Medium Toughness PAEK thermoplastics Toray (Formerly TenCate) Cetex® TC1225 (LM PAEK) T700GC 12K T1E Unidirectional Tape 145 gsm 34% RC Material Allowables Statistical Analysis Report

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1. Introduction

This report contains statistical analysis of the Medium Toughness PAEK thermoplastics Toray (Formerly TenCate) Cetex® TC1225 (LM PAEK) T700GC 12K T1E Unidirectional Tape 145 gsm 34% RC material property data published in NCAMP Test Report CAM-RP-2019-036 Rev A. The lamina and laminate material property data have been generated with NCAMP oversight in accordance with NSP 100 NCAMP Standard Operating Procedures; the test panels and test specimens have been inspected by NCAMP Authorized Inspection Representatives (AIR) and the testing has been witnessed by NCAMP Authorized Engineering Representatives (AER). However, the data may not fulfill all the needs of any specific company's program; specific properties, environments, laminate architecture, and loading situations 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 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.

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 122 Rev Initial Release dated November 20, 2017. NCAMP Material Specification NMS 122/1 was created at later date as a supplement material specification for T700GC 12K T1E Unidirectional Tape fiber. The qualification test panels were consolidated in accordance with NCAMP Process Specification NPS 81225 Rev A dated August 3, 2018 Baseline Consolidate Cycle “C”. The NCAMP Test Plan NTP 1225Q1 was used for this qualification program. The testing was performed at the National Institute for Aviation Research (NIAR) in Wichita, Kansas.

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

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

Part fabricators that wish to utilize the material property data, allowables, and specifications may be able to do so by demonstrating the capability to reproduce the original material properties; a process known as equivalency. More information about this equivalency process including the test statistics and its limitations can be found in Section 6 of DOT/FAA/AR-03/19 and Section 8.4.1 of CMH-17-1G. The applicability of equivalency process must be evaluated on program-by-program basis by the applicant and certifying agency. The applicant and certifying agency must agree that the equivalency test plan along with the equivalency process described in Section 6 of DOT/FAA/AR-03/19 and Section 8.4.1 of CMH-17-1G are adequate for the given program.

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 122/1. NMS 122/1 may 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 122/1.* NMS 122/1 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
Longitudinal Compression	LC
Longitudinal Tension	LT
Transverse Compression	TC
Transverse Tension	TT
In-Plane Shear	IPS
Double Notch Shear	DNS
Laminate Double Notch Shear	DNS1
Short Beam Strength	SBS
Laminate Short Beam Strength	SBS1
Unnotched Tension	UNT
Unnotched Compression	UNC
Filled Hole Tension	FHT
Filled Hole Compression	FHC
Open Hole Tension	OHT
Open Hole Compression	OHC
Single Shear Bearing	SSB
0° Flexural	0FLEX
90° Flexural	90FLEX
Interlaminar Tension	ILT
Curved Beam Strength	CBS
Compression After Impact	CAI

Table 1-1: Test Property Abbreviations

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

Table 1-2: Test Property Symbols

Environmental Condition	Abbreviation	Temperature
Cold Temperature Dry	CTA	−65±5˚F
Room Temperature Dry	RTA	70±10˚F
Elevated Temperature Dry	ETA1	275±5˚F
Elevated Temperature Dry	ETA2	400±5˚F
Elevated Temperature Wet	ETW	275±5˚F

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 50/40/10 layup. This is also referred to as "Hard"

EX: OHT1 is an open hole tension test with a 25/50/25 layup

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2019-036 Rev A.

1.2 Pooling Across Environments

When pooling across environments was allowable, the pooled co-efficient of variation was used. CMH17 STATS (CMH17 Approved **S**tatistical Analysis Program) 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, which are also provided by CMH17 STATS.

1.3 Basis Value Computational Process

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

1.4 Modified Coefficient of Variation (CV) Method

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

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

The material allowables in this report are calculated using both the as-measured CV and modified CV, so users have the choice of using either one. When the measured CV is greater than 8%, the modified CV method does not change the basis value. NCAMP recommended values make use 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 CMH17 STATS. Pooling across environments will be used whenever it is permissible according to CMH-17-1G guidelines. If pooling is not permissible, the results of a single point analysis provided by CMH17 STATS is included instead. If the data does not meet CMH-17-1G requirements for a single point analysis, estimates are created by a variety of methods depending on which is most appropriate for the dataset available. Specific procedures used are presented in the individual sections where the data is presented.

2.1 CMH17 STATS Statistical Formulas and Computations

This section contains the details of the specific formulas CMH17 STATS 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.

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

2.1.3 Basis Value Computations

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

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

2.1.3.1 K-factor computations

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

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

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

Where

r = the number of environments being pooled together

n_j = number of data values for environment j

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

$$f = N - r$$

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

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

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

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

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

2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

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

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

2.1.4.1 Transformation of data based on Modified CV

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

To accomplish this requires a transformation in two steps:

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

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

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

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

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

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

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

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

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

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

2.1.5 Determination of Outliers

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

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

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

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

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

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

$$OSL = \frac{1}{1+e^{-0.48+0.78\ln(AD^*)+4.58AD^*}}, \quad AD^* = \left(1+\frac{4}{n}-\frac{25}{n^2}\right)AD \qquad \textbf{Equation 31}$$

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. CMH-17 STATS 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.

2.1.9 Distribution Tests

In addition to testing for normality using the Anderson-Darling test (see 2.1.7), CMH17 STATS 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 $x_{(1)}, ..., x_{(n)}$.

2.1.9.1 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.

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

The exact computation of k_A 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_A values is used:

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

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

2.1.9.3 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

$$e^{-(a/\alpha)^{\beta}} - e^{-(b/\alpha)^{\beta}} \qquad \textbf{Equation 35}$$

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 2.1.9.3.1). Calculations specific to the goodness-of-fit test for the Weibull distribution are provided in section 2.1.9.3.2.

2.1.9.3.1 Estimating Weibull Parameters

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

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

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

CMH17 STATS solves these equations numerically for $\hat{\beta}$ and $\hat{\alpha}$ in order to compute basis values.

2.1.9.3.2 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 2.1.9.3.1, let

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

The Anderson-Darling test statistic is

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

and the observed significance level is

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

where

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

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

2.1.9.3.3 Basis value calculations for the Weibull distribution

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

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

where

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

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

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

V is the value in Table 2-1 when the sample size is less than 16. For sample sizes of 16 or larger, a numerical approximation to the V values is given in the two equations immediately below.

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

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

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

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

Table 2-1: Weibull Distribution Basis Value Factors

2.1.9.4 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.

2.1.9.4.1 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 Equation 29 above with Equation 47 below:

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

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

The Anderson-Darling statistic is then computed using Equation 30 above and the observed significance level (OSL) is computed using Equation 31 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.

2.1.9.4.2 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.

2.1.10 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.

2.1.10.1 Non-parametric Basis Values for large samples

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

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

For B-basis values:

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

For A-Basis values:

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

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

The B-basis value is the r_B^{th} lowest observation in the data set, while the A-basis value is 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.

2.1.10.2 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

The A-basis value is:

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

where $x_{(n)}$ is the largest data value, $x_{(1)}$ is the smallest, and $x_{(r)}$ is the r^{th} largest data value. The values of r and k depend on n and are listed in Table 2-2. 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 2-3. For an A-basis value that meets all the requirements of CMH-17-1G, there must be at least five batches represented in the data and at least 55 data points. For a B-basis value, there must be at least three batches represented in the data and at least 18 data points.

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

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

2.1.11 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.

2.1.11.1 Calculation of basis values using ANOVA

The following calculations address batch-to-batch variability. In other words, the only grouping is due to batches and the k-sample Anderson-Darling test (Section 2.1.6) indicates that the batch to batch variability is too large to pool the data. The method is based on the one-way analysis of variance random-effects model, and the procedure is documented in reference 10.

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

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

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

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

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 8.3.5 of CMH-17-1Gusing 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

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

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.

2.2 Single Batch and Two Batch Estimates using Modified CV

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

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

2.3 0º Lamina Strength Derivation

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

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

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

$$BF = \frac{E_1\left[V_0 E_2 + (1 - V_0)E_1\right] - (\nu_{12} E_2)^2}{\left[V_0 E_1 + (1 - V_0)E_2\right]\left[V_0 E_2 + (1 - V_0)E_1\right] - (\nu_{12} E_2)^2} \qquad \textbf{Equation 62}$$

V_0=fraction of 0º plies in the cross-ply laminate (1/2 for UNT0 and 1/3 for UNC0)
E_1 = Average across of batches of modulus for LC and LT as appropriate
E_2 = Average across of batches of modulus for TC and TT as appropriate

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

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

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

3. Summary of Results

The basis values for all tests are summarized in the following tables. The NCAMP recommended B-basis values meet all requirements of CMH-17-1G. However, not all test data meets those requirements. The summary tables provide a complete listing of all computed basis values and estimates of basis values. Data that does not meet the requirements of CMH-17-1G are shown in shaded boxes and labeled as estimates. Basis values computed with the modified coefficient of variation (CV) are presented whenever possible. Basis values and estimates computed without that modification are presented for all tests.

3.1 NCAMP Recommended B-basis Values

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

1. Recommended values are NEVER estimates. Only B-basis values that meet all requirements of CMH-17-1G are recommended.
2. Modified CV basis values are preferred. Recommended values will be the modified CV basis value when available. The CV provided with the recommended basis value will be the one used in the computation of the basis value.
3. Only normalized basis values are given for properties that are normalized.
4. ANOVA B-basis values are not recommended since only three batches of material are available and CMH-17-1G recommends that no less than five batches be used when computing basis values with the ANOVA method.
5. Basis values of 90% or more of the mean value imply that the CV is unusually low and may not be conservative. Caution is recommended with B-Basis values calculated from CMH17 STATS 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 CTA-RTA-ETA trend of the basis values is not consistent with the CTA-RTA-ETA trend of the average values), then the B-basis values will not be recommended.

NCAMP Recommended B-basis Values for
Toray Cetex® TC1225 (LM PAEK) T700GC 12k T1E Unitape 145 gsm 34% RC
All B-basis values in this table meet the standards for publication in CMH-17-1G Handbook
Values are for normalized data unless otherwise noted

Lamina Strength Tests

Environment	Statistic	LC from UNC0**	LT	TC	TT	IPS*		DNS†	0FLEX Proc. A	90FLEX Proc. A	[0/90] UNC0
						0.2% Offset	5% Strain				
CTA (-65°F)	B-basis	168.3	304.4	34.81	NA:A	6.159	11.58	15.34	210.7		91.28
	Mean	188.5	358.9	39.49	15.29	6.834	13.14	16.77	232.2		102.2
	CV	7.130	7.875	6.000	7.959	6.000	6.000	6.000	6.000		7.130
RTA (70°F)	B-basis	157.5	285.3	27.12	12.08	4.763	8.379	12.67	179.6	NA:A	85.31
	Mean	177.8	336.8	30.76	13.68	5.437	9.505	14.10	201.1	20.56	96.29
	CV	6.479	8.842	6.000	6.000	6.000	6.000	6.000	6.303	7.201	6.479
ETA1 (275°F)	B-basis	108.0	NA:A	15.21	5.951	1.519	4.025	6.727	116.8		57.81
	Mean	128.2	364.6	17.20	6.750	1.800	4.565	8.161	138.3		68.78
	CV	6.913	8.556	6.000	6.000	8.106	6.000	6.000	6.802		6.913

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
** Derived from cross-ply using back-out factor
† In-Plane (Interlaminar) Shear Double Notch (Round) Shear Strength

Table 3-1: NCAMP Recommended B-basis Values for Lamina Test Data

NCAMP Recommended B-basis Values for
Toray Cetex® TC1225 (LM PAEK) T700GC 12k T1E Unitape 145 gsm 34% RC
All B-basis values in this table meet the standards for publication in CMH-17-1G Handbook
Values are for normalized data unless otherwise noted

Laminate Strength Tests

Lay-up	ENV	Statistic	OHT	OHC	FHT	FHC	UNT	UNC	SSB Proc. C 2% Offset	SSB Proc. C Ult.	DNS1†
25/50/25	CTA (-65°F)	B-basis	62.49		69.85		131.5				
		Mean	70.30		77.60		148.9				
		CV	6.084		6.000		6.000				
	RTA (70°F)	B-basis	60.68	41.39	63.26	66.74	NA:A	69.50	88.05	114.3	10.98
		Mean	68.52	45.79	71.02	73.88	141.0	77.07	100.9	126.9	12.09
		CV	6.355	6.000	6.000	6.000	5.796	6.063	7.950	6.000	6.000
	ETA1 (275°F)	B-basis	NA:A	29.59	62.39	48.33	115.6	51.73	72.15	89.22	5.862
		Mean	66.18	34.00	70.14	55.47	132.4	59.29	84.98	101.8	6.964
		CV	5.796	6.000	6.000	6.000	6.414	6.000	6.960	6.000	6.819
10/80/10	CTA (-65°F)	B-basis	50.71		55.85		72.93				
		Mean	56.03		61.81		83.72				
		CV	6.000		6.000		6.529				
	RTA (70°F)	B-basis	45.71	38.98	47.70	50.26	NA:A	51.68	95.29	121.1	
		Mean	51.03	43.12	53.66	55.99	74.96	58.17	106.5	134.3	
		CV	6.000	6.000	6.682	6.000	5.526	7.212	6.083	6.000	
	ETA1 (275°F)	B-basis	36.75	27.81	38.59	32.98††	52.27	32.98	76.06	92.19	
		Mean	42.06	31.95	44.55	41.88††	59.68	39.47	87.29	105.4	
		CV	6.000	6.000	6.090	6.969	6.289	7.087	6.687	6.000	
50/40/10	CTA (-65°F)	B-basis	87.01		86.41		NA:A				
		Mean	97.90		97.61		198.0				
		CV	6.097		6.522		6.172				
	RTA (70°F)	B-basis	84.18	49.75	81.99	80.74	178.1	87.46	98.32	117.0	
		Mean	95.06	55.04	93.20	89.48	204.6	98.06	109.3	132.7	
		CV	6.295	6.000	6.362	6.000	6.577	6.847	6.000	6.000	
	ETA1 (275°F)	B-basis	NA:A	35.52	NA:A	60.43	NA:A	64.20	71.95	84.70	
		Mean	98.05	40.82	95.04	69.17	188.1	74.81	82.90	96.12	
		CV	4.940	6.000	4.684	6.000	6.465	6.367	6.527	6.015	

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
† In-Plane (Interlaminar) Shear Double Notch (Round) Shear Strength
†† FHC > UNC; when data for FHC>UNC, FHC data is for informational purposes only and it may not substantial enough to be used for design. The UNC basis value is recommended

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

3.2 Lamina and Laminate Summary Tables

Material: Toray Cetex® TC1225 (LM PAEK) T700GC 12k T1E Unitape 145 gsm 34% RC
Material Specification: NMS 122/1
Process Specification: NPS 81225
Fabric: T700GC-12K-T1E **Resin:** TC1225 PAEK

Toray Cetex® TC1225 (LM PAEK) T700GC 12k T1E Unitape 145 gsm 34% RC Lamina Properties Summary

DMA,Tg(ambient): 288.06°F **DSC, Tg(ambient):** 288.84°F **Tg METHOD:** DMA (ASTM D7028) &
DMA,Tg(wet): 272.62°F **DSC, Melt Temperature (Peak):** 582.88°F DSC (ASTM D3418)
DSC, Hot Crystallization Temperature (Peak): 474.11°F

	Lot #1	Lot #2	Lot #3		
Fiber Lot	A1018E2	F5118F1	A1018F1		
Date of fiber manufacture	5/1/2018	6/1/2018	6/1/2018	**Date of testing**	4/2/2019 - 10/08/2019
Resin Lot	V010848	WO019197VIML	V010849	**Date of data submittal**	10/15/2019
Date of resin manufacture	7/17/2017	2/17/2017	7/17/2017	**Date of analysis**	8/1/2019 - 11/18/2019
Prepreg Lot	070618-1TP4	080918-1TP1	090618-1TP4		
Date of prepreg manufacture	7/6/2018	8/9/2018	9/6/2018		
Date of composite manufacture		8/28/2018 - 3/28/2019			

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY
Data reported: As-measured followed by normalized values in parentheses, normalizing tply: 0.0054 in
Values shown in shaded boxes do not meet CMH-17-1G requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test Condition	**CTA (-65°F)**			**RTA (70°F)**			**ETA1 (275°F)**			**ETA2 (400°F)****			**ETW (275°F)**		
Property	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean
F_1^{tu} (ksi)	322.1	321.6	370.7	302.8	302.2	351.3	248.8	322.0	371.1	262.6	235.1	309.8	275.7	258.2	340.2
from LT	(307.3)	(304.4)	(358.9)	(285.3)	NA	(336.8)	(197.1)	NA	(364.6)	(257.8)	(228.6)	(301.2)	(251.7)	(242.1)	(318.9)
E_1^t			19.14			18.93			18.36			18.86			18.43
(Msi)			(18.49)			(18.10)			(17.93)			(18.33)			(17.27)
ν_{12}^t			0.3331			0.3371			0.3253			0.5033			0.3744
F_2^{tu} (ksi)	8.702	NA	15.29	11.06	12.08	13.68	5.850	5.951	6.750	2.887	2.410	3.093	5.655	4.490	5.916
E_2^t (Msi)			1.410			1.318			1.010			0.2574			0.7640
F_1^{cu} (ksi)	176.0	173.5	192.9	164.3	161.8	181.3	116.8	109.6	129.1	39.55	36.51	48.10	73.50	NA	119.4
from UNC0*	(169.6)	(168.3)	(188.5)	(158.8)	(157.5)	(177.8)	(113.5)	(108.0)	(128.2)	(39.83)	(37.14)	(48.93)	(76.21)	NA	(120.9)
E_1^c			17.30			16.94			17.13			16.43			16.63
(Msi)			(16.41)			(15.81)			(16.06)			(15.52)			(15.85)
ν_{12}^c			0.3647			0.3633			0.3614			0.3795			0.3423
F_2^{cu} (ksi)	38.34	34.81	39.49	29.60	27.12	30.76	16.06	15.21	17.20	6.390	5.898	7.435	13.97	11.92	15.70
E_2^c (Msi)			1.413			1.340			1.187			0.337			1.009
$F_{12}^{s5\%strain}$ (ksi)	12.04	11.58	13.14	9.280	8.379	9.505	4.218	4.025	4.565	NA	NA	NA	3.373	2.861	3.770
$F_{12}^{s0.2\%}$ (ksi)	6.270	6.159	6.834	5.179	4.763	5.437	1.519	NA	1.800	0.4929	0.4210	0.5403	0.6990	NA	1.341
G_{12}^s (Msi)			0.7326			0.6739			0.4790			0.09234			0.3746
0° Flex Proc. A	205.2	217.0	242.1	160.0	186.1	211.2	94.98	NA	145.4			***	107.2	86.79	114.3
Strength (ksi)	(220.8)	(210.7)	(232.2)	(149.3)	(179.6)	(201.1)	(123.0)	(116.8)	(138.3)			***	(105.2)	(84.36)	(111.1)
90° Flex Proc. A				18.45	18.17	21.24									
Strength (ksi)				(13.79)	NA	(20.56)									
[0/90] UNC0	93.04	93.73	104.2	89.41	87.18	97.68	62.37	58.43	68.93	20.18	18.62	24.54	38.95	39.09	63.30
Strength (ksi)	(89.73)	(91.28)	(102.2)	(86.86)	(85.31)	(96.29)	(60.87)	(57.81)	(68.78)	(20.34)	(18.97)	(24.99)	(40.50)	(40.63)	(64.27)
[0/90] UNC0			9.497			9.364			9.184			8.681			9.037
Modulus (Msi)			(9.307)			(9.239)			(9.163)			(8.839)			(9.179)
DNS† In-Plane Shear Strength (ksi)	15.54	15.34	16.77	13.39	12.67	14.10	6.363	6.727	8.161			***	6.565	5.621	7.406

**** Derived from cross-ply using back-out factor***
***** ETA2 data is for informational purposes only and it may not substantial enough to be used for design***
****** ETA2 data not available for DNS and 0FLEX due to unacceptable failure mode.***
† In-Plane (Interlaminar) Shear Double Notch (Round) Shear Strength

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

Material: Toray Cetex® TC1225 (LM PAEK) T700GC 12k T1E Unitape 145 gsm 34% RC
Material Specification: NMS 122/1
Process Specification: NPS 81225
Fabric: T700GC-12K-T1E **Resin:** TC1225 PAEK

Toray Cetex® TC1225 (LM PAEK) T700GC 12k T1E Unitape 145 gsm 34% RC Laminate Properties Summary

DMA,Tg (ambient): 288.06°F **DSC Tg(ambient):** 288.84°F **Tg METHOD:** DMA (ASTM D7028) &
DMA,Tg (wet): 272.62°F **DSC, Melt Temperature (Peak):** 582.88°F DSC (ASTM D3418)
DSC, Hot Crystallization Temperature (Peak): 474.11°F

	Lot #1	Lot #2	Lot #3		
Fiber Lot:	A1018E2	F5118F1	A1018F1		
Date of fiber manufacture:	5/1/2018	6/1/2018	6/1/2018	**Date of testing:**	4/2/2019 - 10/08/2019
Resin Lot:	V010848	WO019197VIML	V010849	**Date of data submittal:**	10/15/2019
Date of resin manufacture:	7/17/2017	2/17/2017	7/17/2017	**Date of analysis:**	8/1/2019 - 11/18/2019
Prepreg Lot:	070618-1TP4	080918-1TP1	090618-1TP4		
Date of prepreg manufacture:	7/6/2018	8/9/2018	9/6/2018		
Date of composite manufacture:		8/28/2018 - 3/28/2019			

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY
Data reported as normalized used a normalizing t_{ply} of 0.0054 in
Values shown in shaded boxes do not meet CMH-17-1G requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test	Property	Layup:		Quasi Isotropic 25/50/25			"Soft" 10/80/10			"Hard" 50/40/10		
		Test Condition	Unit	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean
OHT (normalized)	Strength	CTA (-65°F)	ksi	51.62	62.49	70.30	53.58	50.71	56.03	72.66	87.01	97.90
		RTA (70°F)	ksi	53.57	60.68	68.52	48.58	45.71	51.03	72.97	84.18	95.06
		ETA1 (275°F)	ksi	42.54	NA	66.18	39.61	36.75	42.06	67.26	NA	98.05
		ETA2** (400°F)	ksi	54.15	44.04	58.03	---	---	---	---	---	---
		ETW (275°F)	ksi	58.24	47.90	63.11	---	---	---	---	---	---
OHC (normalized)	Strength	RTA (70°F)	ksi	43.07	41.39	45.79	41.72	38.98	43.12	50.19	49.75	55.04
		ETA1 (275°F)	ksi	28.35	29.59	34.00	30.55	27.81	31.95	36.16	35.52	40.82
		ETA2** (400°F)	ksi	15.43	13.19	17.38	---	---	---	---	---	---
		ETW (275°F)	ksi	28.17	22.16	29.19	---	---	---	---	---	---
UNT (normalized)	Strength	CTA (-65°F)	ksi	127.4	131.5	148.9	61.58	72.93	83.72	126.9	NA	198.0
	Modulus		Msi	---	---	7.030	---	---	4.565	---	---	10.46
	Strength	RTA (70°F)	ksi	95.89	NA	141.0	50.80	NA	74.96	151.5	178.1	204.6
	Modulus		Msi	---	---	6.651	---	---	4.188	---	---	10.23
	Strength	ETA1 (275°F)	ksi	94.01	115.6	132.4	48.76	52.27	59.68	114.2	NA	188.1
	Modulus		Msi	---	---	6.447	---	---	3.433	---	---	9.746
	Strength	ETA2** (400°F)	ksi	94.29	78.48	103.4	---	---	---	---	---	---
	Modulus		Msi	---	---	6.028	---	---	---	---	---	---
	Strength	ETW (275°F)	ksi	117.5	94.15	124.0	---	---	---	---	---	---
	Modulus		Msi	---	---	6.020	---	---	---	---	---	---
UNC (normalized)	Strength	RTA (70°F)	ksi	71.98	69.50	77.07	52.43	51.68	58.17	74.07	87.46	98.06
	Modulus		Msi	---	---	6.180	---	---	4.193	---	---	9.351
	Strength	ETA1 (275°F)	ksi	54.21	51.73	59.29	33.73	32.98	39.47	67.82	64.20	74.81
	Modulus		Msi	---	---	6.183	---	---	3.740	---	---	9.501
	Strength	ETA2** (400°F)	ksi	14.05	NA	21.41	---	---	---	---	---	---
	Modulus		Msi	---	---	4.982	---	---	---	---	---	---
	Strength	ETW (275°F)	ksi	48.45	42.55	56.06	---	---	---	---	---	---
	Modulus		Msi	---	---	5.959	---	---	---	---	---	---
FHT (normalized)	Strength	CTA (-65°F)	ksi	60.83	69.85	77.60	51.77	55.85	61.81	70.53	86.41	97.61
		RTA (70°F)	ksi	67.53	63.26	71.02	48.08	47.70	53.66	70.48	81.99	93.20
		ETA1 (275°F)	ksi	59.18	62.39	70.14	40.87	38.59	44.55	65.29	NA	95.04
		ETA2** (400°F)	ksi	57.17	46.02	60.64	---	---	---	---	---	---
		ETW (275°F)	ksi	58.64	51.77	68.21	---	---	---	---	---	---
FHC†† (normalized)	Strength	RTA (70° F)	ksi	70.19	66.74	73.88	49.32	50.26	55.99	85.93††	80.74	89.48
		ETA1 (275° F)	ksi	51.79	48.33	55.47	35.52††	36.15††	41.88††	65.62	60.43	69.17
		ETA2** (400° F)	ksi	21.01††	18.22	24.01††	---	---	---	---	---	---
		ETW (275° F)	ksi	62.89††	50.62††	66.69††	---	---	---	---	---	---
Single Shear Bearing Proc. C (normalized)	2% Offset Strength	RTA (70°F)	ksi	68.72	88.05	100.9	85.25	95.29	106.5	102.0	98.32	109.3
		ETA1 (275°F)	ksi	75.05	72.15	84.98	78.03	76.06	87.29	75.67	71.95	82.90
		ETA2** (400°F)	ksi	40.52	38.39	50.58	---	---	---	---	---	---
		ETW (275°F)	ksi	74.33	66.88	88.12	---	---	---	---	---	---
	Ultimate Strength	RTA (70°F)	ksi	119.3	114.3	126.9	127.4	121.1	134.3	124.6	117.0	132.7
		ETA1 (275°F)	ksi	94.20	89.22	101.8	98.51	92.19	105.4	77.39	84.70	96.12
		ETA2** (400°F)	ksi	64.65	52.64	69.35	---	---	---	---	---	---
		ETW (275°F)	ksi	84.45	72.72	95.82	---	---	---	---	---	---
DNS1† (as-measured)	Strength	RTA (70°F)	ksi	9.960	10.98	12.09						
		ETA1 (275°F)	ksi	6.244	5.862	6.964						
		ETA2** (400°F)	ksi			***						
		ETW (275°F)	ksi	5.555	4.755	6.265						
ILT* (as-measured)	Strength	CTA (-65°F)	ksi	---	---	18.61	---	---	---	---	---	---
		RTA (70°F)	ksi	---	---	16.66	---	---	---	---	---	---
		ETA1 (275°F)	ksi	---	---	8.821	---	---	---	---	---	---
		ETW (275°F)	ksi	---	---	7.036	---	---	---	---	---	---
CBS* (as-measured)	Strength	CTA (-65°F)	lb	---	---	607.7	---	---	---	---	---	---
		RTA (70°F)	lb	---	---	537.9	---	---	---	---	---	---
		ETA1 (275°F)	lb	---	---	289.1	---	---	---	---	---	---
		ETW (275°F)	lb	---	---	236.2	---	---	---	---	---	---
CAI (Normalized)	Strength	RTA (70°F)	ksi	---	---	45.38	---	---	---	---	---	---
		ETA1 (275°F)	ksi	---	---	34.04	---	---	---	---	---	---
		ETA2** (400°F)	ksi	---	---	13.77	---	---	---	---	---	---
		ETW (275°F)	ksi	---	---	31.86	---	---	---	---	---	---

*** The actual layup for ILT is [0]30, (100/0/0).**
***** ETA2 data is for informational purposes only and it may not substantial enough to be used for design***
****** ETA2 data not available for DNS1 due to unacceptable failure mode.***
† In-Plane (Interlaminar) Shear Double Notch (Round) Shear Strength
†† when data for FHC>UNC, FHC data is for informational purposes only and it may not substantial enough to be used for design

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

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

Test data for fiber dominated properties was normalized according to nominal consolidated 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 to be 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 in CMH-17 Vol 1 Chapter 8 section 8.3.10.

