Cytec Cycom 5215 T650 6K-135-5HS Fabric 36% RC Qualification Statistical Analysis Report

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1. Introduction

This report contains statistical analysis of the Cytec Cycom® 5215 T650 6K-135-5HS Fabric material property data published in NCAMP Test Report CAM-RP-2010-056 Rev A. The lamina and laminate material property data have been generated with FAA oversight through FAA Special Project Number SP4612WI-Q and also meet the requirements outlined in NCAMP Standard Operating Procedure NSP 100. The test panels, test specimens, and test setups have been conformed by the FAA and the testing has been witnessed by the FAA.

B-Basis values, A-estimates, and B-estimates were calculated using a variety of techniques that are detailed in section two. The qualification material was procured to NCAMP Material Specification NMS 323/2 Rev A dated July 16, 2007. The qualification test panels were cured in accordance with NCAMP Process Specification NPS 81323 Rev A dated July 16, 2007. The panels were fabricated at Cytec Industries, 1440 N. Kraemer Blvd, Anaheim, CA 92806. The NCAMP Test Plan NTP 3223Q1 Revision A was used for this qualification program.

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

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

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 working draft CMH-17 Rev G. The applicability of equivalency process must be evaluated on program-by-program basis by the applicant and certifying agency. The applicant and certifying agency must agree that the equivalency test plan along with the equivalency process described in Section 6 of DOT/FAA/AR-03/19 and Section 8.4.1 of working draft CMH-17 Rev G are adequate for the given program.

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 323/2. NMS 323/2 have 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 NMS 323/2.* NMS 323/2 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
Laminate Short Beam Strength	SBS1
Filled Hole Tension	FHT
Filled Hole Compression	FHC
Open Hole Tension	OHT
Open Hole Compression	OHC
Single Shear Bearing	SSB
Interlaminar Tension	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
Warp Tension Poisson's Ratio	ν_{12}^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 Peak Strength before 5% strain	F_{12}^{smax}
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°±5°F	CTD
Room Temperature Dry	70°±10°F	RTD
Elevated Temperature Dry	180°±5°F	ETD
Elevated Temperature Wet	180°±5°F	ETW

Table 1-3: Environmental Conditions Abbreviations

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

1 refers to a 25/50/25 layup. This is also referred to as "Quasi-Isotropic"
2 refers to a 10/80/10 layup. This is also referred to as "Soft"
3 refers to a 40/20/40 layup. This is also referred to as "Hard"

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

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2010-056 Rev A.

1.2 Pooling Across Environments

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

When pooling across environments was not advisable because the data was not eligible for pooling and engineering judgment indicated there was no justification for overriding the result, then B-Basis values were computed for each environmental condition separately using Stat-17 version 5.

1.3 Basis Value Computational Process

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

1.4 Modified Coefficient of Variation (CV) Method

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

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

The material allowables in this report are calculated using both the as-measured CV and modified CV, so users have the choice of using either one. When the measured CV is greater than 8%, the modified CV method does not change the basis value. NCAMP recommended values make use 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 may be provided in addition to the ANOVA estimate.

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

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

2. Background

Statistical computations are performed with AGATE Statistical Analysis Program (ASAP) when pooling across environments is permissible according to working draft CMH-17 Rev G guidelines. If pooling is not permissible, a single point analysis using STAT-17 is performed for each environmental condition with sufficient test results. If the data does not meet working draft CMH-17 Rev G 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, S_i indicates the standard deviation of i^{th} sample, 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.

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

2.1.3 Basis Value Computations

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

Basis Values:

$$A-basis = \bar{X} - K_a S$$
$$B-basis = \bar{X} - K_b S$$ **Equation 6**

2.1.3.1 K-factor computations

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

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

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

Where

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

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

$$f = N - r$$

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

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

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

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

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

2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

$$S_p^* = \sqrt{\frac{\sum_{i=1}^{k}\left((n_i - 1)\left(CV_i^* \cdot \overline{X}_i\right)^2\right)}{\sum_{i=1}^{k}(n_i - 1)}}$$ **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 individual data values (X_{ij}) in each batch as follows:

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

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

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

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

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

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

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

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

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

2.1.5 Determination of Outliers

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

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

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

where t is the $1 - \frac{.05}{2n}$ quartile of a t distribution with n−2 degrees of freedom, n being the total number of data values.

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

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

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:

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

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

2.2 STAT-17

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

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

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

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-values for the normal distribution when the sample size is 16 or larger.

Norm. Dist. k Factors for N<16		
N	B-basis	A-basis
2	20.581	37.094
3	6.157	10.553
4	4.163	7.042
5	3.408	5.741
6	3.007	5.062
7	2.756	4.642
8	2.583	4.354
9	2.454	4.143
10	2.355	3.981
11	2.276	3.852
12	2.211	3.747
13	2.156	3.659
14	2.109	3.585
15	2.069	3.520

Table 2-1: K factors for normal distribution

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

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

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

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:

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

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

The Anderson-Darling test statistic is

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

and the observed significance level is

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

where

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

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

where

$$\hat{q} = \hat{\alpha} (0.10536)^{1/\hat{\beta}}$$ **Equation 43**

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

$$\hat{q} = \hat{\alpha} (0.01005)^{1/\beta}$$ **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.

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

$$V_A \approx 6.649 + \exp\left[2.55 - 0.526\ln(n) + \frac{4.76}{n}\right]$$ **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:

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

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

For A-Basis values:

$$r_A = \frac{n}{100} - 1.645\sqrt{\frac{99n}{10,000}} + 0.29 + \frac{19.1}{n}$$ **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.

2.2.3.2 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

The A-basis value is:

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

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 all the requirements of working draft CMH-17 Rev G, there must be at least five batches represented in the data and at least 55 data points. For a B-basis value, there must be at least three batches represented in the data and at least 18 data points.

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

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

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

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

2.2.4 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.

2.2.4.1 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 $\left(n_i, \bar{x}_i, s_i^2\right)$ 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:

$$SSB = \sum_{i=1}^{k} n_i \bar{x}_i^2 - n\bar{x}^2 \qquad \textbf{Equation 52}$$

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

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

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

Next, the mean sums of squares are computed:

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

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

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

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

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

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

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

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

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

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

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

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

2.3 Single Batch and Two Batch Estimates using Modified CV

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

$$\text{Estimated B-Basis} = \bar{X} - k_b S_{adj} = \bar{X} - k_b \cdot 0.08 \cdot \bar{X} \qquad \textbf{Equation 61}$$

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													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
N1+N2-2	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 working draft CMH-17 Rev G. However, not all test data meets those requirements. The summary tables provide a complete listing of all computed basis values and estimates of basis values. Data that does not meet the requirements of working draft CMH-17 Rev G are shown in shaded boxes and labeled as estimates. Basis values computed with the modified coefficient of variation (CV) are presented whenever possible. Basis values and estimates computed without that modification are presented for all tests.

3.1 NCAMP Recommended B-basis Values

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

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

NCAMP Recommended B-basis Values for Cytec Cycom® 5215 T650 6K-135-5HS 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	IPS* Max Strain
CTD (-65°F)	B-basis	108.154	92.808	NA:A	91.899	7.985	7.476		10.533
	Mean	122.200	104.334	115.248	104.121	9.248	8.441		11.893
	CV	6.583	7.980	7.185	7.478	7.238	6.000		6.000
RTD (70°F)	B-basis	114.111	83.647	104.941	81.630	8.190	5.386		
	Mean	128.157	95.117	121.558	93.851	9.258	6.090		
	CV	6.651	6.504	7.097	7.525	6.051	6.000		
ETD (180°F)	B-basis		67.933		67.365	6.897			
	Mean		79.581		79.646	7.787			
	CV		8.655		7.562	6.000			
ETW (180°F)	B-basis	116.392	44.900	NA:A	NA:A	5.689	3.507**	5.359	
	Mean	130.378	56.321	113.731	60.747	6.415	3.611	6.059	
	CV	6.000	9.320	12.906	11.115	6.000	1.734	6.000	

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
Cytec Cycom® 5215 T650 6K-135-5HS 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	SSB 2% Offset	SSB Ult.	SBS1*
25/50/25	CTD (-65°F)	B-basis	42.947		46.593		70.403				
		Mean	48.330		52.122		78.882				
		CV	6.000		6.000		6.000				
	RTD (70°F)	B-basis	45.755	37.408	47.888	58.030	73.188	61.595	79.291	97.165	7.126
		Mean	51.139	41.379	53.418	63.956	81.666	71.994	88.741	107.712	7.894
		CV	6.000	6.000	6.000	6.000	6.000	7.579	6.293	6.000	6.419
	ETW (180°F)	B-basis	50.543	28.802	48.808	39.801	76.064	42.721	67.441	79.201	4.977
		Mean	55.927	32.773	54.337	45.727	84.543	48.236	76.890	89.749	5.747
		CV	6.000	6.000	6.000	6.033	6.000	6.000	6.581	6.000	6.000
10/80/10	CTD (-65°F)	B-basis	32.504		37.667		43.606				
		Mean	36.076		41.616		48.488				
		CV	6.000		6.000		6.365				
	RTD (70°F)	B-basis	31.318	28.207	35.350	41.310	42.943	42.220	76.176	91.516	
		Mean	34.891	31.849	39.300	45.547	47.825	46.486	88.220	102.219	
		CV	6.000	6.000	6.000	6.000	6.000	6.014	9.434	6.476	
	ETW (180°F)	B-basis	28.661	20.877	28.777	28.887	36.497	27.624	57.204	75.142	
		Mean	32.234	23.572	32.726	33.124	41.380	31.889	69.427	86.004	
		CV	6.000	6.000	6.000	6.000	6.000	6.079	6.884	6.484	
40/20/40	CTD (-65°F)	B-basis	54.511		53.430		90.169				
		Mean	61.725		60.341		101.488				
		CV	6.177		6.080		6.000				
	RTD (70°F)	B-basis	59.345	40.115	56.089	59.988	95.840	62.463	73.186	85.643	
		Mean	66.559	45.172	63.000	66.374	107.159	69.995	84.400	95.099	
		CV	6.308	7.341	6.767	6.174	6.507	7.144	7.148	6.000	
	ETW (180°F)	B-basis	67.417	29.585	60.361	42.537	97.804	46.047	56.729	71.186	
		Mean	74.630	34.641	67.272	48.973	109.123	53.579	67.843	80.642	
		CV	6.000	6.626	6.000	6.255	6.000	6.212	9.474	6.115	

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

Table 3-2 : NCAMP Recommended B-basis values for Laminate Test Data

3.2 Lamina and Laminate Summary Tables

Prepreg Material:	CYTEC CYCOM® 5215 T650 6K-135-5HS fabric NMS 323/2 Material Specification		**CYTEC CYCOM® 5215 T650 6K-135-5HS Lamina Properties Summary**
Fabric: T650 6K 5HS		**Resin:** CYTEC CYCOM® 5215	
Tg(dry): 326.70° F	**Tg(wet):** 243.64° F	**Tg METHOD:** DMA (SRM 18-94)	
PROCESSING:	NPS 81323 Baseline "C" Cure Cycle		

Date of fiber manufacture	8/16/2006	**Date of testing**	10/27/2009 - 11/9/2010
Date of resin manufacture	9/25/2006 to 12/06/2006	**Date of data submittal**	2/1/2011
Date of prepreg manufacture	9/27/2006 to 12/13/2006	**Date of analysis**	4/24/2012 - 5/30/2012
Date of composite manufacture	2/1/2009		

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY

Data reported: As measured followed by normalized values in parentheses, normalizing tply: 0.0155 in

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

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

	CTD			RTD			ETD			ETW		
	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}	110.718	108.492	122.590	96.312	114.741	128.839				123.165	116.494	130.531
(ksi)	(110.173)	(108.154)	(122.200)	(96.216)	(114.111)	(128.157)				(123.081)	(116.392)	(130.378)
E_1^t			9.718			10.120						9.574
(Msi)			(9.687)			(10.069)						(9.563)
ν_{12}^t			0.058			0.041						0.047
F_2^{tu}	65.287	98.819	114.580	72.158	105.103	121.772				30.669	73.038	113.237
(ksi)	(65.966)	(99.469)	(115.248)	(72.553)	(104.941)	(121.558)				(28.550)	86.050	(113.731)
E_2^t			9.559			9.513						9.556
(Msi)			(9.614)			(9.496)						(9.609)
F_1^{cu}	93.758	93.223	104.993	85.502	84.969	96.684	69.039	68.498	80.394	45.188	44.658	56.321
(ksi)	(93.350)	(92.808)	(104.334)	(84.186)	(83.647)	(95.117)	(68.480)	(67.933)	(79.581)	(45.437)	(44.900)	(56.321)
E_1^c			8.926			8.785			8.767			8.710
(Msi)			(8.853)			(8.643)			(8.685)			(8.713)
ν_{12}^c			0.075			0.050			0.048			0.045
F_2^{cu}	93.064	92.353	104.778	83.477	82.766	95.191	68.733	68.019	80.505	24.902	47.973	60.942
(ksi)	(92.690)	(91.899)	(104.121)	(82.420)	(81.630)	(93.851)	(68.159)	(67.365)	(79.646)	(27.934)	48.126	(60.747)
E_2^c			8.802			8.829			8.648			8.630
(Msi)			(8.743)			(8.700)			(8.544)			(8.562)
ν_{21}^c			0.085			0.050			0.047			0.042
$F_{12}^{s0.2\%}$ (ksi)	8.005	7.476	8.441	5.928	5.386	6.090				3.507	NA	3.611
$F_{12}^{s5\%}$ (ksi)										5.788	5.359	6.059
F_{12}^{smax} (ksi)	10.159	10.533	11.893									
G_{12}^s (Msi)			0.670			0.557						0.385
SBS (ksi)	8.118	7.985	9.248	8.534	8.190	9.258	7.536	6.897	7.787	5.472	5.689	6.415

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

Prepreg Material: CYTEC CYCOM® 5215 T650 6K-135-5HS fabric
NMS 323/2 Material Specification

Fabric: T650 6K 5HS **Resin:** CYTEC CYCOM® 5215

CYTEC CYCOM® 5215 T650 6K-135-5HS Laminate Properties Summary

Tg(dry): 326.70° F **Tg(wet):** 243.64° F **Tg METHOD:** DMA (SRM 18-94)

PROCESSING: NPS 81323 Baseline "C" Cure Cycle

Date of fiber manufacture	8/16/2006	**Date of testing**	10/27/2009 - 11/9/2010
Date of resin manufacture	9/25/2006 to 12/06/2006	**Date of data submittal**	2/1/2011
Date of prepreg manufacture	9/27/2006 to 12/13/2006	**Date of analysis**	4/24/2012 - 5/30/2012
Date of composite manufacture	2/1/2009		

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY

Data reported as normalized used a normalizing t_{ply} of 0.0155 in

Values shown in shaded boxes do not meet CMH17 Rev G 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	45.659	42.947	48.330	32.238	32.504	36.076	57.003	54.511	61.725
		RTD	ksi	45.038	45.755	51.139	30.989	31.318	34.891	61.836	59.345	66.559
		ETW	ksi	53.260	50.543	55.927	31.172	28.661	32.234	69.908	67.417	74.630
OHC (normalized)	Strength	RTD	ksi	39.621	37.408	41.379	30.205	28.207	31.849	39.423	40.115	45.172
		ETW	ksi	31.015	28.802	32.773	18.847	20.877	23.572	25.642	29.585	34.641
UNT (normalized)	Strength	CTD	ksi	76.400	70.403	78.882	44.568	43.606	48.488	94.267	90.169	101.488
	Modulus		Msi	---	---	6.854	---	---	4.442	---	---	8.735
	Strength	RTD	ksi	68.461	73.188	81.666	46.263	42.943	47.825	99.939	95.840	107.159
	Modulus		Msi	---	---	6.473	---	---	4.175	---	---	8.481
	Strength	ETW	ksi	81.870	76.064	84.543	39.817	36.497	41.380	101.902	97.804	109.123
	Modulus		Msi	---	---	6.558	---	---	3.820	---	---	8.555
UNC (normalized)	Strength	RTD	ksi	62.176	61.595	71.994	42.919	42.220	46.486	61.610	62.463	69.995
	Modulus		Msi	---	---	6.283	---	---	3.939	---	---	7.830
	Poisson's Ratio			---	---	0.338	---	---	0.556	---	---	0.137
	Strength	ETW	ksi	45.435	42.721	48.236	24.765	27.624	31.889	49.064	46.047	53.579
	Modulus		Msi	---	---	6.172	---	---	3.679	---	---	8.002
	Poisson's Ratio			---	---	0.365	---	---	0.616	---	---	0.134
SBS1 (as measured)	Strength	RTD	ksi	7.173	7.126	7.894	---	---	---	---	---	---
		ETW	ksi	5.574	4.977	5.747	---	---	---	---	---	---
FHT (normalized)	Strength	CTD	ksi	49.686	46.593	52.122	39.457	37.667	41.616	48.608	53.430	60.341
		RTD	ksi	50.981	47.888	53.418	37.981	35.350	39.300	46.048	56.089	63.000
		ETW	ksi	51.901	48.808	54.337	31.796	28.777	32.726	52.513	60.361	67.272
FHC (normalized)	Strength	RTD	ksi	60.444	58.030	63.956	42.665	41.310	45.547	61.841	59.988	66.374
		ETW	ksi	42.215	39.801	45.727	30.600	28.887	33.124	44.404	42.537	48.973
Single Shear Bearing (normalized)	2% Offset Strength	RTD	ksi	81.613	79.291	88.741	72.929	76.176	88.220	73.757	73.186	84.400
		ETW	ksi	69.762	67.441	76.890	61.799	57.204	69.427	57.294	56.729	67.843
	Ultimate Strength	RTD	ksi	101.364	97.165	107.712	92.919	91.516	102.219	88.147	85.643	95.099
		ETW	ksi	83.401	79.201	89.749	68.832	75.142	86.004	63.978	71.186	80.642
CAI (normalized)	Strength	RTD	ksi	---	---	25.263	---	---	---	---	---	---
ILT (as measured)	Strength	CTD	ksi	---	---	5.953	---	---	---	---	---	---
		RTD	ksi	---	---	3.922	---	---	---	---	---	---
		ETW	ksi	---	---	3.006	---	---	---	---	---	---
CBS (as measured)	Strength	CTD	lb	---	---	238.630	---	---	---	---	---	---
		RTD	lb	---	---	165.212	---	---	---	---	---	---
		ETW	lb	---	---	129.426	---	---	---	---	---	---

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

4. Individual Test Summaries, Statistics, Basis Values and Graphs

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

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

When a dataset fails the Anderson-Darling k-sample (ADK) test for batch-to-batch variation, an ANOVA analysis is required. In order for B-basis values computed using the ANOVA method, data from five batches are 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 working draft CMH-17 Rev G section 8.3.10.

4.1 Warp Tension (WT)

The Warp Tension data is normalized, so both normalized and as-measured statistics are provided. The data for the RTD condition, both normalized and as-measured, failed the ADK test, but passed with the use of the modified CV method. A- and B-estimates computed using the ANOVA method are provided for the RTD datasets. Pooling across the environments requires that the RTD data be included, so pooling was not appropriate. However, all three conditions could be pooled to compute the modified CV basis values. There were no outliers.

