Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35% RC Material Allowables Statistical Analysis Report

NCAMP Project Number: NPN 012401

NCAMP Report Number: NCP-RP-2025-010 Rev –

Report Date: October 3rd, 2025

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REVISIONS:

Rev	By	Date	Pages Revised or Added
-	Sylvina Castillo	October 3rd, 2025	Document Initial Release

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1 Introduction

This report contains statistical analysis of the Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35% RC material property data published in NCAMP Test Report CAM-RP-2025-021 Rev –. The lamina and laminate material property data have been generated with NCAMP oversight in accordance with NCAMP Standard Operating Procedure NSP 100. 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).

B-Basis values, A-estimates, and B-estimates were calculated using a variety of techniques that are detailed in section 2. The qualification material was procured to NCAMP Material Specification NMS 380/1 Rev – dated May 2, 2024. The qualification test panels were cured in accordance with NCAMP Process Specification NPS 83800 Rev B dated October 22, 2024, using baseline cure cycle “C”. The NCAMP Test Plan NTP 3800Q1 Rev C was used for this qualification program. The panels were fabricated at the National Center for Aviation Training (NCAT) Wichita State University Tech , 4004 North Webb Rd, Wichita, KS 67226. 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 Vol 1. 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 Vol 1 (CMH-17 Vol 1).

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

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

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

Part fabricators that wish to utilize the material property data, allowables, and specifications may be able to do so by demonstrating the capability to reproduce the original material properties; a process known as equivalency. More information about this equivalency process including the test statistics and its limitations can be found in Section 6 of DOT/FAA/AR-03/19 and Chapter 8 of CMH-17 Vol 1. 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 Chapter 8 of CMH-17 Vol 1 are adequate for the given program.

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 380/1. NMS 380/1 has additional requirements that are listed in its prepreg process control document (PCD), fiber specification, fiber PCD, and other raw material specifications and PCDs which impose essential quality controls on the raw materials and raw material manufacturing equipment and processes. *Aircraft companies and certifying agencies should assume that the material property data published in this report is not applicable when the material is not procured to NCAMP Material Specification NMS 380/1.* NMS 380/1 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
Short Beam Strength	SBS
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
Interlaminar Tension	ILT
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 Compression Poisson's Ratio	ν_{21}^{c}
Transverse Tension Strength	F_2^{tu}
Transverse Tension Modulus	E_2^{t}
In Plane Shear Strength at 5% strain	$F_{12}^{s5\%}$
In Plane Shear Strength at 0.2% offset	$F_{12}^{s0.2\%}$
In Plane Shear Modulus	G_{12}^{s}

Table 1-2: Test Property Symbols

Environmental Condition	Abbreviation	Temperature
Cold Temperature Dry	CTD	−65 ± 5˚F
Room Temperature Dry	RTD	70 ± 10˚F
Elevated Temperature Dry	ETD1	180 ± 5˚F
Elevated Temperature Wet	ETW1	180 ± 5˚F
Elevated Temperature Wet	ETW2	250 ± 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-2025-021 Rev –.

1.2 Pooling Across Environments

When pooling across environments was allowable, the pooled co-efficient of variation was used. CMH17 STATS (CMH17 Approved Statistical 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.

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 the *Modified Coefficient Of Variation Approach* section of CMH-17 Vol 1. 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 Vol 1 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 Vol 1 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.

1.1 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.

Basis Values:

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

2.1.3.1 K-factor computations

K_a and K_b are computed according to the methodology documented in the *Statistical Methods* section of the CMH-17 Vol 1 Handbook. 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

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

$$f = N - r$$

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

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

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

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

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

2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

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

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

2.1.4.1 Transformation of data based on Modified CV

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

To accomplish this requires a transformation in two steps:

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

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

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

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

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

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

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

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

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

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

2.1.5 Determination of Outliers

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

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

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

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

If MNR > C, then the X_i associated with the MNR is considered to be an outlier. If an outlier exists, then the X_i associated with the MNR is dropped from the dataset and the MNR procedure is applied again. This process is repeated until no outliers are detected. Additional information on this procedure can be found in references 1 and 2.

