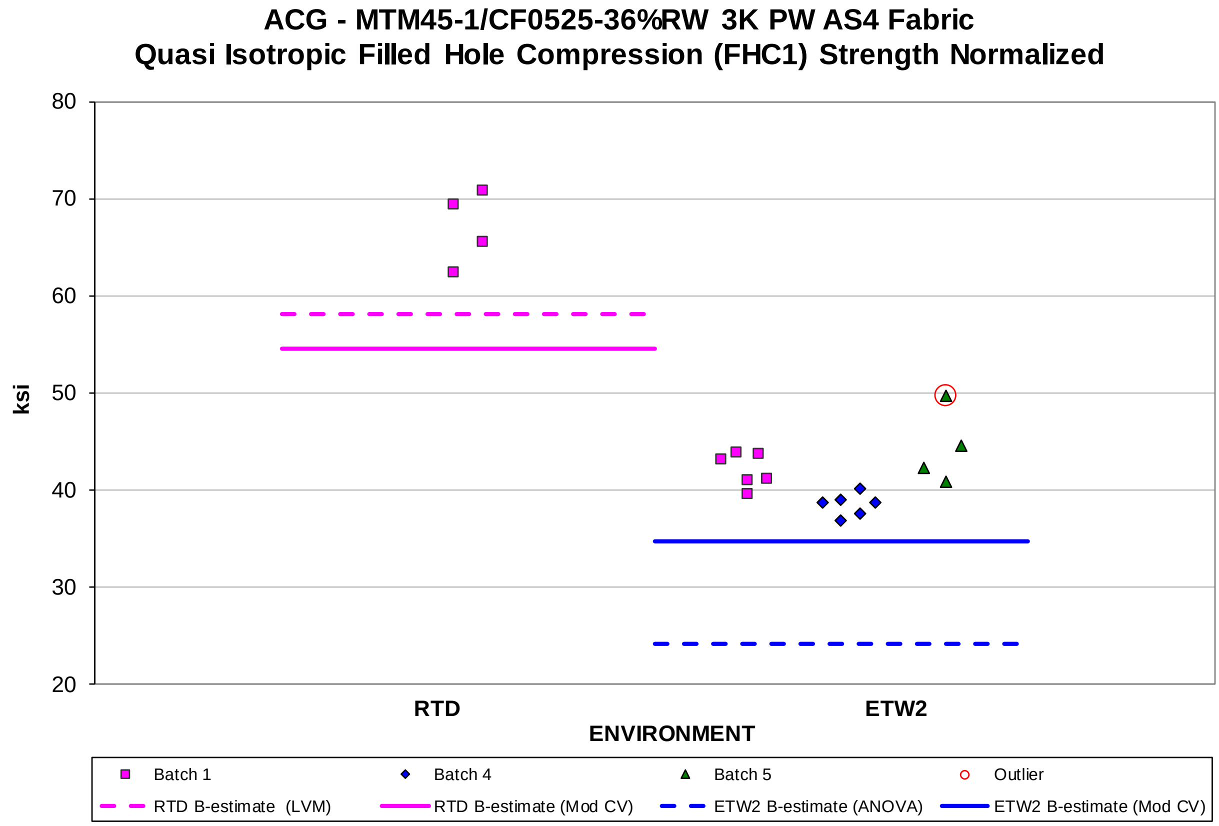

Figure 5-16: Batch Plot for FHC1 Strength Normalized

Quasi Isotropic Filled-Hole Compression (FHC1) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	67.03	41.32	64.17	39.24
Stdev	3.85	3.22	3.96	2.87
CV	5.75	7.80	6.17	7.32
Modified CV	8.00	7.90	8.00	7.66
Min	62.35	36.88	59.70	35.66
Max	70.86	49.78	68.06	47.02
No. Batches	1	3	1	3
No. Spec.	4	16	4	16
Basis Values and/or Estimates				
B-estimate	58.08	24.19	54.98	23.96
A-estimate	NA	11.98	NA	13.07
Method	LVM	ANOVA	LVM	ANOVA
Modified CV Basis Values and/or Estimates				
B-estimate	54.58	34.68	52.24	33.13
A-estimate	NA	30.01	NA	28.83
Method	LVM	Normal	LVM	Normal

Table 5-22: Statistics and Basis Values for FHC1 Strength Data

5.6.2 "Soft" Filled Hole Compression (FHC2)

The FHC2 data is normalized. The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There was one outlier. The highest value in batch one of the RTD condition for both the normalized and as measured datasets. It was an outlier only for batch one, not for the RTD condition. It was retained for this analysis.

Statistics, estimates and basis values are given for FHC2 strength data in Table 5-23. The normalized data, B-estimates and B-basis values are shown graphically in Figure 5-17.