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

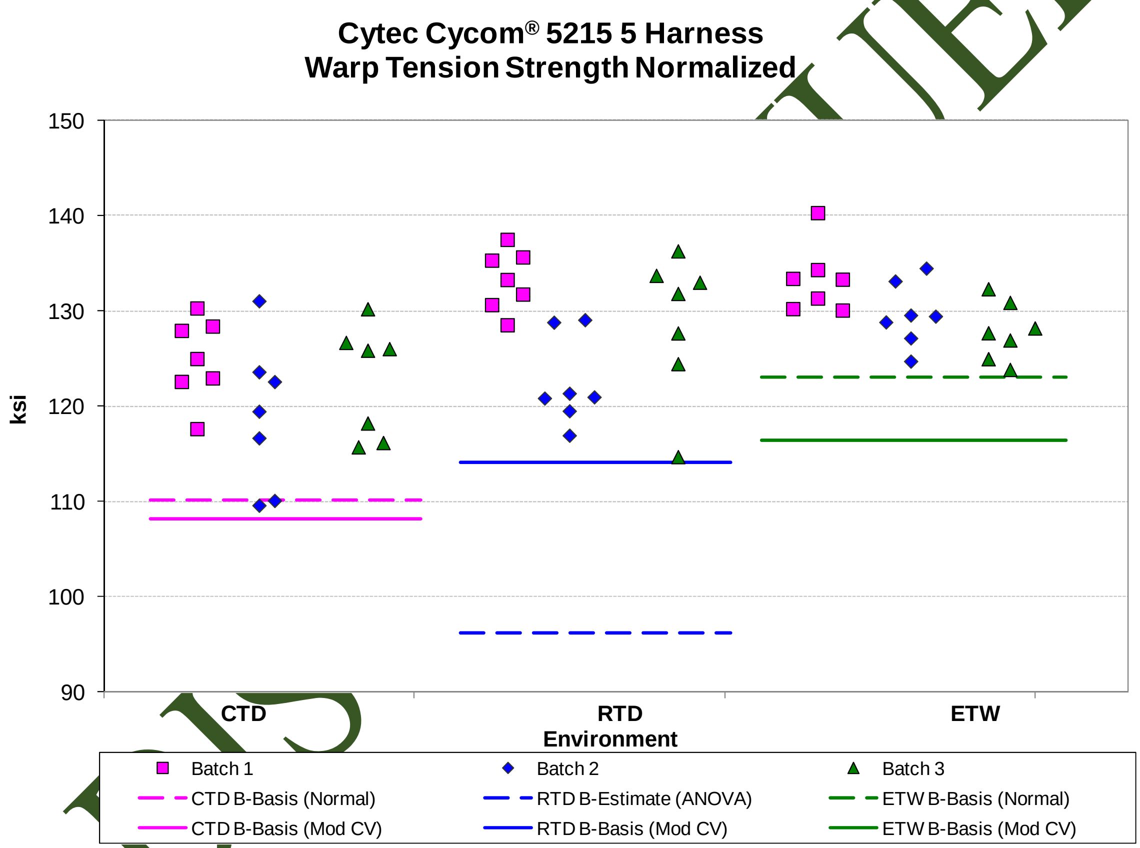

Figure 4-1: Batch plot for WT normalized strength

Warp Tension Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	122.200	128.157	130.378	122.590	128.839	130.531
Stdev	6.314	6.795	3.869	6.232	6.943	3.906
CV	5.167	5.302	2.968	5.084	5.389	2.992
Mod CV	6.583	6.651	6.000	6.542	6.694	6.000
Min	109.566	114.660	123.829	110.322	116.652	124.870
Max	131.024	137.474	140.281	132.340	138.987	140.849
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	22	21	21	22
Basis Values and/or Estimates						
B-basis Value	110.173		123.081	110.718		123.165
B-Estimate		96.216			96.312	
A-Estimate	101.598	73.417	117.869	102.253	73.094	117.903
Method	Normal	ANOVA	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and/or Estimates						
B-basis Value	108.154	114.111	116.392	108.492	114.741	116.494
A-Estimate	98.672	104.629	106.898	98.975	105.224	106.966
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-1: Statistics and Basis values for WT Strength Data

Warp Tension Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	9.687	10.069	9.563	9.718	10.120	9.574
Stdev	0.239	0.643	0.081	0.238	0.609	0.111
CV	2.472	6.382	0.849	2.451	6.021	1.160
Mod CV	6.000	7.191	6.000	6.000	7.011	6.000
Min	9.191	9.525	9.436	9.257	9.526	9.397
Max	10.172	11.683	9.766	10.113	11.526	9.779
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	22	21	21	22

Table 4-2: Statistics from WT Modulus Data

4.2 Fill Tension (FT)

The Fill Tension data is normalized, so both normalized and as-measured statistics are provided. All of the FT datasets, both normalized and as-measured, failed the ADK test even after the modified CV transform was applied to the data. Estimates of basis values were computed using the ANOVA method. These are excessively low, which is not unusual in this type of circumstance.

In addition to the ANOVA estimates, estimates computed using the modified CV method are provided for the RTD condition, both normalized and a measured. However, these values are still considered estimates due to the failure of the ADK test for the modified CV data. The CTD condition, both normalized and as-measured, failed the normality test and the CV for the ETW condition, both normalized and a measured, was over 8%, so the modified CV method could not be applied to those conditions. Additional estimates of basis values are provided for the CTD and ETW conditions by overriding the ADK test results. Caution is recommended regarding the use of the basis values computed by overriding the ADK test results. Batch three values were consistently lower than batch one and two values across the environments, which is a counter-indication for using an override with respect to pooling the environments according to section 4.3.10 of CMH-17 Rev G, so the single point method was used for computing those estimates. There were no outliers.

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

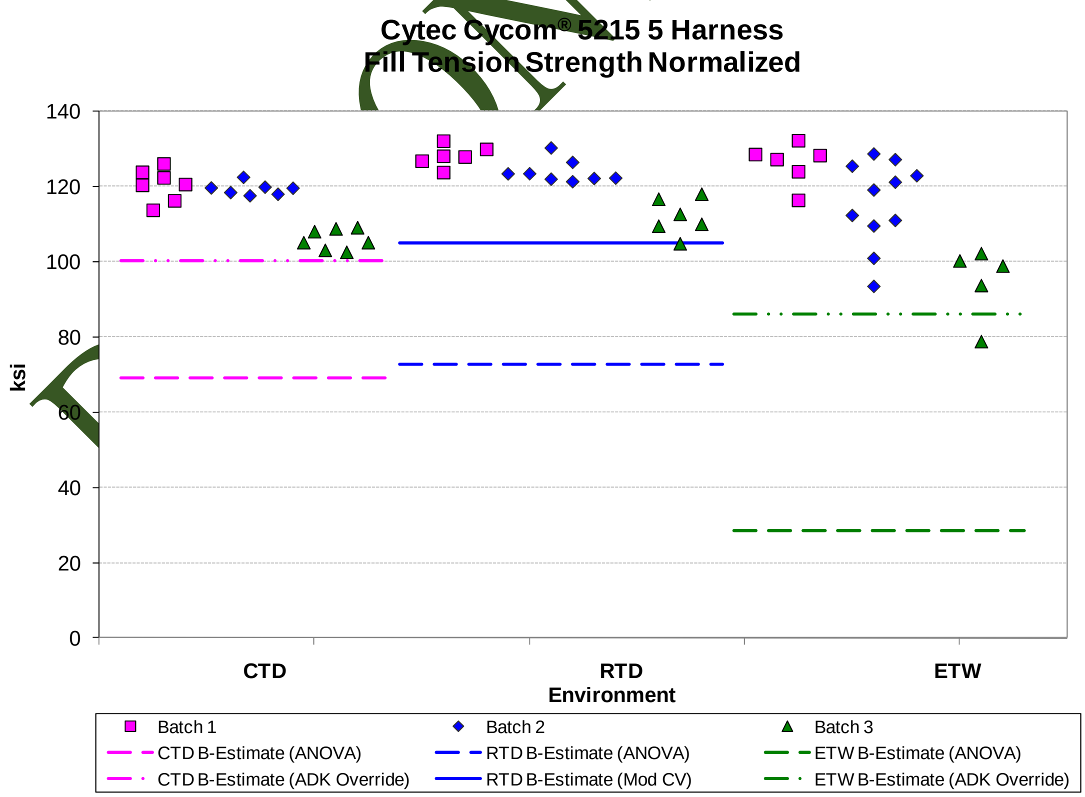

Figure 4-2: Batch Plot for FT normalized strength

Fill Tension Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	115.248	121.558	113.731	114.580	121.772	113.237
Stdev	7.341	7.528	14.678	7.375	7.564	14.406
CV	6.369	6.193	12.906	6.436	6.212	12.722
Mod CV	7.185	7.097	12.906	7.218	7.106	12.722
Min	102.547	104.818	78.830	101.811	104.833	78.085
Max	126.024	132.072	132.205	123.811	131.665	130.729
No. Batches	3	3	3	3	3	3
No. Spec.	21	20	22	21	20	22
Basis Value Estimates						
B-Estimate	65.966	72.553	28.550	65.287	72.158	30.669
A-Estimate	30.781	37.569	0.000	30.094	36.739	0.000
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Value Estimates						
B-Estimate	NA	104.941	NA	NA	105.103	NA
A-Estimate	NA	93.130	NA	NA	93.256	NA
Method	NA	Normal	NA	NA	Normal	NA
Basis Value Estimates with override of ADK test						
B-Estimate	100.082		86.050	98.648		73.038
A-Estimate	84.976		66.278	78.778		40.788
Method	Weibull		Normal	Non Parametric		Non Parametric

Table 4-3: Statistics and Basis Values for FT Strength Data

Fill Tension Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	9.614	9.496	9.609	9.559	9.513	9.556
Stdev	0.136	0.103	0.175	0.165	0.149	0.228
CV	1.417	1.088	1.820	1.729	1.569	2.383
Mod CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	9.441	9.352	9.309	9.353	9.280	9.155
Max	9.899	9.745	9.960	9.967	9.761	9.933
No. Batches	3	3	3	3	3	3
No. Spec.	21	20	25	21	20	25

Table 4-4: Statistics from FT Modulus Data

4.3 Warp Compression (WC)

The Warp Compression data is normalized, so both normalized and as-measured statistics are provided. The data from ETW condition, both normalized and as-measured, failed the normality test. However, the pooled dataset, both normalized and as-measured, passed the normality test so it was acceptable to pool all four environmental conditions to compute basis values. There were no other diagnostic test failures. There was one outlier. The lowest value in the normalized data for batch two from the RTD condition was an outlier for batch two only. It was not an outlier for the RTD condition and it was not an outlier for the as-measured dataset.

Statistics, basis values and estimates 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 values are shown graphically in Figure 4-3.

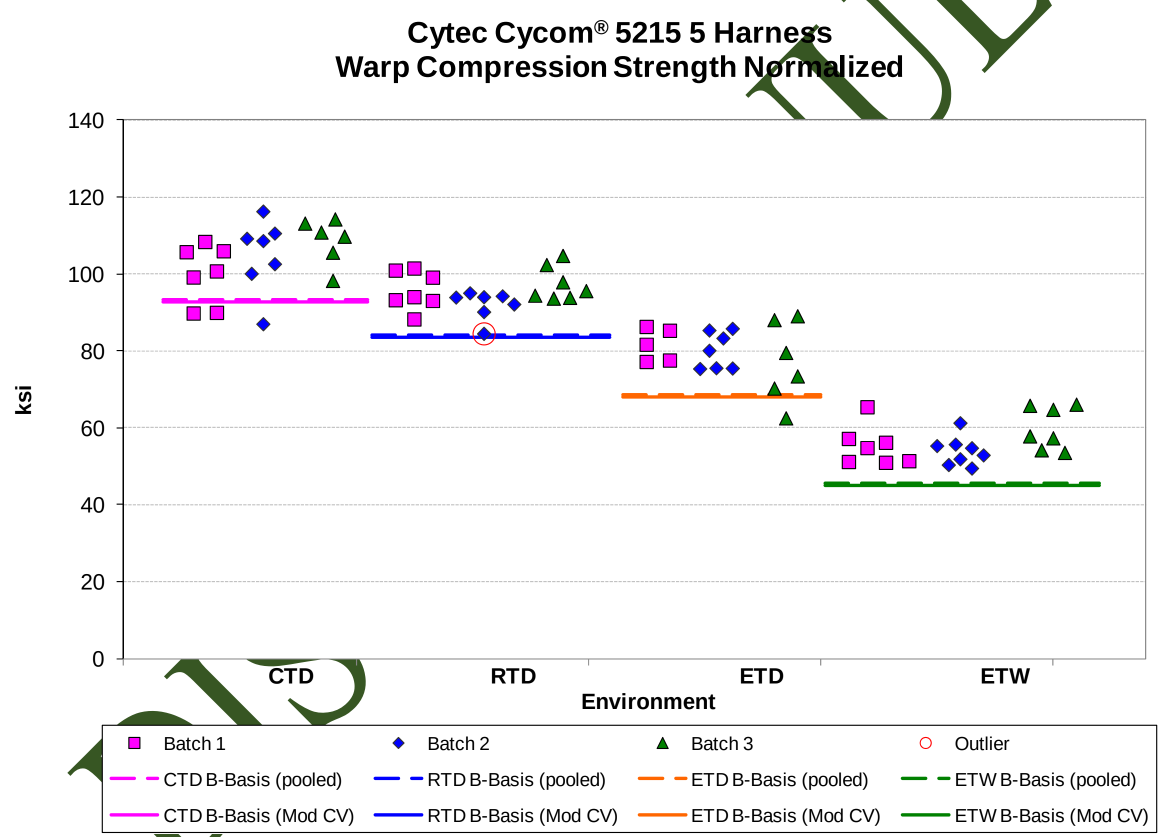

Figure 4-3: Batch plot for WC normalized strength

Warp Compression Strength Basis Values and Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETD	ETW	CTD	RTD	ETD	ETW
Mean	104.334	95.117	79.581	56.321	104.993	96.684	80.394	56.321
Stdev	8.304	4.764	6.888	5.249	8.557	4.855	7.252	5.065
CV	7.959	5.009	8.655	9.320	8.150	5.022	9.021	8.993
Mod CV	7.980	6.504	8.655	9.320	8.150	6.511	9.021	8.993
Min	87.035	84.528	62.553	49.523	88.172	86.315	62.385	49.790
Max	116.311	104.782	89.098	66.125	117.543	104.848	89.459	65.470
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	20	21	18	22	20	21	18	22
Basis Values and/or Estimates								
B-basis Value	93.350	84.186	68.480	45.437	93.758	85.502	69.039	45.188
A-Estimate	86.044	76.872	61.192	38.115	86.284	78.020	61.583	37.698
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and/or Estimates								
B-basis Value	92.808	83.647	67.933	44.900	93.223	84.969	68.498	44.658
A-Estimate	85.142	75.972	60.285	37.217	85.394	77.132	60.688	36.812
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

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

Warp Compression Modulus Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETD	ETW	CTD	RTD	ETD	ETW
Mean	8.853	8.643	8.685	8.713	8.926	8.785	8.767	8.710
Stdev	0.366	0.270	0.358	0.269	0.420	0.292	0.333	0.272
CV	4.130	3.124	4.127	3.093	4.701	3.323	3.804	3.125
Mod CV	6.065	6.000	6.064	6.000	6.351	6.000	6.000	6.000
Min	8.263	8.161	8.089	8.143	8.202	8.310	8.192	8.071
Max	9.672	9.266	9.428	9.214	9.798	9.427	9.462	9.214
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	24	22	25	21	24	22	25	21

Table 4-6: Statistics from WC Modulus Data

4.4 Fill Compression (FC)

The Fill Compression data is normalized, so both normalized and as-measured statistics are provided. The ETW datasets, both normalized and as-measured, failed the ADK test even after the modified CV transform was applied to the data. Estimates of basis values were computed using the ANOVA method. These are excessively low, which is not unusual in this type of circumstance.

In addition to the ANOVA estimates, estimates computed using the modified CV method are provided for the ETW condition, both normalized and a measured. However, these values are still considered estimates due to the failure of the ADK test for the modified CV data. The ETD condition, both normalized and as-measured, failed the normality test, but when the CTD, RTD and ETD data are pooled, the pooled dataset passes the normality test so pooling is acceptable for those three conditions. There were no outliers.

Statistics, basis values and estimates 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.

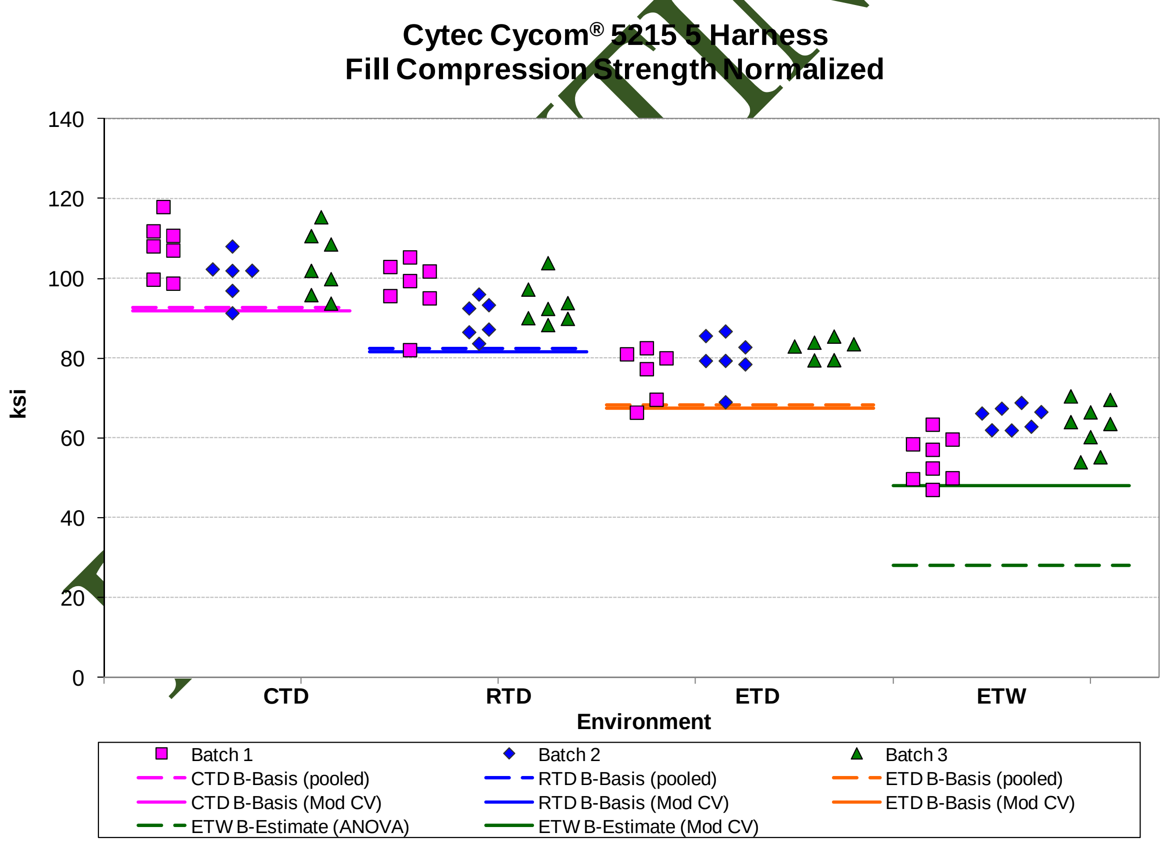

Figure 4-4: Batch Plot for FC normalized strength

Fill Compression Strength Basis Values and Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETD	ETW	CTD	RTD	ETD	ETW
Mean	104.121	93.851	79.646	60.747	104.778	95.191	80.505	60.942
Stdev	7.242	6.616	5.674	6.752	7.120	7.238	5.627	6.938
CV	6.956	7.050	7.124	11.115	6.795	7.604	6.989	11.385
Mod CV	7.478	7.525	7.562	11.115	7.397	7.802	7.495	11.385
Min	91.316	82.073	66.416	47.047	92.059	81.732	66.061	47.085
Max	117.908	105.315	86.737	70.466	118.232	108.620	87.525	70.334
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	20	20	19	23	20	20	19	23
Basis Values and/or Estimates								
B-basis Value	92.690	82.420	68.159		93.064	83.477	68.733	
B-Estimate				27.934				24.902
A-Estimate	84.991	74.721	60.471	4.496	85.175	75.588	60.855	0.000
Method	pooled	pooled	pooled	ANOVA	pooled	pooled	pooled	ANOVA
Modified CV Basis Values and/or Estimates								
B-basis Value	91.899	81.630	67.365		92.353	82.766	68.019	
B-Estimate				48.126				47.973
A-Estimate	83.668	73.398	59.144	39.098	83.985	74.398	59.662	38.697
Method	pooled	pooled	pooled	Normal	pooled	pooled	pooled	Normal

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

Fill Compression Modulus Statistics								
	Normalized				As Measured			
Env	CTD	RTD	ETD	ETW	CTD	RTD	ETD	ETW
Mean	8.743	8.700	8.544	8.562	8.802	8.829	8.648	8.630
Stdev	0.388	0.316	0.242	0.281	0.424	0.356	0.298	0.298
CV	4.432	3.629	2.827	3.277	4.813	4.028	3.449	3.454
Mod CV	6.216	6.000	6.000	6.000	6.406	6.014	6.000	6.000
Min	7.593	8.142	8.063	8.160	7.524	8.382	8.092	8.114
Max	9.430	9.281	9.062	9.002	9.596	9.704	9.373	9.090
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21	21	21

Table 4-8: Statistics from FC Modulus Data

4.5 In-Plane Shear (IPS)

In-Plane Shear data is not normalized. Maximum strength data refers to the peak shear strength before 5% strain and is available only for the CTD condition. Strength at 5% strain data is available only for the ETW condition. The CTD condition had only a single value for strength at 5% strain (11.465) while the RTD condition had no data for that property.