2.1.6 The k-Sample Anderson Darling Test for Batch Equivalency

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

The k-sample Anderson-Darling test statistic is:

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

Where

n_i = the number of test specimens in each batch

$n = n_1 + n_2 + \ldots + n_k$

h_j = the number of values in the combined samples equal to $z_{(j)}$

H_j = the number of values in the combined samples less than $z_{(j)}$ plus ½ the number of values in the combined samples equal to $z_{(j)}$

F_{ij} = the number of values in the i^{th} group which are less than $z_{(j)}$ plus ½ the number of values in this group which are equal to $z_{(j)}$.

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

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

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

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

With

$$a = (4g-6)(k-1) + (10-6g)S$$
$$b = (2g-4)k^2 + 8Tk + (2g-14T-4)S - 8T + 4g - 6$$
$$c = (6T+2g-2)k^2 + (4T-4g+6)k + (2T-6)S + 4T$$
$$d = (2T+6)k^2 - 4Tk$$
$$S = \sum_{i=1}^{k} \frac{1}{n_i}$$
$$T = \sum_{i=1}^{n-1} \frac{1}{i}$$
$$g = \sum_{i=1}^{n-2} \sum_{j=i+1}^{n-1} \frac{1}{(n-i)j}$$

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

2.1.7 The Anderson Darling Test for Normality

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

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

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

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

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

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

The Anderson Darling test statistic (AD) is:

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

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

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

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:

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

If this computed F statistic is less than the critical value for the F-distribution having k-1 numerator and n-k denominator degrees of freedom at the 1-α level of confidence, then the data is not rejected as being too different in terms of the co-efficient of variation. CMH-17 Vol 1 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 non-centrality parameter $1.282\sqrt{n}$ and n − 1 degrees of freedom. Since this is not a calculation that Excel can handle, the following approximation to the k_B values is used:

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

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

2.1.9.2 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 non-centrality 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:

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

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

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

In order to compute a check of the fit of a data set to the Weibull distribution and compute basis values assuming Weibull, it is first necessary to obtain estimates of the population shape and scale parameters (Section 2.1.9.3.1). 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

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

and the observed significance level is

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

where

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

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

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

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.

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

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

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 $\left(0 < a < b < \infty\right)$ is given by the area under the normal distribution between ln(a) and ln(b).

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

2.1.9.4.1 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:

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

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

The Anderson-Darling statistic is then computed using 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:

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

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

The A-basis value is:

$$A = x_{(n)}\left[\frac{x_{(1)}}{x_{(n)}}\right]^k$$ **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 Vol 1, 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 $\left(n_i, \bar{x}_i, s_i^2\right)$ while statistics that were computed with the entire dataset do not have a subscript. Individual data values are represented with a double subscript, the first number indicated the batch and the second distinguishing between the individual data values within the batch. *k* stands for the number of batches in the analysis. With these statistics, the Sum of Squares Between batches (SSB) and the Total Sum of Squares (SST) are computed:

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

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

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

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

Next, the mean sums of squares are computed:

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

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

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

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

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

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

Two k-factors are computed using the methods described in the *Calculation Of Statistically-Based Material Properties* section of the CMH-17 Vol 1 Handbook using a sample size of n (denoted k_0) and a sample size of k (denoted k_1). Whether this value is an A- or B-basis value depends only on whether k_0 and k_1 are computed for A or B-basis values.

Denote the ratio of mean squares by

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

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

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

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

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

2.2 Single Batch and Two Batch Estimates using Modified CV

This method has not been approved for use by the CMH-17 Vol 1 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 Lamina Variability Method (LVM)

This method has not been approved for use by the CMH-17 Vol 1 organization. Values computed in this manner are estimates only. It is used only when the sample size is less than 16 and no valid B-basis value could be computed using any other method. The prime assumption for applying the LVM is that the intrinsic strength variability of the laminate (small) dataset is no greater than the strength variability of the lamina (large) dataset. This assumption was tested and found to be reasonable for composite materials as documented by Tomblin and Seneviratne [12].