4.1 Longitudinal Tension (LT)

The LT data is normalized. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The CTA and RTA conditions met all requirements for pooling, but after the modified CV transformation, the pooled dataset for normalized CTA and RTA conditions failed the normality test, so pooling was not appropriate for the modified CV basis values. The RTA and ETA1 conditions for normalized dataset had a CV greater than 8%, so no modified CV basis values are provided for those conditions.

The ETA1 condition dataset, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The as-measured ETA1 dataset, but not the normalized ETA1 dataset, passed the ADK test after the modified CV transformation was applied, so modified CV basis values are provided for the as-measured ETA1 dataset.

There was one outlier. The largest as-measured value in batch one for the CTA environment was an outlier for batch one, but not for the CTA condition or in the normalized dataset. It was retained for this analysis.

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

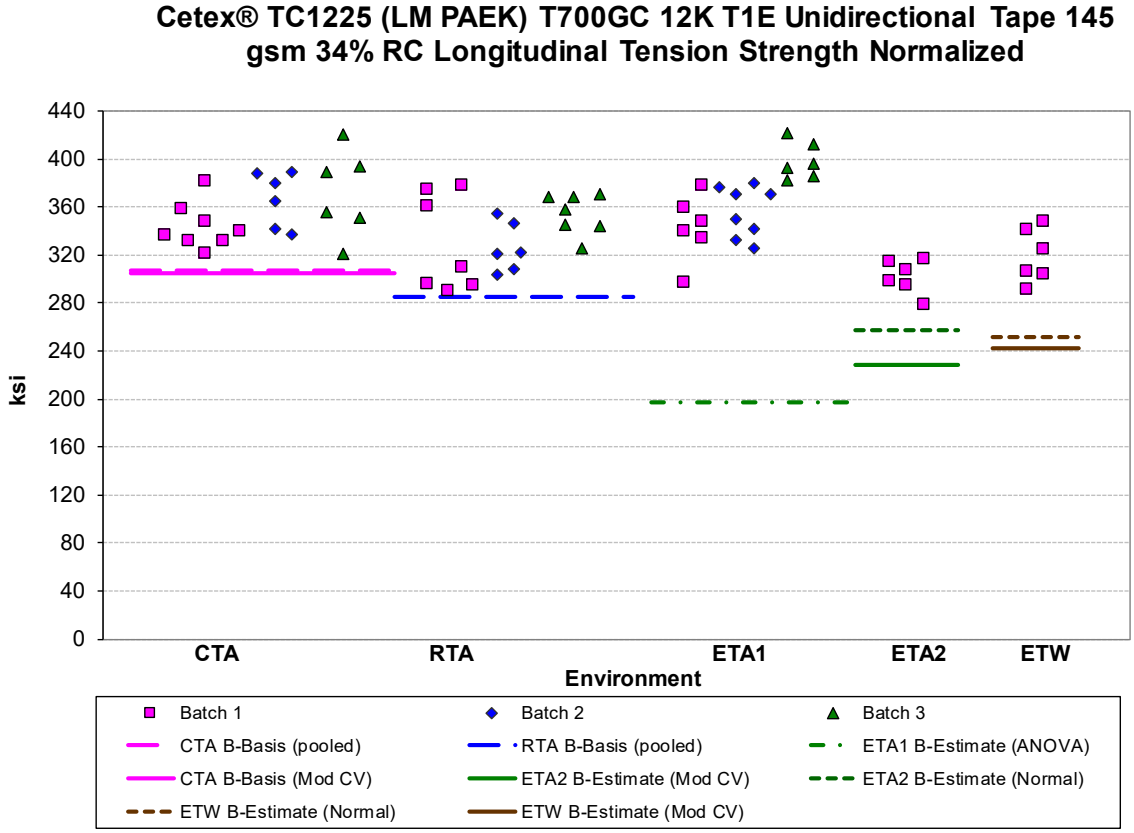

Figure 4-1: Batch plot for LT Strength normalized

Longitudinal Tension Strength Basis Values and Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	358.9	336.8	364.6	301.2	318.9	370.7	351.3	371.1	309.8	340.2
Stdev	27.81	29.78	31.19	14.33	22.20	25.71	28.48	27.12	15.60	21.28
CV	7.750	8.842	8.556	4.756	6.960	6.935	8.107	7.307	5.035	6.255
Mod CV	7.875	8.842	8.556	8.000	8.000	7.468	8.107	7.654	8.000	8.000
Min	321.5	289.6	296.3	278.1	291.3	336.2	308.1	311.0	283.8	311.4
Max	420.4	378.1	421.0	315.9	347.6	427.7	398.5	418.3	326.2	370.0
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	20	20	20	6	6	20	20	20	6	6
Basis Values and Estimates										
B-basis Value	307.3	285.3				322.1	302.8			
B-Estimate			197.1	257.8	251.7			248.8	262.6	275.7
A-Estimate	272.0	250.0	77.52	227.0	203.9	288.9	269.6	161.5	229.0	229.9
Method	pooled	pooled	ANOVA	Normal	Normal	pooled	pooled	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates										
B-basis Value	304.4	NA	NA			321.6	302.2	322.0		
B-Estimate				228.6	242.1				235.1	258.2
A-Estimate	265.7			178.9	189.5	288.5	269.2	289.0	184.1	202.1
Method	Normal			Normal	Normal	pooled	pooled	pooled	Normal	Normal

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

Longitudinal Tension Modulus Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	18.49	18.10	17.93	18.33	17.27	19.14	18.93	18.36	18.86	18.43
Stdev	0.5709	0.6202	0.6770	0.4136	0.2053	0.4001	0.4288	0.4488	0.3967	0.3645
CV	3.088	3.427	3.776	2.256	1.188	2.090	2.265	2.445	2.104	1.978
Mod CV	6.000	6.000	6.000	8.000	8.000	6.000	6.000	6.000	8.000	8.000
Min	17.33	16.92	16.70	17.80	17.12	18.61	18.41	17.54	18.38	17.78
Max	19.56	19.28	19.02	18.82	17.60	19.90	20.02	19.04	19.39	18.77
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	18	18	18	6	6	18	18	18	6	6

Table 4-2: Statistics from LT Modulus data

4.2 Transverse Tension (TT)

Transverse Tension data is not normalized for unidirectional tape. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The CTA, RTA and ETA1 condition datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The RTA and ETA1 datasets, but not the CTA dataset, passed the ADK test after the modified CV transformation was applied, so modified CV basis values are provided for the RTA and ETA1 datasets but not the CTA dataset.

There were two outliers. The smallest value in batch three of the CTA dataset was an outlier for the CTA condition, but not batch three. The largest value in batch two for the ETA1 dataset was an outlier for batch two, but not for the ETA1 condition. Both outliers were retained for this analysis.

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

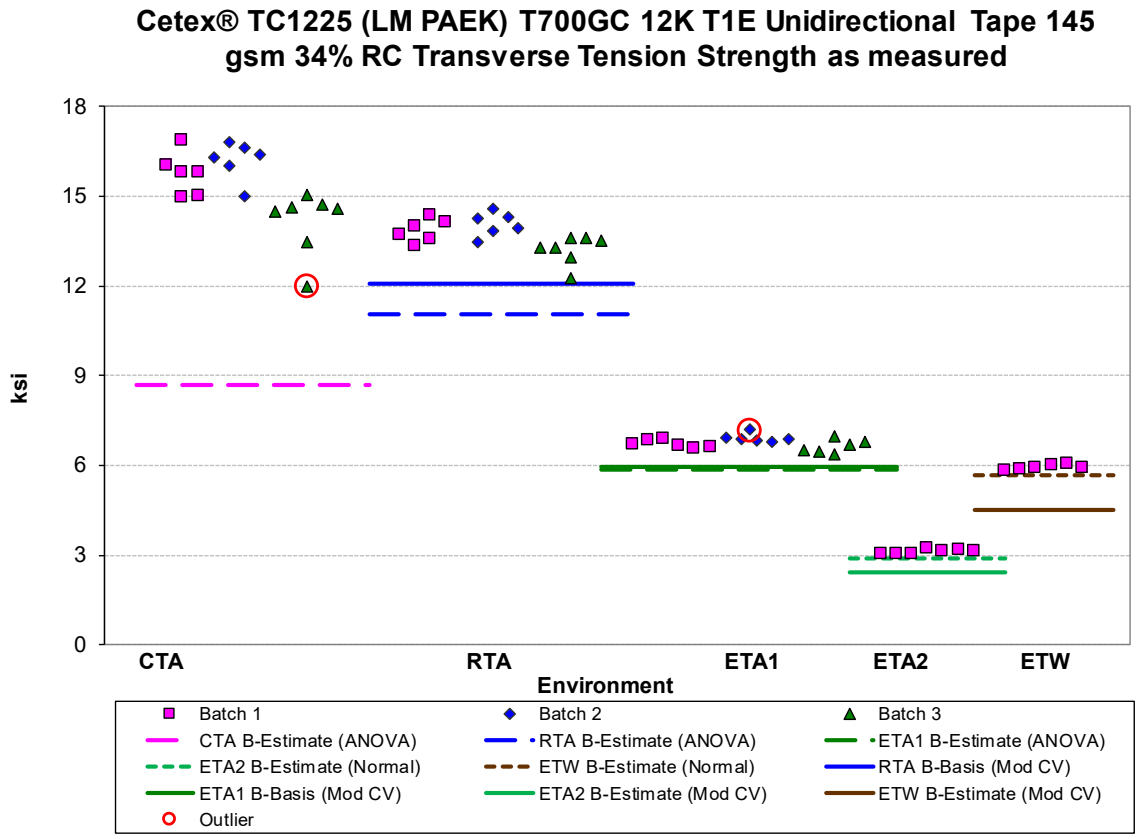

Figure 4-2: Batch Plot for TT Strength as-measured

Transverse Tension Strength Basis Values and Statistics					
As-measured					
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	ETA2 (400º F)	ETW (275º F)
Mean	15.29	13.68	6.750	3.093	5.916
Stdev	1.217	0.5464	0.2050	0.07420	0.08599
CV	7.959	3.995	3.037	2.399	1.454
Mod CV	7.979	6.000	6.000	8.000	8.000
Min	12.01	12.26	6.368	3.013	5.802
Max	16.85	14.59	7.196	3.191	6.030
No. Batches	3	3	3	1	1
No. Spec.	19	19	18	7	6
Basis Value Estimates					
B-estimate	8.702	11.06	5.850	2.887	5.655
A-estimate	4.000	9.186	5.208	2.742	5.470
Method	ANOVA	ANOVA	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates					
B-basis Value	NA	12.08	5.951		
B-estimate				2.410	4.490
A-estimate		10.95	5.385	1.943	3.514
Method		Normal	Normal	Normal	Normal

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

Transverse Tension Modulus Statistics					
As-measured					
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	ETA2 (400º F)	ETW (275º F)
Mean	1.410	1.318	1.010	0.2574	0.7640
Stdev	0.04479	0.03858	0.03689	0.007822	0.02402
CV	3.177	2.928	3.652	3.038	3.144
Mod CV	6.000	6.000	6.000	8.000	8.000
Min	1.336	1.269	0.9600	0.2480	0.7353
Max	1.503	1.404	1.068	0.2684	0.7893
No. Batches	3	3	3	1	1
No. Spec.	20	19	18	7	6

Table 4-4: Statistics from TT Modulus data

4.3 Longitudinal Compression (LC)

The LC data is normalized. The strength values for 0° properties are computed via equation 62 specified in section 2.3. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The CTA and RTA conditions could be pooled together, but when the ETA1 condition was added, the dataset failed Levene's test. All three could be pooled for the modified CV approach. No modified CV basis values could be computed for the ETW condition because the CV of that condition was greater than 8%. There were no statistical outliers.

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

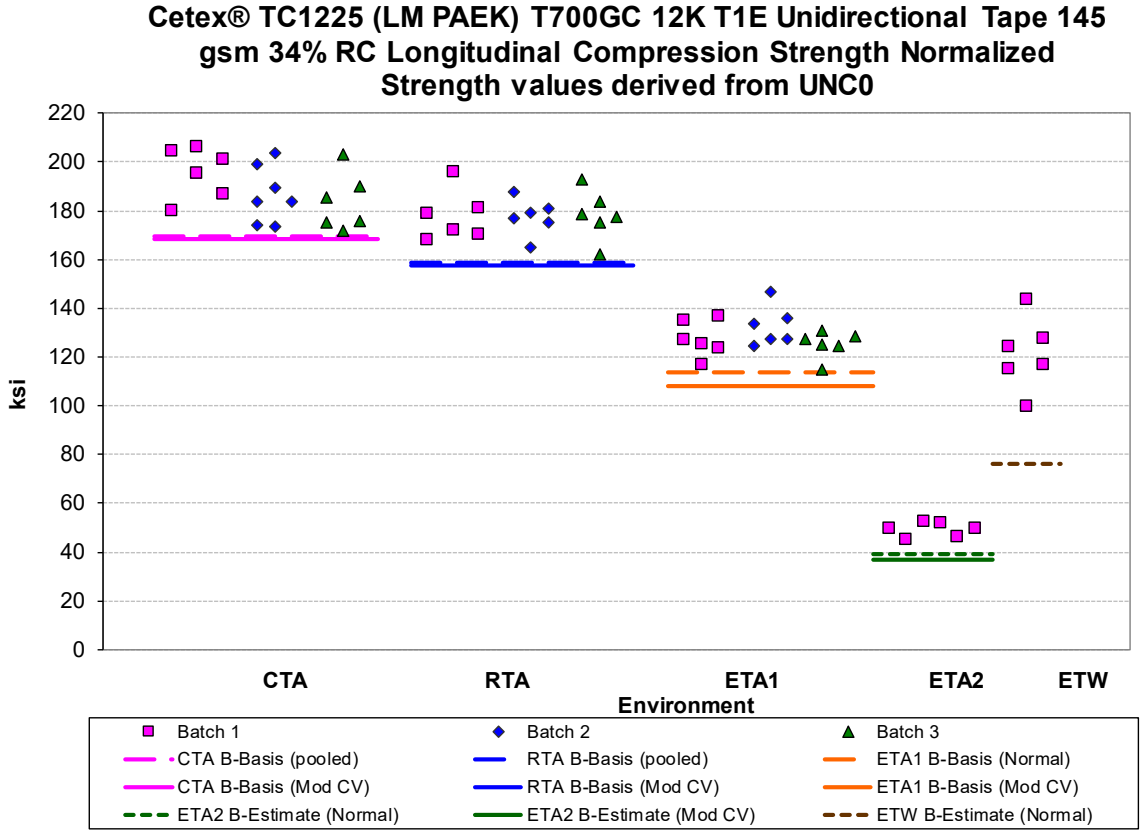

Figure 4-3: Batch plot for LC Strength normalized derived from UNC0

Longitudinal Compression Strength Basis Values and Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	188.5	177.8	128.2	48.93	120.9	192.9	181.3	129.1	48.10	119.4
Stdev	11.80	8.816	7.473	3.007	14.77	10.57	7.771	6.216	2.821	15.17
CV	6.259	4.958	5.827	6.144	12.21	5.482	4.287	4.816	5.864	12.70
Mod CV	7.130	6.479	6.913	8.000	12.21	6.741	6.143	6.408	8.000	12.70
Min	171.9	162.4	114.6	44.89	99.25	177.6	168.8	119.5	44.19	97.75
Max	205.9	195.7	146.8	52.41	143.6	210.2	195.7	144.7	51.92	143.1
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	19	18	18	6	6	19	18	18	6	6
Basis Values and Estimates										
B-basis Value	169.6	158.8	113.5			176.0	164.3	116.8		
B-Estimate				39.83	76.21				39.55	73.50
A-Estimate	156.6	145.9	103.0	33.35	44.41	164.5	152.8	108.1	33.48	40.84
Method	pooled	pooled	Normal	Normal	Normal	pooled	pooled	Normal	Normal	Normal
Modified CV Basis Values and Estimates										
B-basis Value	168.3	157.5	108.0			173.5	161.8	109.6		
B-Estimate				37.14	NA				36.51	NA
A-Estimate	154.8	144.0	94.44	29.07		160.5	148.8	96.57	28.57	
Method	pooled	pooled	pooled	Normal		pooled	pooled	pooled	Normal	

Table 4-5: Statistics and Basis Values for LC Strength derived from UNC0

Longitudinal Compression Modulus Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	16.41	15.81	16.06	15.52	15.85	17.30	16.94	17.13	16.43	16.63
Stdev	0.7062	0.4809	0.5173	1.427	0.8780	0.5653	0.3580	0.4413	1.293	0.5836
CV	4.305	3.041	3.220	9.192	5.541	3.269	2.113	2.576	7.868	3.510
Mod CV	6.152	6.000	6.000	9.192	8.000	6.000	6.000	6.000	8.000	8.000
Min	15.60	15.02	15.28	13.45	14.86	16.54	16.33	16.32	14.61	15.83
Max	18.61	16.48	16.84	17.68	17.10	18.88	17.55	17.89	18.36	17.49
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	18	18	19	6	6	18	18	19	6	6

Table 4-6: Statistics from LC Modulus

4.4 Transverse Compression (TC)

Transverse Compression data is not normalized for unidirectional tape. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The CTA, RTA and ETA1 conditions could be pooled together, but when the data was transformed for the modified CV approach, the dataset failed Levene's test so pooling was not appropriate for the modified CV basis values. There were no statistical outliers.

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

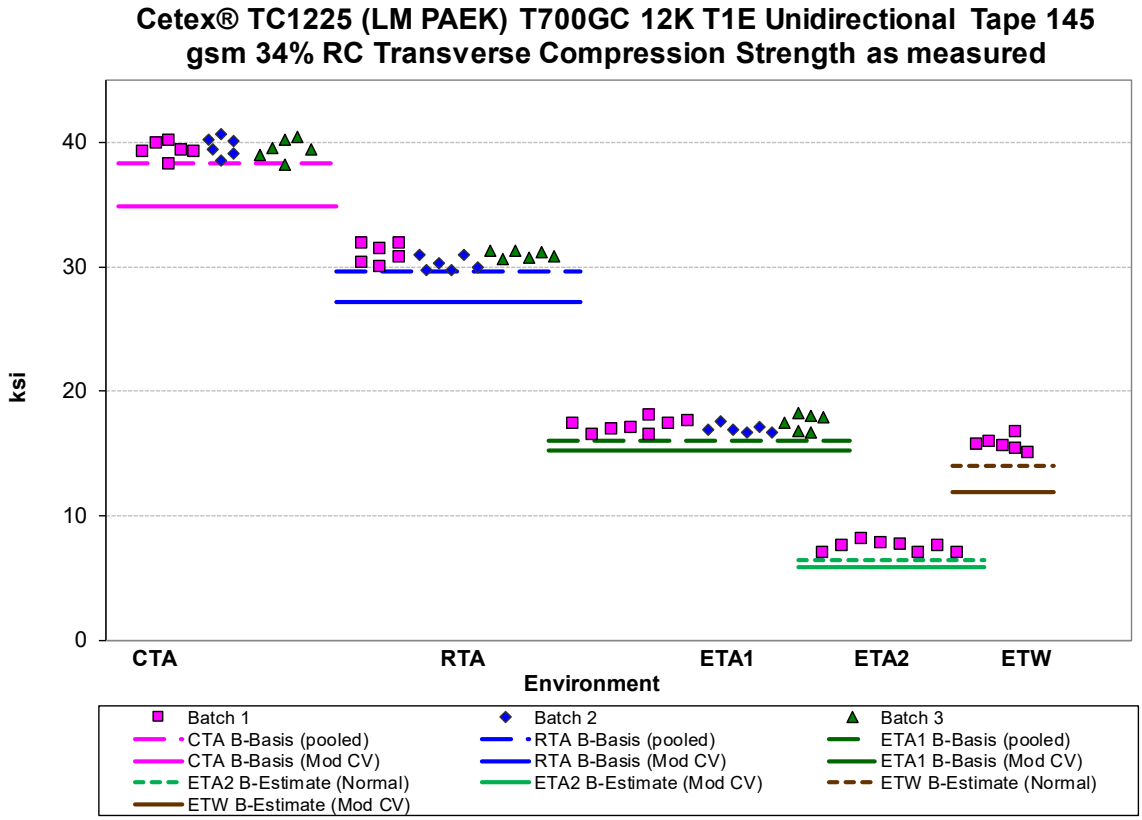

Figure 4-4: Batch Plot for TC Strength as-measured

Transverse Compression Strength Basis Values and Statistics					
As-measured					
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	39.49	30.76	17.20	7.435	15.70
Stdev	0.7244	0.6753	0.5599	0.4021	0.5702
CV	1.834	2.196	3.256	5.408	3.632
Mod CV	6.000	6.000	6.000	8.000	8.000
Min	38.16	29.71	16.46	6.957	15.01
Max	40.61	31.89	18.28	8.054	16.67
No. Batches	3	3	3	1	1
No. Spec.	18	18	20	8	6
Basis Values and Estimates					
B-basis Value	38.34	29.60	16.06		
B-estimate				6.390	13.97
A-estimate	37.57	28.84	15.28	5.659	12.74
Method	pooled	pooled	pooled	Normal	Normal
Modified CV Basis Values and Estimates					
B-basis Value	34.81	27.12	15.21		
B-estimate				5.898	11.92
A-estimate	31.51	24.54	13.80	4.843	9.327
Method	Normal	Normal	Normal	Normal	Normal

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

Transverse Compression Modulus Statistics					
As-measured					
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	1.413	1.340	1.187	0.3367	1.009
Stdev	0.03552	0.02366	0.03021	0.01245	0.04806
CV	2.514	1.766	2.545	3.697	4.764
Mod CV	6.000	6.000	6.000	8.000	8.000
Min	1.368	1.296	1.133	0.3177	0.9342
Max	1.496	1.382	1.237	0.3532	1.055
No. Batches	3	3	3	1	1
No. Spec.	18	18	20	8	6

Table 4-8: Statistics from TC Modulus data

4.5 Lamina Short-Beam Strength (SBS)

The Lamina Short Beam Strength data is not available due to unacceptable failure mode.

4.6 Laminate Short-Beam Strength (SBS1)

The Laminate Short Beam Strength data is not available due to unacceptable failure mode.

4.7 0˚ Flexural Test (0FLEX, Proc. A)

The 0FLEX data is normalized. Only one batch of material was tested in the ETW environmental condition, so only estimates of basis values are available for that conditions. The ETA2 data is not available due to unacceptable failure mode.

The normalized RTA dataset and the as-measured CTA, RTA and ETA1 datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate.

Only the as-measured ETA1 dataset failed to pass the ADK test after the modified CV transformation was applied, so no modified CV basis values are provided for that dataset. Pooling across the conditions was appropriate to compute modified CV basis values for the remaining dataset.

There were no statistical outliers.

Statistics, estimates and basis values are given for the 0FLEX normalized strength data in Table 4-9 and as-measured strength data in Table 4-10. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-5.