The CTD maximum strength dataset fails the ADK test, but passes it with the use of the modified CV transform. The ETW strength at 5% strain data failed the normality test, but passed with the use of the modified CV transform. Modified CV basis values are provided for those datasets.

The RTD, ETW and pooled datasets for the 0.2% offset strength failed normality tests. Pooling was not appropriate for that reason. When the modified CV transformation was applied the CTD, RTD and pooled datasets passed the normality test. However the pooled dataset did not pass Levene's test, so pooling was not appropriate. The modified CV approach assumes the normal distribution, so modified CV basis values for 0.2% offset strength are provided only for the CTD and RTD conditions.

The IPS data had three outliers. The highest value in batch one of the 0.2% offset strength dataset for the RTD condition was an outlier for both batch one and the RTD condition. The highest value in batch one of the strength at 5% strain dataset for the ETW dataset was an outlier for batch one only, but not for the ETW condition. The highest value in batch two of the ETW dataset was an outlier for both the 0.2% offset strength data and the strength at 5% strain data. It was an outlier for both batch two and the ETW condition for the 0.2% offset data but only for the ETW condition and not for batch two for the strength at 5% strain data.

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

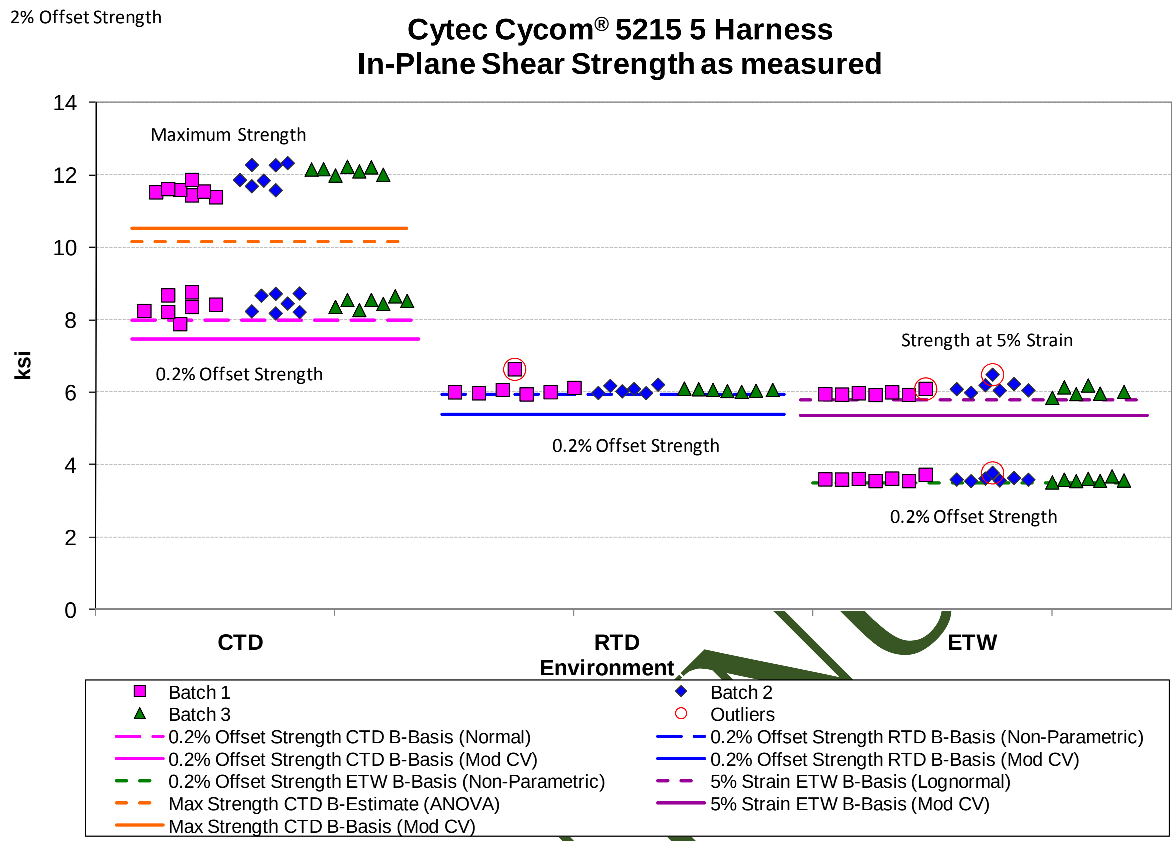

Figure 4-5: Batch plot for IPS strength as measured

In-Plane Shear Strength Basis Values and Statistics As Measured									
	0.2% Offset Strength			Max Strength	Strength at 5% Strain	Modulus Statistics		
Env	CTD	RTD	ETW	CTD	ETW	CTD	RTD	ETW
Mean	8.441	6.090	3.611	11.893	6.059	0.670	0.557	0.385
Stdev	0.229	0.147	0.063	0.311	0.145	0.018	0.010	0.006
CV	2.708	2.416	1.734	2.613	2.395	2.721	1.753	1.604
Mod CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
Min	7.891	5.953	3.523	11.391	5.860	0.623	0.528	0.376
Max	8.768	6.644	3.787	12.333	6.495	0.700	0.575	0.398
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	20	21	21	20	21	25	21
Basis Values and Estimates								
B-basis Value	8.005	5.928	3.507		5.788			
B-Estimate				10.159				
A-Estimate	7.695	5.123	3.205	8.921	5.604			
Method	Normal	Non-Parametric	Non-Parametric	ANOVA	Lognormal			
Modified CV Basis Values and Estimates								
B-basis Value	7.476	5.386	NA	10.533	5.359			
A-Estimate	6.788	4.886	NA	9.565	4.861			
Method	Normal	Normal	NA	Normal	Normal			

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

4.6 Short-Beam Strength (SBS)

The Short Beam Strength data is not normalized. The data for the ETW condition failed the ADK test, but passed with the use of the modified CV method. A- and B-estimates computed using the ANOVA method are provided for the ETW dataset. Modified CV basis values are provided but pooling was not appropriate due to failure of Levene's test.

There was one outlier. The lowest value in batch two of the ETW condition was an outlier for batch two, but not for the ETW condition. It was retained for this analysis.

Statistics, basis values and estimates are given for SBS data in Table 4-10. The data, B-estimates and B-basis values are shown graphically in Figure 4-6.

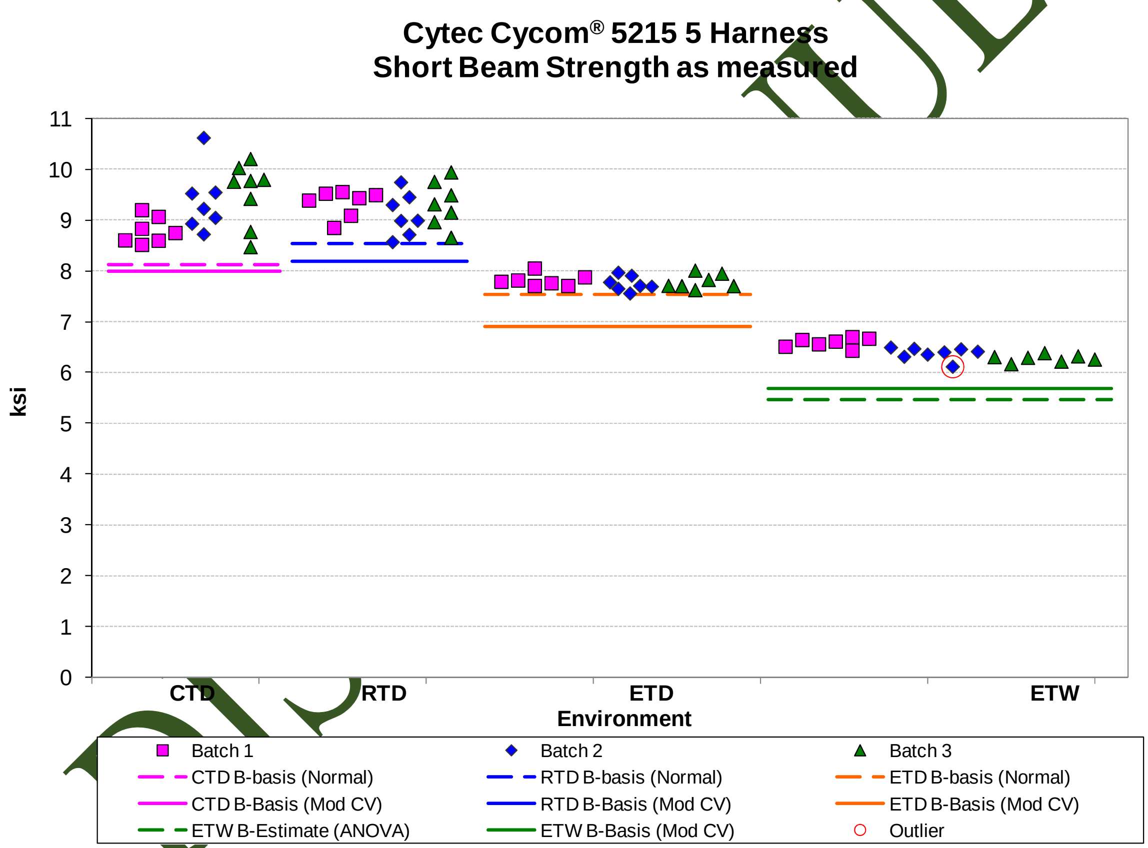

Figure 4-6: Batch plot for SBS as measured

Short Beam Strength (SBS) Basis Values and Statistics As Measured				
Env	CTD	RTD	ETD	ETW
Mean	9.248	9.258	7.787	6.415
Stdev	0.599	0.380	0.132	0.161
CV	6.476	4.102	1.693	2.505
Mod CV	7.238	6.051	6.000	6.000
Min	8.472	8.571	7.560	6.119
Max	10.623	9.943	8.051	6.702
No. Batches	3	3	3	3
No. Spec.	22	21	21	22
Basis Values and Estimates				
B-basis Value	8.118	8.534	7.536	
B-Estimate				5.472
A-Estimate	7.311	8.019	7.357	4.799
Method	Normal	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	7.985	8.190	6.897	5.689
A-Estimate	7.083	7.430	6.263	5.171
Method	Normal	Normal	Normal	Normal

Table 4-10: Statistics and Basis Values for SBS Data

4.7 "25/50/25" Unnotched Tension 1 (UNT1)

The UNT1 data is normalized, so both normalized and as-measured statistics are provided. The data for the RTD condition, both normalized and as-measured, failed the ADK test, but passed with the use of the modified CV method. A- and B-estimates computed using the ANOVA method are provided for the RTD datasets. Pooling across the environments requires that the RTD data be included, so pooling was not appropriate. However, all three conditions could be pooled to compute the modified CV basis values.

There was one outlier. The lowest value in the normalized data from batch two in the RTD condition was an outlier for both batch two and the RTD condition. It was not an outlier for the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for UNT1 strength data in Table 4-11 and for the modulus data in Table 4-12. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-7.

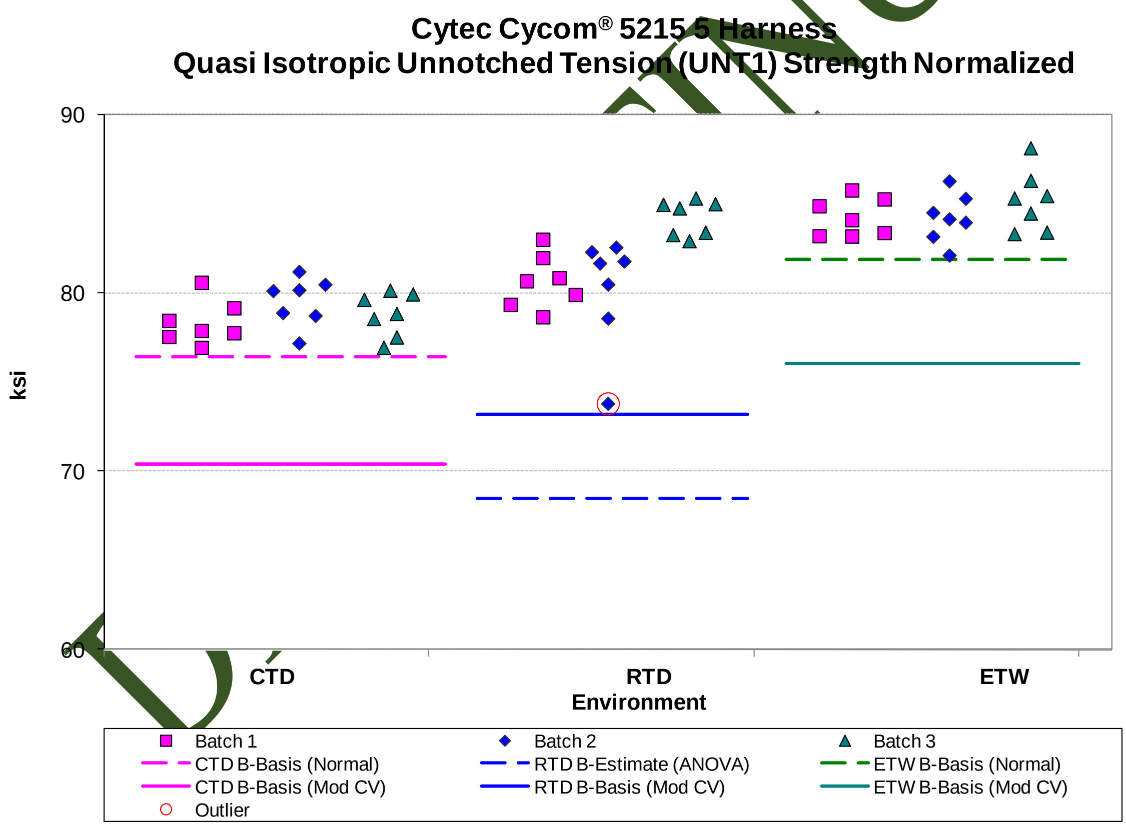

Figure 4-7: Batch Plot for UNT1 normalized strength

Unnotched Tension (UNT1) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	78.882	81.666	84.543	79.218	82.158	84.423
Stdev	1.303	2.710	1.403	1.605	2.391	1.458
CV	1.651	3.319	1.659	2.026	2.910	1.727
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	76.931	73.795	82.106	76.090	76.563	82.150
Max	81.189	85.305	88.119	81.986	86.150	87.660
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value	76.400		81.870	76.161		81.646
B-Estimate		68.461			69.722	
A-Estimate	74.631	59.035	79.965	73.981	60.844	79.667
Method	Normal	ANOVA	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates						
B-basis Value	70.403	73.188	76.064	70.716	73.655	75.920
A-Estimate	64.675	67.460	70.336	64.972	67.911	70.177
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-11: Statistics and Basis Values for UNT1 Strength Data

Unnotched Tension (UNT1) Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	6.854	6.473	6.558	6.883	6.514	6.549
Stdev	0.070	0.144	0.080	0.101	0.179	0.074
CV	1.026	2.230	1.220	1.468	2.746	1.126
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	6.725	6.147	6.423	6.707	6.131	6.399
Max	7.016	6.735	6.739	7.056	6.792	6.727
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21

Table 4-12: Statistics from UNT1 Modulus Data

4.8 "10/80/10" Unnotched Tension 2 (UNT2)

The UNT2 data is normalized, so both normalized and as-measured statistics are provided. The data for the CTD condition, both normalized and as-measured, failed the normality test, but passed with the use of the modified CV method. The pooled dataset, both normalized and as-measured, also failed the normality test with the CTD condition included, but passed with the use of the modified CV method. The RTD and ETW conditions could be pooled, and all three conditions could be pooled to compute the modified CV basis values.

There was one outlier. The lowest value in both the normalized and as-measured data from batch one of the CTD condition was an outlier for both batch one and the CTD condition. It was retained for this analysis.

Statistics, basis values and estimates are given for UNT2 strength data in Table 4-13 and for the modulus data in Table 4-14. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-8.

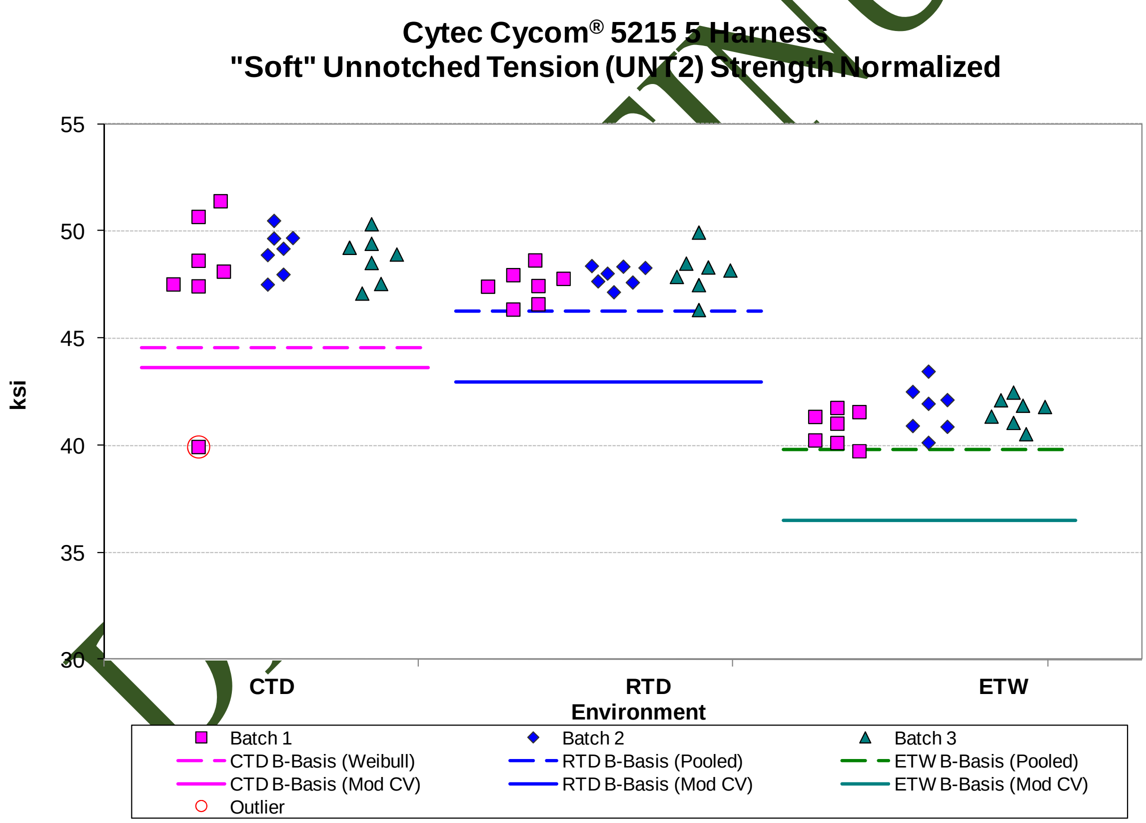

Figure 4-8: Batch Plot for UNT2 normalized strength

Unnotched Tension (UNT2) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	48.488	47.825	41.380	48.862	48.178	41.489
Stdev	2.293	0.827	0.932	2.200	0.939	0.977
CV	4.729	1.730	2.251	4.503	1.949	2.355
Modified CV	6.365	6.000	6.000	6.252	6.000	6.000
Min	39.938	46.330	39.738	40.363	46.201	39.517
Max	51.408	49.943	43.455	51.040	50.219	43.567
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value	44.568	46.263	39.817	45.439	46.479	39.790
A-Estimate	40.390	45.189	38.743	41.715	45.310	38.622
Method	Weibull	pooled	pooled	Weibull	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	43.606	42.943	36.497	43.984	43.299	36.611
A-Estimate	40.308	39.644	33.199	40.688	40.004	33.315
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-13: Statistics and Basis Values for UNT2 Strength Data

Unnotched Tension (UNT2) Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	4.442	4.175	3.820	4.477	4.205	3.830
Stdev	0.054	0.135	0.051	0.066	0.134	0.059
CV	1.216	3.238	1.339	1.469	3.178	1.537
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	4.342	3.950	3.722	4.377	3.951	3.679
Max	4.530	4.396	3.931	4.620	4.425	3.932
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21

Table 4-14: Statistics from UNT2 Modulus Data

4.9 “40/20/40” Unnotched Tension 3 (UNT3)

The UNT3 data is normalized, so both normalized and as-measured statistics are provided. There were no diagnostic test failures or outliers. Statistics, basis values and estimates are given for UNT3 strength data in Table 4-15 and for the modulus data in Table 4-16. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-9.