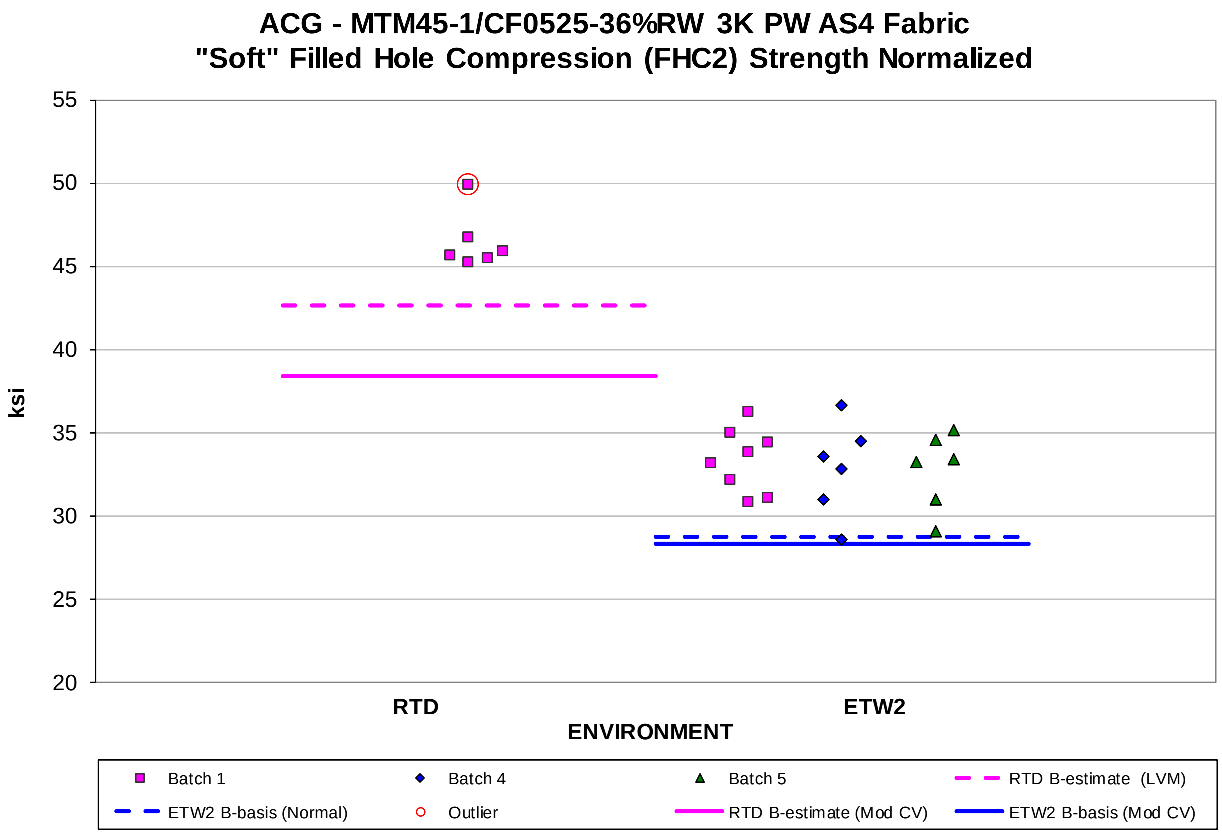

Figure 5-17: Batch Plot for FHC2 Strength Normalized

"Soft" Filled-Hole Compression (FHC2) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	46.47	33.02	44.83	31.71
Stdev	1.74	2.20	1.71	2.07
CV	3.74	6.65	3.82	6.53
Modified CV	8.00	7.33	8.00	7.27
Min	45.20	28.60	43.64	27.86
Max	49.86	36.63	48.18	35.51
No. Batches	1	3	1	3
No. Spec.	6	20	6	20
Basis Values and/or Estimates				
B-basis Value		28.79		27.72
B-estimate	42.68		40.57	
A-estimate	NA	25.78	NA	24.88
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-basis Value		28.36		27.27
B-estimate	38.45		37.09	
A-estimate	NA	25.05	NA	24.12
Method	LVM	Normal	LVM	Normal

Table 5-23: Statistics and Basis Values for FHC2 Strength Data

5.6.3 "Hard" Filled Hole Compression (FHC3)

The FHC3 data is normalized. The ETW2 condition had only four specimens from batch four and those were from only one cure cycle, which is insufficient to compute B-basis values and only B-estimates are provided. Modified CV values are not provided for the ETW2 condition due to the large CV of ETW2 data for this test.

The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were no outliers.

Statistics and A- and B-estimates are given for FHC3 strength data in Table 5-24. The normalized data and B-estimates are shown graphically in Figure 5-18.

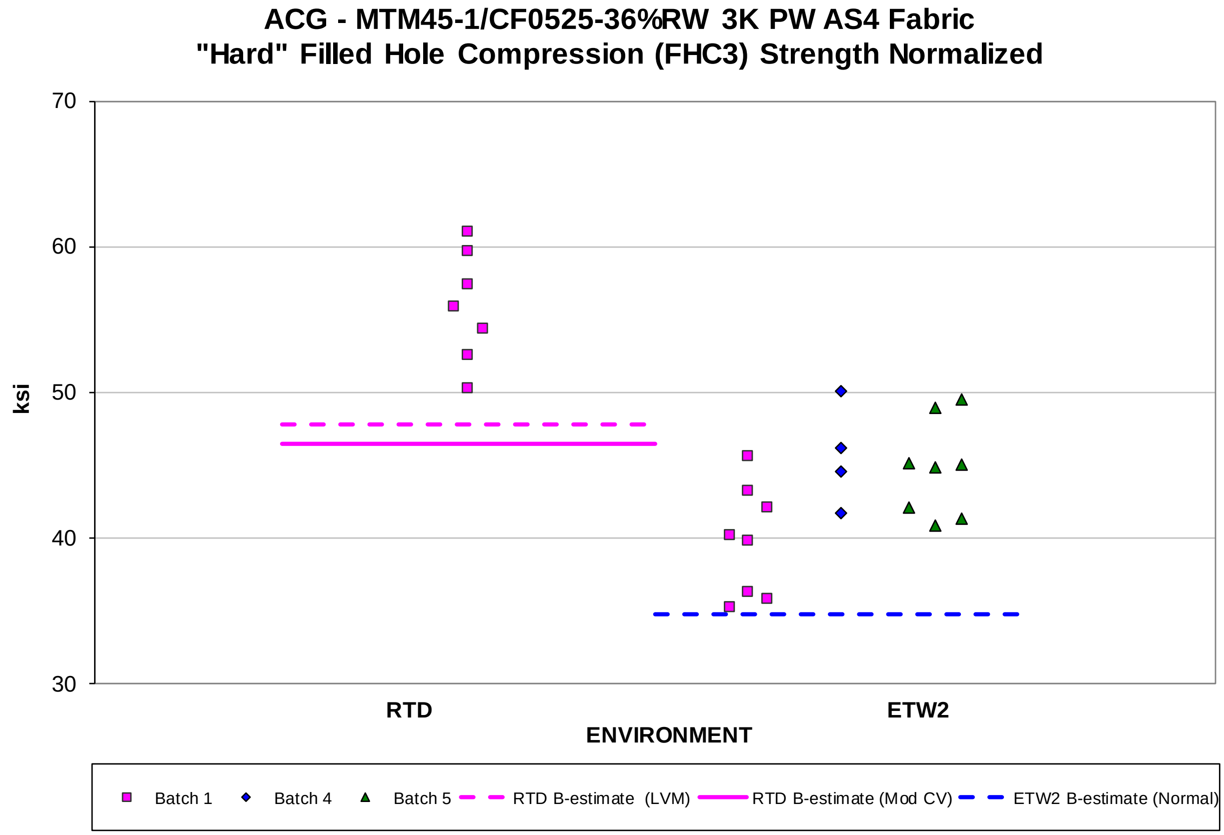

Figure 5-18: Batch Plot for FHC3 Strength Normalized

"Hard" Filled-Hole Compression (FHC3) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW2	RTD	ETW2
Mean	55.88	42.94	58.33	42.63
Stdev	3.84	4.25	3.90	3.62
CV	6.87	9.90	6.68	8.48
Modified CV	8.00	9.90	8.00	8.48
Min	50.25	35.27	52.51	36.74
Max	61.06	50.07	63.92	48.83
No. Batches	1	3	1	3
No. Spec.	7	20	7	20
Basis Values and/or Estimates				
B-estimate	47.82	34.75	50.15	35.66
A-estimate	NA	28.92	NA	30.71
Method	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates				
B-estimate	46.49	NA	48.53	NA
A-estimate	NA	NA	NA	NA
Method	LVM	NA	LVM	NA

Table 5-24: Statistics and Basis Values for FHC3 Strength Data

5.7 Laminate Short Beam Strength (SBS1) Data

The Laminate Short Beam Strength data is not normalized. The ETW data had insufficient data to meet the requirements of CMH-17-1G, so only estimates are provided for that condition. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4. Modified CV values are not provided due to the large CV of the warp compression lamina data for the ETW condition which was used to compute the LVM B-estimate.

The ETW2 data did not pass the Anderson-Darling k-sample test for batch-to-batch variation, so an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates. The ETW2 data did not pass the ADK test under the modified CV transformation. A B-estimate computed using the modified CV method is provided, but is considered an estimate due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method.