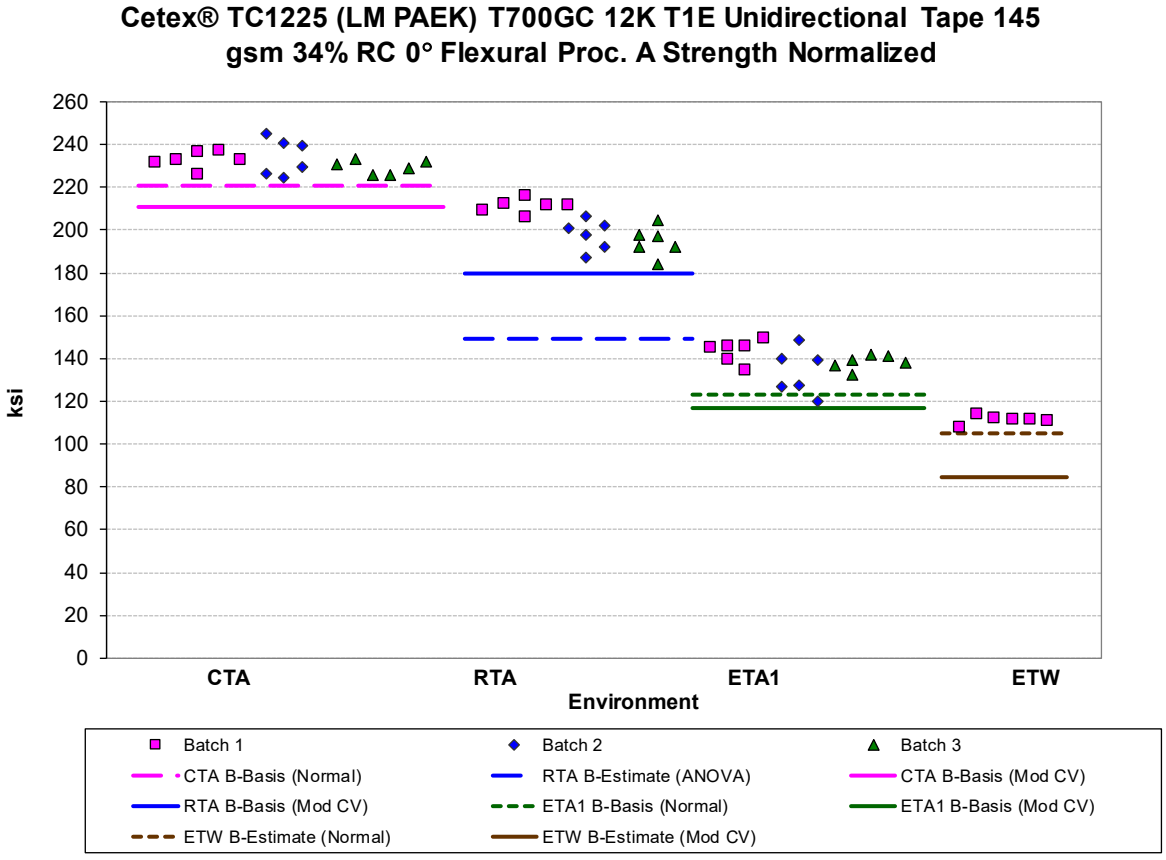

Figure 4-5: Batch plot for 0FLEX Proc. A Strength normalized

0° Flexural Proc. A Strength (ksi) Normalized Basis Values and Statistics				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETW (275° F)
Mean	232.2	201.1	138.3	111.1
Stdev	5.770	9.265	7.752	1.959
CV	2.485	4.607	5.605	1.763
Modified CV	6.000	6.303	6.802	8.000
Min	224.8	183.9	120.1	107.8
Max	245.1	215.8	149.0	113.7
No. Batches	3	3	3	1
No. Spec.	18	18	18	6
Basis Values and Estimates				
B-basis Value	220.8		123.0	
B-estimate		149.3		105.2
A-estimate	212.7	112.4	112.2	101.0
Method	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates				
B-basis Value	210.7	179.6	116.8	
B-estimate				84.36
A-estimate	196.3	165.2	102.4	66.03
Method	pooled	pooled	pooled	Normal

Table 4-9: Statistics and Basis Values for 0FLEX Proc. A Strength normalized data

0° Flexural Proc. A Strength (ksi) As-measured Basis Values and Statistics				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETW (275° F)
Mean	242.1	211.2	145.4	114.3
Stdev	7.279	9.202	9.107	2.375
CV	3.007	4.356	6.262	2.077
Modified CV	6.000	6.178	7.131	8.000
Min	229.8	190.6	124.4	110.5
Max	252.1	224.0	155.9	117.8
No. Batches	3	3	3	1
No. Spec.	18	18	18	6
Basis Values and Estimates				
B-estimate	205.2	160.0	94.98	107.2
A-estimate	178.8	123.5	58.99	102.0
Method	ANOVA	ANOVA	ANOVA	Normal
Modified CV Basis Values and Estimates				
B-basis Value	217.0	186.1	NA	
B-estimate				86.79
A-estimate	199.8	169.0		67.93
Method	pooled	pooled		Normal

Table 4-10: Statistics and Basis Values for 0FLEX Proc. A Strength as-measured data

4.8 90˚ Flexural Test (90FLEX, Proc. A)

The 90FLEX data is normalized. Only one environmental condition was tested: RTA. The only property reported is Strength.

The normalized RTA dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Modified CV values could not be reported for normalized data as it failed the ADK test even after the data was transformed to meet the assumptions of the modified CV method.

There were no statistical outliers.

Statistics, estimates and basis values are given for the 90FLEX strength data in Table 4-11. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-6.

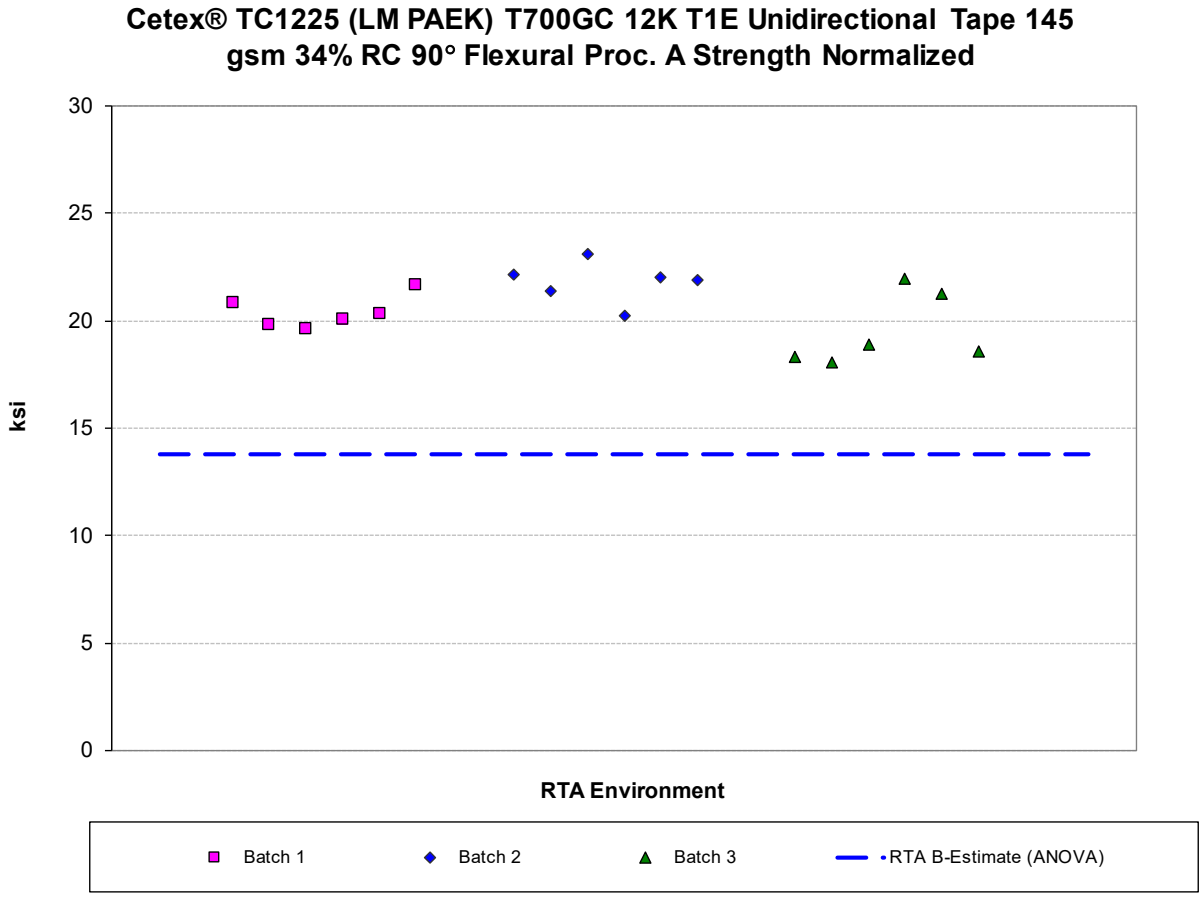

Figure 4-6: Batch plot for 90FLEX Proc. A Strength normalized

90° Flexural Proc. A Strength (ksi) Basis Values and Statistics		
RTA (70° F)	Normalized	As-Measured
Mean	20.56	21.24
Stdev	1.480	1.416
CV	7.201	6.664
Modified CV	7.601	7.332
Min	18.07	19.06
Max	23.12	23.79
No. Batches	3	3
No. Spec.	18	18
Basis Values and Estimates		
B-basis Value		18.45
B-estimate	13.79	
A-estimate	8.972	16.47
Method	ANOVA	Normal
Modified CV Basis Values and Estimates		
B-basis Value	NA	18.17
A-estimate		15.99
Method		Normal

Table 4-11: Statistics and Basis Values for 90FLEX Proc. A Strength data

4.9 In-Plane Shear (IPS)

In-Plane Shear data is not normalized. Data is reported on three properties: 0.2% Offset Strength, Strength at 5% Strain, and Modulus. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions. Strength at 5% Strain is not available for ETA2 because strain gage failed prior to reaching 5% strain.

The CTA condition datasets, both the 0.2% Offset Strength and Strength at 5% Strain properties, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Both CTA datasets passed the ADK test and the normality test after the modified CV transformation was applied, so modified CV basis values are provided. Pooling across conditions was not permissible due to failure of Levene's test for Strength at 5% Strain but the CTA and RTA conditions for 0.2% Offset Strength met all requirements for pooling after the modified CV transformation.

The ETA1 datasets for both strength (0.2% Offset and 5% Strain) properties and the RTA 0.2% Offset Strength data failed the normality test. The ETA1 datasets for the two strength properties had an adequate fit to the Weibull distribution, so that was used to compute basis values. The RTA 0.2% Offset Strength dataset did not have an adequate fit to any of the tested statistical distributions and the non-parametric method was required. The RTA 0.2% Offset Strength and ETA1 Strength at 5% Strain passed the normality test after the modified CV transformation of the data, so modified CV basis values were provided. The ETA1 and ETW datasets for 0.2% Offset Strength had a CV greater than 8%, so modified CV basis values could not be provided for that property and condition.

There were five outliers. The largest value in batch three of the RTA 0.2% Offset Strength dataset was an outlier for both batch three and the RTA condition. The largest value in batch one of the RTA 0.2% Offset Strength dataset was an outlier for batch one, but not for the RTA condition. The lowest value in batch two of the ETA1 condition for Strength at 5% Strain was an outlier for batch two, but not for the ETA1 condition. The lowest value in batch three of the ETA1 condition was an outlier for both strength (0.2% Offset and 5% Strain) properties for batch three, but not for the ETA1 condition. The largest value in batch one of the ETW 0.2% Offset Strength dataset (one batch only) was an outlier. With only one batch tested in this condition, it can only be assessed as an outlier for batch, not the condition. All five outliers were retained for this analysis.

Statistics, estimates and basis values are given for the IPS strength data in Table 4-12 and modulus data in Table 4-13. The as-measured data, B-estimates and B-basis values are shown graphically in Figure 4-7.

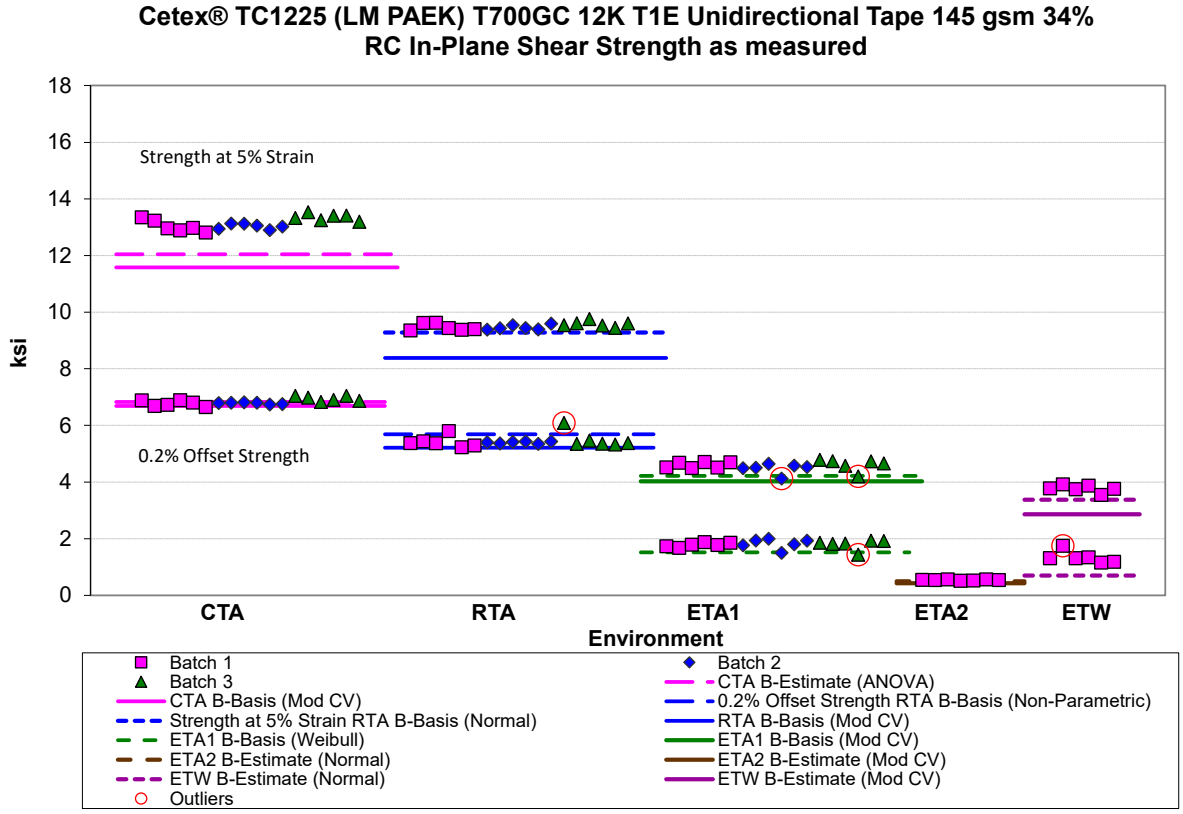

Figure 4-7: Batch plot for IPS for 0.2% Offset Strength and Strength at 5% Strain as-measured

In-Plane Shear Strength Basis Values and Statistics									
	0.2% Offset Strength					Strength at 5% Strain			
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETW (275° F)
Mean	6.834	5.437	1.800	0.5403	1.341	13.14	9.505	4.565	3.770
Stdev	0.1099	0.1988	0.1459	0.01707	0.2120	0.2097	0.1142	0.1757	0.1310
CV	1.609	3.656	8.106	3.160	15.81	1.596	1.201	3.849	3.476
Mod CV	6.000	6.000	8.106	8.000	15.81	6.000	6.000	6.000	8.000
Min	6.650	5.231	1.436	0.5162	1.151	12.81	9.353	4.120	3.541
Max	7.044	6.089	1.994	0.5635	1.745	13.53	9.760	4.781	3.921
No. Batches	3	3	3	1	1	3	3	3	1
No. Spec.	18	18	18	7	6	18	18	18	6
Basis Values and Estimates									
B-basis Value		5.179	1.519				9.280	4.218	
B-estimate	6.270			0.4929	0.6990	12.04			3.373
A-estimate	5.868	4.166	1.251	0.4596	0.2423	11.26	9.120	3.849	3.090
Method	ANOVA	Non-Parametric	Weibull	Normal	Normal	ANOVA	Normal	Weibull	Normal
Modified CV Basis Values and Estimates									
B-basis Value	6.159	4.763	NA		NA	11.58	8.379	4.025	
B-estimate				0.4210					2.861
A-estimate	5.700	4.303		0.3394		10.48	7.583	3.642	2.240
Method	pooled	pooled		Normal		Normal	Normal	Normal	Normal

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

In-Plane Shear Modulus Statistics As-Measured					
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	ETA2 (400º F)	ETW (275º F)
Mean	0.7326	0.6739	0.4790	0.09234	0.3746
Stdev	0.01661	0.01724	0.03946	0.005116	0.03770
CV	2.267	2.558	8.237	5.540	10.06
Mod CV	6.000	6.000	8.237	8.000	10.06
Min	0.7102	0.6437	0.3794	0.08234	0.3355
Max	0.7641	0.7009	0.5423	0.09817	0.4441
No. Batches	3	3	3	1	1
No. Spec.	18	18	18	7	6

Table 4-13: Statistics from IPS Modulus data

4.10 In-Plane (Interlaminar) Shear Double Notch (Round) Shear Strength (DNS)

The DNS data is not normalized. The only property reported is strength. Only one batch of material was tested in the ETW environmental condition, so only estimates of basis values are available for that condition.

The CTA dataset did not pass the normality test, and the Weibull distribution was the best fit for computing design values. The ETA1 dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The ETA1 dataset passed the ADK test and the normality test after the modified CV transformation was applied, so modified CV basis values are provided. Despite the CTA dataset failing the normality test, the pooled dataset passed normality after the modified CV data transformation. Pooling was acceptable to compute the modified CV basis values.

There were two outliers. The lowest value in batch two of the CTA dataset was an outlier for the CTA condition but not for batch two alone. The largest value in batch three of the RTA dataset was an outlier for batch three but not for the RTA condition. Both outliers were retained for this analysis.

Statistics, estimates and basis values are given for the DNS strength data in Table 4-14. The as-measured data, B-basis values and B-estimates are shown in Figure 4-8.

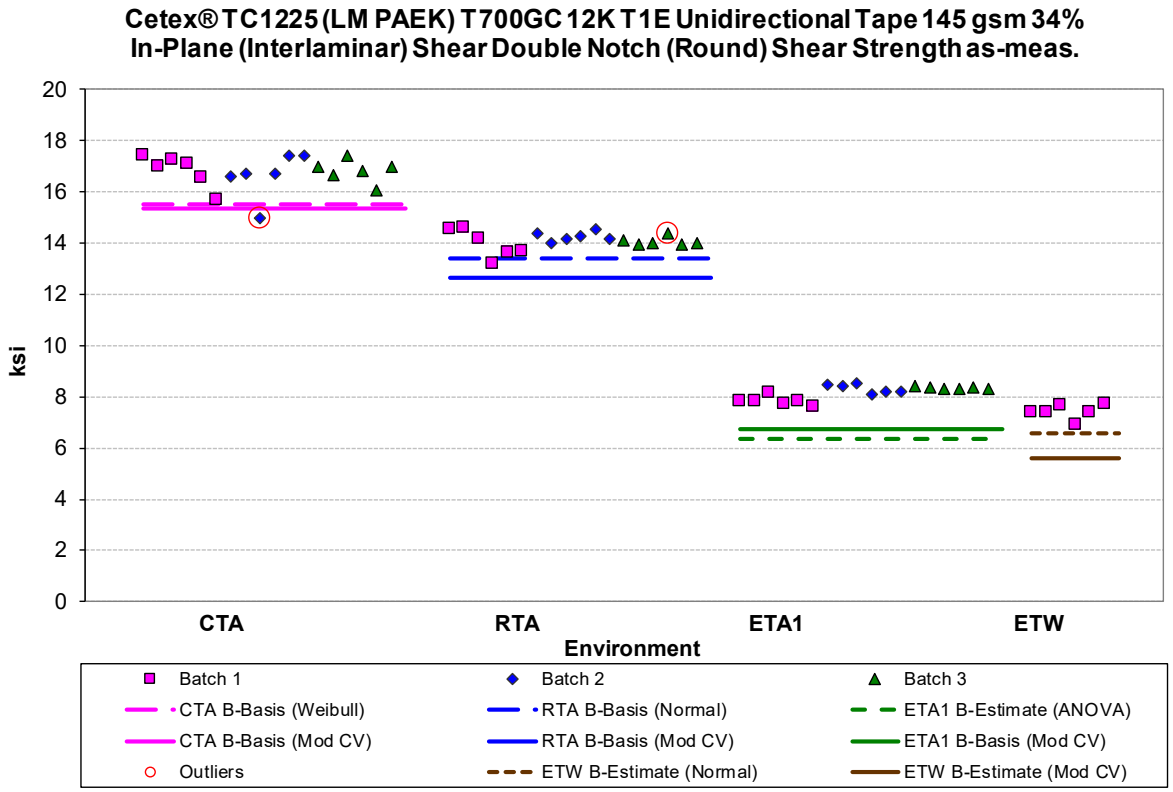

Figure 4-8: Batch plot for DNS Strength as-measured

In-Plane (Interlaminar) Shear Double Notch (Round) Shear Strength (ksi) As-Measured Basis Values and Statistics				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETW (275° F)
Mean	16.77	14.10	8.161	7.406
Stdev	0.6460	0.3611	0.2873	0.2775
CV	3.852	2.561	3.520	3.747
Mod CV	6.000	6.000	6.000	8.000
Min	14.97	13.16	7.597	6.904
Max	17.43	14.60	8.541	7.689
No. Batches	3	3	3	1
No. Spec.	18	18	18	6
Basis Values and Estimates				
B-basis Value	15.54	13.39		
B-estimate			6.363	6.565
A-estimate	14.22	12.88	5.081	5.968
Method	Weibull	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates				
B-basis Value	15.34	12.67	6.727	
B-estimate				5.621
A-estimate	14.38	11.71	5.770	4.400
Method	pooled	pooled	pooled	Normal

Table 4-14: Statistics and Basis Values for DNS Strength data

4.11 Laminate In-Plane Shear (Interlaminar) Double Notch (Round) Shear Strength (DNS1)

The DNS1 data is not normalized. The only property reported is strength. Only one batch of material was tested in the ETW environmental condition, so only estimates of basis values are available for that condition.

The ETA1 dataset did not pass the normality test, and the Lognormal distribution was the best fit for computing design values. The RTA dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The RTA dataset passed the ADK test and the normality test after the modified CV transformation was applied, so modified CV basis values are provided. The ETA1 dataset passed the normality test after the modified CV transformation was applied, so modified CV basis values are provided. Pooling was acceptable to compute the modified CV basis values. There were no statistical outliers.

Statistics, estimates and basis values are given for the DNS1 strength data in Table 4-15. The as-measured data, B-basis values and B-estimates are shown graphically in Figure 4-9.

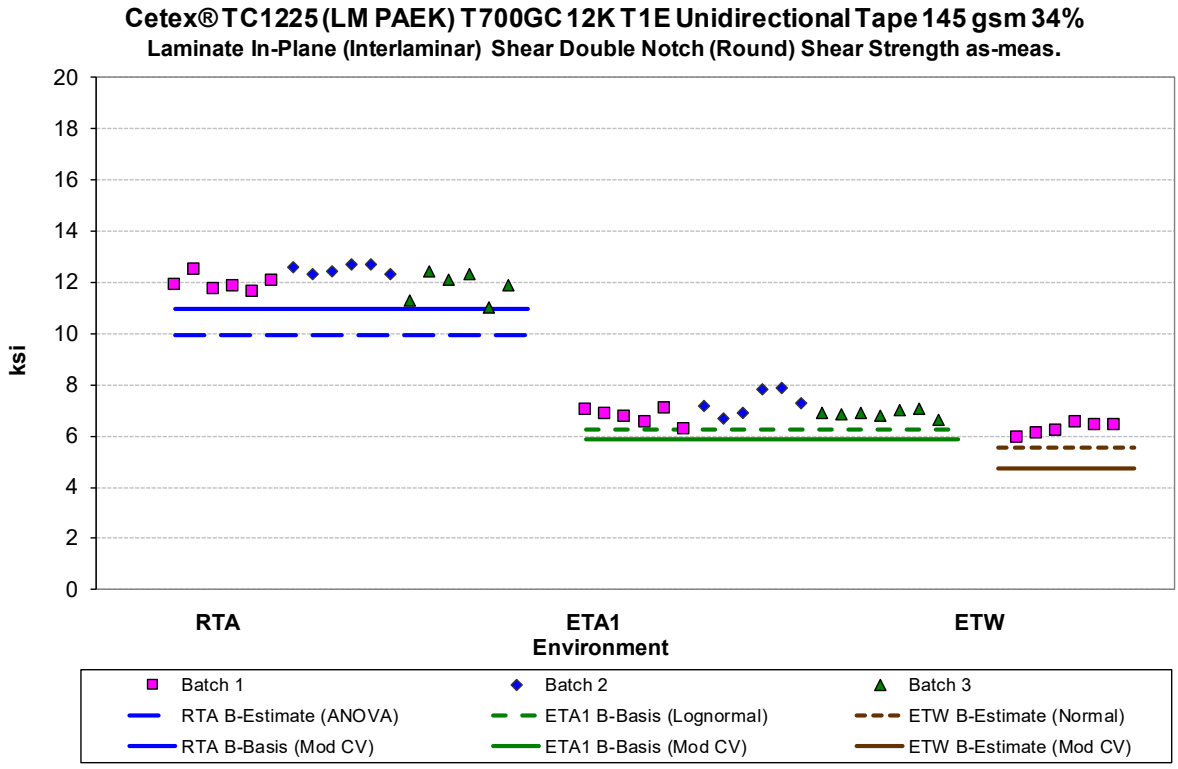

Figure 4-9: Batch plot for DNS1 Strength as-measured

Laminate In-Plane (Interlaminar) Shear Double Notch (Round) Shear Strength (ksi) As-Measured Basis Values and Statistics			
Env	RTA (70º F)	ETA1 (275º F)	ETW (275º F)
Mean	12.09	6.964	6.265
Stdev	0.4804	0.3927	0.2343
CV	3.972	5.638	3.739
Mod CV	6.000	6.819	8.000
Min	11.02	6.262	5.911
Max	12.73	7.874	6.525
No. Batches	3	3	1
No. Spec.	18	19	6
Basis Values and Estimates			
B-basis Value		6.244	
B-estimate	9.960		5.555
A-estimate	8.440	5.785	5.051
Method	ANOVA	Lognormal	Normal
Modified CV Basis Values and Estimates			
B-basis Value	10.984	5.862	
B-estimate			4.755
A-estimate	10.232	5.108	3.722
Method	pooled	pooled	Normal

Table 4-15: Statistics and Basis Values for DNS1 Strength data

4.12 "25/50/25" Unnotched Tension 1 (UNT1)

The UNT1 data is normalized. Data is reported on two properties: Strength and Modulus. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The CTA, RTA and ETA1 condition datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The CTA dataset, both normalized and as-measured, and the normalized ETA1 dataset passed the ADK test after the modified CV transformation was applied, so modified CV basis values are provided for those datasets.