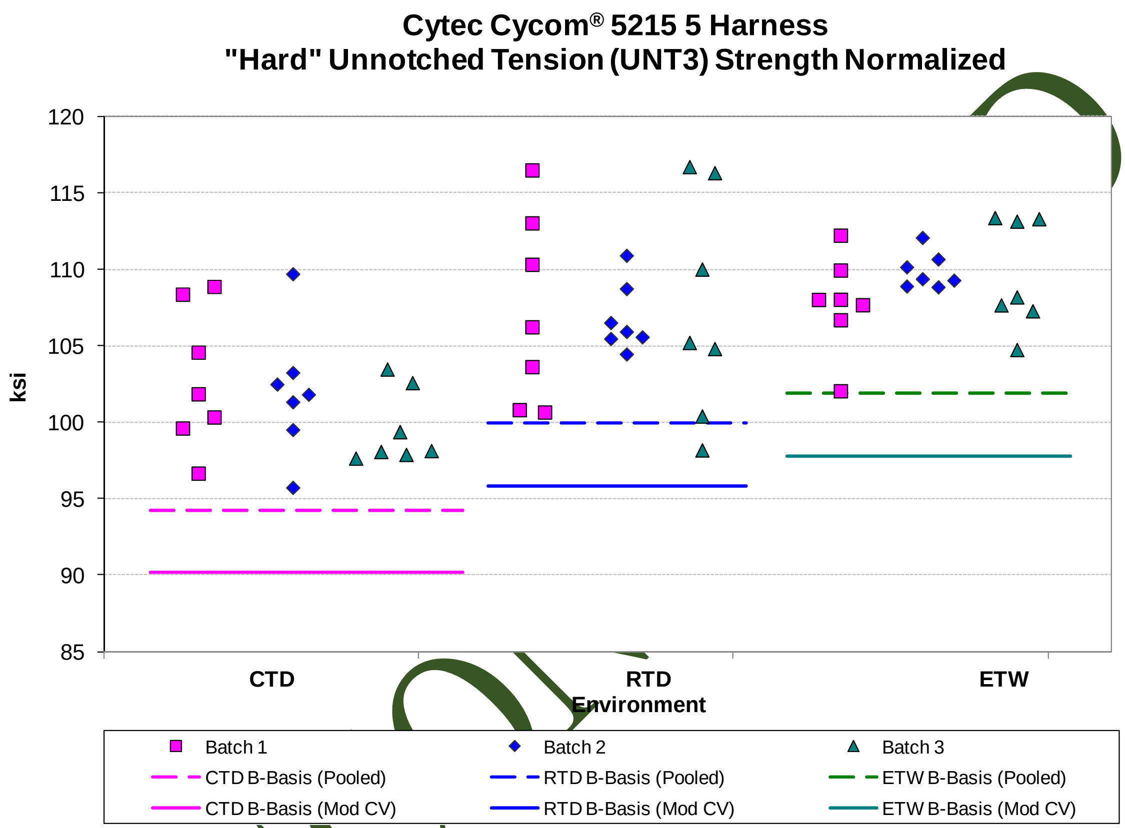

Figure 4-9: Batch Plot for UNT3 normalized strength

Unnotched Tension (UNT3) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	101.488	107.159	109.123	101.664	107.233	109.054
Stdev	3.928	5.373	2.832	4.163	5.362	3.071
CV	3.871	5.014	2.595	4.095	5.001	2.816
Modified CV	6.000	6.507	6.000	6.047	6.500	6.000
Min	95.727	98.175	102.048	94.805	98.748	100.684
Max	109.701	116.706	113.372	109.854	117.387	113.654
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value	94.267	99.939	101.902	94.227	99.795	101.616
A-Estimate	89.389	95.061	97.024	89.202	94.771	96.592
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	90.169	95.840	97.804	90.318	95.886	97.707
A-Estimate	82.523	88.194	90.158	82.653	88.221	90.042
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-15: Statistics and Basis Values for UNT3 Strength Data

Unnotched Tension (UNT3) Modulus Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	8.735	8.481	8.555	8.749	8.488	8.549
Stdev	0.163	0.118	0.142	0.153	0.152	0.150
CV	1.868	1.396	1.658	1.748	1.789	1.760
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	8.460	8.332	8.338	8.403	8.213	8.366
Max	9.035	8.805	8.943	9.022	8.788	8.893
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21

Table 4-16: Statistics from UNT3 Modulus Data

4.10 "25/50/25" Unnotched Compression 1 (UNC1)

The UNC1 data is normalized, so both normalized and as-measured statistics are provided. The RTD and ETW data, both normalized and as-measured, fail Levene's test for equality of variance even with the use of the modified CV method.

There was one outlier. The lowest value in batch two of the as-measured RTD data was an outlier for batch two only, not for the RTD condition. It was not at outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for UNC1 strength data in Table 4-17 and for the modulus data in Table 4-18. The normalized data and B-basis values are shown graphically in Figure 4-10.

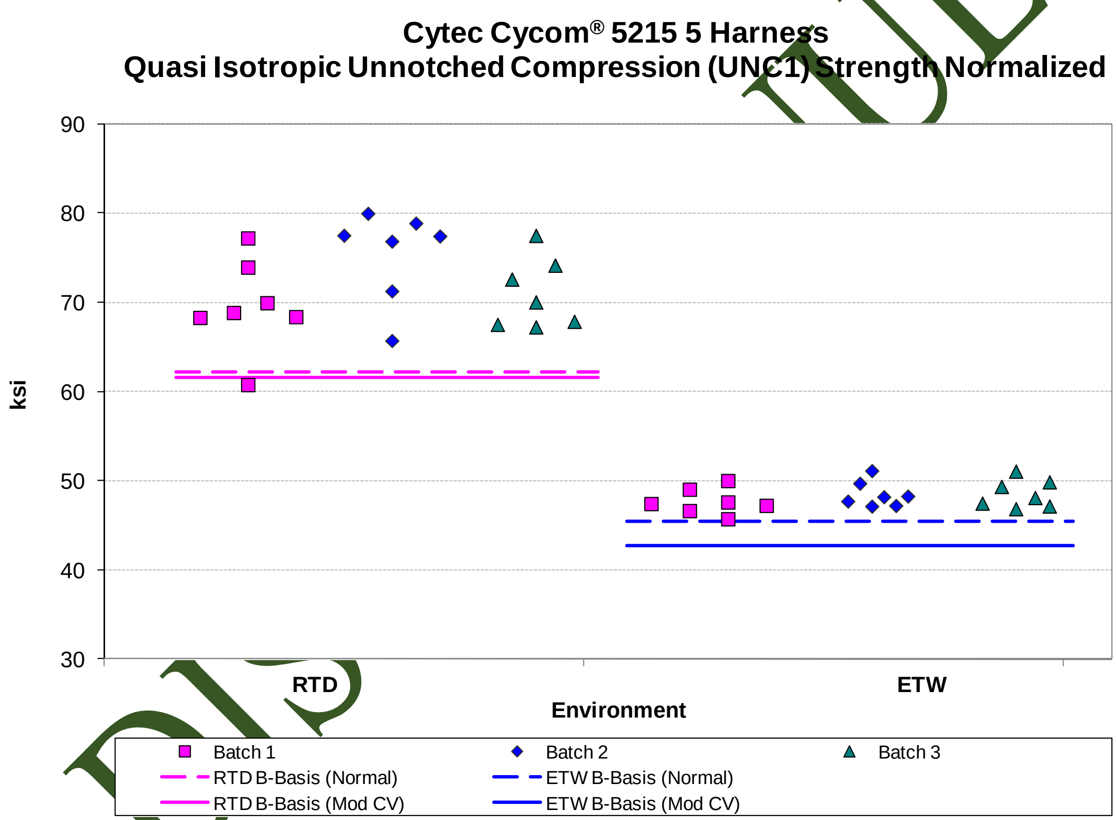

Figure 4-10: Batch plot for UNC1 normalized strength

Unnotched Compression (UNC1) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	71.994	48.236	73.450	48.802
Stdev	5.154	1.470	5.225	1.416
CV	7.159	3.048	7.114	2.902
Modified CV	7.579	6.000	7.557	6.000
Min	60.760	45.728	62.215	46.487
Max	79.970	51.123	80.565	51.237
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	62.176	45.435	63.497	46.104
A-Estimate	55.176	43.438	56.401	44.181
Method	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates				
B-basis Value	61.595	42.721	62.873	43.222
A-Estimate	54.188	38.792	55.339	39.247
Method	Normal	Normal	Normal	Normal

Table 4-17: Statistics and Basis Values for UNC1 Strength Data

Unnotched Compression (UNC1) Modulus Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	6.283	6.172	6.413	6.215
Stdev	0.215	0.218	0.255	0.208
CV	3.416	3.534	3.983	3.343
Modified CV	6.000	6.000	6.000	6.000
Min	5.947	5.722	5.926	5.808
Max	6.947	6.599	7.112	6.583
No. Batches	3	3	3	3
No. Spec.	22	21	22	21

Table 4-18: Statistics from UNC1 Modulus Data

4.11 "10/80/10" Unnotched Compression 2 (UNC2)

The UNC2 data is normalized, so both normalized and as-measured statistics are provided. The ETW datasets, both normalized and as-measured, failed the ADK test but passed with the modified CV transformation of the data. Pooling was acceptable for the modified CV basis values. The normalized modified CV transformed data could be pooled but the as-measured modified CV transformed data failed Levene's test and could not be pooled.

Statistics, basis values and estimates are given for UNC2 strength data in Table 4-19 and for the modulus data in Table 4-20. The normalized data and B-basis values are shown graphically in Figure 4-11.

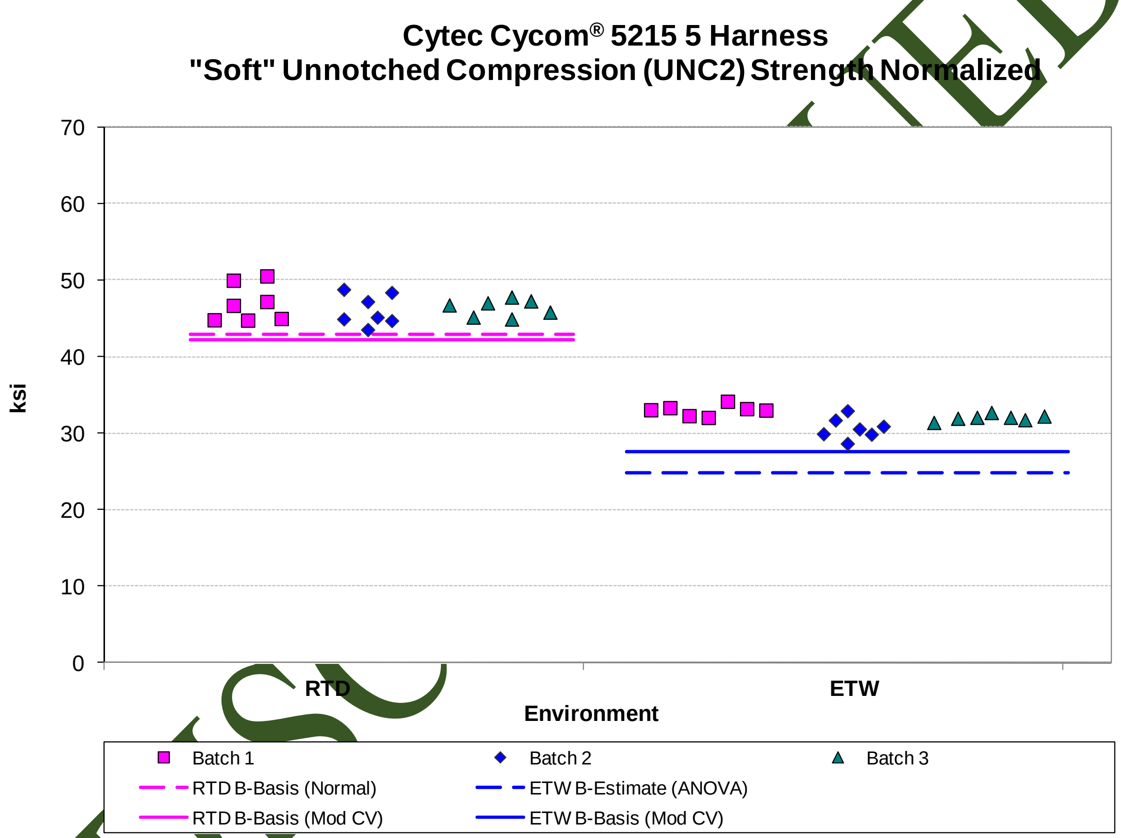

Figure 4-11: Batch plot for UNC2 normalized strength

Unnotched Compression (UNC2) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	46.486	31.889	47.145	32.180
Stdev	1.872	1.326	1.837	1.230
CV	4.028	4.157	3.897	3.822
Modified CV	6.014	6.079	6.000	6.000
Min	43.531	28.650	43.947	29.952
Max	50.534	34.161	51.218	34.139
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	42.919		43.645	
B-Estimate		24.765		25.150
A-Estimate	40.376	19.679	41.149	20.132
Method	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	42.220	27.624	41.755	28.501
A-Estimate	39.287	24.690	37.915	25.880
Method	pooled	pooled	Normal	Normal

Table 4-19: Statistics and Basis Values for UNC2 Strength Data

Unnotched Compression (UNC2) Modulus Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	3.939	3.679	3.994	3.682
Stdev	0.107	0.125	0.097	0.125
CV	2.728	3.385	2.438	3.409
Modified CV	6.000	6.000	6.000	6.000
Min	3.757	3.500	3.850	3.501
Max	4.161	4.011	4.174	4.026
No. Batches	3	3	3	3
No. Spec.	22	21	22	21

Table 4-20: Statistics from UNC2 Modulus Data

4.12 "40/20/40" Unnotched Compression 3 (UNC3)

The UNC3 data is normalized, so both normalized and as-measured statistics are provided. The RTD and ETW datasets, both normalized and as-measured, failed Levene's test for pooling but passed the modified CV transformation of the data, so pooling was used to compute the modified CV basis values. There were no outliers.

Statistics, basis values and estimates are given for UNC3 strength data in Table 4-21 and for the modulus data in Table 4-22. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-12.

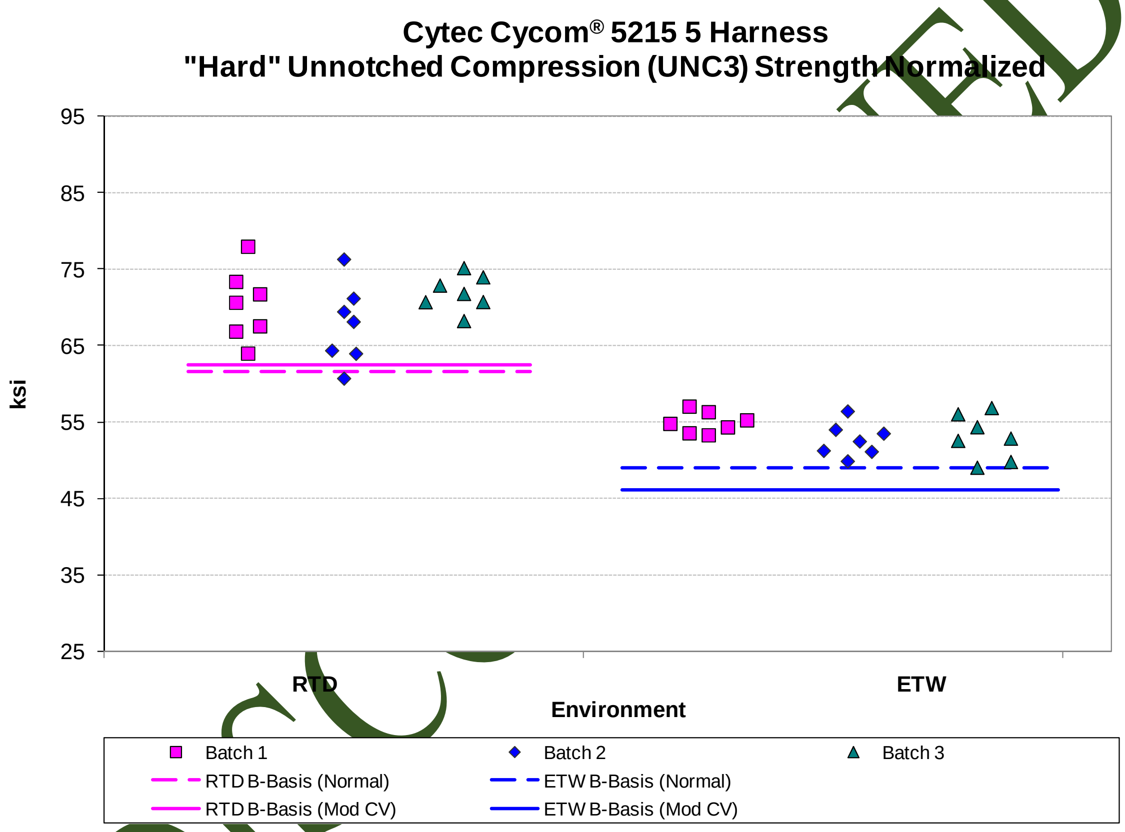

Figure 4-12: Batch plot for UNC3 normalized strength

Unnotched Compression (UNC3) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	69.995	53.579	71.037	53.793
Stdev	4.402	2.370	4.348	2.266
CV	6.289	4.424	6.121	4.212
Modified CV	7.144	6.212	7.060	6.106
Min	60.726	49.078	62.562	49.672
Max	77.967	57.059	79.410	57.201
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	61.610	49.064	62.754	49.477
A-Estimate	55.632	45.845	56.849	46.400
Method	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates				
B-basis Value	62.463	46.047	63.519	46.276
A-Estimate	57.283	40.867	58.349	41.106
Method	pooled	pooled	pooled	pooled

Table 4-21: Statistics and Basis Values for UNC3 Strength Data

Unnotched Compression (UNC3) Modulus Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	7.830	8.002	7.947	7.994
Stdev	0.147	0.313	0.141	0.298
CV	1.881	3.908	1.768	3.733
Modified CV	6.000	6.000	6.000	6.000
Min	7.509	7.521	7.714	7.489
Max	8.130	8.551	8.304	8.497
No. Batches	3	3	3	3
No. Spec.	21	21	21	21

Table 4-22: Statistics from UNC3 Modulus Data

4.13 Laminate Short Beam Strength (SBS1)

The Laminate Short Beam Strength data is not normalized. The RTD and ETW datasets failed the normality test and Levene's test for pooling but passed both tests with the modified CV transformation of the data so pooling the two conditions together was only appropriate for computing the modified CV basis values. There were no outliers.

Statistics, basis values and estimates are given for SBS1 data in Table 4-23. The data, B-estimates and B-basis values are shown graphically in Figure 4-13.

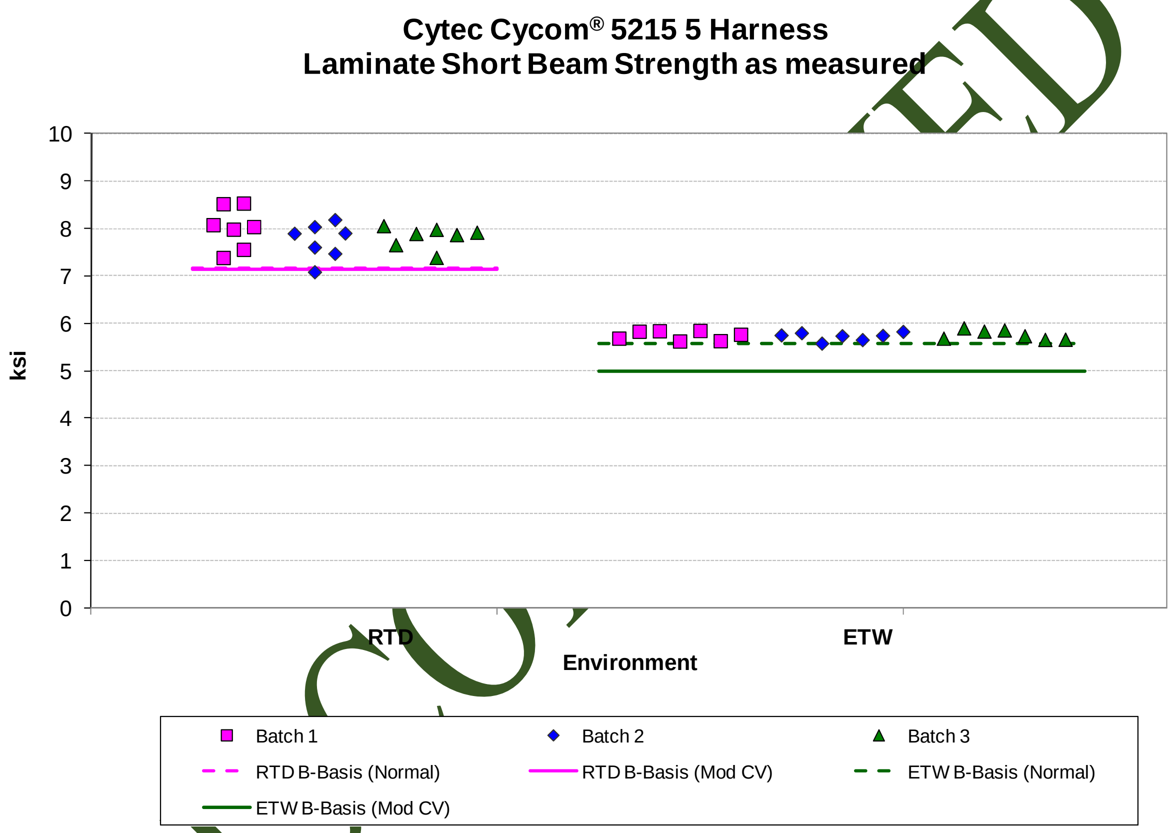

Figure 4-13: Batch plot for SBS1 as measured

Laminate Short Beam Strength (SBS1) Basis Values and Statistics as measured		
Env	RTD	ETW
Mean	7.894	5.747
Stdev	0.382	0.091
CV	4.839	1.586
Modified CV	6.419	6.000
Min	7.086	5.581
Max	8.574	5.903
No. Batches	3	3
No. Spec.	22	21
Basis Value Estimates		
B-basis Value	7.173	5.574
A-Estimate	6.659	5.450
Method	Normal	Normal
Modified CV Basis Values and Estimates		
B-basis Value	7.126	4.977
A-Estimate	6.596	4.447
Method	pooled	pooled

Table 4-23: Statistics and Basis Values for SBS1 Data

4.14 "25/50/25" Open-Hole Tension 1 (OHT1)

The OHT1 data is normalized, so both normalized and as-measured statistics are provided. The RTD datasets, both normalized and as-measured, failed the ADK test but passed with the modified CV transformation of the data. Pooling is only acceptable with the inclusion of the RTD condition, so pooling was acceptable for only the computation of the modified CV basis values.