To compute the estimate, the coefficients of variation (CVs) of laminate data are paired with lamina CV's for the same loading condition and environmental condition. For example, the 0º compression lamina CV CTD condition is used with open hole compression CTD condition.

Bearing and in-plane shear laminate CV's are paired with 0º compression lamina CV's. However, if the laminate CV is larger than the corresponding lamina CV, the larger laminate CV value is used.

The LVM B-basis value is then computed as:

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

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

Mod CV LVM Estimated B-Basis = $\bar{X}_1 - K_{(N_1,N_2)} \cdot \bar{X}_1 \cdot Max\left(8\%, CV_1, CV_2\right)$ **Equation 63**

With:

$\bar{X}_1$ the mean of the laminate (small dataset)
N_1 the sample size of the laminate (small dataset)
N_2 the sample size of the lamina (large dataset)
CV_1 is the coefficient of variation of the laminate (small dataset)
CV_2 is the coefficient of variation of the lamina (large dataset)
$K_{(N_1,N_2)}$ is given in Table 2-4

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

Table 2-4: B-Basis Factors for Small Datasets Using Variability of Corresponding Large Dataset

2.4 0º Lamina Strength Derivation

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

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

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

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

V_0=fraction of 0º plies in the cross-ply laminate (½ for [0/90]ns and 1/3 for [90/0/90]n)
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 Vol 1.

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

2.4.1 0º Lamina Strength Derivation (Alternate Formula)

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

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

$$F_{0^\circ}^{cu} = F_{0^\circ/90^\circ}^{cu} \frac{E_1^c}{E_{0^\circ/90^\circ}^c}, \quad F_{0^\circ}^{tu} = F_{0^\circ/90^\circ}^{tu} \frac{E_1^t}{E_{0^\circ/90^\circ}^t} \qquad \textbf{Equation 65}$$

with

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

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

E_1^c, E_1^t are the modulus values for LC and LT respectively

$E_{0^\circ/90^\circ}^c$, $E_{0^\circ/90^\circ}^t$ are the modulus values for UNC0 and UNT0 respectively

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

2.5 Specification Limits

Specification limits are calculated based in the qualification dataset only. In order to compute specification limits we make the following assumptions: a) The qualification dataset represents the population[1] b) In the future we might draw a new sample of size n=5 c) In the future we might run an acceptance test for the new sample statistics (this is a hypothesis testing approach; testing the hypothesis that the sample statistics equal the population parameters with $\alpha = 1\%$). Then, the specification limits are computed as the limits required by the statistics of the future sample to pass the acceptance test. The statistics to be tested are be the modulus mean, the strength mean or the strength minimum individual of the qualification dataset. In the case of modulus mean, a two-tails interval is used. In case of strength mean and strength minimum individual, a one-tail left interval is used.

[1] This is a different assumption than the one required for computing allowables. While computing allowables, we assume that all the future material properties values are the population and the qualification dataset is the sample.

Therefore, in order to compute the specification limits we need to compute the intervals around the mean and minimum individual values from the qualification dataset for some specific material property, according to the following formulas. First, assume the following:

$x = \text{Some Material Strength Property}$
$\overline{x} = \text{Mean of x}$
$S = \text{Standard Deviation of x}$

Then we define:

$\mathrm{W_{mean}} = \mathrm{W_{mean}}$= Specification limit for the mean
$\mathrm{W_{min\,indiv}} = \mathrm{W_{min\,indiv}}$ = Specification limit for the minimum individual

We compute these as the following:

$$\mathrm{W_{mean}} = \overline{x} - \mathrm{k_n^{mean}}.\mathrm{S}$$ **Equation 66**

$$\mathrm{W_{min\,indiv}} = \overline{x} - \mathrm{k_n^{min\,indiv}}.\mathrm{S}$$ **Equation 67**

Where the tolerance factor k^{mean} is found in table 8.5.17 in CMH-17-1H Vol 1 for n=5 and α =0.01 and tolerance factor $k^{min\ indiv}$ is found in table 8.5.18 in CMH-17-1H Vol 1 for n=5 and α =0.01