There was one outlier. The smallest value in batch two for the RTA environment was an outlier for batch two, but not for the RTA condition. It was an outlier for both the normalized and as-measured datasets. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNT1 strength data in Table 4-16 and modulus data in Table 4-17. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-10.

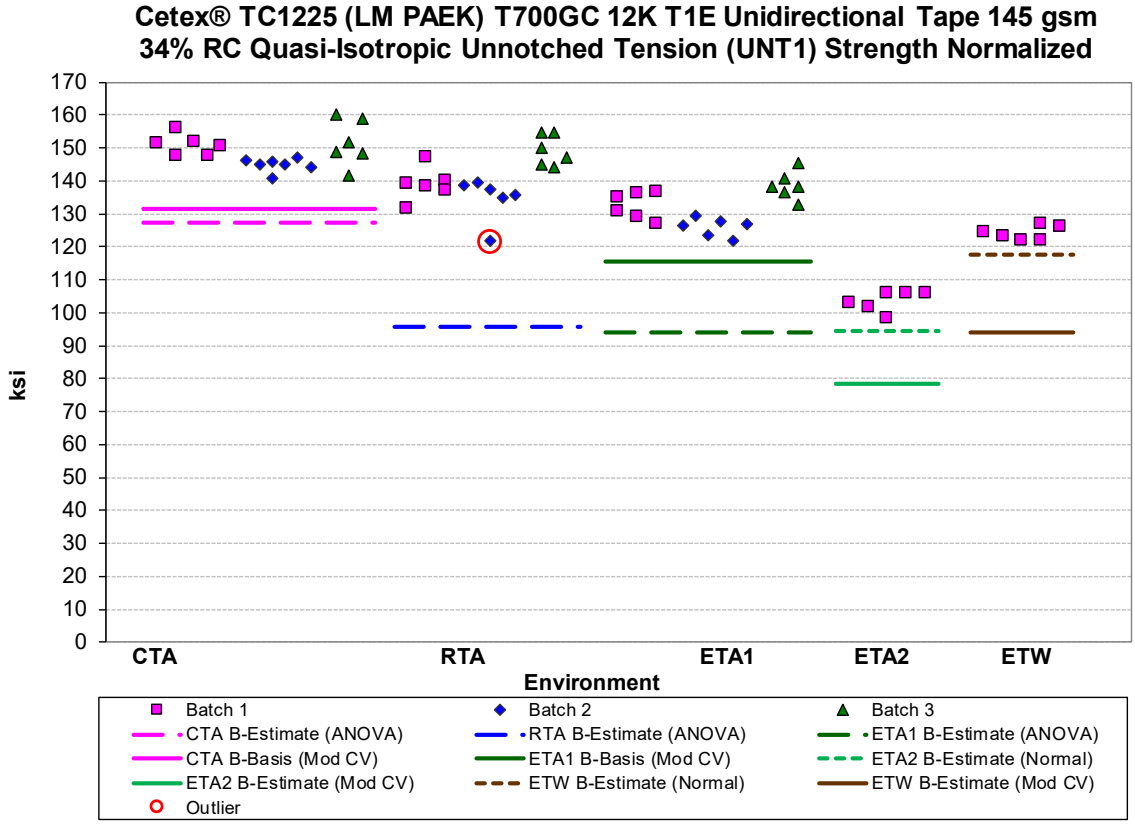

Figure 4-10: Batch Plot for UNT1 Strength normalized

Unnotched Tension (UNT1) Strength Basis Values and Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	148.9	141.0	132.4	103.4	124.0	153.9	147.5	137.1	107.3	129.7
Stdev	5.252	8.172	6.392	3.005	2.175	7.133	10.24	9.198	4.151	3.000
CV	3.527	5.796	4.828	2.907	1.754	4.634	6.943	6.708	3.868	2.313
Modified CV	6.000	6.898	6.414	8.000	8.000	6.317	7.471	7.354	8.000	8.000
Min	141.0	121.9	122.0	98.48	121.7	144.9	125.8	123.6	101.0	126.3
Max	160.4	154.9	145.7	106.0	127.0	169.9	164.5	154.8	111.2	133.7
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	19	18	18	6	6	19	18	18	6	6
Basis Values and Estimates										
B-estimate	127.4	95.89	94.01	94.29	117.5	114.9	83.80	75.42	94.74	120.6
A-estimate	112.1	63.73	66.63	87.82	112.8	86.97	38.37	31.39	85.80	114.2
Method	ANOVA	ANOVA	ANOVA	Normal	Normal	ANOVA	ANOVA	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates										
B-basis Value	131.5	NA	115.6			135.0	NA	NA		
B-estimate				78.48	94.15				81.45	98.46
A-estimate	119.2		103.8	61.43	73.70	121.5			63.75	77.07
Method	Normal		Normal	Normal	Normal	Normal			Normal	Normal

Table 4-16: Statistics and Basis Values for UNT1 Strength data

Unnotched Tension (UNT1) Modulus Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	7.030	6.651	6.447	6.028	6.020	7.270	6.955	6.674	6.255	6.294
Stdev	0.1980	0.1625	0.1081	0.08035	0.1973	0.3061	0.2381	0.2203	0.1090	0.1730
CV	2.816	2.443	1.676	1.333	3.277	4.211	3.423	3.301	1.743	2.748
Modified CV	6.000	6.000	6.000	8.000	8.000	6.105	6.000	6.000	8.000	8.000
Min	6.539	6.338	6.142	5.907	5.751	6.727	6.638	6.201	6.125	5.970
Max	7.341	6.917	6.595	6.112	6.309	7.741	7.379	7.013	6.399	6.487
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	18	18	18	6	6	18	18	18	6	6

Table 4-17: Statistics from UNT1 Modulus data

4.13 "10/80/10" Unnotched Tension 2 (UNT2)

The UNT2 data is normalized. Data is reported on two properties: Strength and Modulus. The CTA, RTA and ETA1 condition datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The ETA1 dataset, both normalized and as-measured, and the normalized CTA dataset passed the ADK test after the modified CV transformation was applied, so modified CV basis values are provided for those datasets.

There was one outlier. The largest value in batch three for the ETA1 environment was an outlier for batch three and for the ETA1 condition. It was an outlier for both the normalized and as-measured datasets. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNT2 strength data in Table 4-18 and modulus data in Table 4-19. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-11.

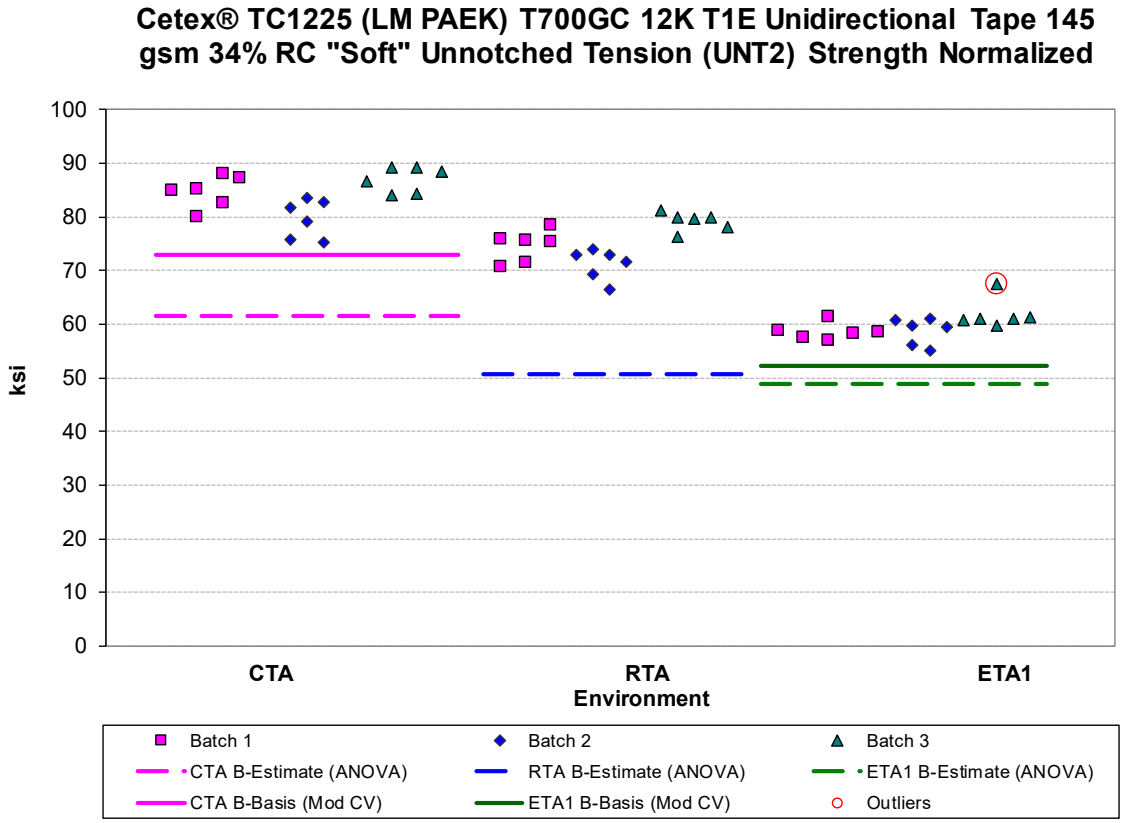

Figure 4-11: Batch Plot for UNT2 Strength normalized

Unnotched Tension (UNT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	83.72	74.96	59.68	86.37	77.82	61.63
Stdev	4.235	4.143	2.733	5.011	4.609	3.036
CV	5.058	5.526	4.579	5.802	5.923	4.926
Modified CV	6.529	6.763	6.289	6.901	6.961	6.463
Min	75.14	66.50	55.08	76.55	68.32	56.20
Max	89.22	81.32	67.54	93.13	84.57	70.33
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-estimate	61.58	50.80	48.76	57.96	49.28	47.72
A-estimate	45.79	33.55	40.98	37.69	28.91	37.80
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	72.93	NA	52.27	NA	NA	53.77
A-estimate	65.30		47.03			48.21
Method	Normal		Normal			Normal

Table 4-18: Statistics and Basis Values for UNT2 Strength data

Unnotched Tension (UNT2) Modulus Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	4.565	4.188	3.433	4.707	4.346	3.545
Stdev	0.07756	0.1372	0.1297	0.09973	0.1306	0.1395
CV	1.699	3.275	3.779	2.119	3.006	3.936
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	4.409	3.900	3.219	4.555	4.106	3.333
Max	4.700	4.432	3.775	4.913	4.628	3.931
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-19: Statistics from UNT2 Modulus data

4.14 "50/40/10" Unnotched Tension 3 (UNT3)

The UNT3 data is normalized. Data is reported on two properties: Strength and Modulus. The CTA, RTA and ETA1 condition datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Only the normalized RTA dataset passed the ADK test after the modified CV transformation was applied, so modified CV basis values are provided only for that dataset.

There was one outlier. The largest value in batch two of the CTA normalized dataset was an outlier for batch two, but not for the CTA condition. It was not an outlier in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNT3 strength data in Table 4-20 and modulus data in Table 4-21. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-12.

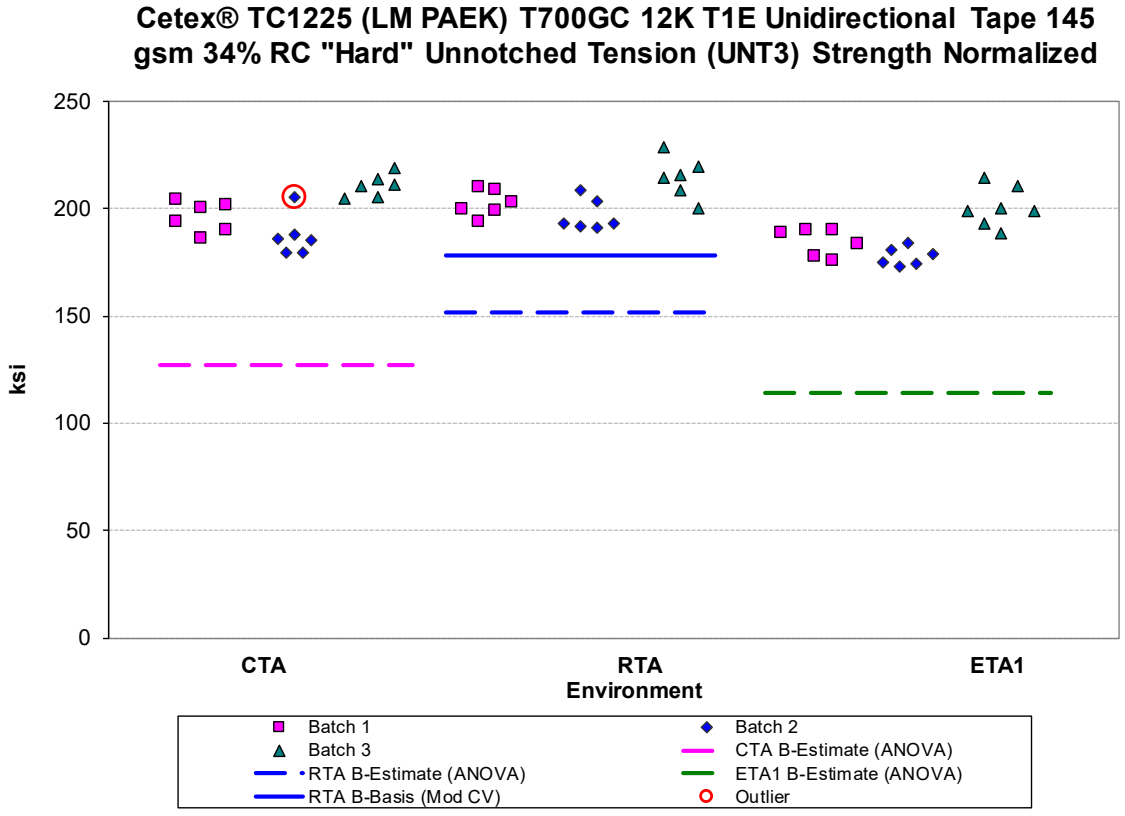

Figure 4-12: Batch Plot for UNT3 Strength normalized

Unnotched Tension (UNT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	198.0	204.6	188.1	206.5	214.3	198.0
Stdev	12.22	10.55	12.16	14.94	14.29	15.92
CV	6.172	5.154	6.465	7.236	6.666	8.037
Modified CV	7.086	6.577	7.233	7.618	7.333	8.037
Min	179.5	191.5	172.8	183.6	195.8	178.7
Max	218.8	228.5	214.6	230.7	245.2	232.2
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	19	18	18	19
Basis Values and Estimates						
B-estimate	126.9	151.5	114.2	113.6	134.8	98.47
A-estimate	76.21	113.5	61.42	47.21	78.14	27.40
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	NA	178.1	NA	NA	NA	NA
A-estimate		159.3				
Method		Normal				

Table 4-20: Statistics and Basis Values for UNT3 Strength data

Unnotched Tension (UNT3) Modulus Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	10.46	10.23	9.746	10.91	10.71	10.23
Stdev	0.3409	0.3253	0.2008	0.4034	0.3802	0.2926
CV	3.258	3.179	2.061	3.699	3.550	2.861
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	9.994	9.720	9.348	10.25	9.994	9.855
Max	11.16	10.92	10.00	11.56	11.25	10.89
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-21: Statistics from UNT3 Modulus data

4.15 "50/0/50" Unnotched Compression 0/90 (UNC0)

The UNC0 data is normalized. Data is reported on two properties: Strength and Modulus. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

Pooling across conditions was not permissible due to failure of Levene's test, but there were no other diagnostic test failures. After the modified CV transformation was applied to the data, pooling requirements were met, so modified CV basis values were computed by pooling the CTA, RTA and ETA1 conditions. The ETW condition had a CV greater than 8%, so no modified CV basis values are provided for that condition. There were no statistical outliers.

Statistics, basis values and estimates are given for the UNC0 strength data in Table 4-22 and modulus data in Table 4-23. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-13.

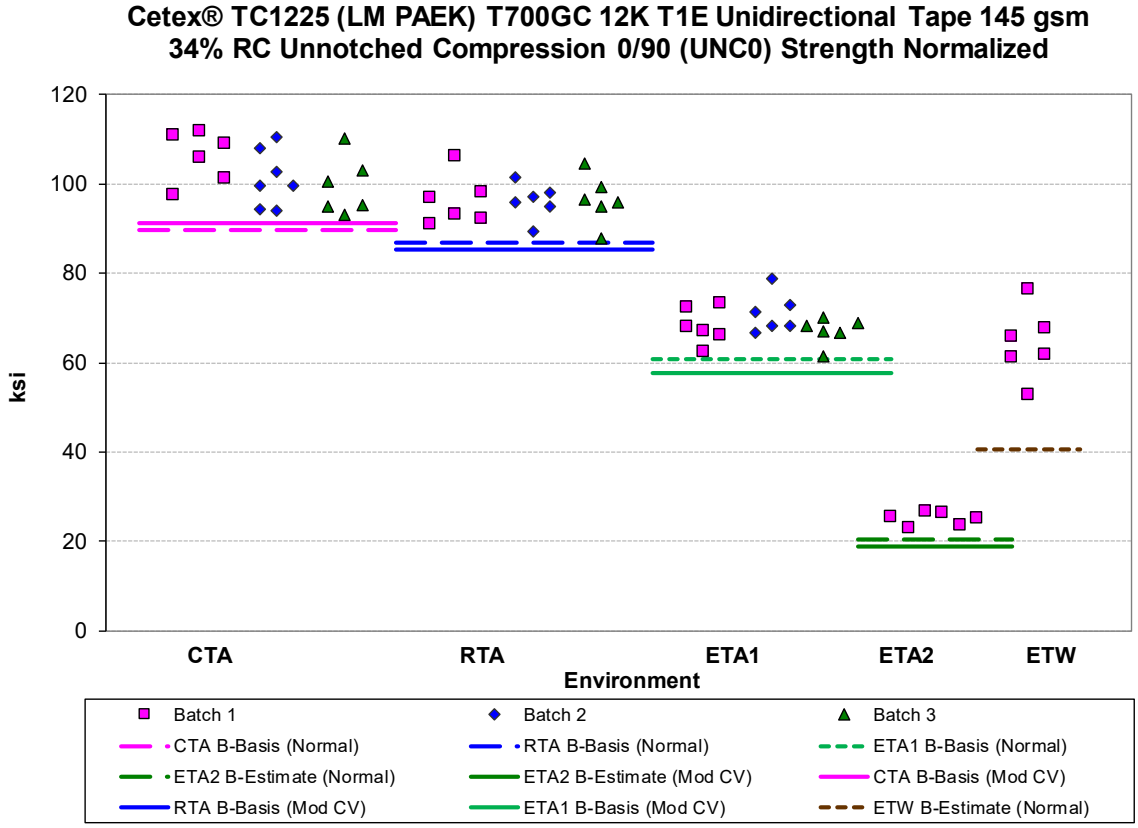

Figure 4-13: Batch Plot for UNC0 Strength normalized

Unnotched Compression 0/90 (UNC0) Strength Basis Values and Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	102.2	96.29	68.78	24.99	64.27	104.2	97.68	68.93	24.54	63.30
Stdev	6.397	4.774	4.008	1.536	7.847	5.710	4.187	3.320	1.439	8.038
CV	6.259	4.958	5.827	6.144	12.21	5.482	4.287	4.816	5.864	12.70
Modified CV	7.130	6.479	6.913	8.000	12.21	6.741	6.143	6.408	8.000	12.70
Min	93.19	87.94	61.46	22.93	52.74	95.93	90.98	63.82	22.55	51.80
Max	111.7	106.0	78.73	26.77	76.31	113.5	105.4	77.30	26.49	75.86
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	19	18	18	6	6	19	18	18	6	6
Basis Values and Estimates										
B-basis Value	89.73	86.86	60.87			93.04	89.41	62.37		
B-estimate				20.34	40.50				20.18	38.95
A-estimate	80.88	80.18	55.27	17.04	23.60	85.14	83.55	57.73	17.08	21.64
Method	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates										
B-basis Value	91.28	85.31	57.81		NA	93.73	87.18	58.43		NA
B-estimate				18.97					18.62	
A-estimate	83.96	78.00	50.50	14.85		86.72	80.18	51.43	14.58	
Method	pooled	pooled	pooled	Normal		pooled	pooled	pooled	Normal	

Table 4-22: Statistics and Basis Values for UNC0 Strength data

Unnotched Compression 0/90 (UNC0) Modulus Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	9.307	9.239	9.163	8.839	9.179	9.497	9.364	9.184	8.681	9.037
Stdev	0.3188	0.2691	0.3072	0.3994	0.1600	0.3847	0.1725	0.2418	0.4271	0.1999
CV	3.426	2.913	3.353	4.518	1.743	4.051	1.842	2.633	4.920	2.212
Mod CV	6.000	6.000	6.000	8.000	8.000	6.025	6.000	6.000	8.000	8.000
Min	8.756	8.723	8.651	8.257	8.942	8.794	9.056	8.835	7.997	8.750
Max	9.854	9.716	9.620	9.297	9.374	10.09	9.724	9.583	9.258	9.319
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	18	18	18	6	6	18	18	18	6	6

Table 4-23: Statistics from UNC0 Modulus data

4.16 "25/50/25" Unnotched Compression 1 (UNC1)

The UNC1 data is normalized. Data is reported on two properties: Strength and Modulus. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

There were no diagnostic test failures. The RTA and ETA1 conditions could be pooled. The ETA2 condition had a CV greater than 8%, so no modified CV basis values are provided for that condition.

There were two outliers. The lowest value in batch one for the as-measured ETA1 environment was an outlier for batch one, but not for the ETA1 condition. It was not an outlier for the normalized dataset. The lowest value in the normalized ETW environment was an outlier. With only one batch tested in this condition, it can only be assessed as an outlier for batch, not the condition. It was not an outlier for the as measured dataset. Both outliers were retained for this analysis.

Statistics, basis values and estimates are given for the UNC1 strength data in Table 4-24 and modulus data in Table 4-25. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-14.

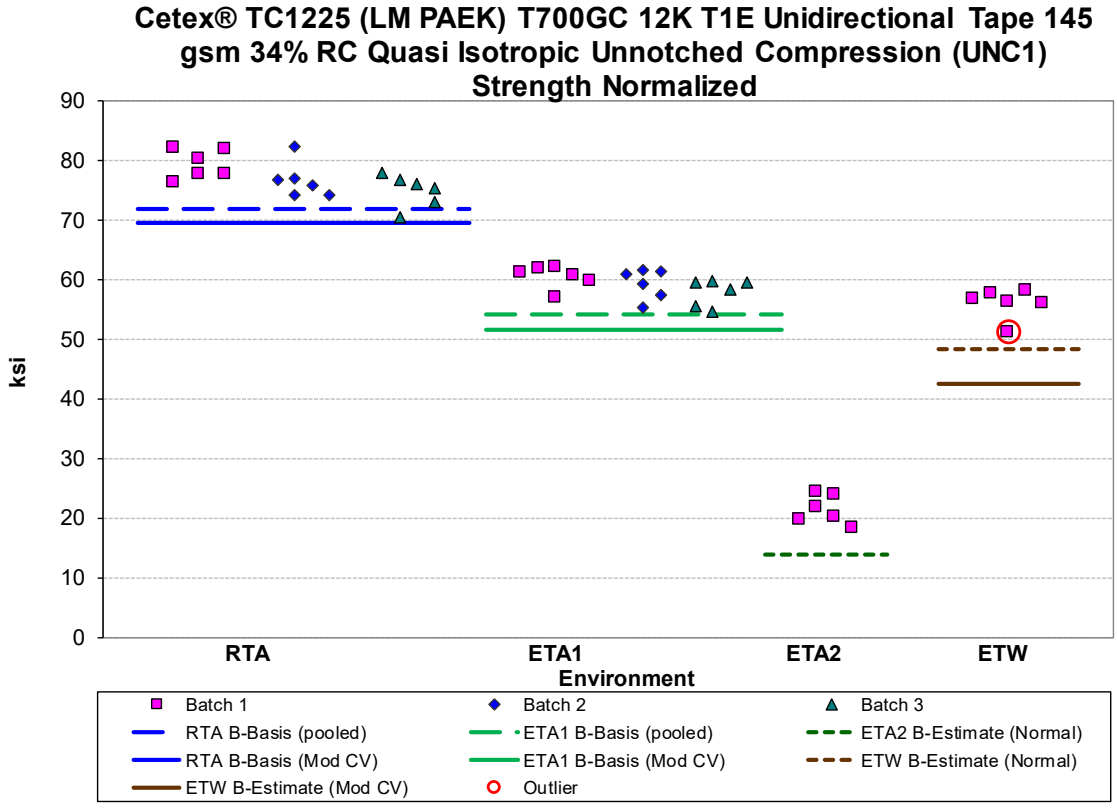

Figure 4-14: Batch plot for UNC1 Strength normalized

Unnotched Compression (UNC1) Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	77.07	59.29	21.41	56.06	81.18	62.31	22.24	58.82
Stdev	3.180	2.340	2.430	2.514	3.001	2.199	2.423	3.200
CV	4.126	3.946	11.35	4.484	3.697	3.528	10.89	5.440
Modified CV	6.063	6.000	11.35	8.000	6.000	6.000	10.89	8.000
Min	70.55	54.73	18.36	51.22	75.33	57.94	18.66	53.08
Max	82.46	62.05	24.41	58.14	86.15	64.91	25.08	61.83
No. Batches	3	3	1	1	3	3	1	1
No. Spec.	18	18	6	6	18	18	6	6
Basis Values and Estimates								
B-basis Value	71.98	54.21			76.39	57.52		
B-estimate			14.05	48.45			14.90	49.13
A-estimate	68.52	50.75	8.818	43.04	73.13	54.26	9.687	42.24
Method	pooled	pooled	Normal	Normal	pooled	pooled	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	69.50	51.73	NA		73.28	54.40	NA	
B-estimate				42.55				44.64
A-estimate	64.36	46.58		33.31	67.90	49.02		34.94
Method	pooled	pooled		Normal	pooled	pooled		Normal

Table 4-24: Statistics and Basis Values for UNC1 Strength data

Unnotched Compression (UNC1) Modulus Statistics								
	Normalized				As-measured			
Env	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	6.180	6.183	4.982	5.959	6.511	6.503	5.176	6.249
Stdev	0.1359	0.2522	0.1586	0.1251	0.1224	0.2727	0.08618	0.1066
CV	2.200	4.079	3.184	2.100	1.881	4.194	1.665	1.706
Modified CV	6.000	6.040	8.000	8.000	6.000	6.097	8.000	8.000
Min	5.941	5.855	4.781	5.775	6.288	6.202	5.061	6.118
Max	6.434	6.632	5.126	6.079	6.711	6.929	5.255	6.431
No. Batches	3	3	1	1	3	3	1	1
No. Spec.	18	18	6	6	18	18	6	6

Table 4-25: Statistics from UNC1 Modulus data

4.17 "10/80/10" Unnotched Compression 2 (UNC2)

The UNC2 data is normalized. Data is reported on two properties: Strength and Modulus.