There was one outlier. The highest value in batch two of the ETW data was an outlier. It was an outlier for both batch two and the ETW condition in the normalized dataset. It was an outlier for the ETW condition but not batch two in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for OHT1 strength data in Table 4-24. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-14.

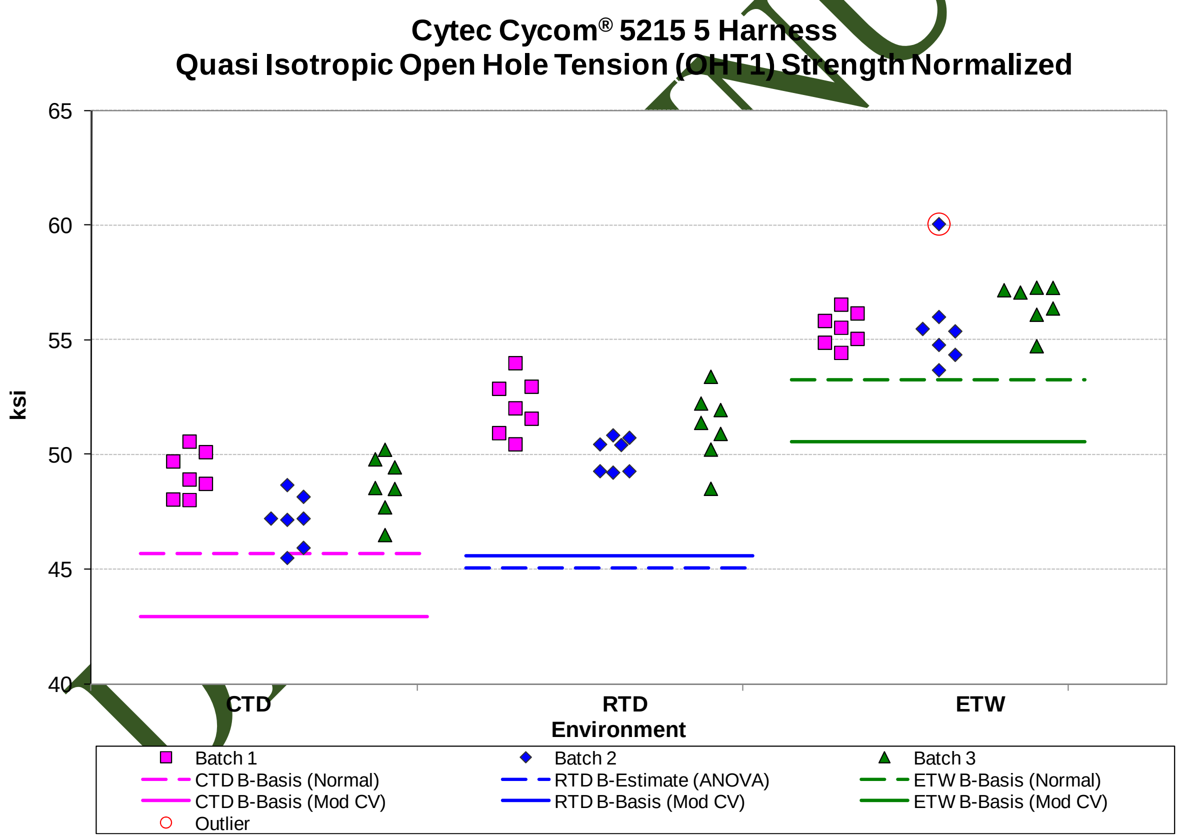

Figure 4-14: Batch Plot for OHT1 normalized strength

Open Hole Tension (OHT1) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	48.330	51.139	55.927	48.617	51.514	55.984
Stdev	1.402	1.460	1.400	1.556	1.534	1.341
CV	2.902	2.855	2.503	3.201	2.979	2.396
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	45.508	48.525	53.697	45.897	48.590	53.639
Max	50.581	54.004	60.067	50.934	53.961	60.116
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value	45.659		53.260	45.652		53.429
B-Estimate		45.038			44.879	
A-Estimate	43.754	40.684	51.358	43.538	40.143	51.607
Method	Normal	ANOVA	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and/or Estimates						
B-basis Value	42.947	45.755	50.543	43.209	46.107	50.577
A-Estimate	39.310	42.119	46.906	39.556	42.454	46.924
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-24: Statistics and Basis Values for OHT1 Strength Data

4.15 "10/80/10" Open-Hole Tension 2 (OHT2)

The OHT2 data is normalized, so both normalized and as-measured statistics are provided. The CTD and RTD datasets, both normalized and as-measured, and the as-measured ETW dataset failed the ADK test, so estimates of basis values were computed using the ANOVA method. These datasets all passed the ADK test with the modified CV transformation of the data and pooling was acceptable to compute the modified CV basis values.

There were two outliers. The lowest value in batch three of the as-measured CTD dataset and the lowest value in batch one of the as-measured ETW dataset were outliers. Both were outliers for their respective batches but not their respective conditions. Neither were outliers in the normalized datasets. Both outliers were retained for this analysis.

Statistics, basis values and estimates are given for OHT2 strength data in Table 4-25. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-15.

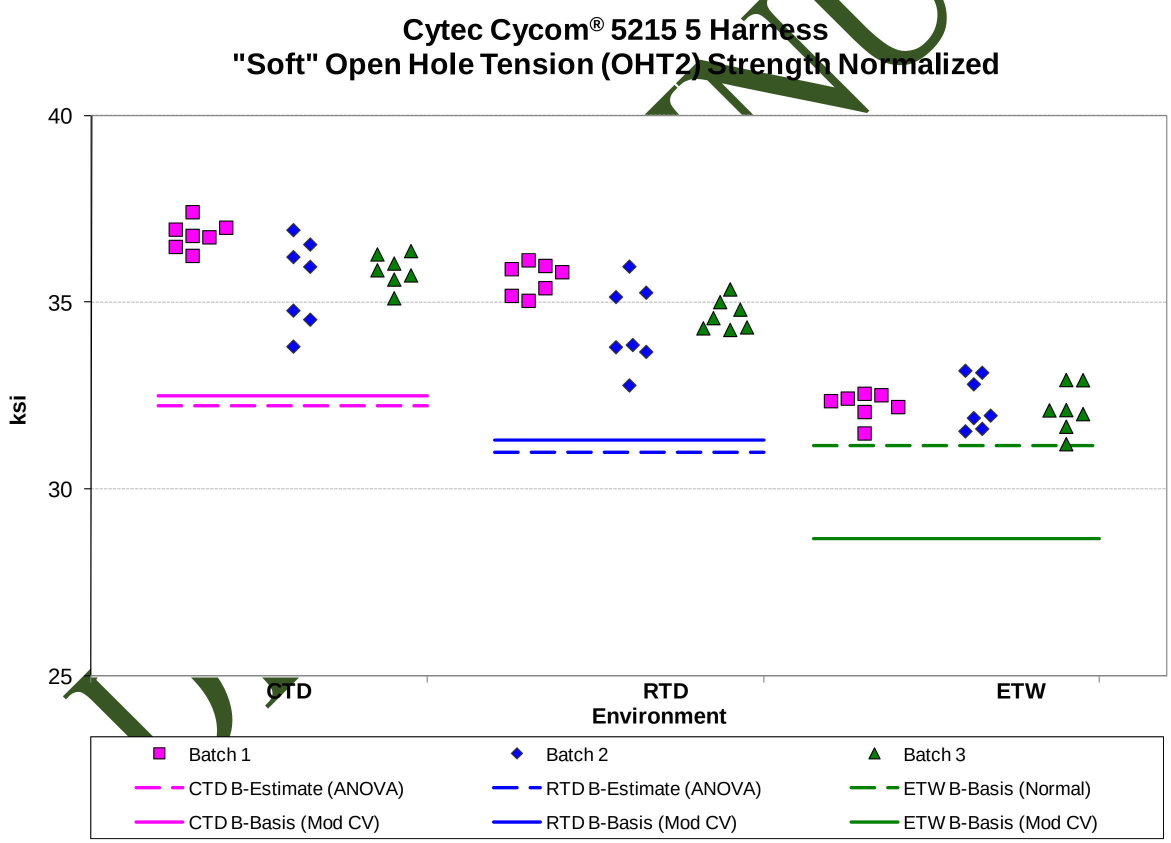

Figure 4-15: Batch Plot for OHT2 normalized strength

Open Hole Tension (OHT2) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	36.076	34.891	32.234	36.165	34.932	32.234
Stdev	0.898	0.889	0.558	0.876	0.803	0.599
CV	2.490	2.547	1.730	2.422	2.298	1.857
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	33.827	32.787	31.215	34.601	33.835	30.795
Max	37.426	36.137	33.179	37.673	36.266	33.152
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value			31.172			
B-Estimate	32.238	30.989		31.961	30.116	29.518
A-Estimate	29.498	28.205	30.414	28.960	26.677	27.580
Method	ANOVA	ANOVA	Normal	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	32.504	31.318	28.661	32.588	31.355	28.657
A-Estimate	30.090	28.905	26.248	30.171	28.938	26.240
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-25: Statistics and Basis Values for OHT2 Strength Data

4.16 "40/20/40" Open-Hole Tension 3 (OHT3)

The OHT3 data is normalized, so both normalized and as-measured statistics are provided. There were no diagnostic test failures, so pooling was used to compute all basis values and estimates. There was one outlier. The lowest value in batch one of the CTD datasets, both normalized and as-measured, was an outlier for batch one but not for the CTD condition.

Statistics, basis values and estimates are given for OHT3 strength data in Table 4-26. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-16.

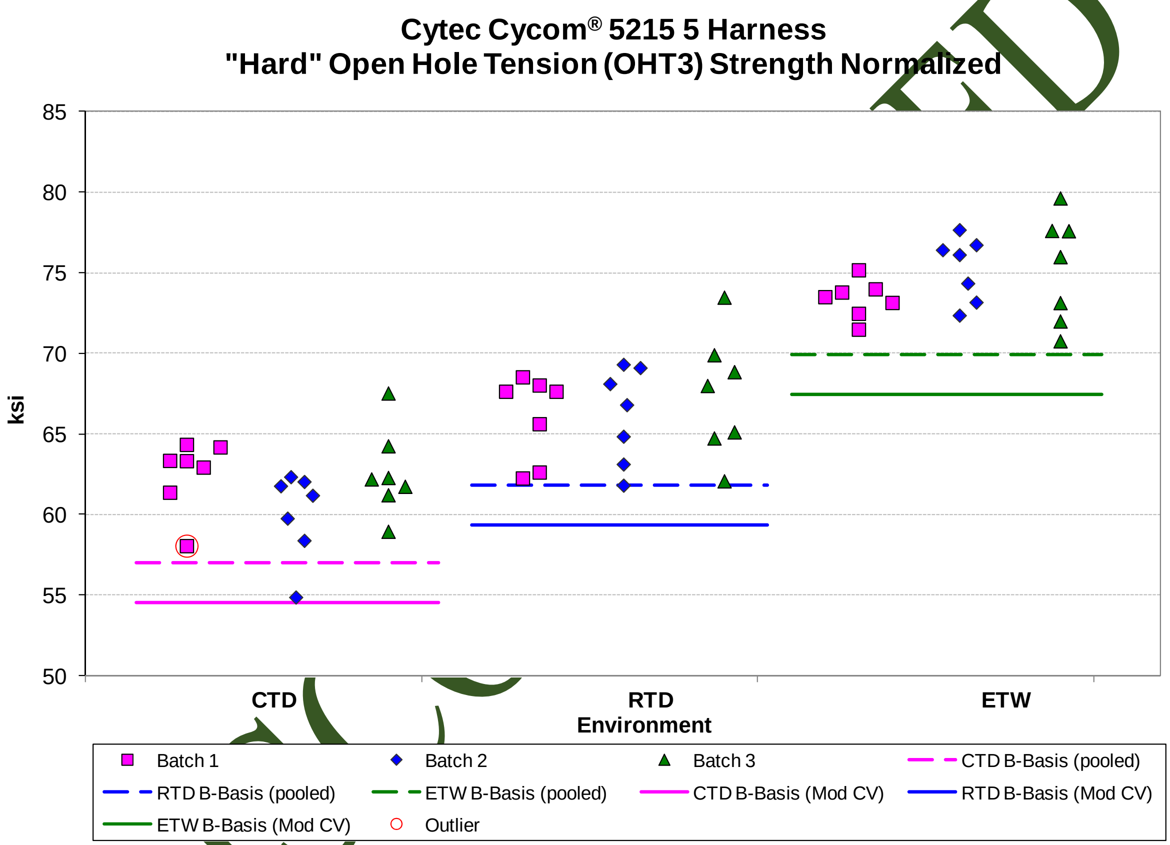

Figure 4-16: Batch Plot for OHT3 normalized strength

Open Hole Tension (OHT3) Strength (ksi) Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	61.725	66.559	74.630	62.456	66.968	75.323
Stdev	2.688	3.072	2.391	2.812	3.314	2.889
CV	4.354	4.616	3.204	4.503	4.949	3.836
Modified CV	6.177	6.308	6.000	6.252	6.474	6.000
Min	54.878	61.818	70.774	56.127	61.775	70.713
Max	67.537	73.481	79.632	68.795	74.694	81.616
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Value Estimates						
B-basis Value	57.003	61.836	69.908	57.246	61.758	70.113
A-Estimate	53.812	58.646	66.718	53.727	58.238	66.594
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	54.511	59.345	67.417	55.089	59.601	67.956
A-Estimate	49.639	54.472	62.544	50.112	54.624	62.979
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-26: Statistics and Basis Values for OHT3 Strength Data

4.17 "25/50/25" Filled-Hole Tension 1 (FHT1)

The FHT1 data is normalized, so both normalized and as-measured statistics are provided. The as-measured CTD dataset failed the ADK test, so estimates of basis values for that dataset were computed using the ANOVA method. Pooling was acceptable for the RTD and ETW as-measured datasets. The as-measured CTD dataset passed the ADK test with the modified CV transformation of the data, so pooling all three conditions was acceptable to compute the normalized modified CV basis values. The normalized datasets had no diagnostic test failures, so pooling was accepting for computing all basis values. There were no outliers.

Statistics, basis values and estimates are given for FHT1 strength data in Table 4-27. The normalized data and B-basis values are shown graphically in Figure 4-17.

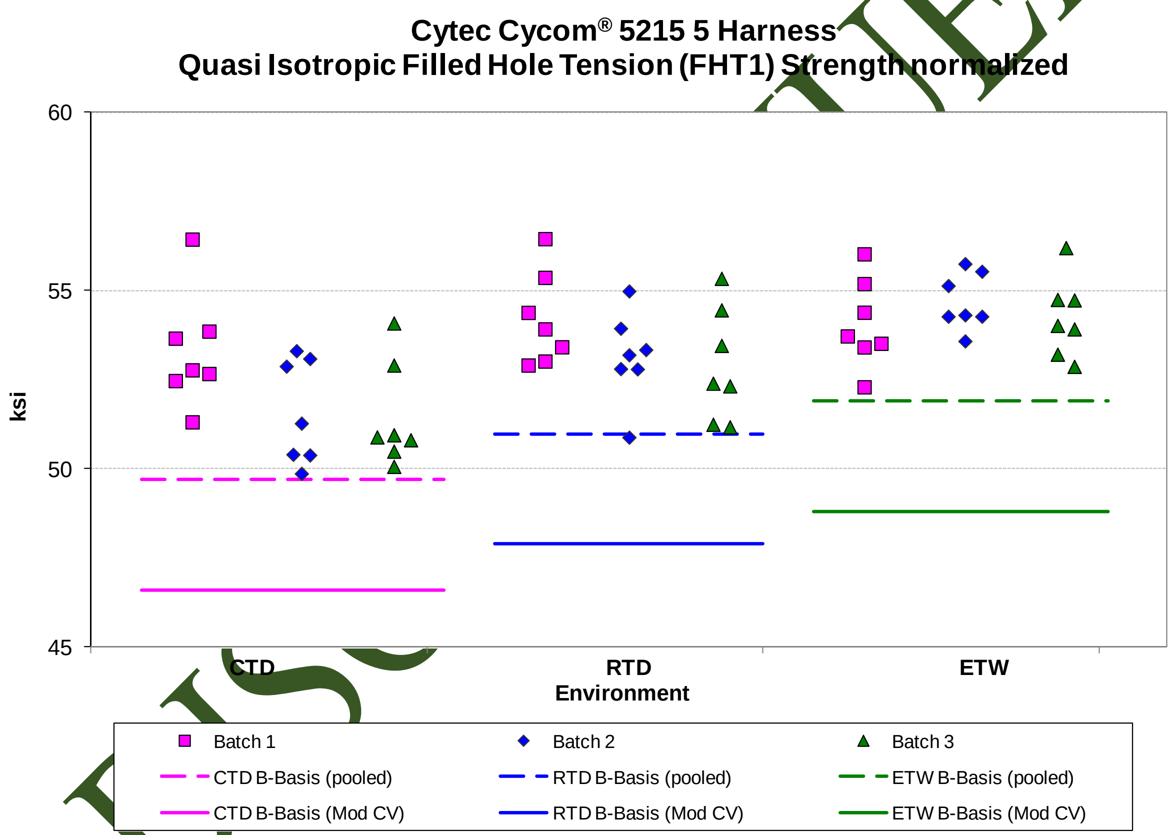

Figure 4-17: Batch plot for FHT1 normalized strength

Filled Hole Tension (FHT1) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	52.122	53.418	54.337	52.251	53.266	54.292
Stdev	1.675	1.437	1.043	1.632	1.605	1.092
CV	3.213	2.690	1.920	3.123	3.014	2.011
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	49.868	50.884	52.296	49.963	50.294	52.373
Max	56.435	56.449	56.196	55.991	56.411	56.128
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value	49.686	50.981	51.901		50.832	51.858
B-Estimate				45.120		
A-Estimate	48.040	49.335	50.255	40.031	49.158	50.184
Method	pooled	pooled	pooled	ANOVA	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	46.593	47.888	48.808	46.724	47.739	48.765
A-Estimate	42.858	44.153	45.072	42.990	44.006	45.032
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-27: Statistics and Basis Values for FHT1 Strength Data

4.18 “10/80/10” Filled-Hole Tension 2 (FHT2)

The FHT2 data is normalized, so both normalized and as-measured statistics are provided. Both as-measured and normalized datasets failed Levene's test for equality of variance, but passed with the modified CV transformation of the data and there were no other diagnostic test failures, so pooling all three conditions was acceptable to compute the modified CV basis values. There were no outliers.

Statistics, basis values and estimates are given for FHT2 strength data in Table 4-28. The normalized data and the B-basis values are shown graphically in Figure 4-18.