There was one outlier. It was in the RTD condition on the low side of batch five. It was an outlier only for batch five, not for the RTD condition.

Statistics, estimates and basis values are given for SBS1 strength data in Table 5-25. The as measured data, B-estimates and B-basis values are shown graphically in Figure 5-19.

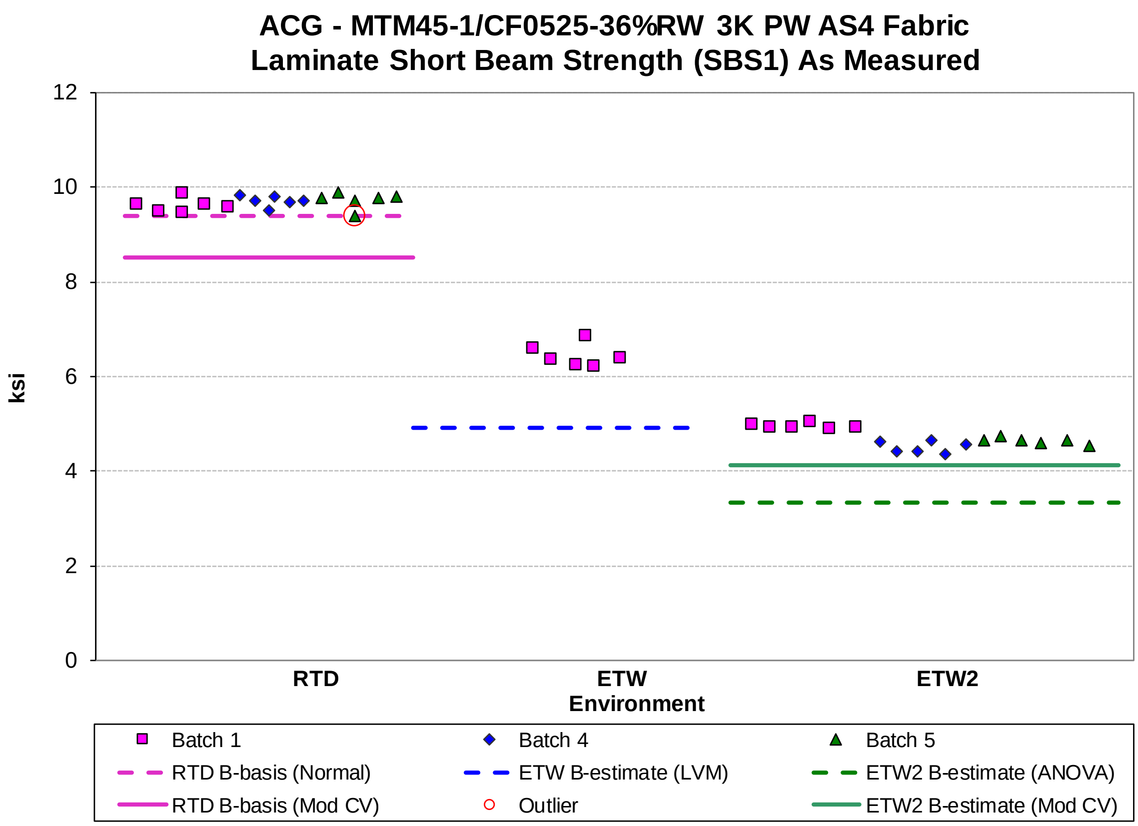

Figure 5-19: Batch Plot for SBS1 As-Measured

Laminate Short Beam Strength (SBS1) As-Measured Basis Values and Statistics			
Env	RTD	ETW	ETW2
Mean	9.68	6.43	4.70
Stdev	0.15	0.24	0.20
CV	1.53	3.74	4.34
Modified CV	6.00	8.00	6.17
Min	9.39	6.22	4.37
Max	9.89	6.84	5.04
No. Batches	3	1	3
No. Spec.	18	6	18
Basis Values and/or Estimates			
B-basis Value	9.39		
B-estimate		4.93	3.33
A-estimate	9.18	NA	2.36
Method	Normal	LVM	ANOVA
Modified CV Basis Values and/or Estimates			
B-basis Value	8.53		
B-estimate		NA	4.12
A-estimate	7.72	NA	3.72
Method	Normal	NA	Normal

Table 5-25: Statistics and Basis Values for SBS1 Data

5.8 Pin Bearing

5.8.1 Quasi Isotropic Pin Bearing (PB1)

The PB1 data is normalized. The ETW2 data did not pass the Anderson-Darling k-sample test for batch-to-batch variation for both the 2% offset and ultimate strength, both normalized and as measured, so an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method, data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates and may be overly conservative.

The ETW2 datasets, both normalized and as measured, failed the normality test but passed it after the transformation to meet the assumptions of the modified CV method. However, the ETW2 data for ultimate strength, both normalized and as measured, did not pass the ADK test under the modified CV transformation. B-estimates computed using the modified CV method are provided, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method. However, modified CV basis values are not provided for the 2% offset strength for ETW2 condition due to the large CV of both the as measured and normalized data. Instead, estimates of basis values that were computed with an override of the ADK test results are provided.

The data for the RTD condition did not pass the Anderson-Darling k-sample test for batch-to-batch variation for the normalized ultimate strength data. That data did pass the normality test, and passed the ADK test under the modified CV transformation, so modified CV values are provided for that dataset. However, modified CV basis values are not provided for the 2% offset strength for RTD condition due to the large CV of both the as measured and normalized data.

There was one outlier. The highest value in the batch four of the as measured RTD ultimate strength data. It was an outlier only for batch four, but not for the RTD condition.