For modulus properties we define:

$\mathrm{W_{lower}}$ = Lower specification limit for the mean of modulus property
$\mathrm{W_{upper}}$ = Upper specification limit for the mean of modulus property

We compute these as the following:

$$\mathrm{W_{lower}} = \overline{x} - \mathrm{k.S}$$ **Equation 68**

$$\mathrm{W_{upper}} = \overline{x} + \mathrm{k.S}$$ **Equation 69**

Where the tolerance factor k is determined by the following equations:

$$k = t_c.\sqrt{(\frac{1}{N} + \frac{1}{n})}$$ **Equation 70**

and

$$t_c = t.INV(\alpha, N)$$ **Equation 71**

Where t.INV is the inverse of the cumulative Student's t-distribution, N=sample size of the qualification dataset, n=5 and α =0.01.

2.5.1.1 Specification Limits for Program

The qualification data statistics and specification limits summary are shown in Table 2-5 for Strength property and in Table 2-6 for Modulus property.

Test Property	Test Condition	Mean [ksi]	CV (%)	Mod CV (%)	k_mean	k_min indiv	As-is		Mod CV		Notes
							W_mean [ksi]	W_min indiv [ksi]	W_mean [ksi]	W_min indiv [ksi]	
0° Tension (LT) Strength Normalized	RTD (70°F)	472.6	3.715	6.000	1.143	3.072	452.5	418.7	440.2	385.5	Qualification Data Only
(0/90) Unnotched Cross-Ply Compression (UNC0) Strength Normalized	RTD (70°F)	84.16	5.000	6.500	1.143	3.072	79.35	71.23	77.91	67.35	Qualification Data Only
Short Beam Strength As-Measured	RTD (70°F)	14.40	2.139	6.000	1.143	3.072	14.05	13.46	13.42	11.75	Qualification Data Only

Table 2-5: Specification Limits for Strength Properties

Test Property	Test Condition	Mean [Msi]	CV (%)	Mod CV (%)	t_statistic	As-is		Mod CV		Notes
						Lower Limit [Msi]	Upper Limit [Msi]	Lower Limit [Msi]	Upper Limit [Msi]	
0° Tension (LT) Modulus Normalized	RTD (70°F)	22.84	0.02924	6.000	2.831	21.88	23.80	20.88	24.80	Qualification Data Only
(0/90) Unnotched Cross-Ply Compression (UNC0) Modulus Normalized	RTD (70°F)	7.729	0.03715	6.000	2.831	7.318	8.140	7.066	8.393	Qualification Data Only

Table 2-6: Specification Limits for Modulus Properties

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 Vol 1. 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 Vol 1 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 Vol 1 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 Vol 1 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 CMH-17 Vol 1 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 CTD-RTD-ETD1-ETW1-ETW2 trend of the basis values is not consistent with the CTD-RTD-ETD1-ETW1-ETW2 trend of the average values), then the B-basis values will not be recommended.

NCAMP Recommended B-Basis Values for
Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35% RC Prepreg
All B-Basis Values in this Table Meet the Standards for Publication in the CMH-17 Volume 1 Handbook
Values Are for Normalized Data Unless Noted