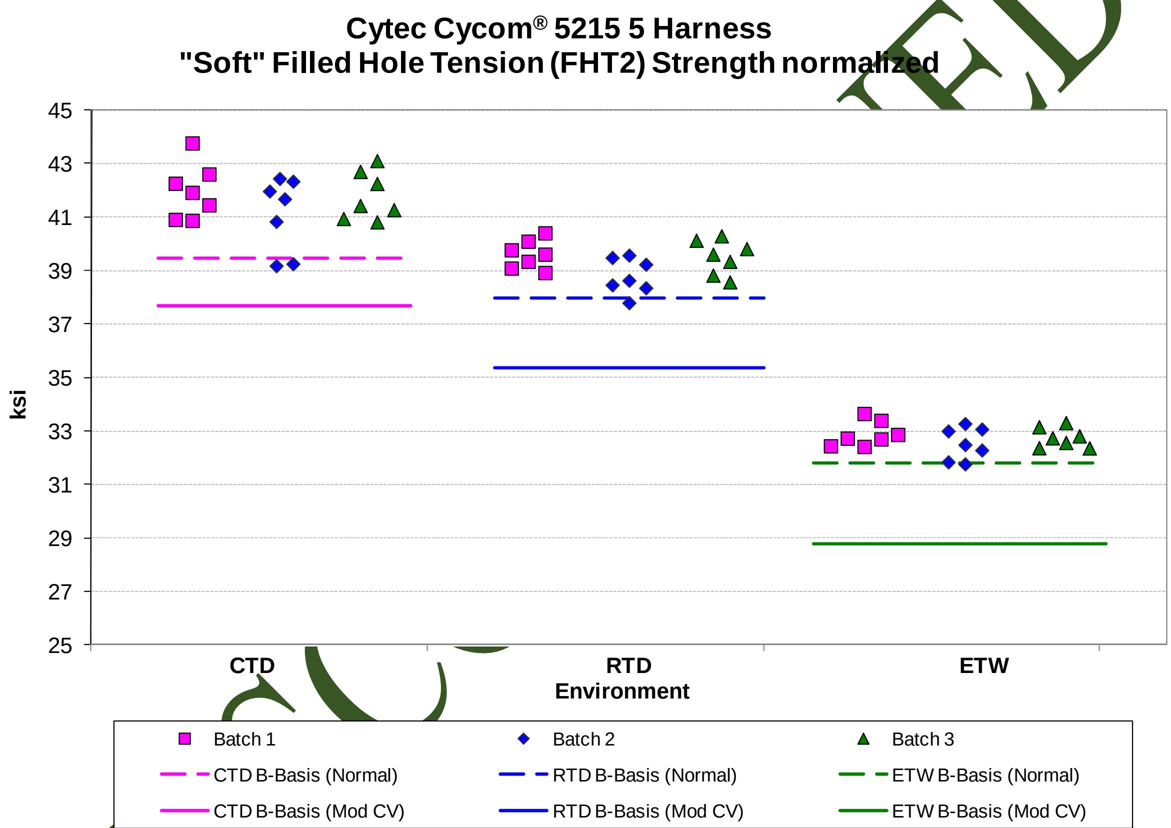

Figure 4-18: Batch plot for FHT2 normalized strength

Filled Hole Tension (FHT2) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	41.616	39.300	32.726	41.800	39.365	32.755
Stdev	1.133	0.692	0.488	1.175	0.655	0.533
CV	2.723	1.761	1.491	2.811	1.663	1.626
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	39.178	37.793	31.766	39.356	38.179	31.914
Max	43.762	40.405	33.650	44.180	40.509	33.754
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value	39.457	37.981	31.796	39.561	38.118	31.741
A-Estimate	37.918	37.041	31.134	37.965	37.228	31.017
Method	Normal	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-basis Value	37.667	35.350	28.777	37.841	35.405	28.796
A-Estimate	34.999	32.683	26.109	35.166	32.731	26.122
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-28: Statistics and Basis Values for FHT2 Strength Data

4.19 "40/20/40" Filled-Hole Tension 3 (FHT3)

The FHT3 data is normalized, so both normalized and as-measured statistics are provided. The CTD and RTD dataset, both normalized and as-measured, and the normalized ETW dataset failed the ADK test, so estimates of basis values for those datasets were computed using the ANOVA method. All of these datasets passed the ADK test with the modified CV transformation of the data and there were no other diagnostic test failures, so pooling all three conditions was acceptable to compute the modified CV basis values. There were no outliers.

Statistics, basis values and estimates are given for FHT3 strength data in Table 4-29. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-19.

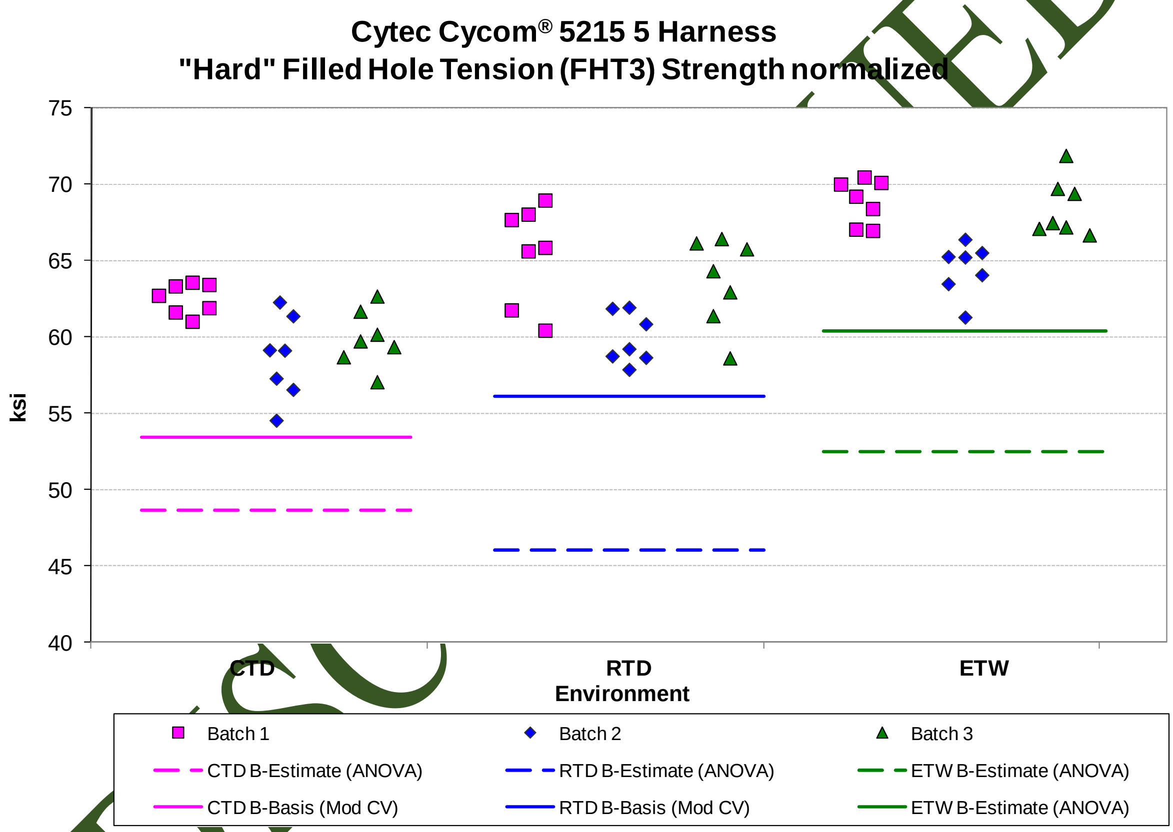

Figure 4-19: Batch plot for FHT3 normalized strength

Filled Hole Tension (FHT3) Strength Basis Values and Statistics						
	Normalized			As Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	60.341	63.000	67.272	60.693	63.273	67.512
Stdev	2.510	3.487	2.602	2.484	3.434	1.943
CV	4.160	5.534	3.867	4.093	5.427	2.877
Modified CV	6.080	6.767	6.000	6.046	6.713	6.000
Min	54.537	57.867	61.286	54.968	57.882	63.168
Max	63.567	68.943	71.866	63.980	70.312	70.554
No. Batches	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21
Basis Values and Estimates						
B-basis Value						63.811
B-Estimate	48.608	46.048	52.513	50.709	48.072	
A-Estimate	40.232	33.947	41.976	43.583	37.222	61.173
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	Normal
Modified CV Basis Values and Estimates						
B-basis Value	53.430	56.089	60.361	53.782	56.363	60.601
A-Estimate	48.762	51.421	55.693	49.115	51.695	55.933
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-29: Statistics and Basis Values for FHT3 Strength Data

4.20 "25/50/25" Open-Hole Compression 1 (OHC1)

The OHC1 data is normalized, so both normalized and as-measured statistics are provided. Pooling was acceptable for both as-measured and normalized datasets.

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

Statistics, B-basis values and estimates are given for OHC1 strength data in Table 4-30. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-20.

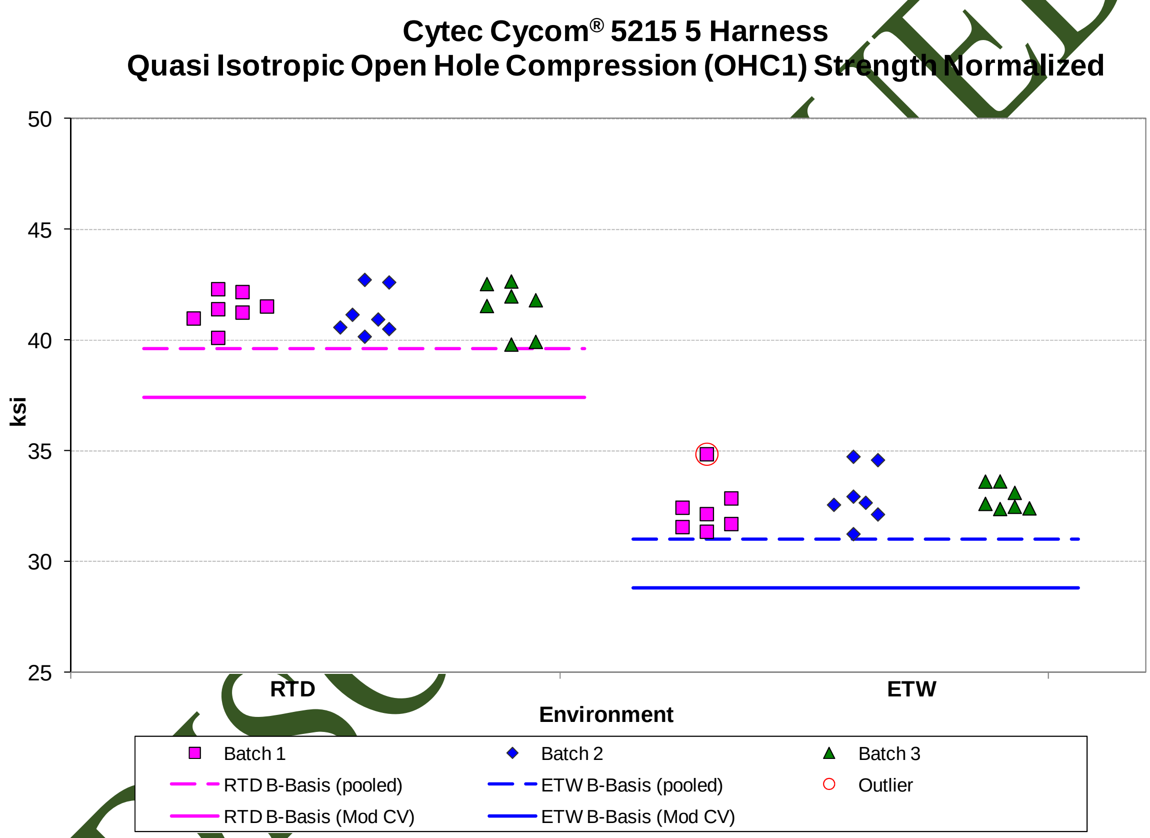

Figure 4-20: Batch plot for OHC1 normalized strength

Open Hole Compression (OHC1) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	41.379	32.773	41.661	32.950
Stdev	0.946	1.035	1.006	1.107
CV	2.287	3.157	2.414	3.360
Modified CV	6.000	6.000	6.000	6.000
Min	39.820	31.255	40.093	31.478
Max	42.742	34.865	43.318	35.394
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	39.621	31.015	39.785	31.075
A-Estimate	38.412	29.805	38.495	29.785
Method	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates				
B-basis Value	37.408	28.802	37.664	28.954
A-Estimate	34.677	26.070	34.916	26.206
Method	pooled	pooled	pooled	pooled

Table 4-30: Statistics and Basis Values for OHC1 Strength Data

4.21 “10/80/10” Open-Hole Compression 2 (OHC2)

The OHC2 data is normalized, so both normalized and as-measured statistics are provided. The ETW dataset, both normalized and as-measured, and the as-measured RTD dataset failed the ADK test, so estimates of basis values for those datasets were computed using the ANOVA method. All of these datasets passed the ADK test with the modified CV transformation of the data, so modified CV basis values are provided but because both the as-measured and normalized datasets failed the normality test the two conditions could not be pooled for computing the modified CV basis values.

Statistics, basis values and estimates are given for OHC2 strength data in Table 4-31. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-21.

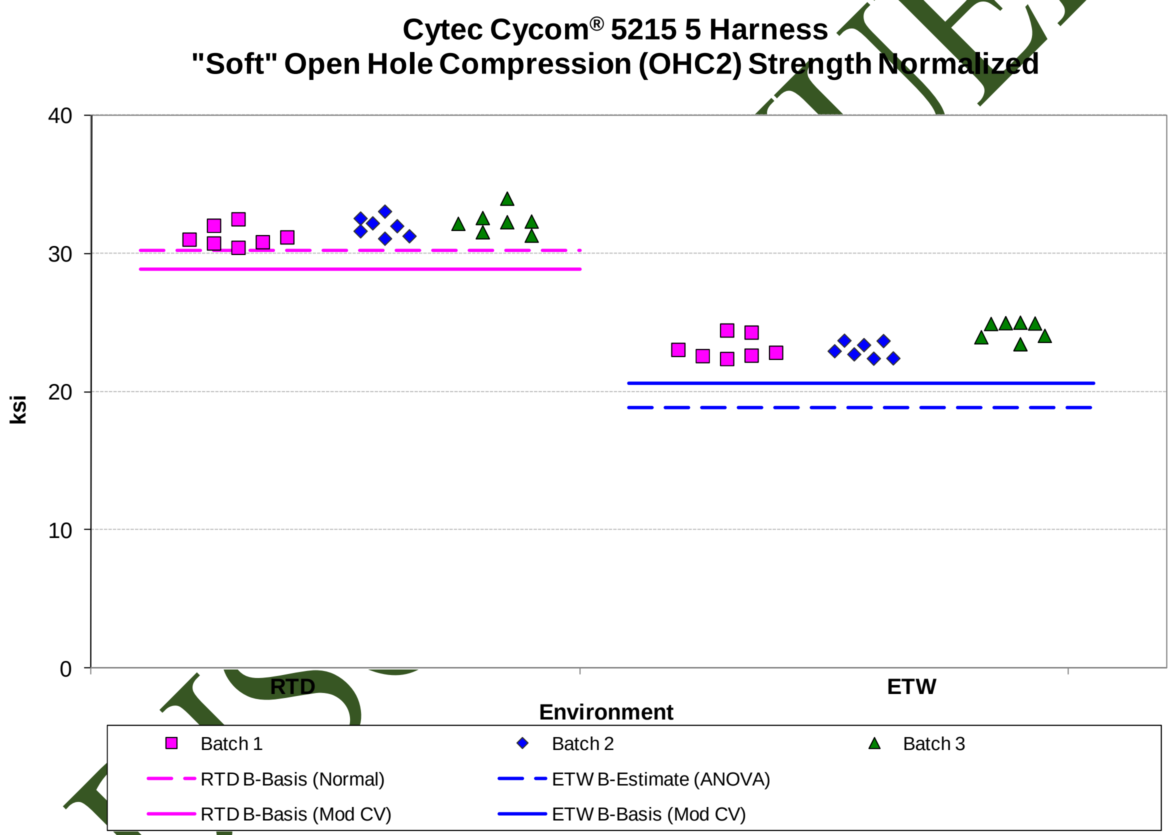

Figure 4-21: Batch plot for OHC2 normalized strength

Open Hole Compression (OHC2) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	31.849	23.572	31.881	23.579
Stdev	0.863	0.932	0.857	0.870
CV	2.710	3.954	2.688	3.690
Modified CV	6.000	6.000	6.000	6.000
Min	30.432	22.389	30.568	22.440
Max	33.994	25.023	33.726	24.945
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	30.205			
B-Estimate		18.847	28.559	19.021
A-Estimate	29.032	15.473	26.189	15.767
Method	Normal	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	28.207	20.877	28.236	20.883
A-Estimate	25.613	18.957	25.640	18.963
Method	Normal	Normal	Normal	Normal

Table 4-31: Statistics and Basis Values for OHC2 Strength Data

4.22 "40/20/40" Open-Hole Compression 3 (OHC3)

The OHC3 data is normalized, so both normalized and as-measured statistics are provided. The ETW dataset, both normalized and as-measured, failed the ADK test, so estimates of basis values for those datasets were computed using the ANOVA method. Both of those datasets passed the ADK test with the modified CV transformation of the data, so modified CV basis values are provided. There were no other diagnostic test failures so pooling was acceptable to compute the modified CV basis values.

There was one outlier. The highest value of batch two in the as-measured ETW dataset was an outlier for batch two. It was not an outlier for the ETW condition or for the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for OHC3 strength data in Table 4-32. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-22.

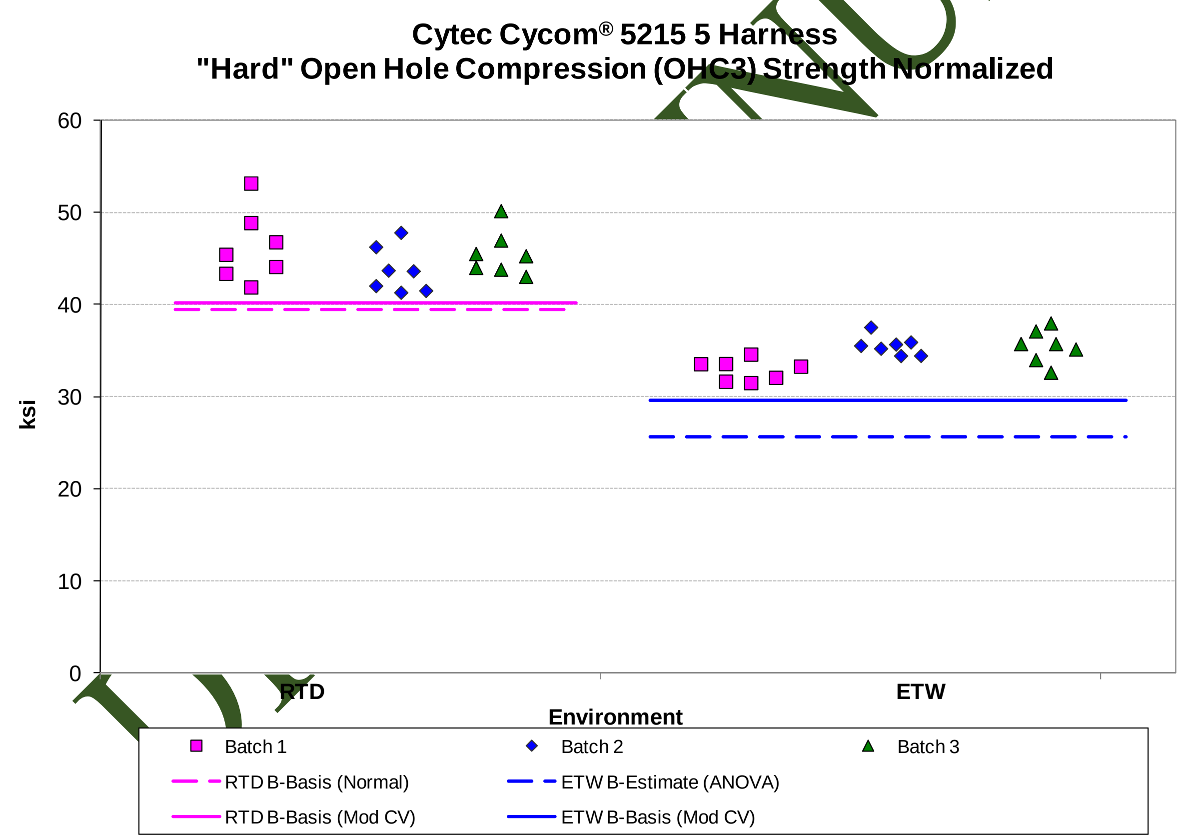

Figure 4-22: Batch plot for OHC3 normalized strength

Open Hole Compression (OHC3) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	45.172	34.641	45.261	34.803
Stdev	3.018	1.819	3.304	1.908
CV	6.681	5.252	7.300	5.483
Modified CV	7.341	6.626	7.650	6.741
Min	41.309	31.501	40.887	31.702
Max	53.161	37.986	53.144	39.222
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	39.423		38.967	
B-Estimate		25.642		26.781
A-Estimate	35.324	19.219	34.480	21.055
Method	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	40.115	29.585	40.017	29.559
A-Estimate	36.638	26.107	36.410	25.952
Method	pooled	pooled	pooled	pooled

Table 4-32: Statistics and Basis Values for OHC3 Strength Data

4.23 "25/50/25" Filled-Hole Compression 1 (FHC1)

The FHC1 data is normalized, so both normalized and as-measured statistics are provided. There were no diagnostic test failures, so pooling the RTD and ETW conditions was acceptable. There were no outliers.