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

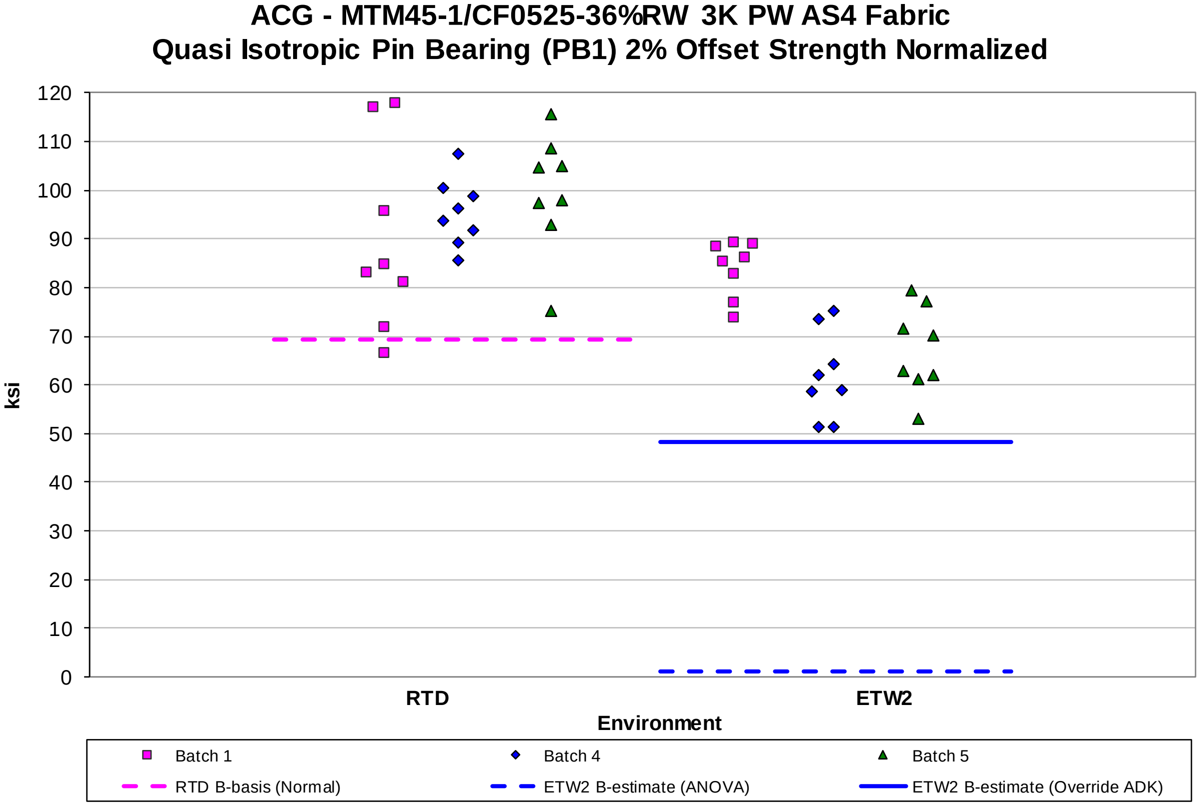

Figure 5-20: Batch Plot for PB1 2% Offset Strength Normalized

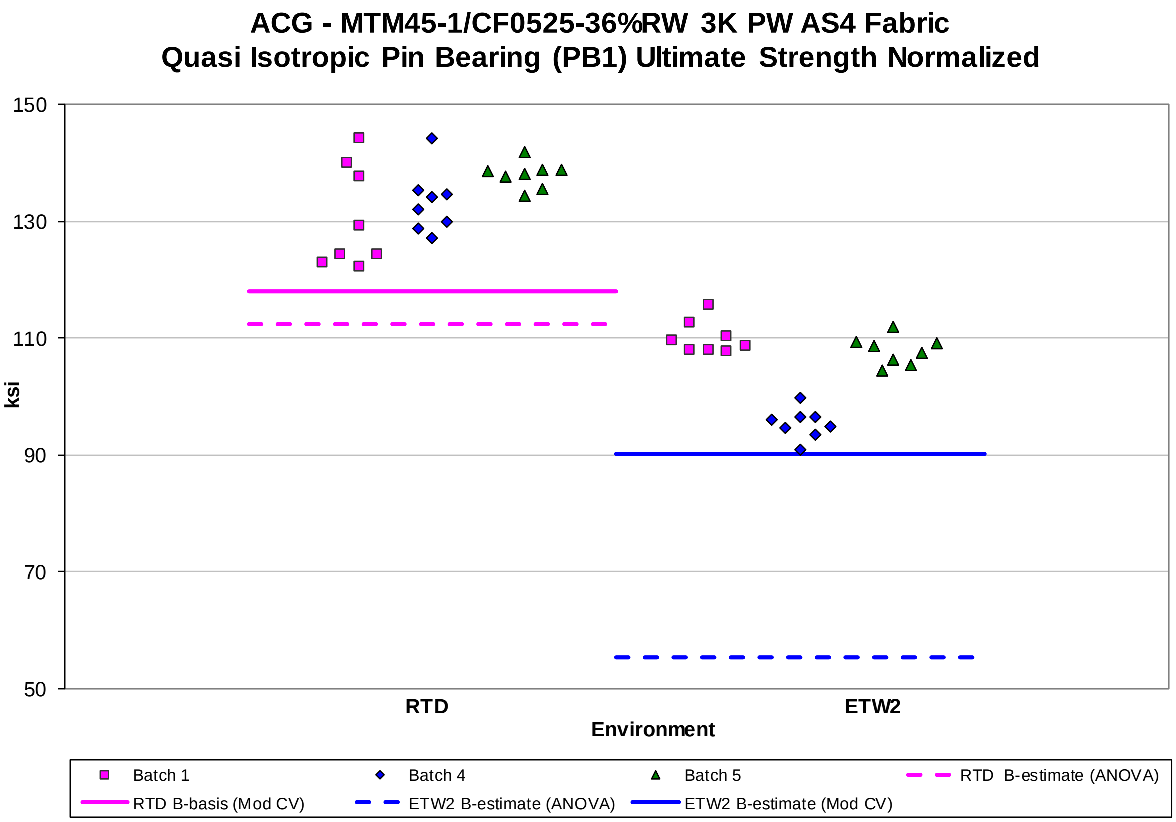

Figure 5-21: Batch Plot for PB1 Ultimate Strength Normalized

Quasi Isotropic Pin Bearing (PB1) Strength Basis Values and Statistics								
	Normalized				As measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
ENV	RTD	ETW2	RTD	ETW2	RTD	ETW2	RTD	ETW2
Mean	94.95	70.98	133.91	104.36	91.43	67.34	128.94	99.13
Stdev	13.77	12.29	6.58	7.10	13.61	11.03	7.25	6.43
CV	14.50	17.32	4.92	6.81	14.88	16.37	5.62	6.48
Modified CV	14.50	17.32	6.46	7.40	14.88	16.37	6.81	7.24
Min	66.41	51.20	122.07	90.80	64.57	49.41	115.98	87.36
Max	117.96	89.12	144.24	115.68	116.49	83.75	142.43	111.28
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	24	24	24	24	24	24	24	24
Basis Values and/or Estimates								
B-basis Value	69.44				66.22		115.51	
B-estimate		1.21	112.36	55.37		4.36		56.52
A-estimate	51.15	0.00	96.94	20.40	48.16	0.00	105.88	26.10
Method	Normal	ANOVA	ANOVA	ANOVA	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and/or Estimates								
B-basis Value	NA		117.89		NA		112.66	
B-estimate				90.04				85.83
A-estimate	NA		106.40	79.78	NA		101.00	76.30
Method	NA		Normal	Normal	NA		Normal	Normal
Basis Value Estimates with override of ADK test result								
B-estimate		48.21				46.92		
A-estimate		31.88				32.28		
Method		Normal				Normal		

Table 5-26: Statistics and Basis Values for PB1 Strength Data

5.8.2 "Soft" Pin Bearing (PB2)

The PB2 data is normalized. The ETW2 condition data did not pass the Anderson-Darling k-sample test for batch-to-batch variation for the 2% offset, so an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method data from five batches is required. Since this dataset has only three batches, the basis values computed using ANOVA are considered estimates and may be overly conservative. They did not pass the ADK test under the modified CV transformation, so B-estimates computed using the modified CV method are provided, but they are considered estimates due to the failure of the ADK test after the transformation to meet the assumptions of the modified CV method. However, modified CV basis values are not provided for the 2% offset strength for ETW2 condition due to the large CV of both the as measured and normalized data. Instead, estimates of basis values that were computed with an override of the ADK test results are provided.