There were no diagnostic failures in the normalized dataset, but pooling across conditions was not permissible for the as-measured datasets due to failure of Levene's test.

There was one statistical outlier. The largest value in batch one of the normalized RTA dataset was an outlier for batch one, but not for the RTA condition and not for the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNC2 strength data in Table 4-26 and modulus data in Table 4-27. The normalized data and the B-basis values are shown graphically in Figure 4-15.

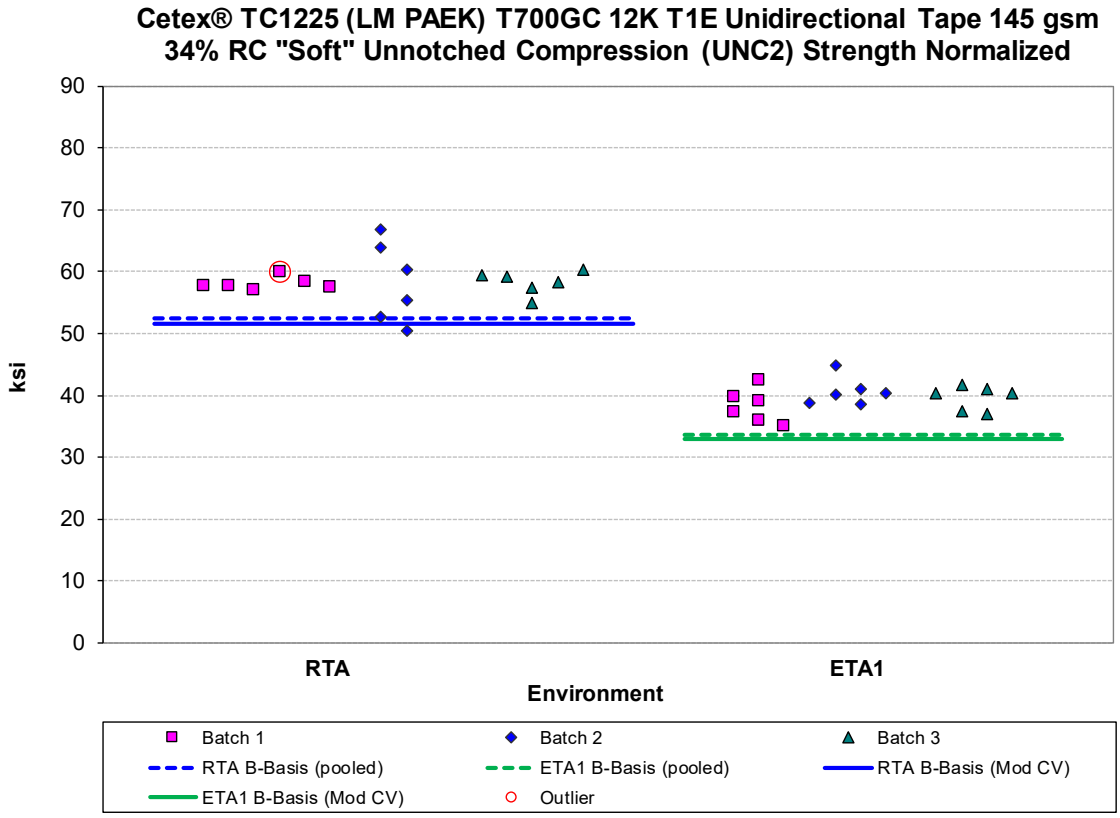

Figure 4-15: Batch plot for UNC2 Strength normalized

Unnotched Compression (UNC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)
Mean	58.17	39.47	60.77	40.92
Stdev	3.737	2.437	4.058	1.958
CV	6.423	6.174	6.678	4.785
Modified CV	7.212	7.087	7.339	6.392
Min	50.46	34.89	51.73	37.04
Max	66.94	44.84	67.96	44.25
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value	52.43	33.73	52.76	37.06
A-estimate	48.52	29.82	47.08	34.32
Method	pooled	pooled	Normal	Normal
Modified CV Basis Values and Estimates				
B-basis Value	51.68	32.98	51.97	35.76
A-estimate	47.26	28.56	45.74	32.11
Method	pooled	pooled	Normal	Normal

Table 4-26: Statistics and Basis Values for UNC2 Strength data

Unnotched Compression (UNC2) Modulus Statistics				
	Normalized		As-measured	
Env	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)
Mean	4.193	3.740	4.379	3.879
Stdev	0.1648	0.2116	0.1473	0.1721
CV	3.931	5.657	3.365	4.436
Modified CV	6.000	6.828	6.000	6.218
Min	4.033	3.485	4.199	3.608
Max	4.737	4.331	4.809	4.273
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-27: Statistics from UNC2 Modulus data

4.18 "50/40/10" Unnotched Compression 3 (UNC3)

The UNC3 data is normalized. Data is reported on two properties: Strength and Modulus.

The normalized RTA condition dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The normalized RTA dataset passed the ADK test after the modified CV transformation was applied, so modified CV basis values are provided for that dataset. There were no other diagnostic test failures. Pooling was acceptable for the as-measured datasets and for the modified CV approach, both normalized and as-measured.

There was one outlier. The lowest value in batch one for the RTA environment was an outlier for batch one but not for the RTA condition. It was an outlier only for the normalized dataset, not for the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNC3 strength data in Table 4-28 and modulus data in Table 4-29. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-16.

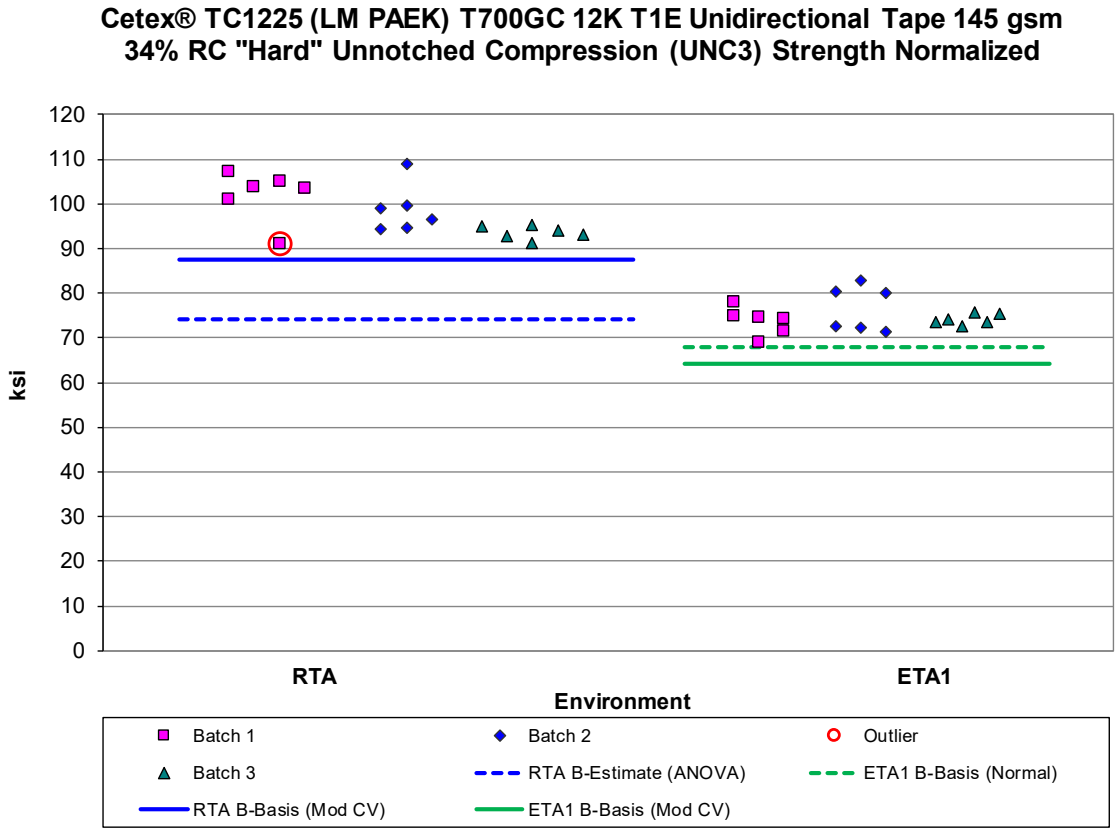

Figure 4-16: Batch plot for UNC3 Strength normalized

Unnotched Compression (UNC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70º F)	ETA1 (275º F)	RTA (70º F)	ETA1 (275º F)
Mean	98.06	74.81	102.8	78.41
Stdev	5.584	3.541	4.412	3.002
CV	5.695	4.733	4.291	3.829
Modified CV	6.847	6.367	6.146	6.000
Min	90.95	68.94	94.82	71.87
Max	109.1	82.81	110.9	82.81
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value		67.82	95.93	71.53
B-estimate	74.07			
A-estimate	56.97	62.86	91.26	66.86
Method	ANOVA	Normal	pooled	pooled
Modified CV Basis Values and Estimates				
B-basis Value	87.46	64.20	92.66	68.26
A-estimate	80.25	56.99	85.76	61.36
Method	pooled	pooled	pooled	pooled

Table 4-28: Statistics and Basis Values for UNC3 Strength data

Unnotched Compression (UNC3) Modulus Statistics				
	Normalized		As-measured	
Env	RTA (70º F)	ETA1 (275º F)	RTA (70º F)	ETA1 (275º F)
Mean	9.351	9.501	9.818	9.961
Stdev	0.3492	0.3485	0.3659	0.3337
CV	3.734	3.668	3.727	3.350
Modified CV	6.000	6.000	6.000	6.000
Min	8.776	8.908	9.290	9.449
Max	10.09	10.40	10.34	10.60
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-29: Statistics from UNC3 Modulus data

4.19 "25/50/25" Open-Hole Tension 1 (OHT1)

The OHT1 data is normalized. The only property measurement reported is strength. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The CTA, RTA and ETA1 condition datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Only the normalized CTA and RTA datasets passed the ADK test after the data was transformed for the modified CV method, but not for the normalized ETA1 and the as-measured CTA, RTA and ETA1 datasets. Modified CV basis values can be provided for the normalized CTA and RTA conditions and pooling was appropriate for the modified CV basis value computations.

There was one outlier. The largest value in batch one of the ETA1 normalized dataset was an outlier for batch one, but not for the ETA1 condition or the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHT1 strength data in Table 4-30. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-17.

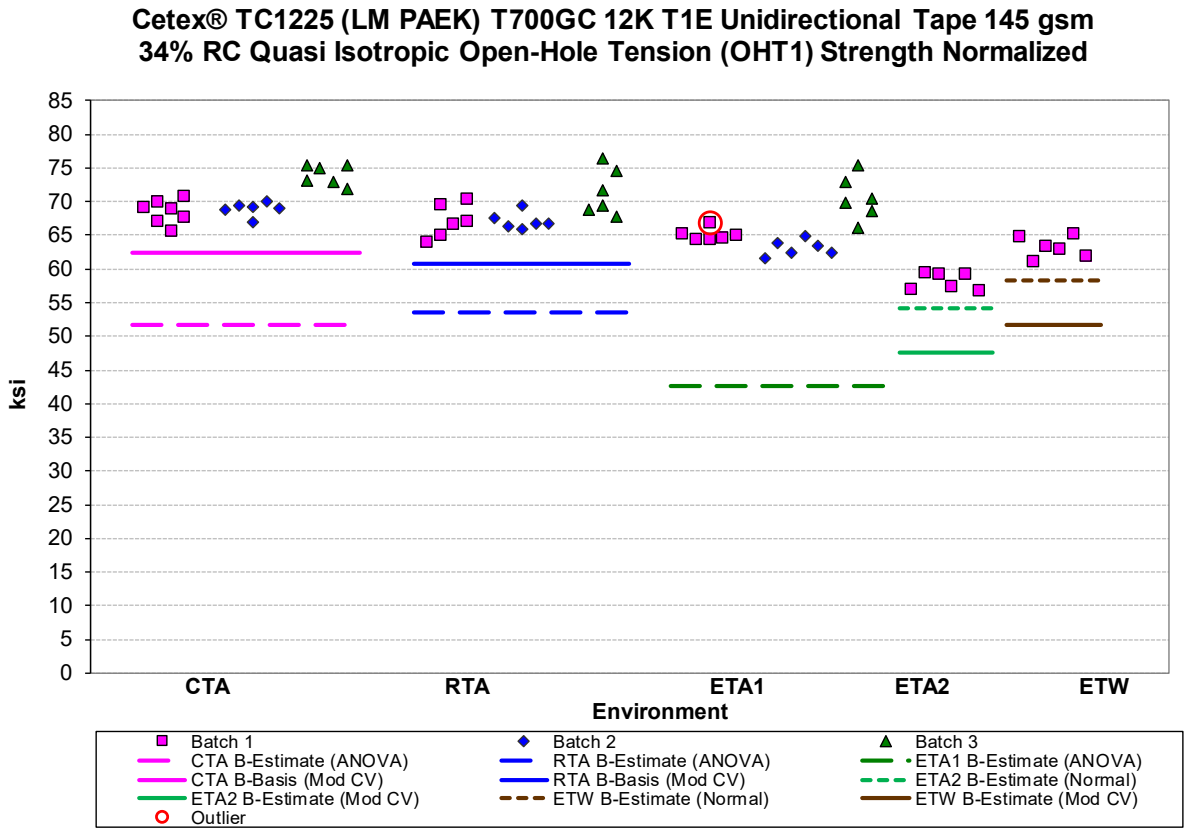

Figure 4-17: Batch Plot for OHT1 Strength normalized

Open-Hole Tension (OHT1) Strength Basis Values and Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	70.30	68.52	66.18	58.03	63.11	71.72	69.82	67.24	60.12	65.00
Stdev	2.931	3.227	3.836	1.281	1.608	3.903	4.287	5.125	1.623	1.759
CV	4.169	4.710	5.796	2.208	2.547	5.442	6.141	7.623	2.700	2.706
Modified CV	6.084	6.355	6.898	8.000	8.000	6.721	7.070	7.811	8.000	8.000
Min	65.42	63.82	61.50	56.55	60.97	66.24	63.21	59.29	57.80	63.12
Max	75.35	76.45	75.44	59.29	65.01	78.42	78.29	77.38	62.74	67.61
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	19	18	18	6	6	19	18	18	6	6
Basis Values and Estimates										
B-estimate	51.62	53.57	42.54	54.15	58.24	45.99	44.84	34.56	55.20	59.68
A-estimate	38.28	42.90	25.68	51.39	54.77	27.62	27.02	11.24	51.71	55.89
Method	ANOVA	ANOVA	ANOVA	Normal	Normal	ANOVA	ANOVA	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates										
B-basis Value	62.49	60.68	NA			NA	NA	NA		
B-estimate				44.04	47.90				45.63	49.34
A-estimate	57.16	55.35		34.47	37.49				35.72	38.62
Method	pooled	pooled		Normal	Normal				Normal	Normal

Table 4-30: Statistics and Basis Values for OHT1 Strength data

4.20 "10/80/10" Open-Hole Tension 2 (OHT2)

The OHT2 data is normalized. The only property measurement reported is strength.

The normalized CTA, RTA and ETA1 datasets had no diagnostic test failures and met all requirements for pooling together. The as-measured CTA, RTA and ETA1 condition datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. All three datasets passed the ADK test after the data was transformed for the modified CV method, so modified CV basis values can be provided for the as-measured CTA, RTA and ETA1 datasets. Pooling was appropriate for the modified CV basis value computations.

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

Statistics, basis values and estimates are given for the OHT2 strength data in Table 4-31. The normalized data and the B-basis values are shown graphically in Figure 4-18.

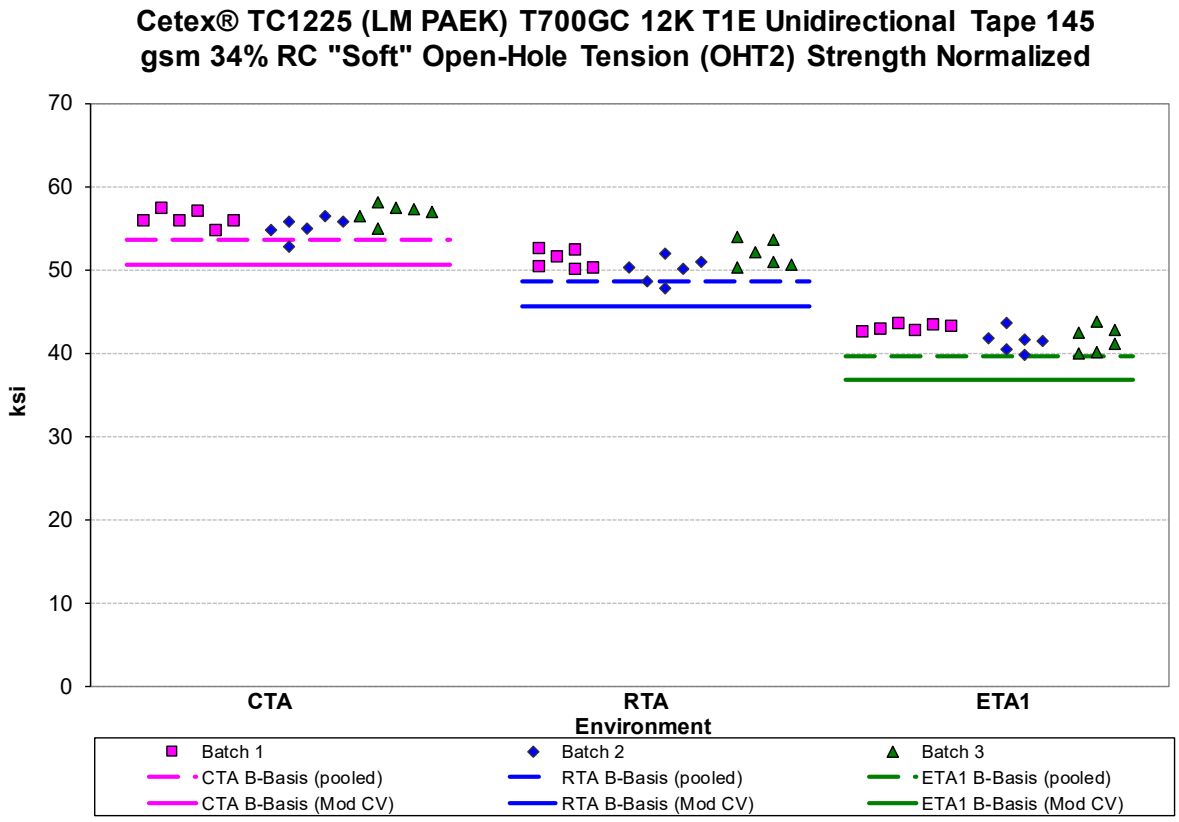

Figure 4-18: Batch Plot for OHT2 Strength normalized

Open-Hole Tension (OHT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	56.03	51.03	42.06	57.23	52.45	43.20
Stdev	1.262	1.567	1.303	1.972	2.099	1.559
CV	2.253	3.070	3.099	3.447	4.001	3.608
Modified CV	6.000	6.000	6.000	6.000	6.001	6.000
Min	52.85	47.88	39.85	53.29	48.78	40.55
Max	58.11	53.96	43.77	60.65	56.54	45.77
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-basis Value	53.58	48.58	39.61			
B-estimate				46.43	42.46	35.23
A-estimate	51.94	46.94	37.98	38.73	35.34	29.55
Method	pooled	pooled	pooled	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	50.71	45.71	36.75	51.78	47.00	37.75
A-estimate	47.17	42.16	33.20	48.14	43.37	34.11
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-31: Statistics and Basis Values for OHT2 Strength data

4.21 "50/40/10" Open-Hole Tension 3 (OHT3)

The OHT3 data is normalized. The only property measurement reported is strength.

The CTA, RTA and ETA1 condition datasets, both normalized and as-measured, all failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The CTA and RTA datasets, both normalized and as-measured, passed the ADK test after the data was transformed for the modified CV method, but the ETA1 datasets did not. Modified CV basis values can be provided for the CTA and RTA conditions and pooling was appropriate for the modified CV basis value computations.

There were two outliers. The largest value in batch three of the CTA as-measured dataset was an outlier for batch three but not for the CTA condition or the normalized dataset. The largest value in batch three of the ETA1 normalized dataset was an outlier for batch three but not for the ETA1 condition or the as-measured dataset. Both outliers were retained for this analysis.

Statistics, basis values and estimates are given for the OHT3 strength data in Table 4-32. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-19.

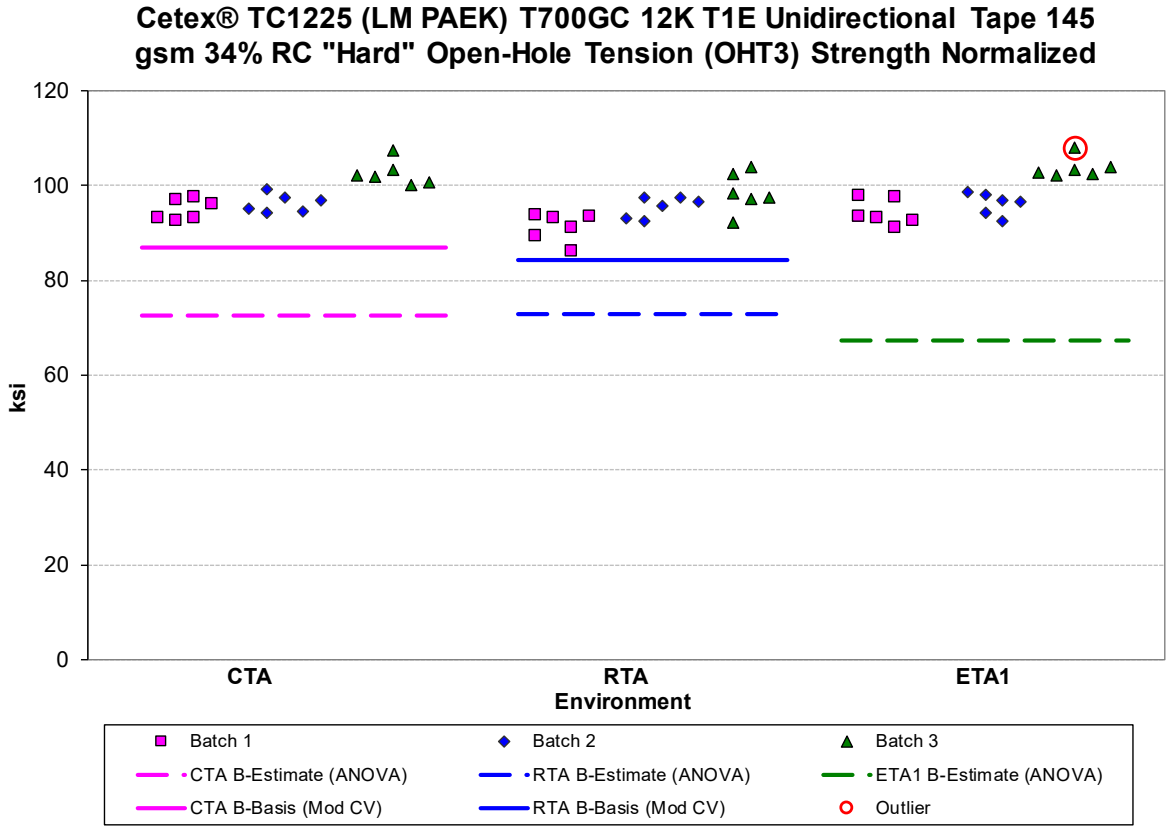

Figure 4-19: Batch Plot for OHT3 Strength normalized

Open-Hole Tension (OHT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	97.90	95.06	98.05	104.5	102.8	105.2
Stdev	4.107	4.363	4.844	4.276	4.398	5.117
CV	4.195	4.590	4.940	4.091	4.279	4.863
Modified CV	6.097	6.295	6.470	6.045	6.140	6.431
Min	92.48	86.06	90.90	99.05	94.24	98.64
Max	107.6	103.9	108.0	114.9	112.6	114.6
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Value Estimates						
B-estimate	72.66	72.97	67.26	77.83	79.47	72.05
A-estimate	54.64	57.21	45.29	58.78	62.84	48.38
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	87.01	84.18	NA	93.04	91.28	NA
A-estimate	79.61	76.77		85.21	83.45	
Method	pooled	pooled		pooled	pooled	

Table 4-32: Statistics and Basis Values for OHT3 Strength data

4.22 "25/50/25" Filled-Hole Tension 1 (FHT1)

The FHT1 data is normalized. The only property measurement reported is strength. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The as-measured CTA, RTA and ETA1 datasets and the normalized CTA and ETA1 datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Only the as-measured CTA dataset failed the ADK test after the data was transformed for the modified CV method, so modified CV basis values can be provided for the normalized CTA and ETA1 and the as-measured RTA and ETA1 datasets. The normalized CTA, RTA and ETA1 datasets and the as-measured RTA and ETA1 datasets met all requirements for pooling across the conditions for the modified CV basis value computations.

There was one outlier. The largest value in batch one of the CTA as-measured dataset was an outlier for batch one, but not for the CTA condition or the normalized dataset. It was retained for this analysis.

Statistics, estimates and basis values are given for the FHT1 strength data in Table 4-33. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-20.