Lamina Strength Tests

Environment	Statistic	LT	LC from UNC0	TT*	TC*	UNC0	IPS* 0.2% Offset Strength	IPS* Strength at 5% Strain	SBS*
CTD (-65°F)	B-basis	NA: A	227.3	10.19	36.67	84.94	NA: A	14.04	17.36
	Mean	470.6	251.4	11.86	41.47	93.84	8.201	14.86	19.21
	CV	6.935	6.378	7.232	6.000	6.378	8.785	4.245	6.000
RTD (70°F)	B-basis	418.1	202.8	NA: A	26.87	75.35	5.655	10.06	12.55
	Mean	472.6	226.7	10.70	29.33	84.16	6.369	11.16	14.40
	CV	6.000	6.500	6.904	6.000	6.500	7.042	6.000	6.000
ETD1 (180°F)	B-basis	420.5	182.4	NA: A	20.36	66.92	4.598	7.756	NA: I
	Mean	475.0	206.3	10.04	22.78	75.72	5.311	8.857	11.15
	CV	7.268	7.311	7.729	6.000	7.311	6.120	6.000	2.345
ETW1 (180°F)	B-basis	424.4	148.8	NA: A	14.89	54.25	NA: A	NA: A	NA: A
	Mean	478.9	172.8	5.145	17.29	63.10	4.118	6.425	8.892
	CV	6.000	7.447	7.034	6.000	7.447	7.088	4.832	7.641
ETW2 (250°F)	B-basis	396.4	126.2	3.581	11.66	45.24	NA: A	NA: A	NA: A
	Mean	450.9	150.2	4.199	13.07	54.09	3.097	4.956	7.013
	CV	7.269	7.061	8.629	6.000	7.061	8.177	7.350	9.682

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's recommended requirements.
"NA: A" indicates ANOVA with 3 batches. "NA: I" indicates insufficient data points.
* Data is as-measured rather than normalized

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

NCAMP Recommended B-Basis Values for
Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35% RC Prepreg
All B-Basis Values in this Table Meet the Standards for Publication in the CMH-17 Volume 1 Handbook
Values Are for Normalized Data Unless Noted

Laminate Strength Tests

Layup	Environment	Statistic	UNT	UNC	OHT	FHT	OHC	FHC	SSB Proc C. 2% Offset Strength	SSB Proc C. Ultimate Strength	CAI
25/50/25	CTD (-65°F)	B-basis	151.3	90.61	67.37	72.75	NA: I	NA: I			48.37
		Mean	168.5	100.9	75.88	81.91	48.89	81.42			55.71
		CV	6.000	6.186	6.000	6.000	2.586	3.983			6.675
	RTD (70°F)	B-basis	152.4	76.57	72.46	75.13	38.56	61.82	102.3	134.0	NA: A
		Mean	169.7	86.75	80.97	84.29	43.04	68.03	114.0	147.8	50.29
		CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.358
	ETD1 (180°F)	B-basis		NA: I	74.87		34.63				
		Mean		77.70	83.39		39.09				
		CV		2.470	6.000		6.000				
	ETW1 (180°F)	B-basis	145.1	56.83	77.70	82.63	35.73	50.37	96.01	110.0	
		Mean	162.3	65.48	88.15	91.79	37.67	56.58	107.7	123.8	
		CV	6.000	6.695	6.000	6.000	4.090	6.000	6.359	6.123	
	ETW2 (250°F)	B-basis	140.1	NA: A	80.28	82.39	28.97	42.95	84.40	98.47	
		Mean	157.4	57.80	91.07	91.56	32.87	49.16	96.06	112.2	
		CV	6.000	5.277	6.000	6.000	6.000	6.000	6.285	6.000	
10/80/10	CTD (-65°F)	B-basis	83.47	64.86	54.25	63.60	NA: I	NA: I			
		Mean	92.00	72.30	60.58	69.97	43.69	65.41			
		CV	6.000	6.187	6.000	6.000	3.631	2.478			
	RTD (70°F)	B-basis	77.15	53.54	48.76	53.91	32.99	50.21	106.9	126.6	
		Mean	85.68	60.99	55.09	60.28	37.42	55.34	119.0	141.2	
		CV	6.000	6.000	6.000	6.000	6.000	6.284	6.000	6.000	
	ETD1 (180°F)	B-basis		NA: I	NA: I		NA: I				
		Mean		51.13	52.78		31.92				
		CV		0.9003	1.172		1.524				
	ETW1 (180°F)	B-basis	67.23	37.99	46.28	50.77	26.49	40.66*	91.01	107.0	
		Mean	75.76	43.29	52.50	57.14	30.05	45.84*	103.1	121.7	
		CV	6.000	6.199	6.000	6.000	6.000	6.283	6.986	6.212	
	ETW2 (250°F)	B-basis	62.34	NA: A	45.40	48.38	22.41	32.05*	83.97	100.2	
		Mean	70.87	34.55	51.51	54.75	25.42	37.23*	96.10	113.6	
		CV	6.000	6.226	6.000	6.000	6.000	6.000	6.409	6.000	
50/40/10	CTD (-65°F)	B-basis	236.0	138.7	104.5	103.8	NA: I	NA: I			
		Mean	264.0	156.3	117.9	117.8	64.57	101.5			
		CV	6.000	6.637	6.000	6.000	3.855	4.014			
	RTD (70°F)	B-basis	243.2	120.6	114.2	112.0	50.43	76.20	101.8	127.6	
		Mean	271.1	138.3	127.7	126.0	57.23	83.98	113.5	140.7	
		CV	6.000	6.567	6.000	6.000	6.017	6.044	6.069	6.050	
	ETD1 (180°F)	B-basis		NA: I	NA: I		NA: I				
		Mean		119.1	135.2		52.95				
		CV		5.289	4.501		3.930				
	ETW1 (180°F)	B-basis	238.6	78.88	NA: A	127.2	42.05	59.61	85.16	101.5	
		Mean	266.0	97.71	151.5	141.1	48.83	67.44	96.88	114.6	
		CV	6.047	10.00	7.279	6.069	7.032	6.587	7.523	6.228	
	ETW2 (250°F)	B-basis	241.0	NA: A	NA: A	132.1	37.35	48.89	76.49	92.96	
		Mean	269.0	73.87	166.3	146.2	42.37	56.72	88.21	106.0	
		CV	6.000	10.00	9.467	6.016	6.000	6.322	6.277	6.000	