The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

There were no outliers.

Statistics, basis values and estimates are given for the strength data in Table 5-27. The normalized data, B-basis values and B-estimates for the 2% offset strength data are shown graphically in Figure 5-22 and for the ultimate strength data in Figure 5-23.

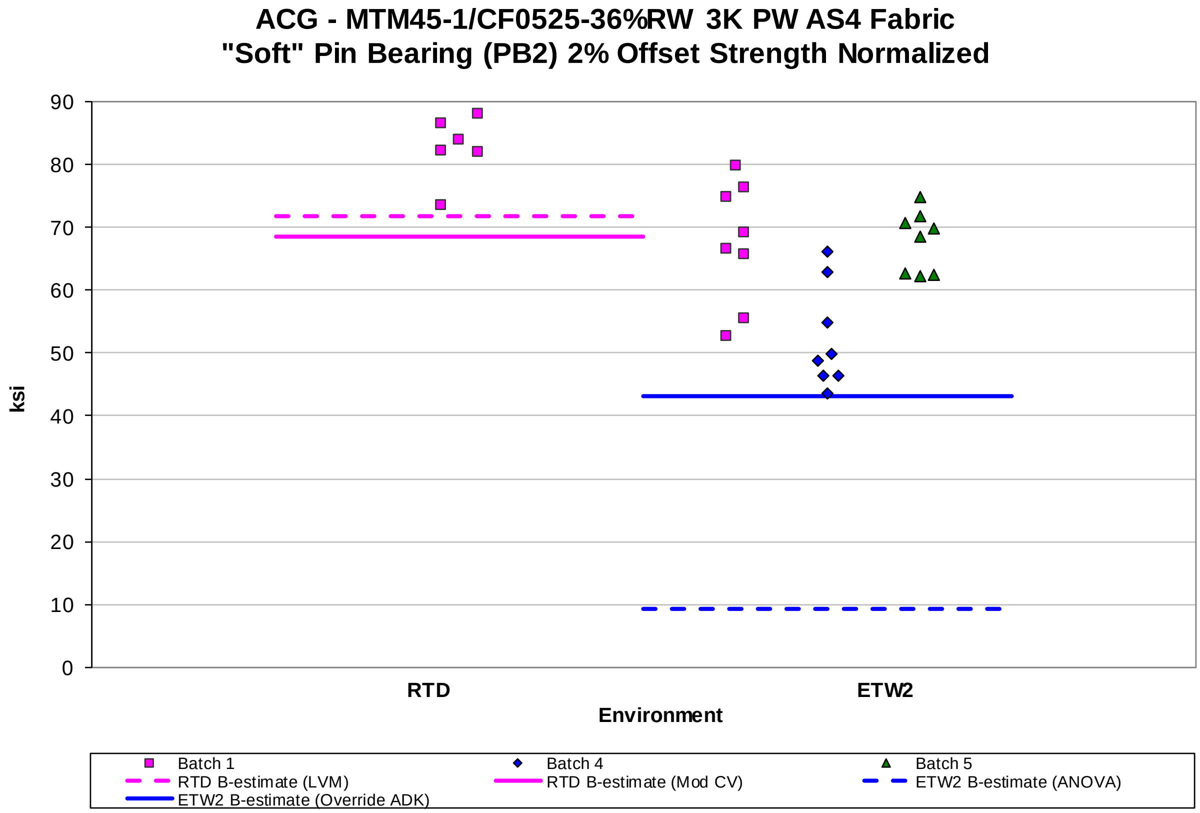

Figure 5-22: Batch Plot for PB2 2% Offset Strength Normalized

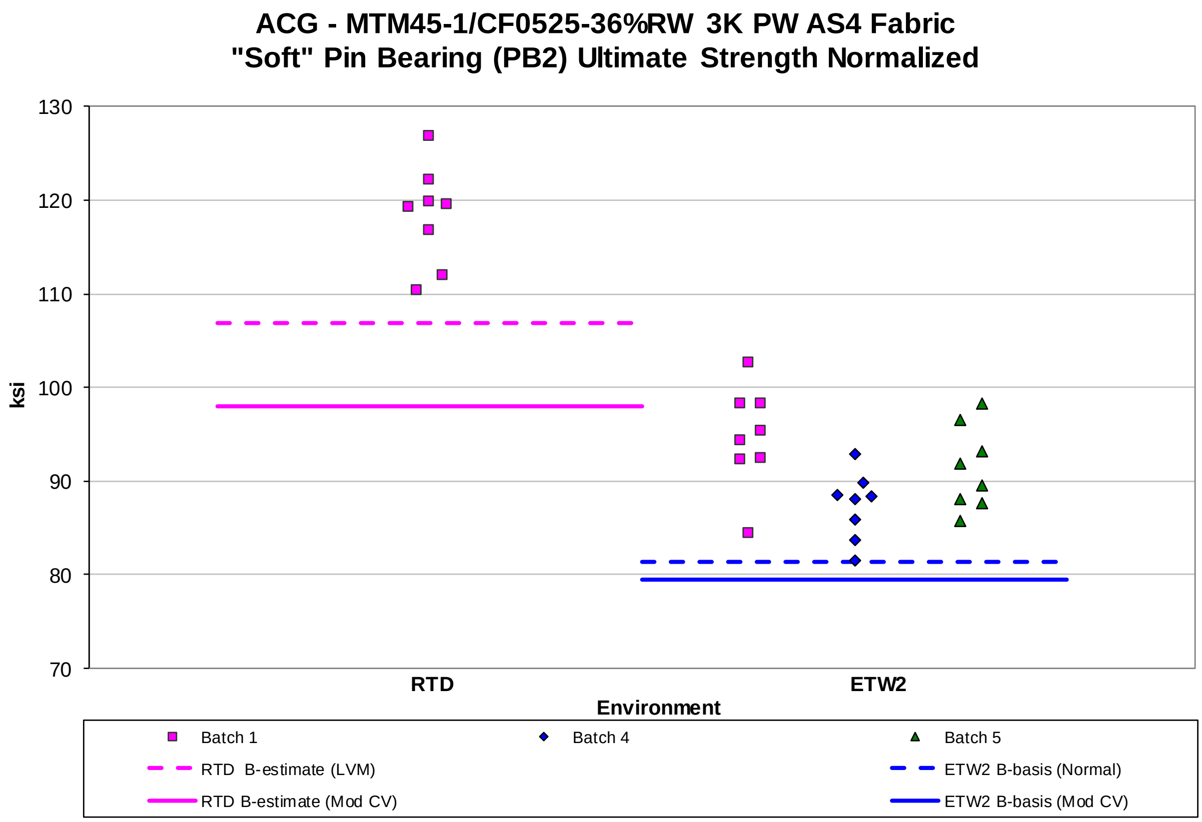

Figure 5-23: Batch Plot for PB2 Ultimate Strength Normalized

"Soft" Pin Bearing (PB2) Strength Basis Values and Statistics								
	Normalized				As measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
ENV	RTD	ETW2	RTD	ETW2	RTD	ETW2	RTD	ETW2
Mean	82.80	62.63	118.36	91.16	82.68	59.99	118.06	87.38
Stdev	5.11	10.55	5.35	5.33	5.97	9.84	6.78	4.95
CV	6.17	16.84	4.52	5.85	7.22	16.40	5.74	5.66
Modified CV	8.00	16.84	8.00	6.92	8.00	16.40	8.00	6.83
Min	73.63	43.60	110.33	81.56	73.16	42.16	109.21	78.87
Max	88.22	79.77	126.91	102.71	90.81	76.33	130.63	97.10
No. Batches	1	3	1	3	1	3	1	3
No. Spec.	6	24	8	24	6	24	8	24
Basis Values and/or Estimates								
B-basis Value				81.29				78.21
B-estimate	71.77	9.31	107.36		69.80	12.17	104.13	
A-estimate	NA	0.00	NA	74.21	NA	0.00	NA	71.64
Method	LVM	ANOVA	LVM	Normal	LVM	ANOVA	LVM	Normal
Modified CV Basis Values and/or Estimates								
B-basis Value				79.47				76.32
B-estimate	68.51		98.90		68.41		98.65	
A-estimate	NA		NA	71.08	NA		NA	68.39
Method	LVM		LVM	Normal	LVM		LVM	Normal
Basis Value Estimates with override of ADK test result								
B-estimate		43.09				41.76		
A-estimate		29.08				28.70		
Method		Normal				Normal		

Table 5-27: Statistics and Basis Values for PB2 Strength Data

5.8.3 "Hard" Pin Bearing (PB3)

The PB3 data is normalized. The RTD condition had data from only one batch available, so there was insufficient data to meet the requirements of CMH-17-1G. B-estimates were prepared using the laminate variability method (LVM) which is detailed in section 2.4.

Modified CV values are not provided for the 2% offset strength normalized data and the as measured ETW2 data due to the large CV of the data for those tests. There were no outliers.

Statistics, estimates and basis values are given for the strength data in Table 5-28. The normalized data, B-estimates and the B-basis values for the 2% offset strength data are shown graphically in Figure 5-24 and for the ultimate strength data in Figure 5-25.