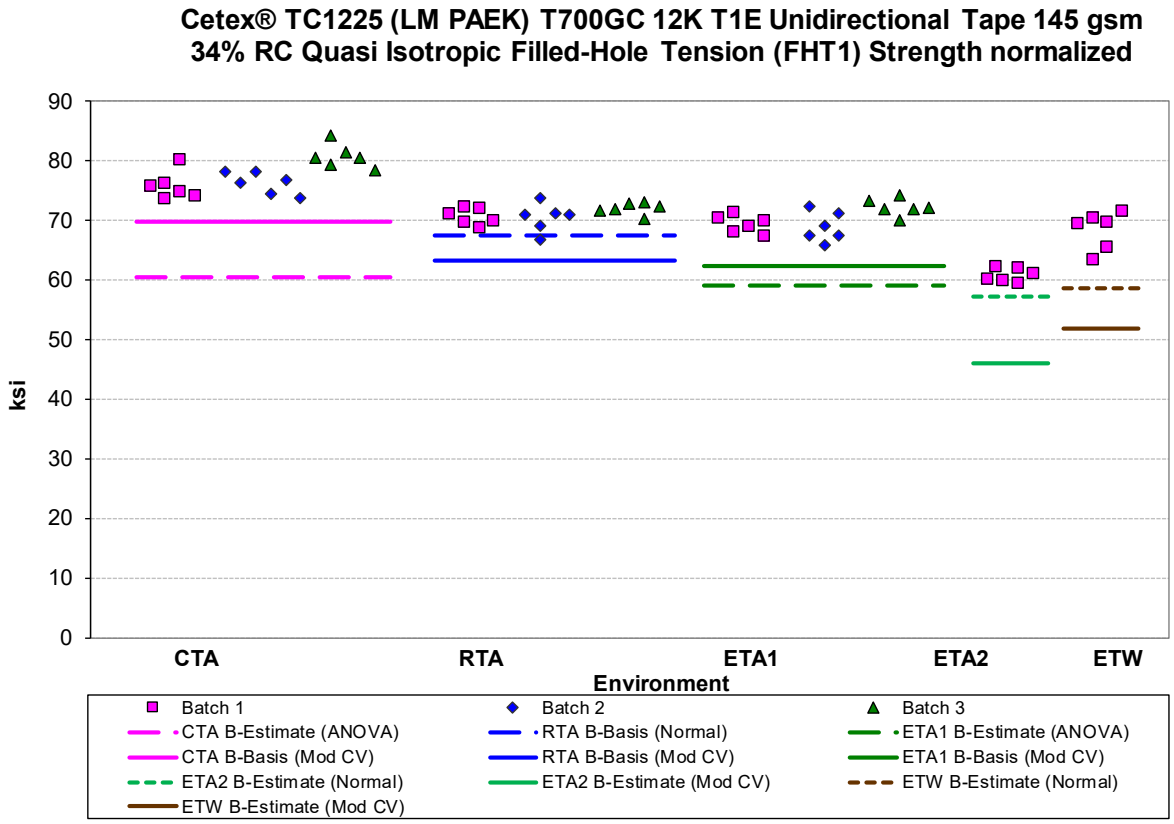

Figure 4-20: Batch plot for FHT1 Strength normalized

Filled-Hole Tension (FHT1) Strength Basis Values and Statistics										
	Normalized					As-measured				
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	77.60	71.02	70.14	60.64	68.21	79.60	73.54	72.31	61.96	70.26
Stdev	3.059	1.767	2.345	1.143	3.161	3.770	2.319	3.086	1.262	2.951
CV	3.942	2.488	3.343	1.886	4.634	4.736	3.154	4.268	2.036	4.199
Modified CV	6.000	6.000	6.000	8.000	8.000	6.368	6.000	6.134	8.000	8.000
Min	73.58	66.69	65.94	59.33	63.32	75.67	69.43	68.07	60.45	65.80
Max	84.30	73.89	74.34	62.08	71.46	87.13	77.69	77.19	63.92	72.94
No. Batches	3	3	3	1	1	3	3	3	1	1
No. Spec.	18	18	18	6	6	18	18	18	6	6
Basis Values and Estimates										
B-basis Value		67.53								
B-estimate	60.83		59.18	57.17	58.64	55.00	59.63	51.99	58.14	61.32
A-estimate	48.87	65.06	51.36	54.71	51.83	37.45	49.69	37.48	55.42	54.97
Method	ANOVA	Normal	ANOVA	Normal	Normal	ANOVA	ANOVA	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates										
B-basis Value	69.85	63.26	62.39			NA	65.49	64.25		
B-estimate				46.02	51.77				47.02	53.33
A-estimate	64.67	58.09	57.21	36.02	40.52		60.00	58.77	36.81	41.74
Method	pooled	pooled	pooled	Normal	Normal		pooled	pooled	Normal	Normal

Table 4-33: Statistics and Basis Values for FHT1 Strength data

4.23 "10/80/10" Filled-Hole Tension 2 (FHT2)

The FHT2 data is normalized. The normalized RTA dataset failed the normality test. The Weibull distribution provided the best fit for the data. The normalized and as-measured CTA datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Both CTA datasets passed the ADK test after the data was transformed for the modified CV method, so modified CV basis values can be provided. The datasets met all requirements for pooling across the conditions for the modified CV basis value computations.

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

Statistics, basis values and estimates are given for the FHT2 strength data in Table 4-34. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-21.

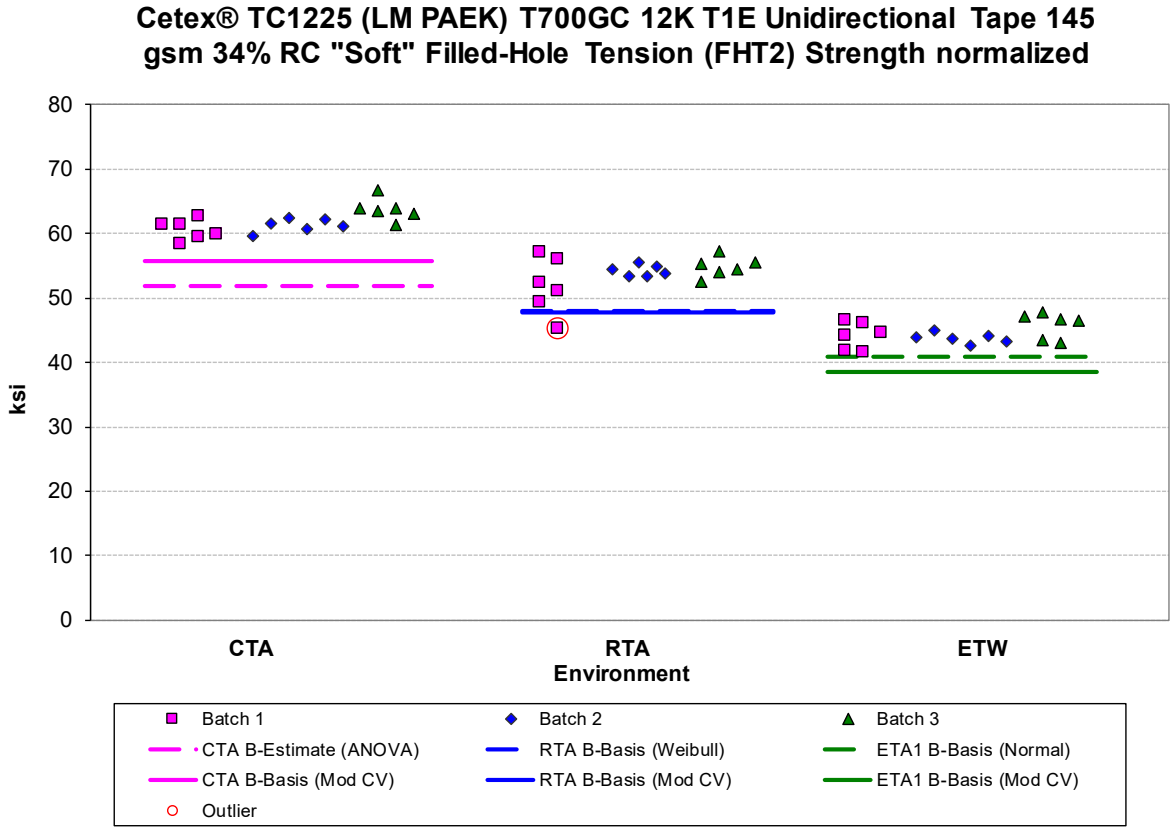

Figure 4-21: Batch plot for FHT2 Strength normalized

Filled-Hole Tension (FHT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	61.81	53.66	44.55	63.41	55.37	45.93
Stdev	1.974	2.878	1.862	2.154	2.654	1.913
CV	3.193	5.363	4.180	3.397	4.793	4.165
Modified CV	6.000	6.682	6.090	6.000	6.396	6.082
Min	58.38	45.26	41.50	60.15	48.14	43.25
Max	66.69	57.31	47.69	68.62	59.26	48.74
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-basis Value		48.08	40.87		51.16	41.72
B-estimate	51.77			51.89		
A-estimate	44.61	42.37	38.27	43.67	48.29	38.85
Method	ANOVA	Weibull	Normal	ANOVA	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	55.85	47.70	38.59	57.38	49.34	39.90
A-estimate	51.88	43.72	34.62	53.36	45.31	35.87
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-34: Statistics and Basis Values for FHT2 Strength data

4.24 "50/40/10" Filled-Hole Tension 3 (FHT3)

The FHT3 data is normalized. The normalized and as-measured datasets for all three environmental conditions failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The normalized CTA and RTA datasets and the as-measured RTA dataset passed the ADK test after the data was transformed for the modified CV method, so modified CV basis values can be provided. The normalized CTA and RTA datasets met all requirements for pooling across the conditions for the modified CV basis value computations.

There was one outlier. The lowest value in batch two of the as-measured ETA1 dataset was an outlier for batch two but not for the ETA1 condition and not for the normalized dataset. It was retained for this analysis.

Statistics, estimates and basis values are given for the FHT3 strength data in Table 4-35. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-22.

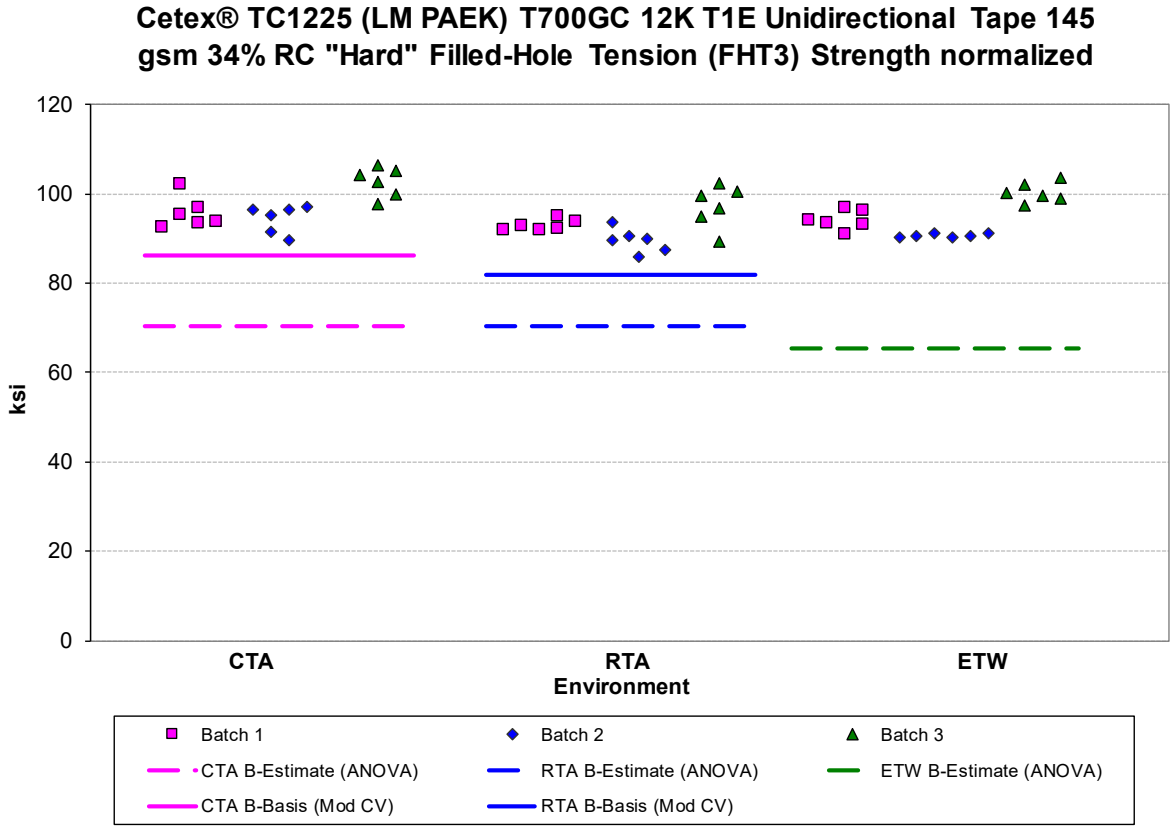

Figure 4-22: Batch plot for FHT3 Strength normalized

Filled-Hole Tension (FHT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)	CTA (-65º F)	RTA (70º F)	ETA1 (275º F)
Mean	97.61	93.20	95.04	103.0	99.81	102.1
Stdev	4.924	4.402	4.452	6.088	5.012	5.680
CV	5.044	4.723	4.684	5.912	5.022	5.564
Modified CV	6.522	6.362	6.342	6.956	6.511	6.782
Min	89.75	85.87	90.15	93.40	91.29	95.09
Max	106.6	102.3	103.8	114.8	110.4	111.2
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Value Estimates						
B-estimate	70.53	70.48	65.29	66.21	71.42	62.59
A-estimate	51.20	54.27	44.05	39.98	51.17	34.38
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	86.41	81.99	NA	NA	86.98	NA
A-estimate	78.78	74.37			77.90	
Method	pooled	pooled			Normal	

Table 4-35: Statistics and Basis Values for FHT3 Strength data

4.25 "25/50/25" Open-Hole Compression 1 (OHC1)

The OHC1 data is normalized. The only property measurement reported is strength. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions.

The ETA1 condition datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Both datasets passed the ADK test after the data was transformed for the modified CV method. Pooling RTA and ETA1 conditions was appropriate for the modified CV basis value computations.

The as-measured ETA2 dataset failed all distribution tests and required the use of the non-parametric approach for computing basis values. Modified CV basis values could not be computed due to the non-normality of the dataset.

There was one outlier. The largest value in the ETA2 condition was an outlier for the as-measured dataset, but not for the normalized dataset. With only one batch tested in this condition, it can only be assessed as an outlier for batch, not the condition. It was retained for this analysis.

Statistics, estimates and basis values are given for the OHC1 strength data in Table 4-36. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-23.

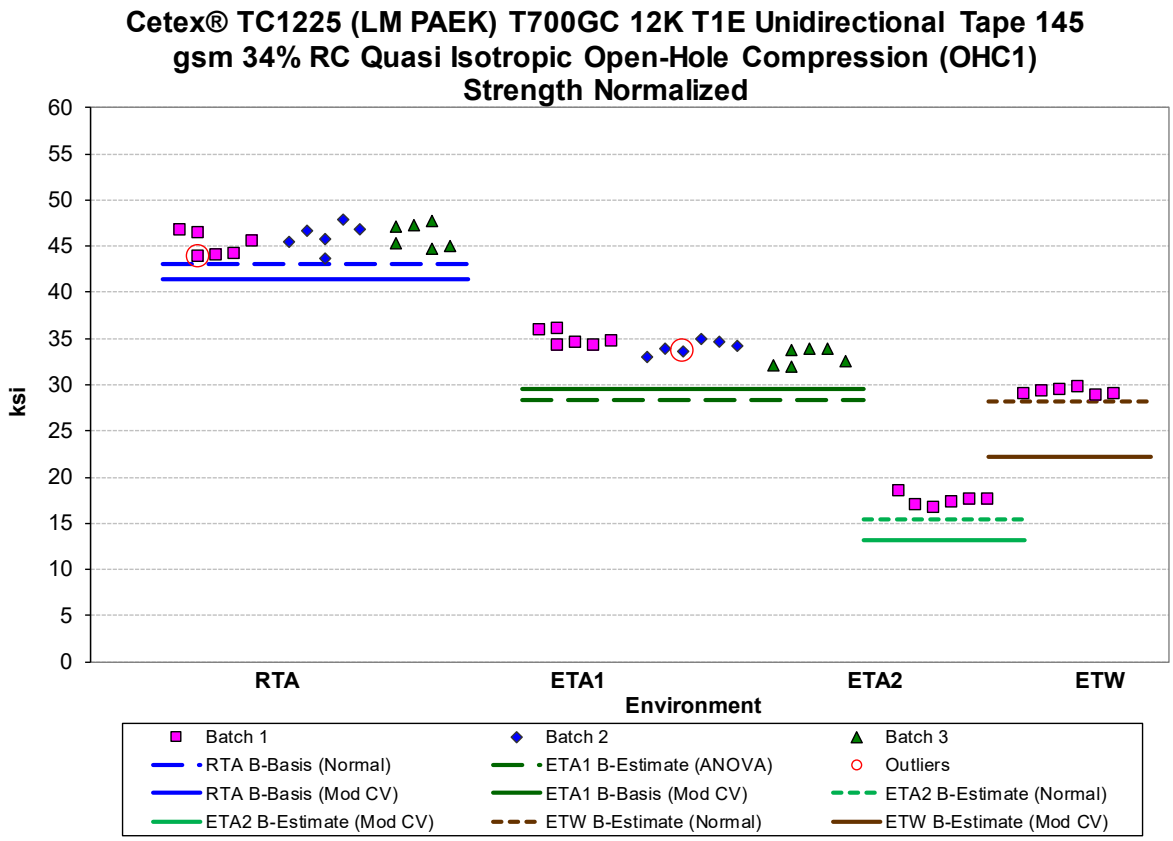

Figure 4-23: Batch plot for OHC1 Strength normalized

Open-Hole Compression (OHC1) Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	45.79	34.00	17.38	29.19	47.33	34.96	17.77	29.93
Stdev	1.380	1.111	0.6432	0.3394	1.235	1.261	0.7136	0.6402
CV	3.014	3.268	3.701	1.163	2.610	3.607	4.015	2.139
Modified CV	6.000	6.000	8.000	8.000	6.000	6.000	8.000	8.000
Min	43.64	31.95	16.64	28.83	44.99	33.02	17.28	28.98
Max	47.95	35.99	18.47	29.72	48.95	37.47	19.19	30.74
No. Batches	3	3	1	1	3	3	1	1
No. Spec.	18	18	6	6	18	18	6	6
Basis Values and Estimates								
B-basis Value	43.07				44.89			
B-estimate		28.35	15.43	28.17		27.74	16.40	27.99
A-estimate	41.14	24.32	14.05	27.43	43.16	22.58	10.72	26.61
Method	Normal	ANOVA	Normal	Normal	Normal	ANOVA	Non-Parametric	Normal
Modified CV Basis Values and Estimates								
B-basis Value	41.39	29.59			42.78	30.41	NA	
B-estimate			13.19	22.16				22.72
A-estimate	38.39	26.59	10.33	17.34	39.69	27.32		17.78
Method	pooled	pooled	Normal	Normal	pooled	pooled		Normal

Table 4-36: Statistics and Basis Values for OHC1 Strength data

4.26 "10/80/10" Open-Hole Compression 2 (OHC2)

The OHC2 data is normalized. The only property measurement reported is strength. The as-measured ETA1 dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. This dataset passed the ADK test after the modified CV transformation was applied, so modified CV basis values are provided for that dataset. There were no other diagnostic test failures. Pooling was acceptable for the normalized datasets and for the modified CV approach, both normalized and as-measured.

There was one outlier. The largest value in batch two for the normalized ETA1 dataset was an outlier. It was an outlier only for the ETA1 condition, but not for the batch two alone or the as-measured dataset. It was retained for this analysis.

Statistics, estimates and basis values are given for the OHC2 strength data in Table 4-37. The normalized data and the B-basis values are shown graphically in Figure 4-24.

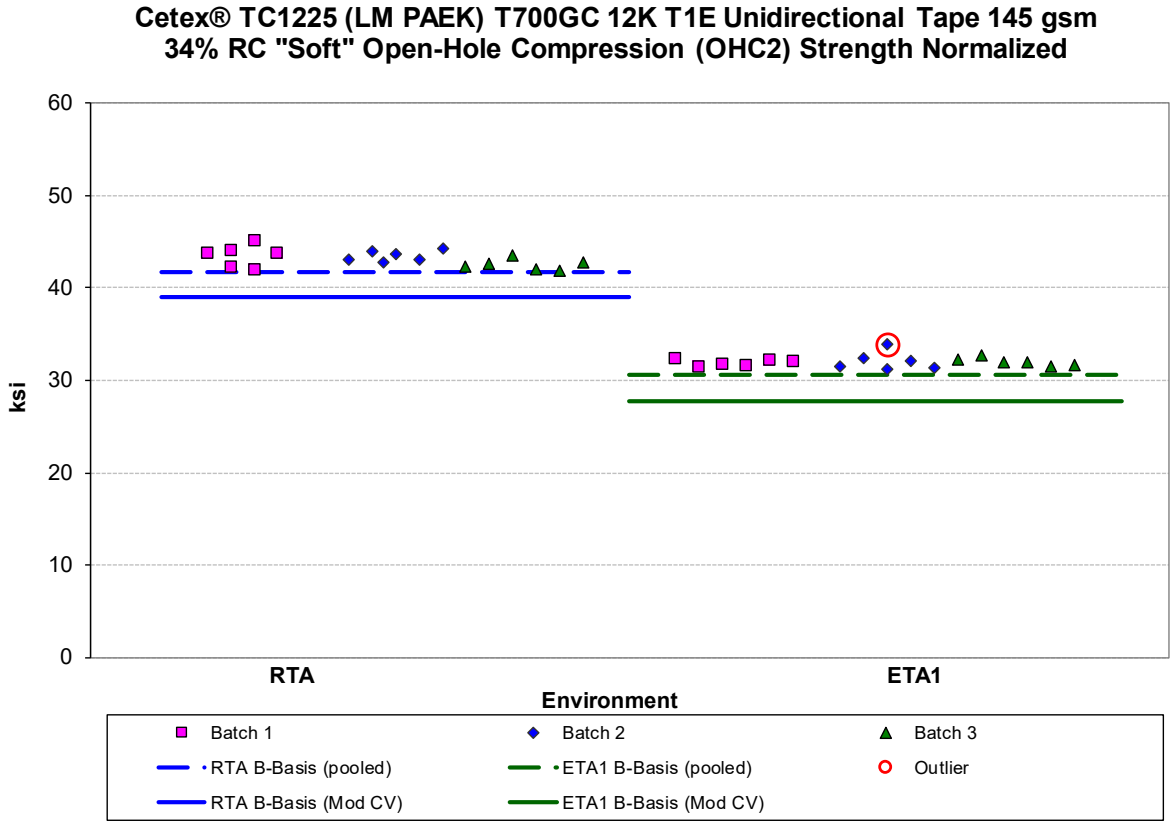

Figure 4-24: Batch plot for OHC2 Strength normalized

Open-Hole Compression (OHC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)
Mean	43.12	31.95	45.10	33.14
Stdev	0.8906	0.6286	0.8266	0.8509
CV	2.065	1.967	1.833	2.568
Modified CV	6.000	6.000	6.000	6.000
Min	41.88	31.22	43.46	31.91
Max	44.98	33.84	46.62	34.93
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value	41.72	30.55	43.47	
B-estimate				28.79
A-estimate	40.76	29.60	42.31	25.69
Method	pooled	pooled	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	38.98	27.81	40.77	28.81
A-estimate	36.15	24.99	37.83	25.87
Method	pooled	pooled	pooled	pooled

Table 4-37: Statistics and Basis Values for OHC2 Strength data

4.27 "50/40/10" Open-Hole Compression 3 (OHC3)

The OHC3 data is normalized. The only property measurement reported is strength. The normalized RTA dataset and both the normalized and as-measured ETA1 datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. All three of these datasets passed the ADK test after the modified CV transformation was applied, so mod CV basis values are provided. There were no other diagnostic test failures. Pooling was acceptable for the modified CV approach, both normalized and as-measured.

There were two outliers, both in the ETA1 condition. The lowest values in batch one and batch three for the ETA1 environment were outliers for their respective batches, but not for the ETA1 condition or for the as-measured dataset. Both outliers were retained for this analysis.

Statistics, estimates and basis values are given for the OHC3 strength data in Table 4-38. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-25.

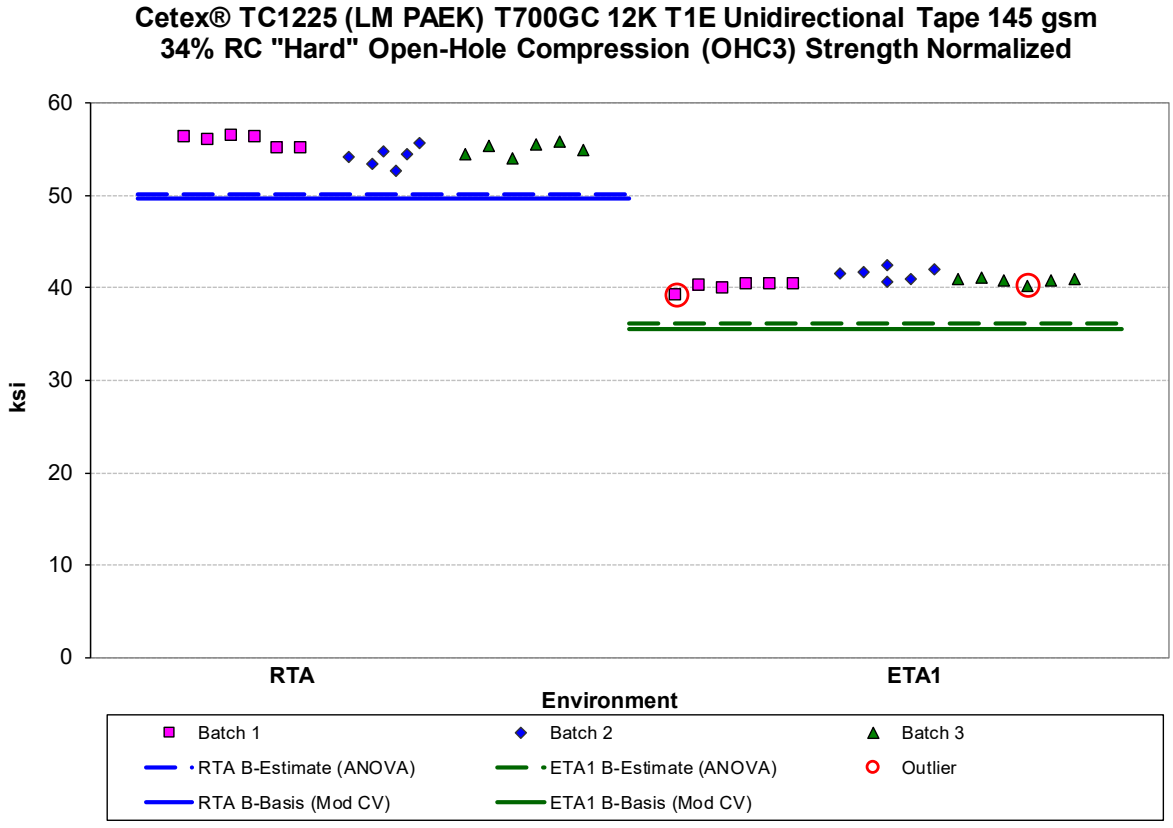

Figure 4-25: Batch plot for OHC3 Strength normalized

Open-Hole Compression (OHC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)
Mean	55.04	40.82	57.59	42.47
Stdev	1.038	0.8034	0.8612	1.448
CV	1.886	1.968	1.496	3.409
Modified CV	6.000	6.000	6.000	6.000
Min	52.64	39.19	56.16	40.35
Max	56.50	42.54	59.23	45.09
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value			55.89	
B-estimate	50.19	36.16		32.57
A-estimate	46.73	32.84	54.68	25.50
Method	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	49.75	35.52	52.06	36.94
A-estimate	46.14	31.92	48.29	33.18
Method	pooled	pooled	pooled	pooled

Table 4-38: Statistics and Basis Values for OHC3 Strength data

4.28 "25/50/25" Filled-Hole Compression 1 (FHC1)

The FHC1 data is normalized. The only property measurement reported is strength. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those conditions. When the FHC1 mean or basis value is greater than the corresponding value for UNC1, the FHC1 data is for informational purposes only and it may not substantial enough to be used for design.