Statistics, basis values and estimates are given for FHC1 strength data in Table 4-33. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-23.

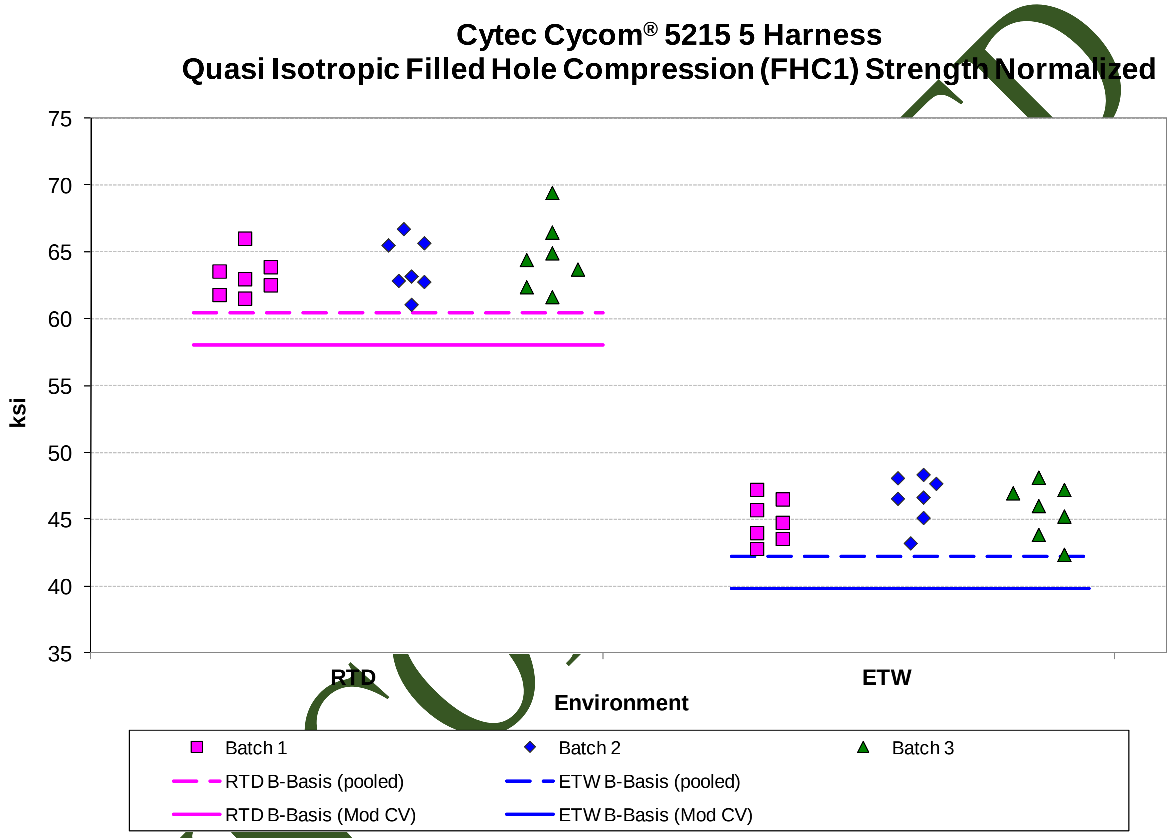

Figure 4-23: Batch plot for FHC1 normalized strength

Filled Hole Compression (FHC1) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	63.956	45.727	64.167	45.909
Stdev	2.095	1.859	2.239	1.954
CV	3.275	4.065	3.489	4.256
Modified CV	6.000	6.033	6.000	6.128
Min	61.071	42.386	61.291	42.428
Max	69.431	48.358	69.737	48.584
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	60.444	42.215	60.441	42.183
A-Estimate	58.029	39.800	57.879	39.621
Method	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates				
B-basis Value	58.030	39.801	58.188	39.930
A-Estimate	53.955	35.726	54.076	35.818
Method	pooled	pooled	pooled	pooled

Table 4-33: Statistics and Basis Values for FHC1 Strength Data

4.24 "10/80/10" Filled-Hole Compression 2 (FHC2)

The FHC2 data is normalized, so both normalized and as-measured statistics are provided. The as-measured RTD dataset and the pooled datasets, both normalized and as-measured, failed the normality test, so pooling was not appropriate. The Weibull distribution was the best fit for the as-measured RTD dataset. The as-measured RTD dataset and the pooled datasets, both normalized and as-measured, passed the normality test with the modified CV transformation of the data, so pooling was used to compute the modified CV basis values.

There was one outlier. It was the lowest value in batch two of the RTD dataset. It was an outlier for both the normalized and the as-measured datasets. It was an outlier only for batch two, not for the RTD condition.

Statistics, basis values and estimates are given for FHC2 strength data in Table 4-34. The normalized data and the B-basis values are shown graphically in Figure 4-24.

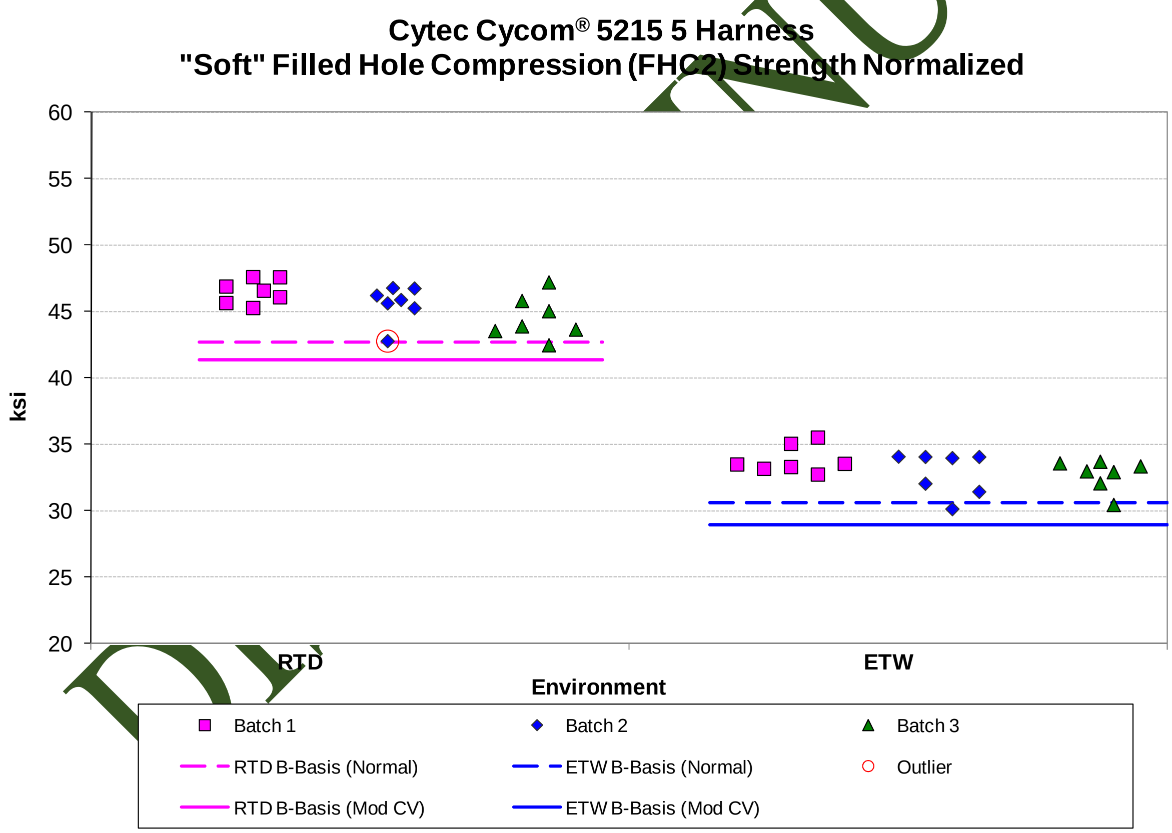

Figure 4-24: Batch plot for FHC2 normalized strength

Filled Hole Compression (FHC2) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	45.547	33.124	45.479	33.102
Stdev	1.513	1.325	1.408	1.353
CV	3.322	4.000	3.096	4.088
Modified CV	6.000	6.000	6.000	6.044
Min	42.470	30.137	42.513	30.079
Max	47.595	35.514	47.336	35.223
No. Batches	3	3	3	3
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis Value	42.665	30.600	42.610	30.525
A-Estimate	40.610	28.800	39.482	28.687
Method	Normal	Normal	Weibull	Normal
Modified CV Basis Values and Estimates				
B-basis Value	41.310	28.887	41.237	28.860
A-Estimate	38.396	25.973	38.319	25.942
Method	pooled	pooled	pooled	pooled

Table 4-34: Statistics and Basis Values for FHC2 Strength Data

4.25 "40/20/40" Filled-Hole Compression 3 (FHC3)

The FHC3 data is normalized, so both normalized and as-measured statistics are provided. There were no diagnostic test failures, so pooling the RTD and ETW conditions was acceptable. There were no outliers.

Statistics, basis values and estimates are given for FHC3 strength data in Table 4-35. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-25.

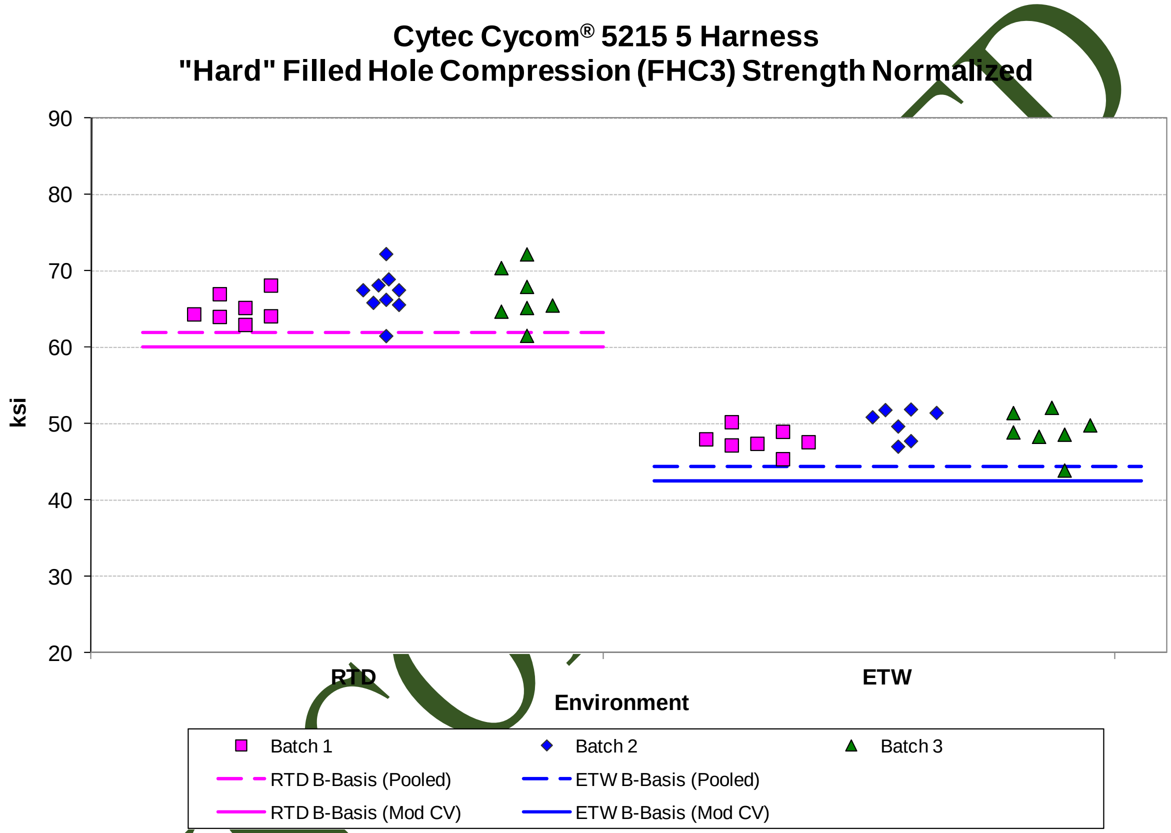

Figure 4-25: Batch plot for FHC3 normalized strength

Filled Hole Compression (FHC3) Strength Basis Values and Statistics				
	Normalized		As Measured	
Env	RTD	ETW	RTD	ETW
Mean	66.374	48.973	66.061	48.819
Stdev	2.886	2.208	2.941	2.371
CV	4.349	4.509	4.453	4.857
Modified CV	6.174	6.255	6.226	6.428
Min	61.502	43.915	60.622	43.295
Max	72.231	52.113	72.332	52.364
No. Batches	3	3	3	3
No. Spec.	23	21	23	21
Basis Values and Estimates				
B-basis Value	61.841	44.404	61.354	44.075
A-Estimate	58.698	41.269	58.090	40.819
Method	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates				
B-basis Value	59.988	42.537	59.607	42.314
A-Estimate	55.561	38.122	55.132	37.851
Method	pooled	pooled	pooled	pooled

Table 4-35: Statistics and Basis Values for FHC3 Strength Data

4.26 "25/50/25" Single-Shear Bearing 1 (SSB1)

The SSB1 data is normalized, so both normalized and as-measured statistics are provided. There were no diagnostic test failures for the 2% offset strength data. Basis values were computed after pooling the two environmental conditions.

Pooling was acceptable for the normalized ultimate strength datasets. The as-measured ultimate strength RTD dataset failed the ADK test, so estimates of basis values for that dataset were computed using the ANOVA method. The single point normal distribution method was used for the as-measured ultimate strength ETW dataset. The as-measured ultimate strength RTD dataset passed the ADK test with the modified CV transformation of the data, so modified CV basis values are provided. There were no other diagnostic test failures for the ultimate strength datasets so pooling was acceptable. There were no outliers.

Statistics, basis values and estimates are given for the SSB1 strength data in Table 4-36. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-26.

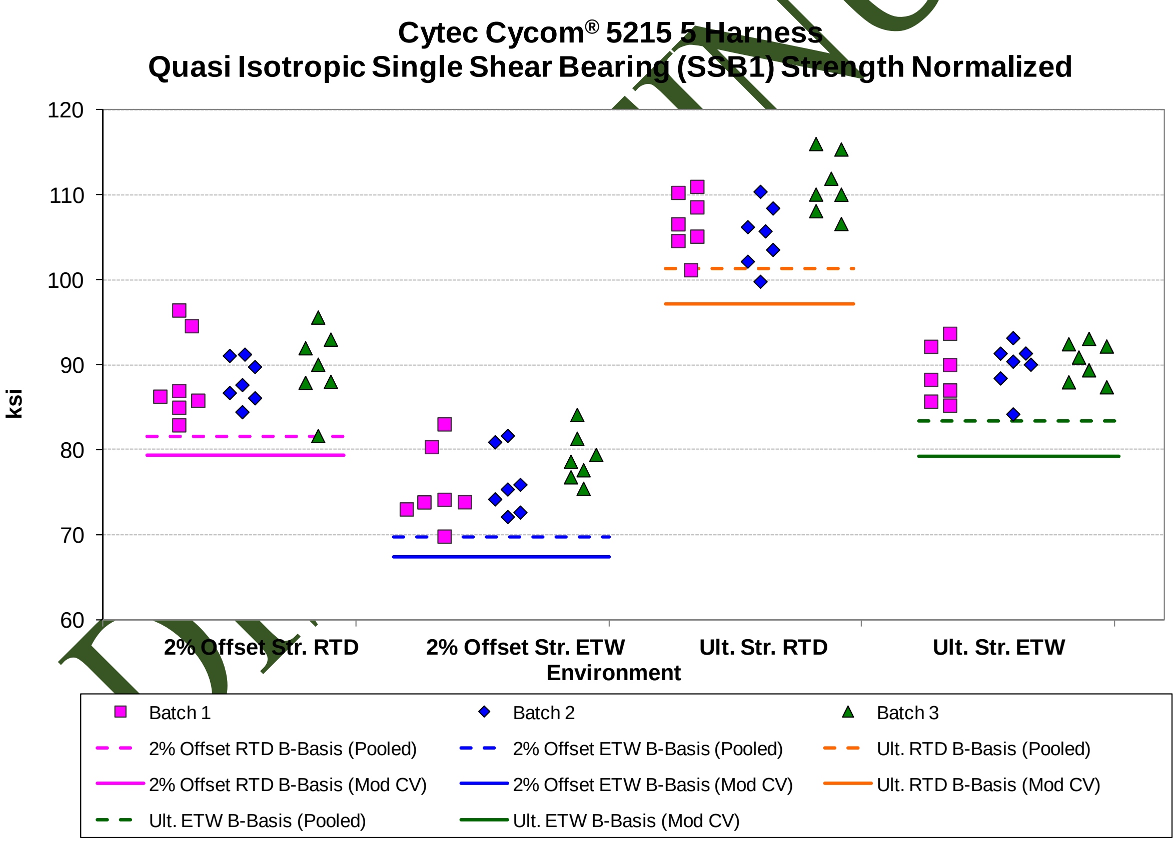

Figure 4-26: Batch plot for SSB1 normalized strength

Single Shear Bearing (SSB1) Strength Basis Values and Statistics								
	Normalized				As measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTD	ETW	RTD	ETW	RTD	ETW	RTD	ETW
Mean	88.741	76.890	107.712	89.749	90.905	77.744	110.347	90.760
Stdev	4.070	3.968	4.245	2.759	3.828	3.832	4.061	2.915
CV	4.587	5.161	3.941	3.074	4.211	4.929	3.680	3.212
Modified CV	6.293	6.581	6.000	6.000	6.106	6.465	6.000	6.000
Min	81.664	69.844	99.815	84.216	85.166	70.508	102.502	85.069
Max	96.447	84.153	116.028	93.704	98.648	84.010	118.350	94.402
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	21	21	21	21	21	21	21	21
Basis Values and Estimates								
B-basis Value	81.613	69.762	101.364	83.401	84.113	70.952		85.206
B-Estimate							94.365	
A-Estimate	76.711	64.860	96.998	79.035	79.441	66.281	82.959	81.246
Method	pooled	pooled	pooled	pooled	pooled	pooled	ANOVA	Normal
Modified CV Basis Values and Estimates								
B-basis Value	79.291	67.441	97.165	79.201	81.516	68.355	99.598	80.011
A-Estimate	72.793	60.942	89.910	71.947	75.059	61.898	92.205	72.618
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-36: Statistics and Basis Values for SSB1 Strength Data

4.27 "10/80/10" Single-Shear Bearing 2 (SSB2)

The SSB2 data is normalized, so both normalized and as-measured statistics are provided.

Both as-measured and normalized 2% offset strength datasets failed Levene's test for equality of variance, but passed with the modified CV transformation of the data and there were no other diagnostic test failures, so pooling the RTD and ETW 2% offset strength datasets was acceptable to compute the modified CV basis values.

The normalized ETW ultimate strength dataset failed the ADK test, so estimates of basis values for that dataset were computed using the ANOVA method. The single point normal distribution method was used for the normalized ultimate strength RTD dataset. The normalized ultimate strength ETW dataset passed the ADK test with the modified CV transformation of the data, so modified CV basis values are provided. There were no other diagnostic test failures for the ultimate strength datasets so pooling was acceptable.

There were no outliers.

Statistics, basis values and estimates are given for the SSB2 strength data in Table 4-37. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-27.