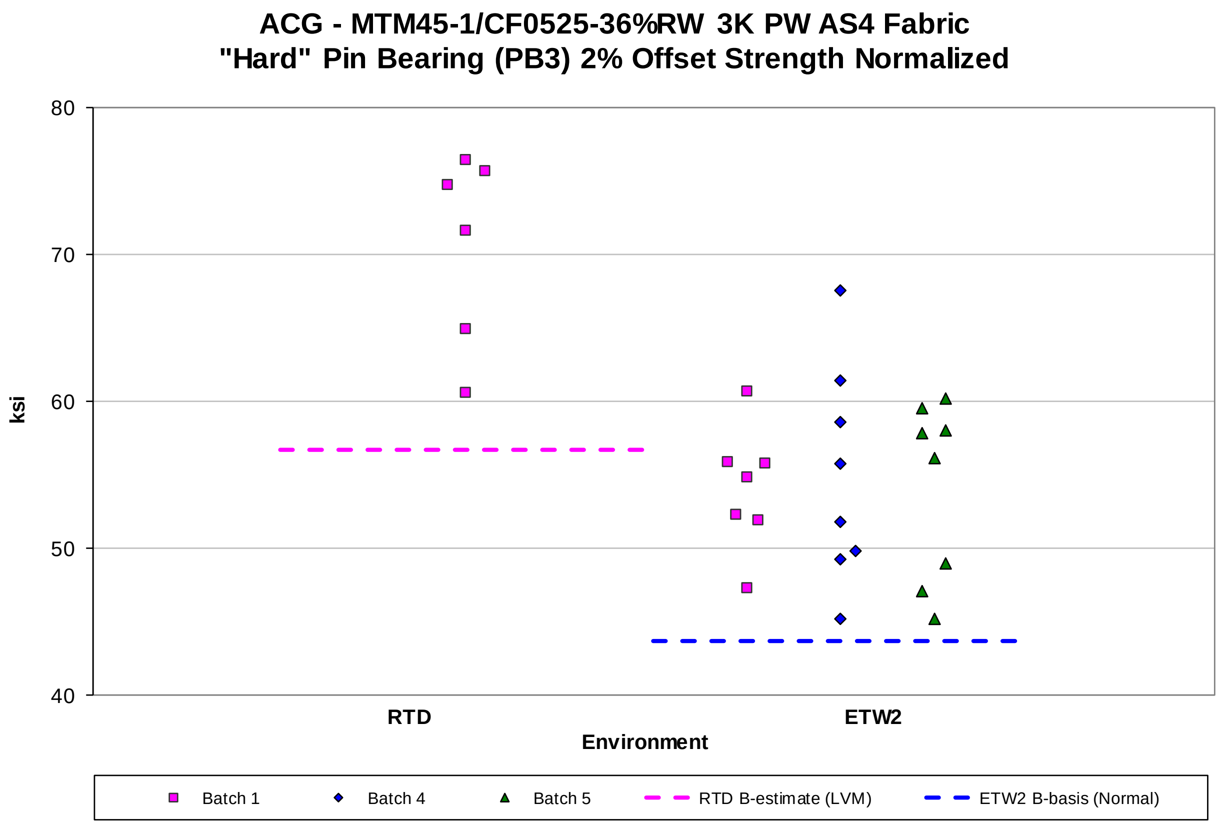

Figure 5-24: Batch Plot for PB3 2% Offset Strength Normalized

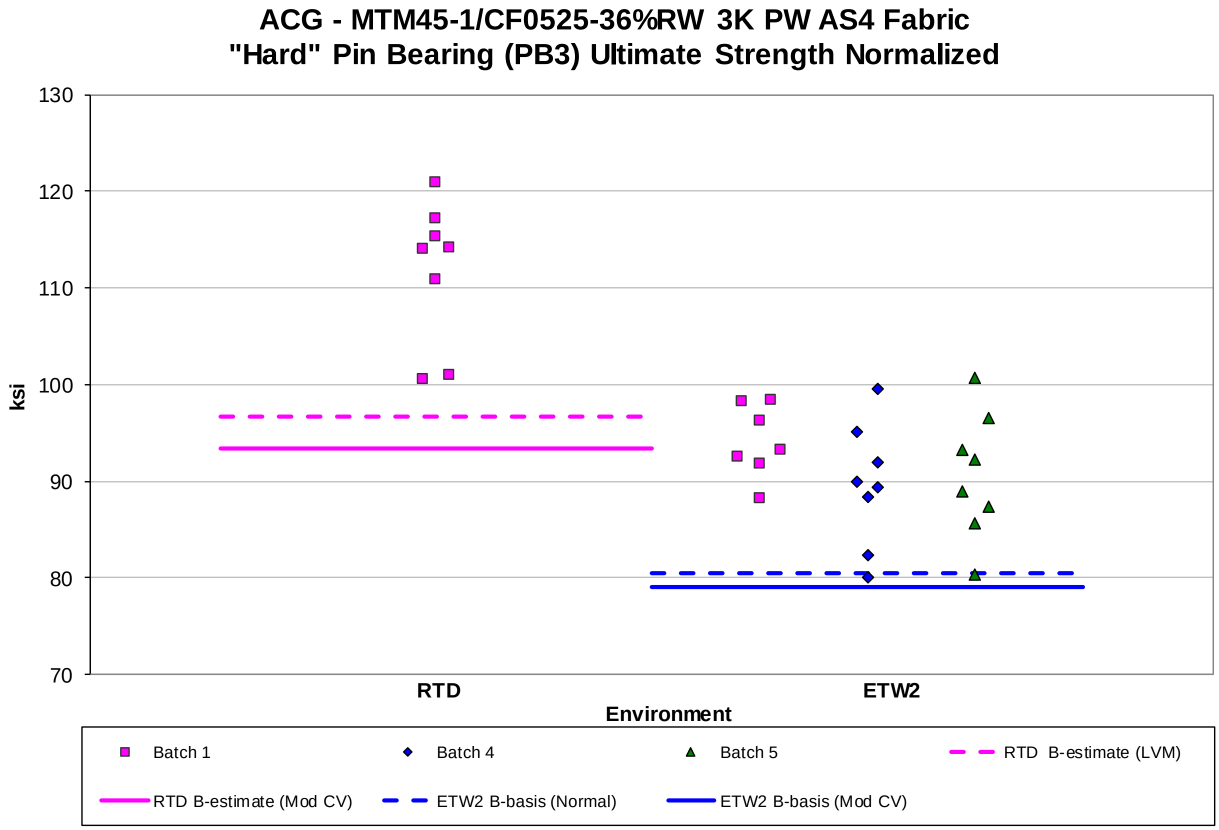

Figure 5-25: Batch Plot for PB3 Ultimate Strength Normalized

"Hard" Pin Bearing (PB3) Strength Basis Values and Statistics								
	Normalized				As measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
ENV	RTD	ETW2	RTD	ETW2	RTD	ETW2	RTD	ETW2
Mean	70.67	54.42	111.78	91.30	68.08	52.30	108.10	87.70
Stdev	6.49	5.76	7.37	5.80	5.35	5.73	6.44	5.53
CV	9.18	10.59	6.59	6.35	7.86	10.95	5.95	6.31
Modified CV	9.18	10.59	8.00	7.17	8.00	10.95	8.00	7.15
Min	60.59	45.15	100.57	79.97	59.09	42.95	98.49	77.61
Max	76.45	67.58	120.95	100.68	73.06	65.19	115.58	96.62
No. Batches	1	3	1	3	1	3	1	3
No. Spec.	6	23	8	23	6	23	8	23
Basis Values and/or Estimates								
B-basis Value		43.65		80.48		41.60		77.37
B-estimate	56.68		96.64		56.54		94.87	
A-estimate	NA	35.95	NA	72.73	NA	33.94	NA	69.98
Method	LVM	Normal	LVM	Normal	LVM	Normal	LVM	Normal
Modified CV Basis Values and/or Estimates								
B-basis Value		NA		79.06		NA		75.98
B-estimate	NA		93.40		56.33		90.33	
A-estimate	NA	NA	NA	70.30	NA	NA	NA	67.59
Method	NA	NA	LVM	Normal	LVM	NA	LVM	Normal

Table 5-28: Statistics and Basis Values for PB3 Strength Data