The as-measured RTA condition dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. It passed the ADK test after the data was transformed for the modified CV method. There were no other diagnostic test failures. Pooling RTA and ETA1 conditions was appropriate for the normalized data and the as-measured modified CV basis value computations. There were no statistical outliers.

Statistics, estimates and basis values are given for the FHC1 strength data in Table 4-39. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-26.

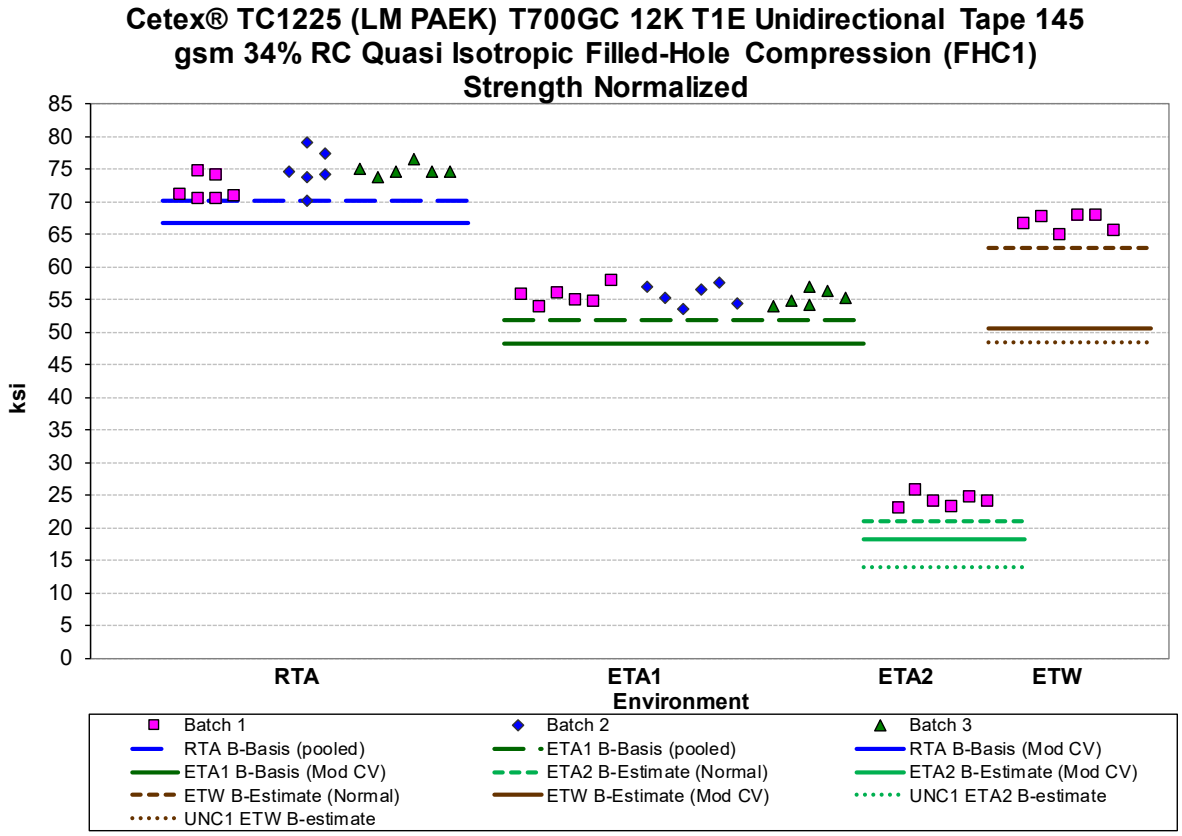

Figure 4-26: Batch plot for FHC1 Strength normalized

Filled-Hole Compression (FHC1) Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	73.88	55.47	24.01	66.69	77.79	57.94	24.79	68.44
Stdev	2.536	1.320	0.9906	1.254	3.040	1.572	1.057	1.212
CV	3.433	2.379	4.125	1.881	3.907	2.714	4.263	1.771
Modified CV	6.000	6.000	8.000	8.000	6.000	6.000	8.000	8.000
Min	70.10	53.51	23.00	64.82	73.04	55.27	23.57	66.92
Max	79.15	57.75	25.63	67.85	82.36	60.53	26.51	69.86
No. Batches	3	3	1	1	3	3	1	1
No. Spec.	18	18	6	6	18	18	6	6
Basis Values and Estimates								
B-basis Value	70.19	51.79				54.84		
B-estimate			21.01	62.89	63.02		21.59	64.77
A-estimate	67.69	49.28	18.88	60.19	52.48	52.64	19.32	62.16
Method	pooled	pooled	Normal	Normal	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	66.74	48.33			70.29	50.45		
B-estimate			18.22	50.62			18.82	51.95
A-estimate	61.88	43.48	14.27	39.62	65.19	45.35	14.73	40.66
Method	pooled	pooled	Normal	Normal	pooled	pooled	Normal	Normal
UNC1 B-Basis Values and B-Estimates								
B-basis Value	71.98	54.21			76.39	57.52		
Mod CV B-Basis	69.50	51.73			73.28	54.40		
B-estimate			14.05	48.45			14.90	49.13
Mod CV B-Estimate			NA	42.55			NA	44.64

Shaded values indicate that FHC1 > UNC1;when data for FHC>UNC, FHC data is for informational purposes only and it may not substantial enough to be used for design

Table 4-39: Statistics and Basis Values for FHC1 Strength data

4.29 "10/80/10" Filled-Hole Compression 2 (FHC2)

The FHC2 data is normalized. The only property measurement reported is strength. When the FHC2 mean or basis value is greater than the corresponding value for UNC2, the FHC2 data is for informational purposes only and it may not substantial enough to be used for design.

The normalized RTA condition dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. It passed the ADK test after the data was transformed for the modified CV method. The ETA1 datasets, both normalized and as-measured, failed all distribution tests and required the use of the non-parametric approach for computing basis values. Pooling RTA and ETA1 normalized datasets was appropriate for the modified CV basis value computations, but the as-measured pooled dataset failed the normality test and could not be pooled. There were no statistical outliers.

Statistics, estimates and basis values are given for the FHC2 strength data in Table 4-40. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-27.

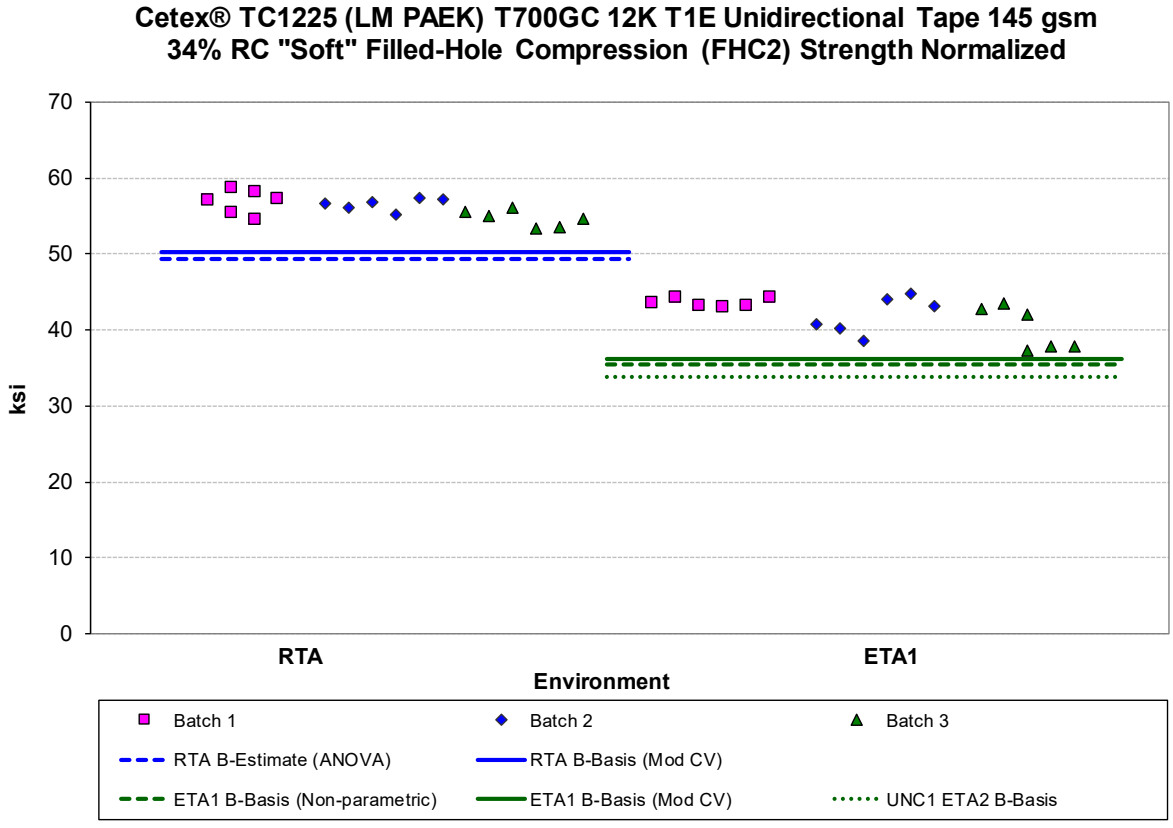

Figure 4-27: Batch plot for FHC2 Strength normalized

Filled-Hole Compression (FHC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)
Mean	55.99	41.88	58.03	43.17
Stdev	1.499	2.487	1.166	2.349
CV	2.677	5.938	2.010	5.442
Modified CV	6.000	6.969	6.000	6.721
Min	53.40	37.32	56.44	39.19
Max	58.65	44.82	59.79	46.18
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value		35.52	55.73	37.60
B-estimate	49.32			
A-estimate	44.57	28.37	54.09	30.66
Method	ANOVA	Non-Parametric	Normal	Non-Parametric
Modified CV Basis Values and Estimates				
B-basis Value	50.26	36.15	51.15	37.44
A-estimate	46.36	32.25	46.29	33.39
Method	pooled	pooled	Normal	Normal
UNC2 B-Basis Values				
B-basis Value	52.43	33.73	52.76	37.06
Mod CV B-Basis	51.68	32.98	51.97	35.76

Shaded values indicate that FHC2 > UNC2; when data for FHC>UNC, FHC data is for informational purposes only and it may not substantial enough to be used for design

Table 4-40: Statistics and Basis Values for FHC2 Strength data

4.30 "50/40/10" Filled-Hole Compression 3 (FHC3)

The FHC3 data is normalized. The only property measurement reported is strength. When the FHC3 mean or basis value is greater than the corresponding value for UNC3, the FHC3 data is for informational purposes only and it may not substantial enough to be used for design.

The as-measured RTA and ETA1 condition datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Both datasets passed the ADK test after the data was transformed for the modified CV method and pooling was acceptable. Pooling RTA and ETA1 normalized datasets was appropriate. There were no statistical outliers.

Statistics, estimates and basis values are given for the FHC3 strength data in Table 4-41. The normalized data and the B-basis values are shown graphically in Figure 4-28.

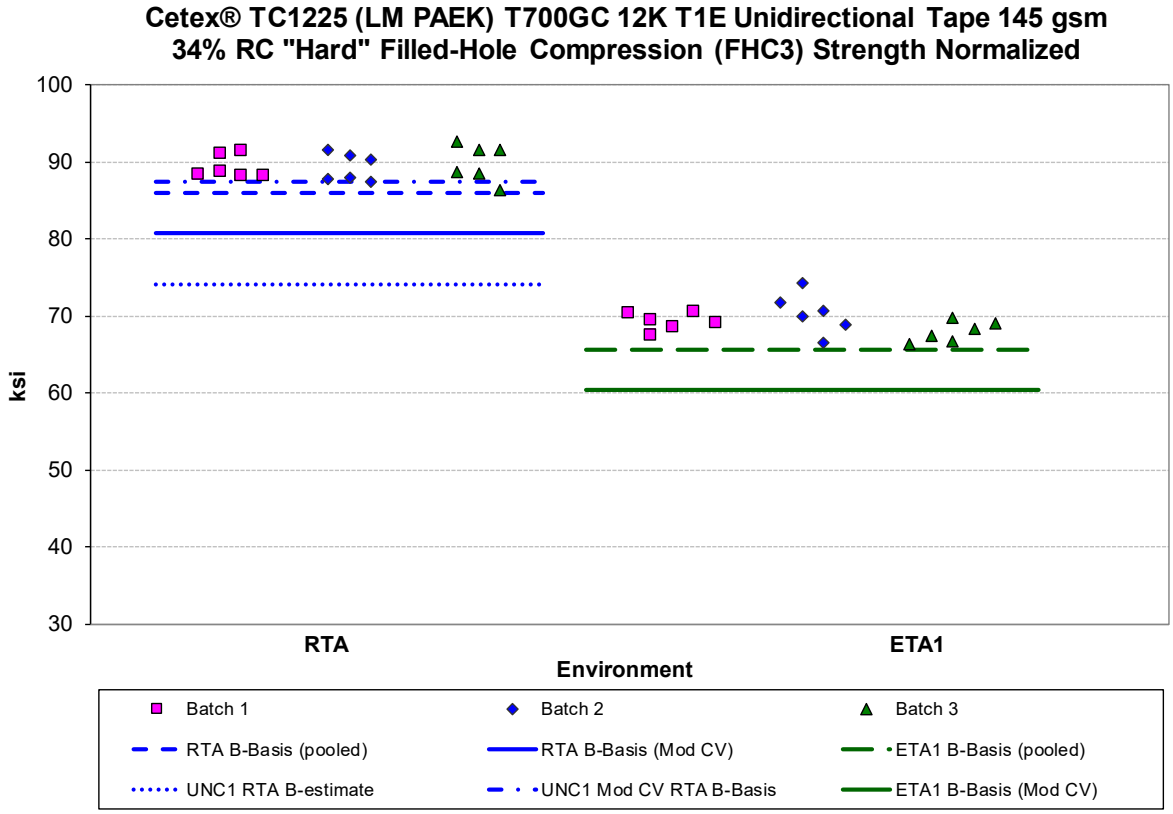

Figure 4-28: Batch plot for FHC3 Strength normalized

Filled-Hole Compression (FHC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70º F)	ETA1 (275º F)	RTA (70º F)	ETA1 (275º F)
Mean	89.48	69.17	93.74	72.23
Stdev	1.889	1.998	3.369	2.874
CV	2.111	2.889	3.594	3.979
Modified CV	6.000	6.000	6.000	6.000
Min	86.26	66.26	88.36	69.02
Max	92.72	74.33	98.82	78.86
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value	85.93	65.62		
B-estimate			76.99	56.24
A-estimate	83.53	63.22	65.04	44.84
Method	pooled	pooled	ANOVA	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	80.74	60.43	84.59	63.08
A-estimate	74.79	54.48	78.37	56.86
Method	pooled	pooled	pooled	pooled
UNC3 B-Basis Values and B-Estimates				
B-basis Value		67.82	95.93	71.53
B-estimate	74.07			
Mod CV B-Basis	87.46	64.20	92.66	68.26

Shaded values indicate that FHC3 > UNC3; when data for FHC>UNC, FHC data is for informational purposes only and it may not substantial enough to be used for design

Table 4-41: Statistics and Basis Values for FHC3 Strength data

4.31 "25/50/25" Single-Shear Bearing 1 (SSB1, Proc. C)

The SSB1 data is normalized. Data is reported on two properties: 2% Offset Strength and Ultimate Strength. Only one batch of material was tested in the ETA2 and ETW environmental conditions, so only estimates of basis values are available for those condition.

The normalized 2% Offset Strength dataset for the RTA condition failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. The RTA 2% Offset Strength dataset passed the ADK test and the normality test after the modified CV transformation was applied, so mod CV basis values are provided.

There were three outliers in the SSB1 datasets. The lowest value in batch one of the 2% Offset Strength ETA1 as-measured dataset was an outlier for the ETA1 condition, but not for batch one or the normalized dataset. The largest value in batch three of the Ultimate Strength ETA1 as-measured dataset was an outlier for batch three, but not for the ETA1 condition or the normalized dataset. The lowest value in the 2% Offset Strength ETW dataset was an outlier in the normalized dataset but not the as-measured dataset. With only one batch tested in this condition, it can only be assessed as an outlier for batch, not the condition. All outliers were retained for this analysis.

Statistics, estimates and basis values are given for the SSB1 2% Offset Strength data in Table 4-42 and Ultimate Strength in Table 4-43. The normalized data, B-basis values and B-estimates are shown graphically for the SSB1 2% Offset Strength data in Figure 4-29 and Ultimate Strength in Figure 4-30.

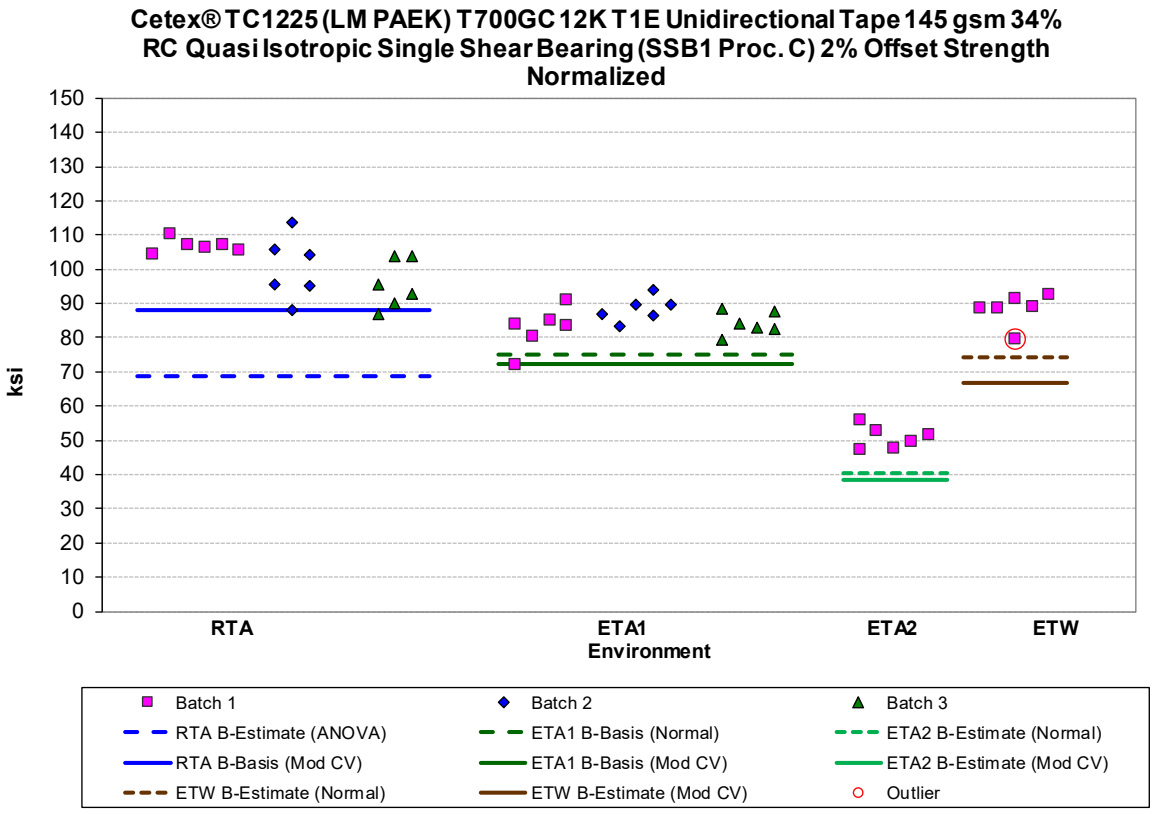

Figure 4-29: Batch plot for SSB1 Proc. C 2% Offset Strength normalized

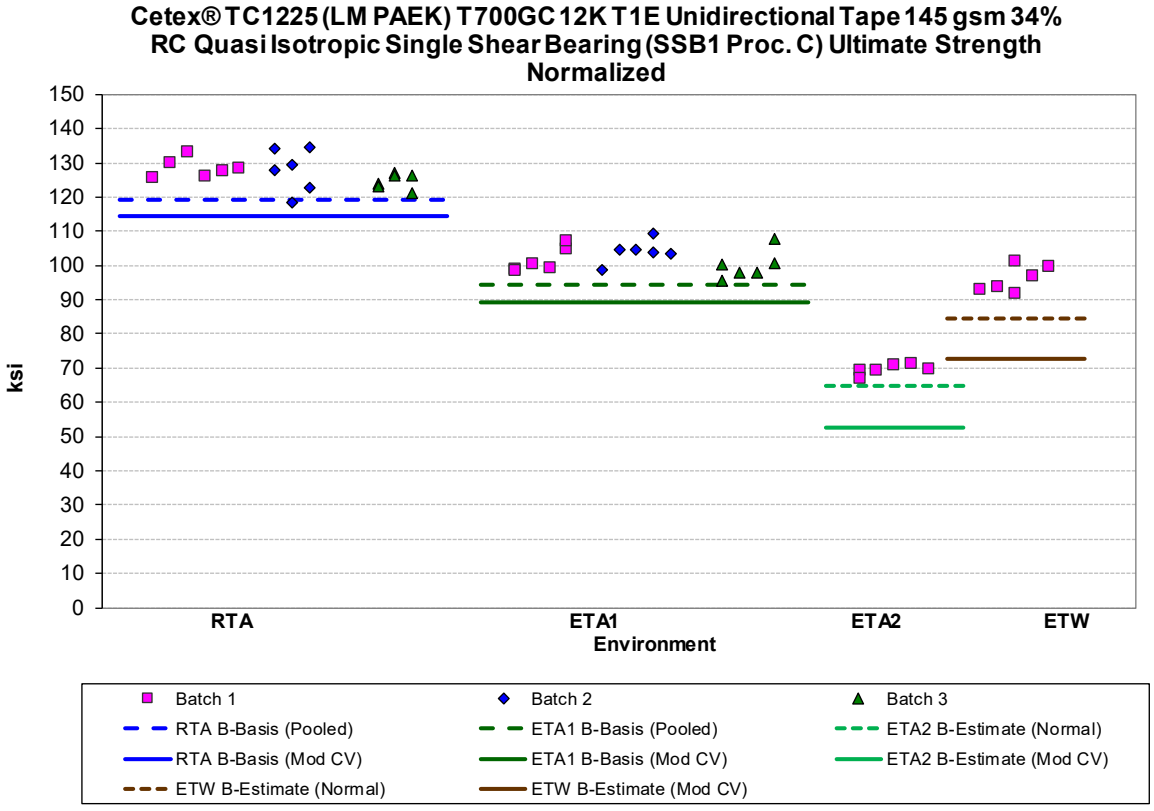

Figure 4-30: Batch plot for SSB1 Proc. C Ultimate Strength normalized

Single Shear Bearing (SSB1 Proc. C) 2% Offset Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	100.9	84.98	50.58	88.12	107.2	89.28	52.32	91.08
Stdev	7.969	5.031	3.323	4.552	7.308	5.142	2.921	5.390
CV	7.900	5.920	6.569	5.166	6.820	5.759	5.582	5.918
Modified CV	7.950	6.960	8.000	8.000	7.410	6.880	8.000	8.000
Min	87.04	71.88	47.01	79.51	92.64	75.08	48.19	81.38
Max	113.8	94.02	55.75	92.57	119.5	96.56	56.36	96.52
No. Batches	3	3	1	1	3	3	1	1
No. Spec.	18	18	6	6	18	18	6	6
Basis Values and Estimates								
B-basis Value		75.05			95.65	77.77		
B-estimate	68.72		40.52	74.33			43.47	74.75
A-estimate	45.80	68.01	33.36	64.53	87.82	69.94	37.18	63.14
Method	ANOVA	Normal	Normal	Normal	pooled	pooled	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	88.05	72.15			94.23	76.35	39.71	69.13
B-estimate			38.39	66.88				
A-estimate	79.32	63.41	30.05	52.35	85.44	67.55	31.08	54.11
Method	pooled	pooled	Normal	Normal	pooled	pooled	Normal	Normal

Table 4-42: Statistics and Basis Values for SSB1 Proc. C 2% Offset Strength data

Single Shear Bearing (SSB1 Proc. C) Ultimate Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	126.9	101.8	69.35	95.82	134.9	106.9	71.80	99.04
Stdev	4.328	4.004	1.553	3.754	4.529	3.850	2.771	4.964
CV	3.410	3.933	2.240	3.918	3.357	3.600	3.859	5.012
Modified CV	6.000	6.000	8.000	8.000	6.000	6.000	8.000	8.000
Min	118.2	95.60	66.66	91.68	124.4	101.0	68.34	93.83
Max	134.5	109.5	71.06	100.9	140.6	116.2	75.06	105.2
No. Batches	3	3	1	1	3	3	1	1
No. Spec.	18	18	6	6	18	18	6	6
Basis Values and Estimates								
B-basis Value	119.3	94.20			127.3	99.28		
B-estimate			64.65	84.45			63.41	84.00
A-estimate	114.2	89.04	61.30	76.36	122.1	94.07	57.44	73.31
Method	pooled	pooled	Normal	Normal	pooled	pooled	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	114.3	89.22			121.6	93.63		
B-estimate			52.64	72.72			54.50	75.17
A-estimate	105.8	80.67	41.20	56.92	112.6	84.58	42.66	58.84
Method	pooled	pooled	Normal	Normal	pooled	pooled	Normal	Normal

Table 4-43: Statistics and Basis Values for SSB1 Proc. C Ultimate Strength data

4.32 "10/80/10" Single-Shear Bearing 2 (SSB2, Proc. C)

The SSB2 data is normalized. Data is reported on two properties: 2% Offset Strength and Ultimate Strength.