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA implies that tests were run but data did not meet NCAMP's recommended requirements.
"NA: A" indicates ANOVA with 3 batches. "NA:I" indicates insufficient data points.
*In some cases, when FHC > UNC, the UNC data is recommened for design. The FHC data is for informational pusposes only and is not appropriate to be used for design.
Shaded empty boxes indicate that test data is not available for that property and condition.

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

3.2 Lamina and Laminate Summary Tables

Prepreg Material:	Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35%RC prepreg		**Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35% RC Prepreg Lamina Properties Summary**
Material Specification:	NMS 380/1		
Process Specification:	NPS 83800		
Fabric:	T1100GC 24K 71E	**Resin:** TC380	
Tg(dry): 408.2 °F	**Tg(wet):** 332.4 °F	**Tg METHOD:** ASTM D7028	

	Lot 1	Lot 2	Lot 3
Date of fiber manufacture	9/1/2022	12/1/2023	2/1/2023
Date of resin manufacture	3/26/2024	3/26/2024	3/26/2024
Date of prepreg manufacture	4/11/2024	5/29/2024	6/19/2024
Date of composite manufacture		9/16/2024 - 1/23/2025	
Date of testing		1/14/2025 - 7/15/2025	
Date of data submittal		9/4/2025	
Date of analysis		9/5/2025	

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY

Data reported: As-Measured Followed by Normalized Values in Parentheses. Normalizing CPT: 0.004800 in

Values Shown in Shaded Boxes do not Meet CMH-17 Volume 1 Requirements and are Estimates Only

These Values may not be Used for Certification Unless Specifically Allowed by the Certifying Agency