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

The ILT and CBS data is not normalized. Basis values are not computed for these properties. Only one batch of material was tested. There were no outliers. However the summary statistics are presented in Table 5-29 and the data are displayed graphically in Figure 5-26.

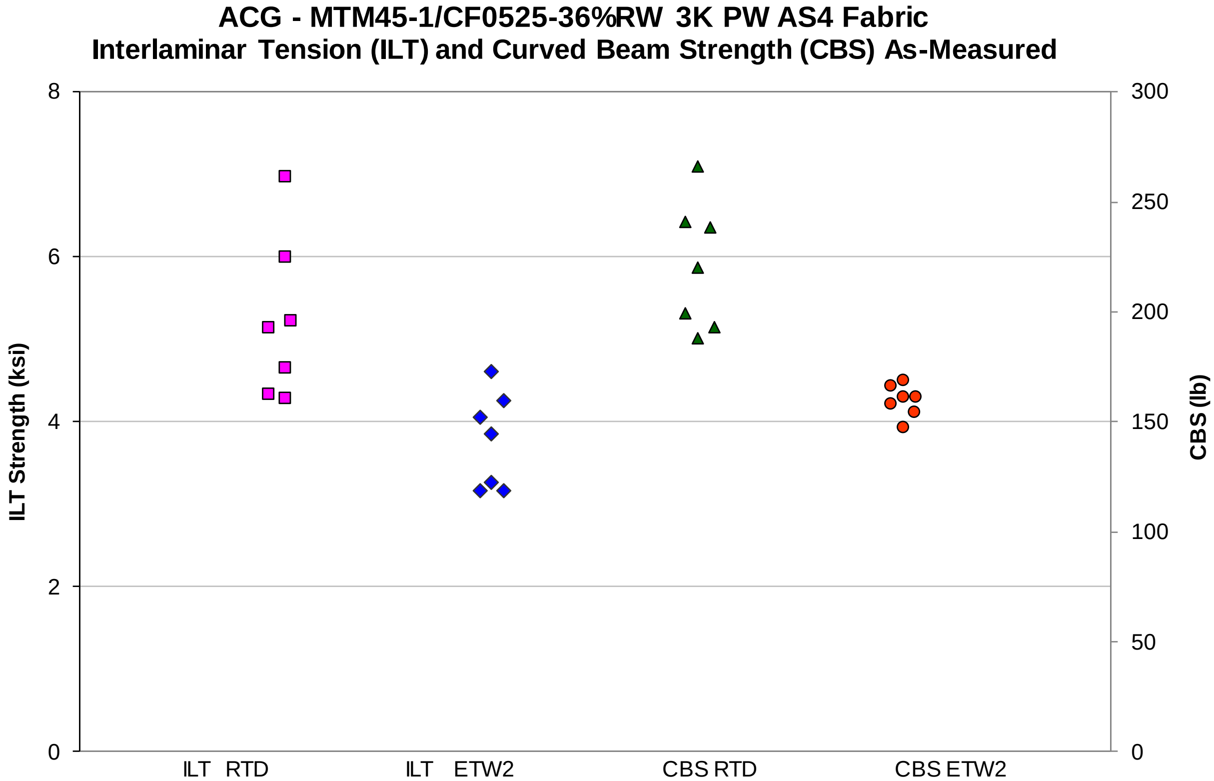

Figure 5-26: Plot for Interlaminar Tension and Curved Beam Strength As-Measured

Interlaminar Tension (ILT) and Curved Beam Strength (CBS) Statistics As Measured				
Property	ILT (ksi)		CBS (lb)	
Env	RTD	ETW2	RTD	ETW2
Mean	5.22	3.77	220.89	159.24
Stdev	0.97	0.58	28.86	7.21
CV	18.55	15.35	13.06	4.53
Mod CV	18.55	15.35	13.06	6.26
Min	4.28	3.17	188.37	147.15
Max	6.96	4.61	265.88	168.42
No. Batches	1	1	1	1
No. Spec.	7	7	7	7

Table 5-29: Statistics for ILT and CBS Data

5.10 Compression After Impact Strength

The CAI data is normalized, so both normalized and as-measured statistics are provided. Basis values are not computed for this property. Only one batch of material was tested. Testing was done only for the RTD condition. There were no outliers. However the summary statistics are presented in Table 5-30 and the data are displayed graphically in Figure 5-27.