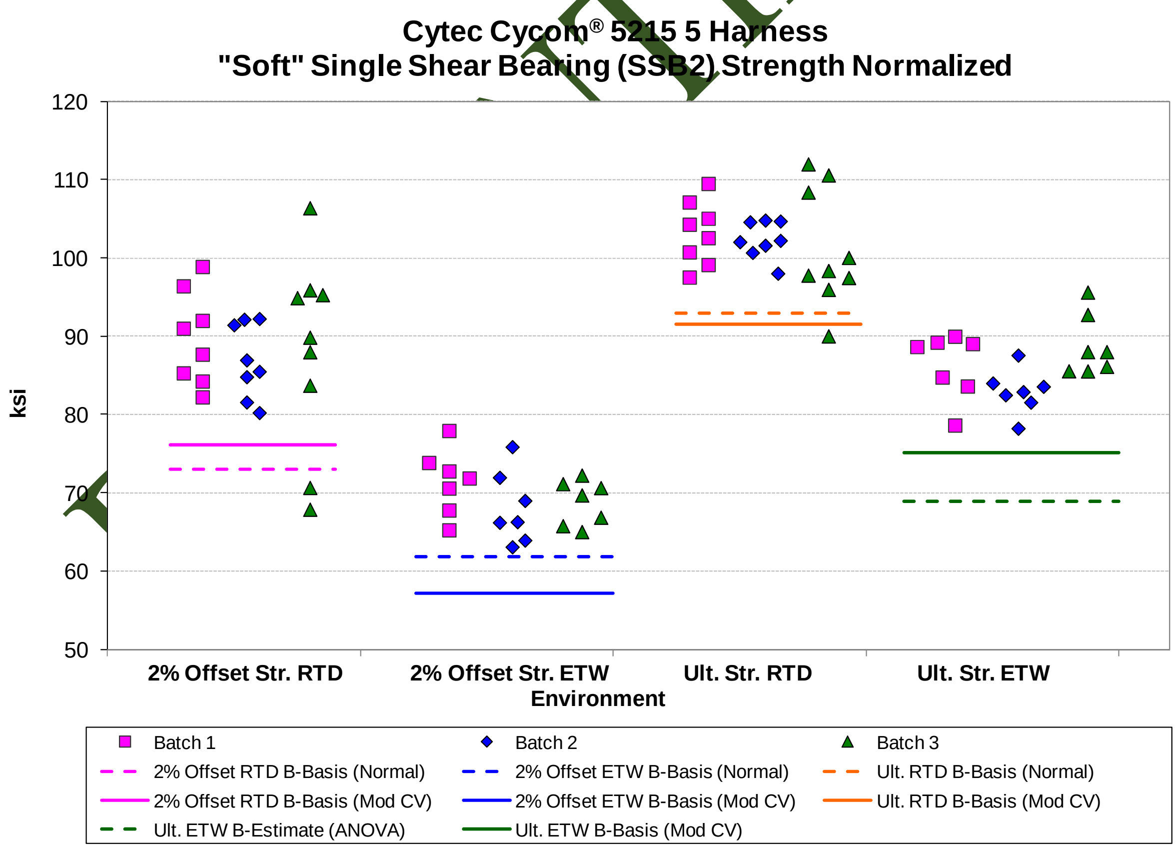

Figure 4-27: Batch plot for SSB2 normalized strength

Single Shear Bearing (SSB2) Strength Basis Values and Statistics								
	Normalized				As measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTD	ETW	RTD	ETW	RTD	ETW	RTD	ETW
Mean	88.220	69.427	102.219	86.004	89.555	69.778	103.800	86.438
Stdev	8.322	4.004	5.062	4.272	7.891	3.750	4.737	3.897
CV	9.434	5.768	4.952	4.967	8.811	5.375	4.564	4.508
Modified CV	9.434	6.884	6.476	6.484	8.811	6.687	6.282	6.254
Min	67.894	63.099	90.033	78.241	69.128	64.293	91.670	79.057
Max	106.392	77.940	112.003	95.629	104.948	77.161	112.159	94.854
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	25	21	25	21	25	21	25	21
Basis Values and Estimates								
B-basis Value	72.929	61.799	92.919		75.057	62.634	96.207	78.732
B-Estimate				68.832				
A-Estimate	61.949	56.361	86.239	56.576	64.646	57.540	90.905	73.455
Method	Normal	Normal	Normal	ANOVA	Normal	Normal	pooled	pooled
Modified CV Basis Values and Estimates								
B-basis Value	76.176	57.204	91.516	75.142	78.061	58.114	93.318	75.801
A-Estimate	67.767	48.836	84.043	67.704	70.036	50.128	86.000	68.518
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-37: Statistics and Basis Values for SSB2 Strength Data

4.28 "40/20/40" Single-Shear Bearing 3 (SSB3)

The SSB3 data is normalized, so both normalized and as-measured statistics are provided. The 2% offset strength datasets had no diagnostic test failures. Pooling the RTD and ETW datasets was acceptable.

The ETW ultimate strength datasets, both normalized and as-measured, failed the ADK test, so estimates of basis values for that dataset were computed using the ANOVA method. The single point normal distribution method was used for the ultimate strength RTD datasets. The ultimate strength ETW datasets, both normalized and as-measured, passed the ADK test with the modified CV transformation of the data, so modified CV basis values are provided. There were no other diagnostic test failures for the ultimate strength datasets so pooling was acceptable.

There was one outlier. The highest value in batch two of the as-measured RTD 2% offset strength dataset was an outlier. It was an outlier for the RTD condition, but not for batch two. It was not an outlier for the normalized 2% offset strength dataset or for the normalized or as-measured ultimate strength datasets. It was retained for this analysis.

Statistics, basis values and estimates are given for the SSB3 strength data in Table 4-38. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-28.

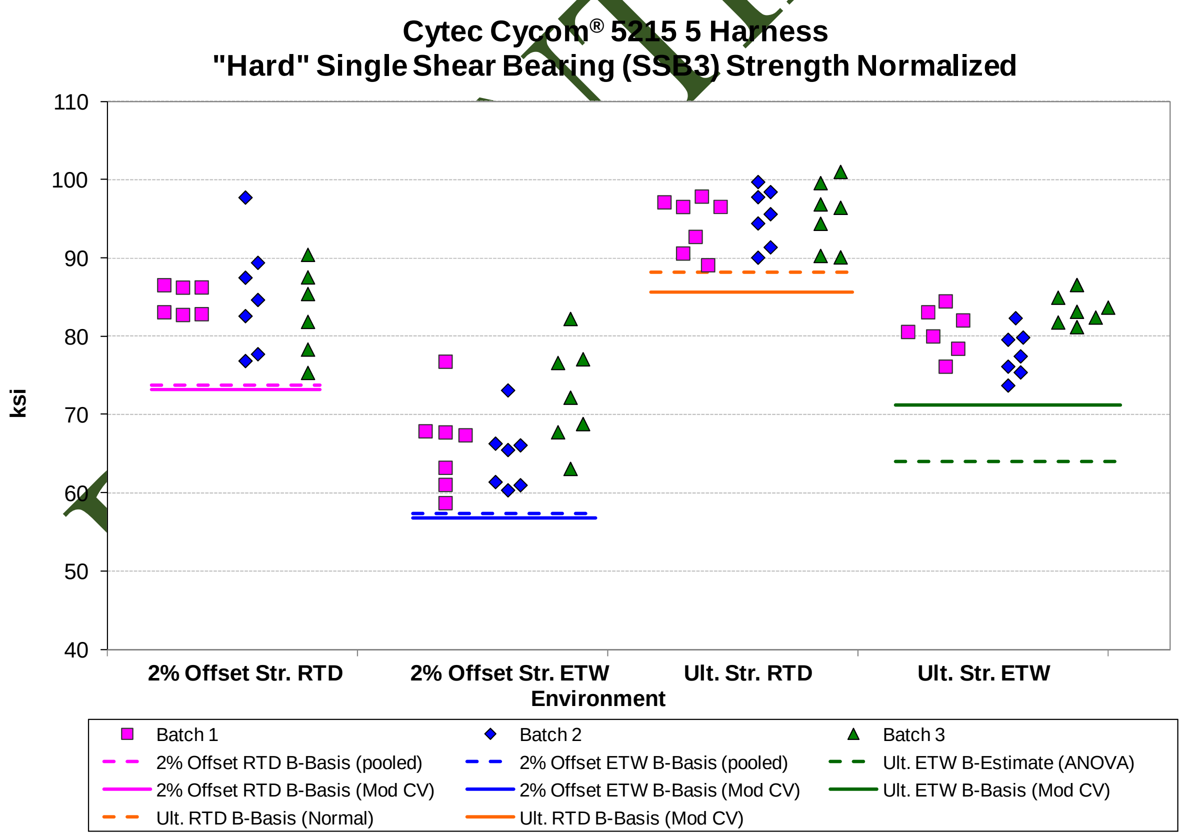

Figure 4-28: Batch plot for SSB3 normalized strength

Single Shear Bearing (SSB3) Strength Basis Values and Statistics								
	Normalized				As measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTD	ETW	RTD	ETW	RTD	ETW	RTD	ETW
Mean	84.400	67.843	95.099	80.642	86.439	67.901	97.424	80.710
Stdev	5.313	6.427	3.650	3.410	5.466	6.385	3.779	3.335
CV	6.296	9.474	3.838	4.229	6.324	9.403	3.878	4.133
Modified CV	7.148	9.474	6.000	6.115	7.162	9.403	6.000	6.066
Min	75.369	58.736	89.114	73.750	76.756	57.816	90.615	75.230
Max	97.762	82.251	101.042	86.598	101.540	81.584	103.331	87.520
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	19	21	21	21	19	21	21	21
Basis Values and Estimates								
B-basis Value	73.757	57.294	88.147		75.722	57.278	90.226	
A-Estimate				63.978				65.024
A-Estimate	66.505	50.022	83.190	52.084	68.420	49.954	85.094	53.827
Method	pooled	pooled	Normal	ANOVA	pooled	pooled	Normal	ANOVA
B-basis Value								
B-basis Value	73.186	56.729	85.643	71.186	75.136	56.697	87.863	71.149
A-Estimate	65.546	49.066	79.140	64.683	67.434	48.973	81.288	64.574
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-38: Statistics and Basis Values for SSB3 Strength Data

4.29 Compression After Impact 1 (CAI1)

The CAI1 data is normalized, so both normalized and as-measured statistics are provided. Basis values are not computed for this property. Testing is done only for the RTD condition. Summary statistics are presented in Table 4-39 and the normalized data are displayed graphically in Figure 4-29. There were no outliers. Only one batch of material was tested.

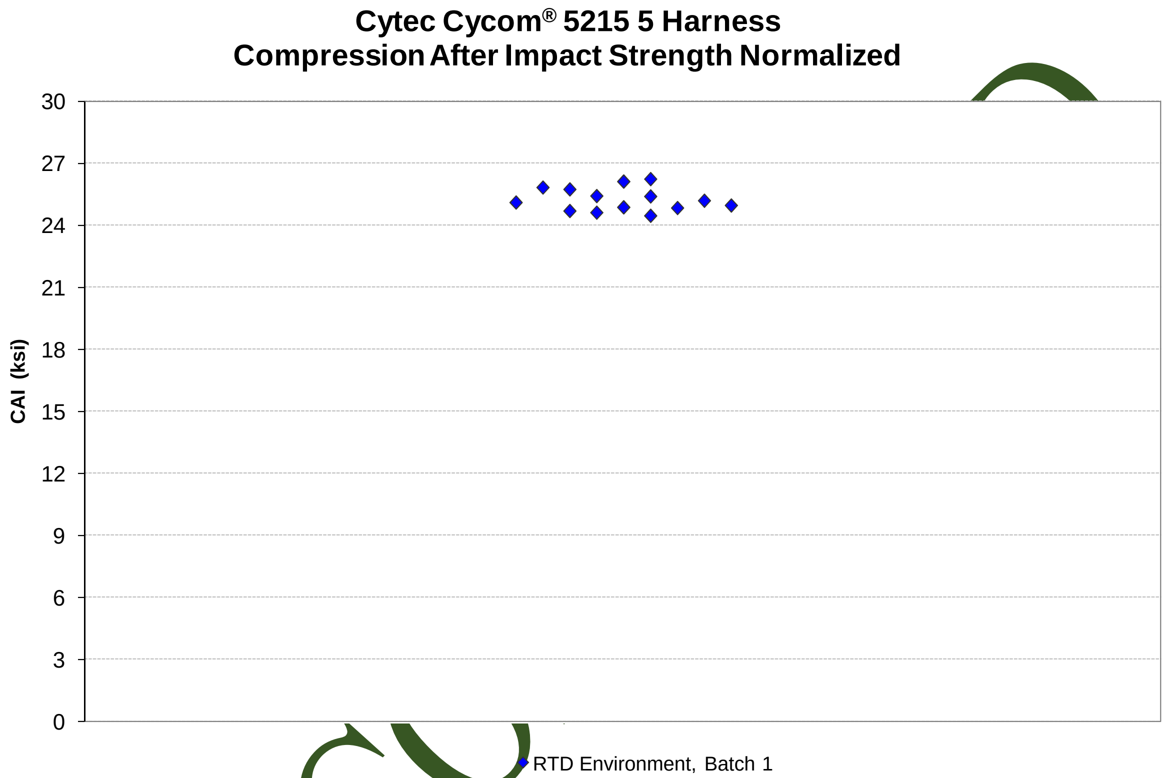

Figure 4-29: Plot for Compression After Impact normalized strength

Compression After Impact (CAI1) Strength Statistics		
	Normalized	As Measured
Env	RTD	RTD
Mean	25.263	25.426
Stdev	0.562	0.471
CV	2.224	1.854
Modified CV	6.000	6.000
Min	24.477	24.788
Max	26.252	26.348
No. Batches	1	1
No. Spec.	14	14

Table 4-39: Statistics for Compression After Impact Strength Data

4.30 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. However the summary statistics are presented in Table 4-40 and the data are displayed graphically in Figure 4-30. There were no outliers. Only one batch of material was tested.

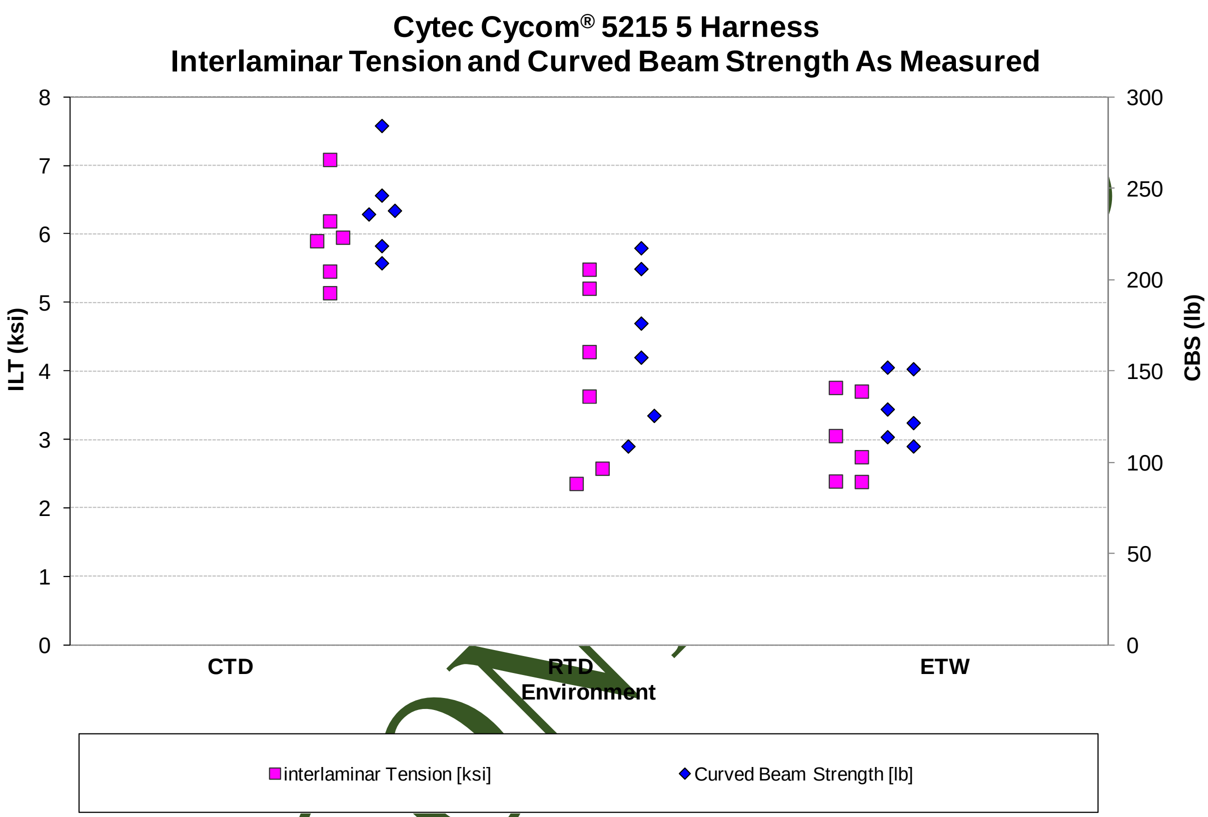

Figure 4-30: Plot for Interlaminar Tension and Curved Beam Strength as measured

Interlaminar Tension (ILT) and Curved Beam Strength (CBS) Statistics as measured						
	ILT (ksi)			CBS (lbs)		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	5.953	3.922	3.006	238.630	165.212	129.426
Stdev	0.671	1.308	0.614	26.178	43.138	18.471
CV	11.272	33.356	20.440	10.970	26.110	14.271
Modified CV	11.272	33.356	20.440	10.970	26.110	14.271
Min	5.139	2.356	2.384	209.098	108.810	108.823
Max	7.086	5.483	3.757	284.293	217.319	151.974
No. Batches	1	1	1	1	1	1
No. Spec.	6	6	6	6	6	6

Table 4-40: Statistics for ILT and CBS Strength Data

5. Outliers

Outliers were identified according to the standards documented in section 2.1.5, which are in accordance with the guidelines developed in section 8.3.3 of working draft CMH-17 Rev G. An outlier may be an outlier in the normalized data, the as-measured data, or both. A specimen may be an outlier for the batch only (before pooling the three batches within a condition together) or for the condition (after pooling the three batches within a condition together) or both.

Approximately 5 out of 100 specimens will be identified as outliers due to the expected random variation of the data. This test is used only to identify specimens to be investigated for a cause of the extreme observation. Outliers that have an identifiable cause are removed from the dataset as they inject bias into the computation of statistics and basis values. Specimens that are outliers for the condition and in both the normalized and as-measured data are typically more extreme and more likely to have a specific cause and be removed from the dataset than other outliers. Specimens that are outliers only for the batch, but not the condition and specimens that are identified as outliers only for the normalized data or the as-measured data but not both, are typical of normal random variation.

All outliers identified were investigated to determine if a cause could be found. Outliers with causes were removed from the dataset and the remaining specimens were analyzed for this report. Information about specimens that were removed from the dataset along with the cause for removal is documented in the material property data report, NCAMP Test Report CAM-RP-2010-056 Rev A.

Outliers for which no causes could be identified are listed in Table 5-1. 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
WC	RTD	2	C0ELB113A	84.528	Not an outlier	Low	Yes	No
IPS - 0.2% Offset	RTD	1	C0ENA111A	NA	6.644	High	Yes	Yes
IPS - 0.2% Offset	ETW	2	C0ENB11AM	NA	3.787	High	Yes	Yes
IPS - 5% Strain					6.495	High	No	Yes
IPS - 5% Strain	ETW	1	C0ENA11EM	NA	6.104	High	Yes	No
SBS	ETW	2	C0EQB11HM	NA	6.119	Low	Yes	No
UNT1	RTD	2	C0EAB111A	73.795	Not an outlier	Low	Yes	Yes
UNT2	CTD	1	C0EBA116B	39.938	40.363	Low	Yes	Yes
UNC1	RTD	2	C0EWB112A	Not an outlier	65.835	Low	Yes	No
OHT1	ETW	2	C0EDB119M	60.067	60.116	High	Yes - Norm No - as meas	Yes
OHT2	CTD	3	C0EEC214B	Not an outlier	34.601	Low	Yes	No
OHT2	ETW	1	C0EEA11CM	Not an outlier	31.318	Low	Yes	No
OHT3	CTD	1	C0EFA214B	58.064	58.008	Low	Yes	No
OHC1	ETW	1	C0EGA216M	34.865	35.394	High	Yes	No
OHC3	ETW	2	C0EIB218M	Not an outlier	37.926	High	Yes	No
FHC2	RTD	2	C0E8B114A	42.778	42.513	Low	Yes	No
SSB3 2% Offset	RTD	2	C0E3B212A	Not an outlier	101.540	High	No	Yes

Table 5-1: List of Outliers

6. References

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