The 2% Offset Strength datasets, both normalized and as-measured, and the as-measured Ultimate Strength dataset for the RTA condition failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. All three of these datasets passed the ADK test and the normality test after the modified CV transformation was applied, so modified CV basis values are provided. Pooling across the RTA and ETA1 conditions was appropriate for the normalized Ultimate Strength datasets and for all the modified CV basis values.

There were no statistical outliers.

Statistics, estimates and basis values are given for the SSB2 strength data in Table 4-44. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-31.

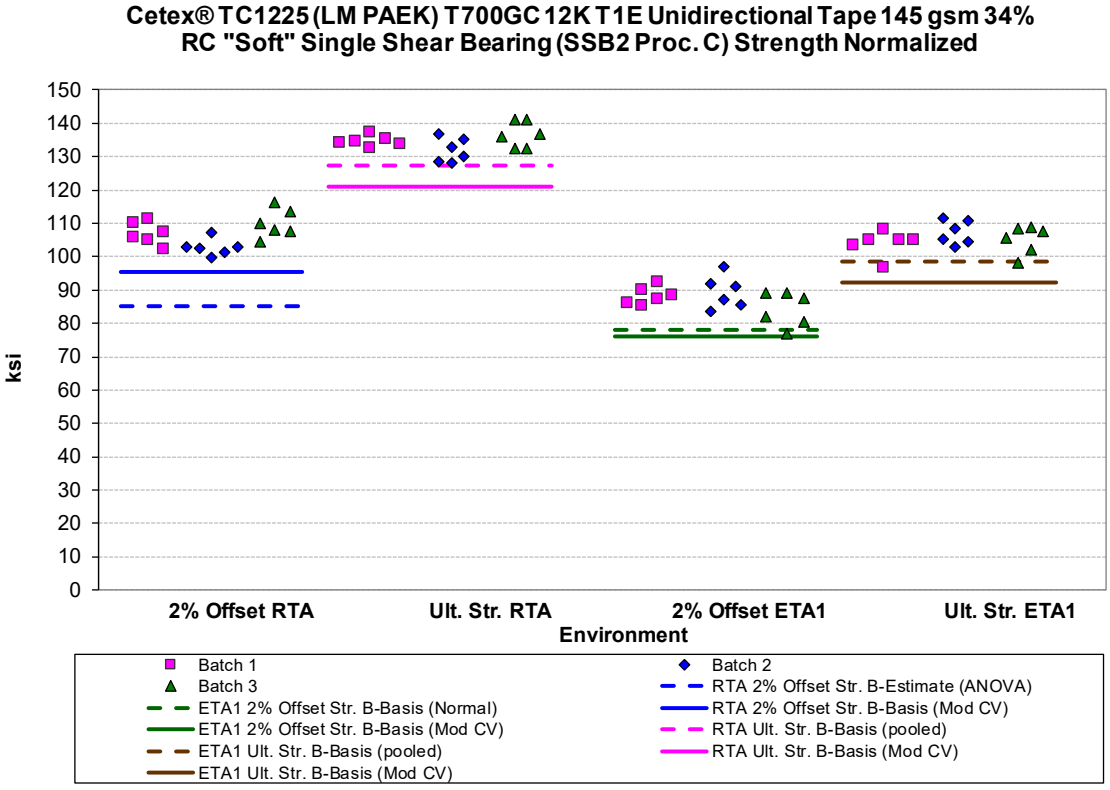

Figure 4-31: Batch plot for SSB2 Proc. C Strength normalized

Single Shear Bearing (SSB2 Proc. C) Strength Basis Values and Statistics								
	Normalized				As-measured			
	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)
Mean	106.5	87.29	134.3	105.4	112.7	89.76	142.1	108.4
Stdev	4.438	4.692	3.613	3.930	5.757	4.252	4.886	4.002
CV	4.166	5.375	2.690	3.729	5.107	4.737	3.438	3.692
Modified CV	6.083	6.687	6.000	6.000	6.553	6.368	6.000	6.000
Min	99.57	77.01	127.9	96.63	104.1	81.74	134.4	101.2
Max	116.1	97.13	141.2	111.7	124.9	97.67	152.6	115.0
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-basis Value		78.03	127.4	98.51		81.36		100.5
B-estimate	85.25				81.43		115.7	
A-estimate	70.08	71.47	122.8	93.83	59.11	75.41	96.94	94.89
Method	ANOVA	Normal	pooled	pooled	ANOVA	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates								
B-basis Value	95.29	76.06	121.1	92.19	100.7	77.73	128.3	94.58
A-estimate	87.65	68.42	112.1	83.21	92.51	69.54	118.9	85.18
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-44: Statistics and Basis Values for SSB2 Proc. C Strength data

4.33 "50/40/10" Single-Shear Bearing 3 (SSB3, Proc. C)

The SSB3 data is normalized. Data is reported on two properties: 2% Offset Strength and Ultimate Strength.

The Ultimate Strength datasets, both normalized and as-measured, for the ETA1 condition failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that pooling across environments was not acceptable and CMH-17 Rev G guidelines required using the ANOVA analysis. With fewer than 5 batches, this is considered an estimate. Both of these datasets passed the ADK test and the normality test after the modified CV transformation was applied, so modified CV basis values are provided. Pooling across the RTA and ETA1 conditions was appropriate for the normalized and as measured 2% Offset Strength datasets and for the modified CV basis values for the as-measured Ultimate Strength datasets. The normalized Ultimate Strength datasets could not be pooled for the modified CV basis values due to a failure of Levene's test.

There were two statistical outliers. The largest value in batch three of the Ultimate Strength data for the ETA1 condition was an outlier for both the normalized and as-measured datasets. It was an outlier for both batch three and the ETA1 condition for the as-measured dataset, but only for batch three and not the ETA1 condition for the normalized dataset. The lowest value in batch three of the 2% Offset Strength data for the ETA1 condition was an outlier for both the normalized and as-measured datasets. It was an outlier only for batch three and not for the ETA1 condition. Both outliers were retained for this analysis.

Statistics, estimates and basis values are given for the SSB3 strength data in Table 4-45. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-32.

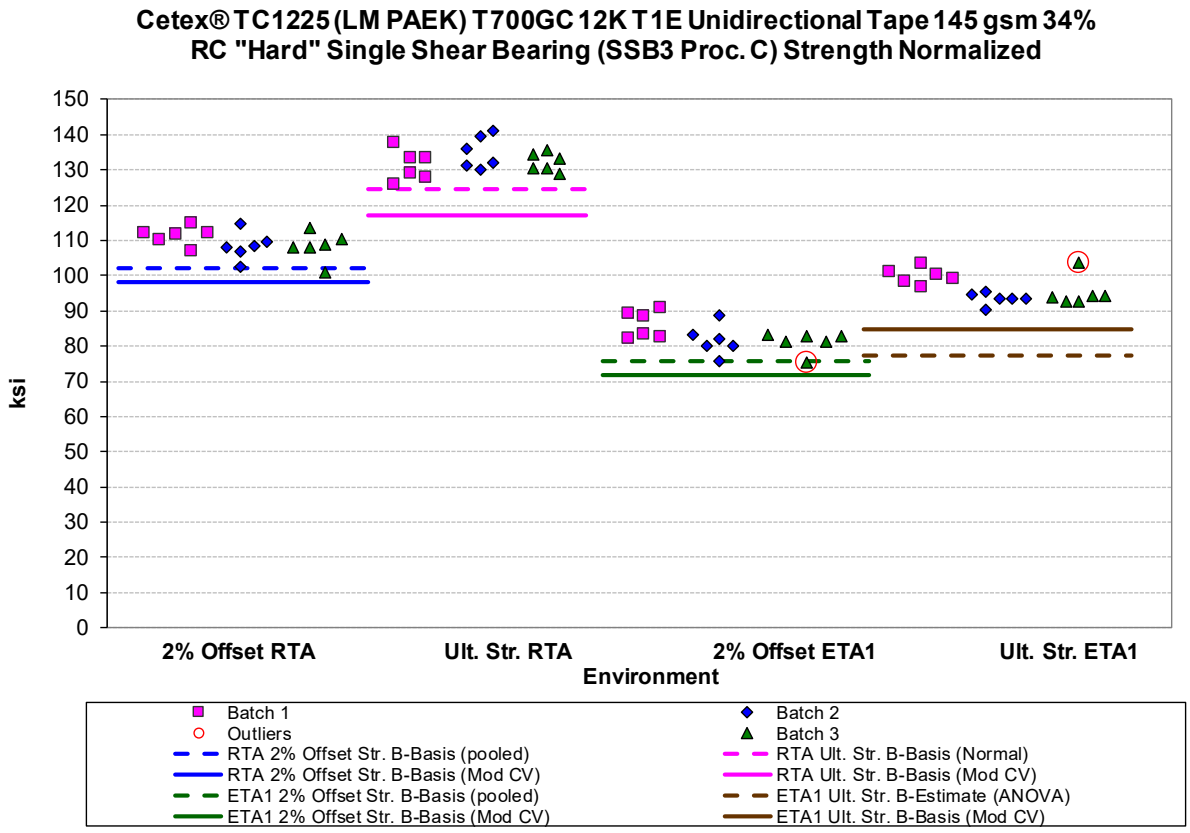

Figure 4-32: Batch plot for SSB3 Proc. C Strength normalized

Single Shear Bearing (SSB3 Proc. C) Strength Basis Values and Statistics								
	Normalized				As-measured			
	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)	RTA (70° F)	ETA1 (275° F)
Mean	109.3	82.90	132.7	96.12	117.5	88.85	142.8	103.1
Stdev	3.730	4.190	4.104	3.874	3.553	3.301	4.880	3.739
CV	3.414	5.054	3.092	4.031	3.022	3.715	3.417	3.628
Modified CV	6.000	6.527	6.000	6.015	6.000	6.000	6.000	6.000
Min	100.7	75.33	125.6	90.16	110.0	81.71	132.8	97.54
Max	114.7	90.79	140.9	103.8	123.4	95.24	150.0	114.6
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-basis Value	102.0	75.67	124.6		111.3	82.60	133.2	
B-estimate				77.39				91.38
A-estimate	97.13	70.76	118.9	64.04	107.0	78.35	126.3	83.08
Method	pooled	pooled	Normal	ANOVA	pooled	pooled	Normal	ANOVA
Modified CV Basis Values and Estimates								
B-basis Value	98.32	71.95	117.0	84.70	106.2	77.46	129.2	89.44
A-estimate	90.87	64.50	105.9	76.63	98.41	69.72	119.9	80.19
Method	pooled	pooled	Normal	Normal	pooled	pooled	pooled	pooled

Table 4-45: Statistics and Basis Values for SSB3 Proc. C Strength data

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

The ILT test data is not normalized. Data is reported on two properties: Interlaminar Tension Strength and Curved Beam Strength. There were no statistical outliers. Basis values are not computed for these properties. However, the summary statistics are presented in Table 4-46 and the as-measured data are displayed graphically in Figure 4-33 (ILT) and Figure 4-34 (CBS).

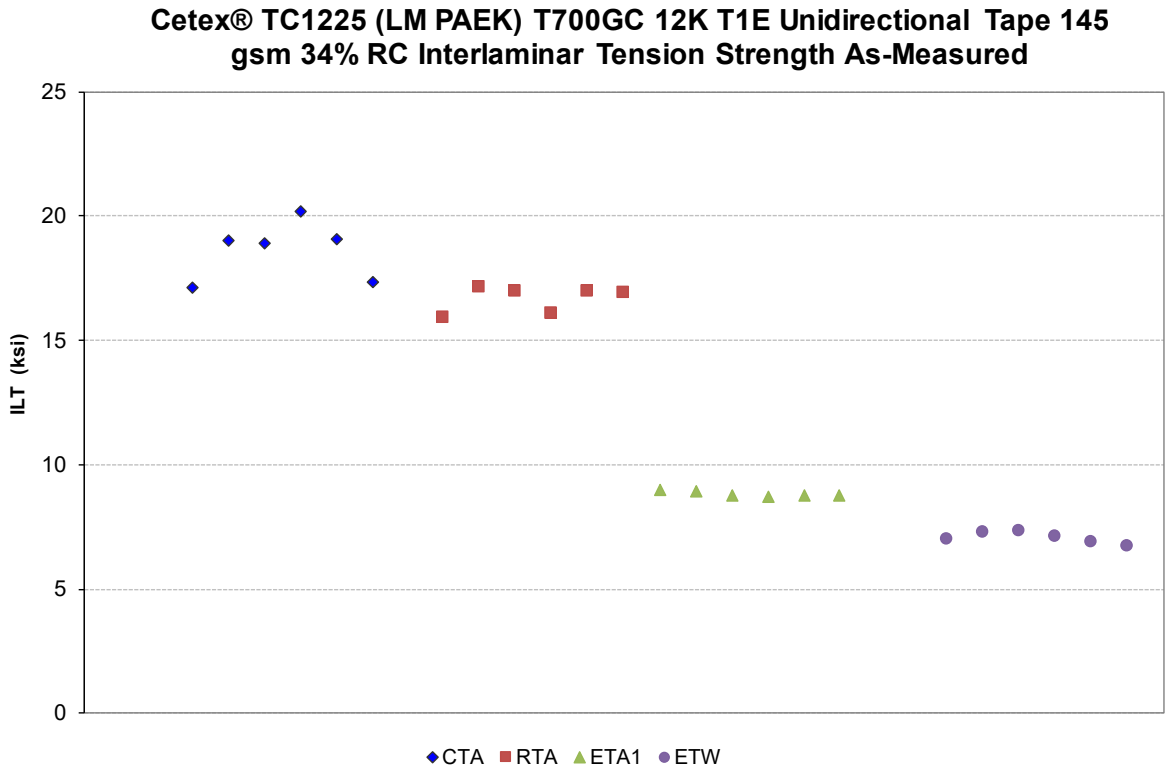

Figure 4-33: Plot for Interlaminar Tension (ILT) Strength as-measured

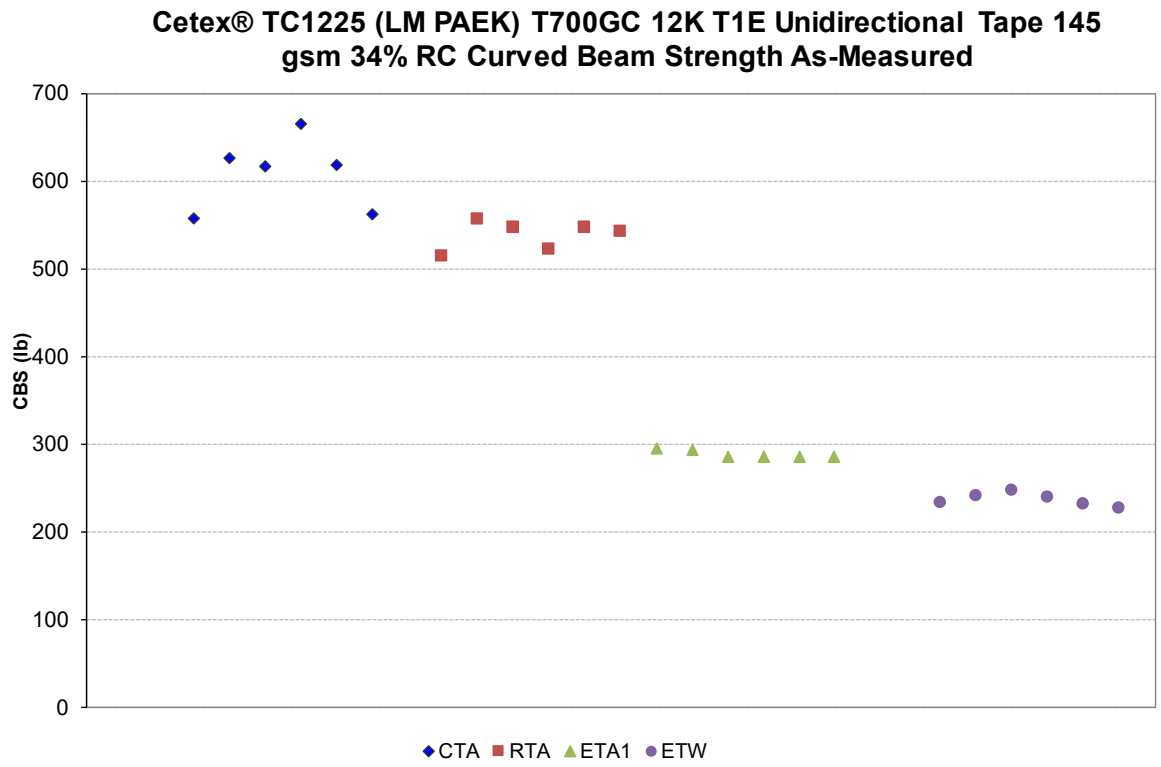

Figure 4-34: Plot for Curved Beam Strength (CBS) as-measured

Interlaminar Tension (ILT) and Curved Beam Strength (CBS) Statistics As-Measured								
	Interlaminar Strength (ksi)				Curved Beam Strength (lb)			
Env	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETW (275° F)	CTA (-65° F)	RTA (70° F)	ETA1 (275° F)	ETW (275° F)
Mean	18.61	16.66	8.821	7.036	607.7	537.9	289.1	236.2
Stdev	1.159	0.5235	0.1202	0.2322	40.88	16.46	4.590	7.218
CV	6.228	3.143	1.363	3.299	6.727	3.060	1.588	3.055
Min	17.15	15.92	8.719	6.711	557.8	514.4	285.8	227.1
Max	20.18	17.12	9.006	7.323	665.2	555.9	295.7	247.1
No. Batches	1	1	1	1	1	1	1	1
No. Spec.	6	6	6	6	6	6	6	6

Table 4-46: Statistics for ILT and CBS data

4.35 "25/50/25" Compression After Impact 1 (CAI1)

The CAI1 test data is normalized. Data is reported on only one property, Strength. There was one outlier. The largest value in the ETA1 dataset was an outlier for the normalized and the as-measured dataset. With only one batch tested in this condition, it can only be assessed as an outlier for batch, not the condition. Basis values are not computed for these properties. However the summary statistics are presented in Table 4-47 and the data are displayed graphically in Figure 4-35.

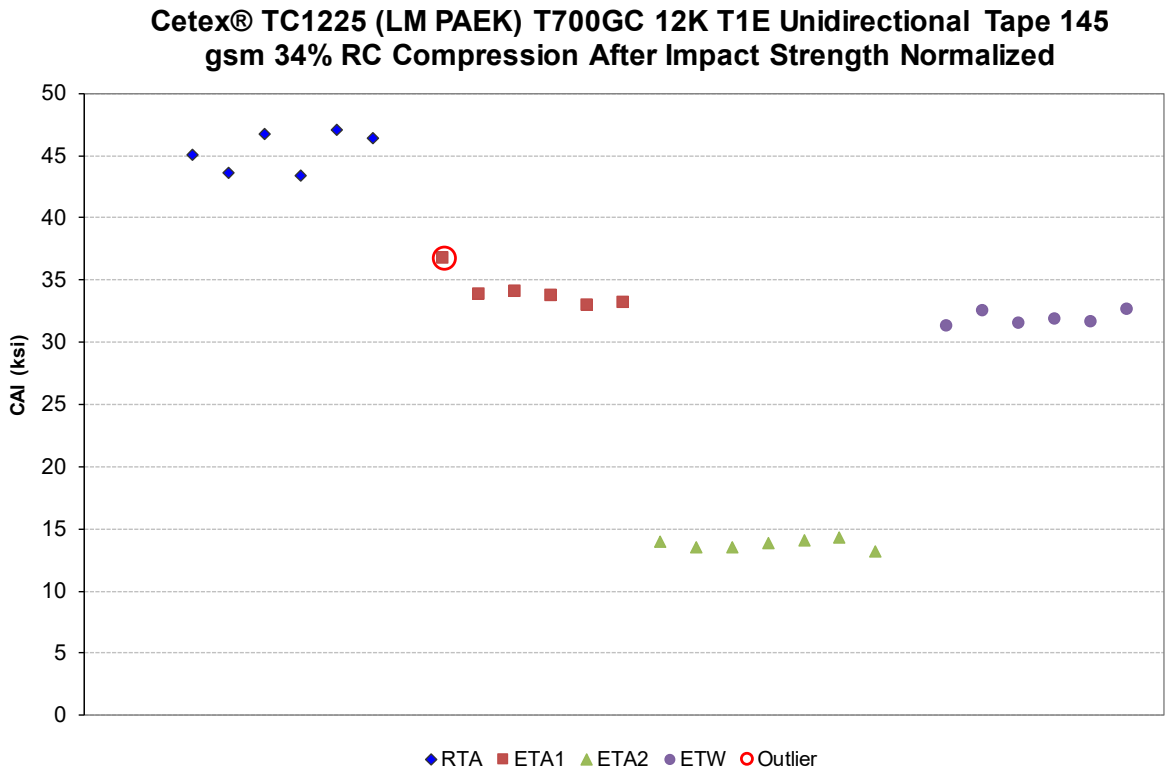

Figure 4-35: Plot for CAI1 Strength normalized

Compression After Impact (CAI1) Strength (ksi) Statistics								
	Normalized				As-measured			
Env	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)	RTA (70° F)	ETA1 (275° F)	ETA2 (400° F)	ETW (275° F)
Mean	45.38	34.04	13.77	31.86	46.10	34.44	14.14	32.56
Stdev	1.609	1.374	0.3824	0.5476	1.719	1.404	0.4658	0.4867
CV	3.544	4.035	2.777	1.719	3.730	4.077	3.295	1.495
Min	43.39	32.94	13.17	31.25	43.65	33.25	13.37	32.07
Max	47.10	36.71	14.29	32.60	48.06	37.13	14.76	33.13
No. Batches	1	1	1	1	1	1	1	1
No. Spec.	6	6	7	6	6	6	7	6

Table 4-47: Statistics for CAI1 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 CMH-17-1G. 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-2019-036 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
LT	CTA (-65º F)	1	TCAJA214B	Not an Outlier	399.9	High	Yes	No
TT	CTA (-65º F)	3	TCAUC112B	NA	12.01	Low	No	Yes
TT	ETA1 (275º F)	2	TCANA311A	NA	7.196	High	Yes	No
IPS - 0.2% Offset	RTA (70º F)	1	TCANA311A	NA	5.798	High	Yes	No
IPS - 0.2% Offset	RTA (70º F)	3	TCANC111A	NA	6.737	High	Yes	Yes
IPS - 0.2% Offset	ETA1 (275º F)	3	TCANC211C	NA	1.436	Low	Yes	No
IPS - 5% Strain					4.201			
IPS - 5% Strain	ETA1 (275º F)	2	TCANB211C	NA	4.120	Low	Yes	No
IPS - 0.2% Offset	ETW (275º F)	1	TCANA112E	NA	1.745	High	Yes	NA
DNS	CTA (-65º F)	2	TCAVB113B	NA	14.97	Low	No	Yes
DNS	RTA (70º F)	3	TCAVC211A	NA	14.37	High	Yes	No
UNT1	RTA (70º F)	2	TCAAB211A	121.9	125.8	Low	Yes	No
UNT2	ETA1 (275º F)	3	TCABC111C	67.54	70.33	High	Yes	Yes
UNT3	CTA (-65º F)	2	TCACB112B	205.7	Not an Outlier	High	Yes	No
UNC1	ETA1 (275º F)	1	TCAWA111C	Not an Outlier	60.73	Low	Yes	No
UNC1	ETW (275º F)	1	TCAWA212E	51.22	Not an Outlier	Low	Yes	NA
UNC2	RTA (70º F)	1	TCAXA112A	59.97	Not an Outlier	High	Yes	No
UNC3	RTA (70º F)	1	TCAYA213A	90.95	Not an Outlier	Low	Yes	No
OHC1	ETA2 (400º F)	1	TCAGA111D	Not an Outlier	19.19	High	Yes	NA
OHC2	ETA1 (275º F)	2	TCAHB211C	33.84	Not an Outlier	High	No	Yes
OHC3	ETA1 (275º F)	1	TCAIA111C	39.19	Not an Outlier	Low	Yes	No
OHC3	ETA1 (275º F)	3	TCAIC211C	40.22	Not an Outlier	Low	Yes	No
OHT1	ETA1 (275º F)	1	TCADA211C	66.78	Not an Outlier	High	Yes	No
OHT2	CTA (-65º F)	2	TCAEB113B	Not an Outlier	53.29	Low	Yes	No
OHT3	CTA (-65º F)	3	TCAFC111B	Not an Outlier	114.9	High	Yes	No
OHT3	ETA1 (275º F)	3	TCAFC111C	108.0	Not an Outlier	High	Yes	No
FHT1	CTA (-65º F)	1	TCA4A212B	Not an Outlier	81.07	High	Yes	No
FHT2	RTA (70º F)	1	TCA5A211A	45.26	48.14	Low	No	Yes
FHT3	ETA1 (275º F)	2	TCA6B111C	Not an Outlier	95.09	Low	Yes	No
SSB1 - 2% Offset	ETA1 (275º F)	1	TCA1A112C	Not an Outlier	75.08	Low	No	Yes
SSB1 - Ult. Str.	ETA1 (275º F)	3	TCA1C212C	Not an Outlier	116.2	High	Yes	No
SSB1 - 2% Offset	ETW (275º F)	1	TCA1A113E	79.51	Not an Outlier	Low	Yes	NA
SSB3 - Ult. Str.	ETA1 (275º F)	3	TCA3C112C	103.8	114.6	High	Yes	No - Norm, Yes - As Meas.
SSB3 - 2% Offset	ETA1 (275º F)	3	TCA3C113C	75.33	81.83	Low	Yes	No
CAI1	ETA1 (275º F)	1	TCAKA211C	36.71	37.13	High	Yes	NA

Table 5-1: List of Outliers

6. References

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