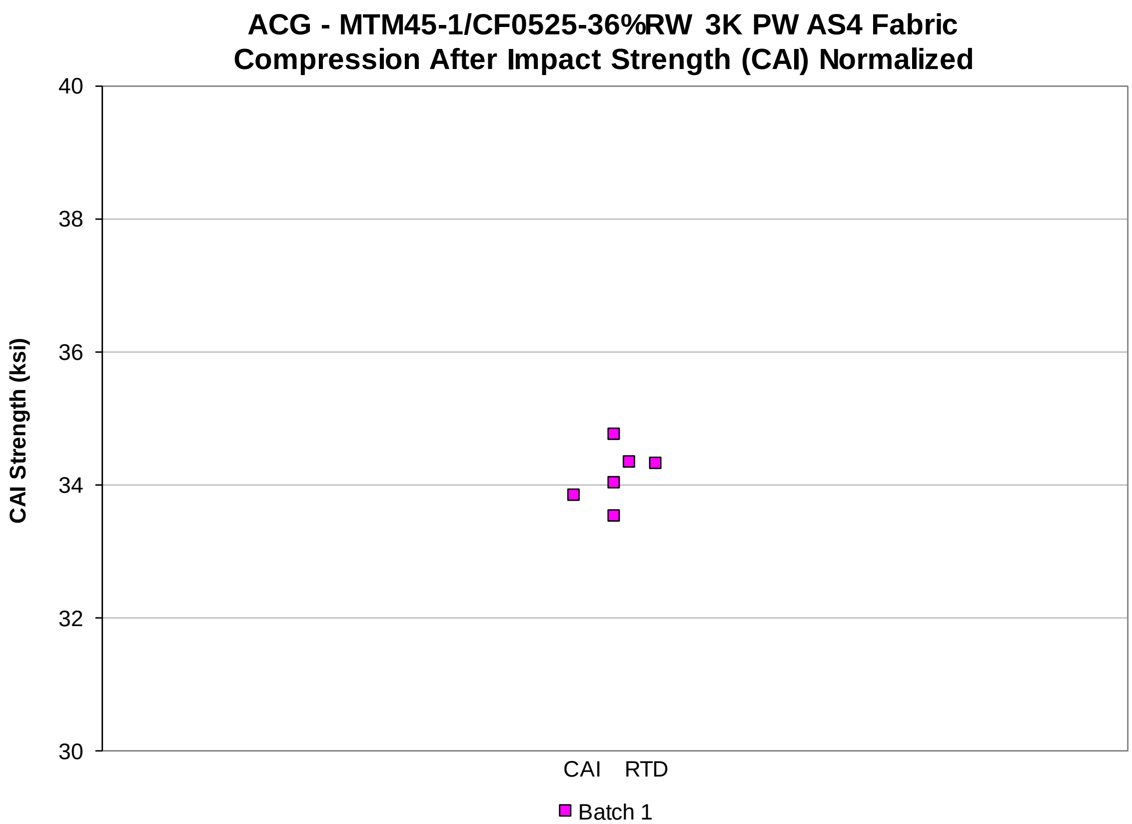

Figure 5-27: Plot for normalized Compression After Impact (CAI) Strength Data

Compression After Impact Strength (ksi) Statistics		
	Normalized	As Measured
Env	RTD	RTD
Mean	34.44	32.63
Stdev	0.70	1.48
CV	2.03	4.54
Modified CV	6.00	6.27
Min	33.52	31.33
Max	35.76	34.98
No. Batches	1	1
No. Spec.	8	8

Table 5-30: Statistics for CAI 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 chapter 8. 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. 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	Strength As Measured	High/ Low	Batch Outlier	Condition Outlier
WT	ETW2	3	AITR1392-PWC1-WT-C-MH1-ETW2-1	Not an Outlier	120.53	Low	Yes	No
FT	CTD	3	AITR1392-PWC1-FT-C-MH1-CTD-3	91.46	86.83	Low	No	Yes
FT	RTD	2	AITR1392-PWC1-FT-B-MH1-RTD-1	Not an Outlier	110.99	Low	Yes	No
FC	CTD	3	AITR1392-PWC1-FC-C-MH2-CTD-3	71.99	70.12	Low	Yes	No
IPS - 0.2% Offset	ETW	2	AITR1392-PWC1-IPS-B-MH1-ETW-3	NA	2.84	Low	Yes	No
IPS - 0.2% Offset	ETW	3	AITR1392-PWC1-IPS-C-MH1-ETW-2	NA	3.98	High	Yes	No
IPS - 0.2% Offset	ETW2	1	AITR1392-PWC1-IPS-A-MH2-ETW2-1	NA	3.47	High	Yes	Yes
IPS - 5% Strain	RTD	3	AITR1392-PWC1-IPS-C-MH2-RTD-2	NA	10.17	High	Yes	No
SBS	ETW2	2	AITR1392-PWC1-SBS-B-MH1-ETW2-1	NA	5.10	High	Yes	No
SBS	ETW2	3	AITR1392-PWC1-SBS-C-MH1-ETW2-3	NA	4.37	Low	Yes	No
UNT1	CTD	1	AITR1392-PWC1-UNT1-A-MH1-CTD-1	93.12	Not an Outlier	Low	Yes	No
UNT1	RTD	1	AITR1392-PWC1-UNT1-A-MH2-RTD-3	106.70	102.88	High	Yes	No
UNC1	RTD	4	AITR1392-PWC1-UNC1-D-MH1-RTD-1	64.87	62.75	Low	Yes	No
OHC1	RTD	1	AITR1392-PWC1-OHC1-A-MH2-RTD-3	Not an Outlier	41.86	High	Yes	No
OHC2	ETW2	5	AITR1392-PWC1-OHC2-E-MH1-ETW2-1	25.42	24.76	Low	Yes	No
FHC1	ETW2	5	AITR1392-PWC1-FHC1-E-MH2-ETW2-3	49.78	47.02	High	No	Yes
FHC2	RTD	1	AITR1392-PWC1-FHC2-A-MH1-RTD-1	49.86	48.18	High	Yes	No
SBS1	RTD	5	AITR1392-PWC1-SBS1-E-MH1-RTD-3	NA	9.39	Low	Yes	No
PB1 - Ult. Str.	RTD	4	AITR1392-PWC1-PB1-D-MH2-RTD-3	Not an Outlier	139.18	High	Yes	No

Table 6-1: List of outliers

7. References

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