Test Condition	CTD (-65 °F)			RTD (70 °F)			ETD1 (180 °F)			ETW1 (180 °F)			ETW2 (250 °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}	276.9	NA	452.9	442.3	424.1	475.3	430.1	412.0	463.2	436.7	418.6	469.8	276.4	NA	437.2
(ksi)	(274.7)	NA	(470.6)	(437.9)	(418.1)	(472.6)	(319.4)	(420.5)	(475.0)	(449.6)	(424.4)	(478.9)	(299.8)	(396.4)	(450.9)
E_1^t			23.02			22.97			22.64			23.04			23.03
(Msi)			(23.91)			(22.84)			(23.20)			(23.48)			(23.76)
ν_{12}^t			0.3251			0.3132			0.3142			0.3076			0.2952
F_2^{tu} (ksi)	10.37	10.19	11.86	6.931	NA	10.70	6.133	NA	10.04	3.065	NA	5.145	3.581	NA	4.199
E_2^t (Msi)			1.273			1.111			1.013			0.9254			0.7605
F_1^{cu} from UNC0 *	174.9	218.4	246.2	180.1	208.7	236.2	174.5	173.9	201.3	116.7	NA	174.2	109.9	131.3	151.9
(ksi)	(231.2)	(227.3)	(251.4)	(206.7)	(202.8)	(226.7)	(186.3)	(182.4)	(206.3)	(152.7)	(148.8)	(172.8)	(130.1)	(126.2)	(150.2)
E_1^c			21.13			20.83			20.79			20.96			21.23
(Msi)			(21.66)			(20.85)			(21.44)			(21.44)			(21.25)
ν_{12}^c			0.3880			0.3621			0.3862			0.3847			0.4063
F_2^{cu} (ksi)	35.65	36.67	41.47	24.89	26.87	29.33	21.93	20.36	22.78	15.14	14.89	17.29	10.93	11.66	13.07
E_2^c (Msi)			1.313			1.198			1.098			1.030			0.8591
(0/90) UNC0 Strength	65.44	81.82	92.12	66.87	77.49	87.69	64.25	63.93	74.12	42.68	NA	63.70	39.56	47.29	54.68
(ksi)	(86.40)	(84.94)	(93.84)	(76.80)	(75.35)	(84.16)	(68.36)	(66.92)	(75.72)	(55.70)	(54.25)	(63.10)	(46.69)	(45.24)	(54.09)
(0/90) UNC0 Modulus			7.671			8.079			7.627			7.829			7.762
(Msi)			(7.818)			(7.729)			(7.858)			(7.760)			(7.688)
$F_{12}^{s0.2\%}$ (ksi)	5.379	NA	8.201	5.604	5.655	6.369	4.867	4.598	5.311	2.670	NA	4.118	1.600	NA	3.097
$F_{12}^{s5\%}$ (ksi)	14.04	NA	14.86	10.34	10.06	11.16	8.035	7.756	8.857	4.247	NA	6.425	2.566	NA	4.956
G_{12}^s (Msi)			0.6923			0.5740			0.4882			0.3900			0.3051
SBS (ksi)	17.41	17.36	19.21	12.47	12.55	14.40	10.36	8.451	11.15	4.018	NA	8.892	2.088	NA	7.013

*** Derived from cross-ply backout factor.**

Table 3-3: Summary of B-Basis Values and B-Estimates for Lamina Tests

Prepreg Material:	Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35%RC prepreg		**Toray Advanced Composites TC380 T1100GC 24K 120gsm Unitape with 35% RC Prepreg Laminate Properties Summary**
Material Specification:	NMS 380/1		
Process Specification:	NPS 83800		
Fabric:	T1100GC 24K 71E	**Resin:** TC380	
Tg(dry): 408.2 °F	**Tg(wet):** 332.4 °F	**Tg METHOD:** ASTM D7028	

	Lot 1	Lot 2	Lot 3
Date of fiber manufacture	9/1/2022	12/1/2023	2/1/2023
Date of resin manufacture	3/26/2024	3/26/2024	3/26/2024
Date of prepreg manufacture	4/11/2024	5/29/2024	6/19/2024
Date of composite manufacture		9/16/2024 - 1/23/2025	
Date of testing		1/14/2025 - 7/15/2025	
Date of data submittal		9/4/2025	
Date of analysis		9/5/2025	

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY
Data Reported Normalized, Unless Noted, Normalizing CPT: 0.004800 in
Values Shown in Shaded Boxes do not Meet CMH-17 Volume 1 Requirements and are Estimates Only
These Values may not be Used for Certification Unless Specifically Allowed by the Certifying Agency

			Layup:	Quasi Isotropic 25/50/25			"Soft" 10/80/10			"Hard" 50/40/10		
Test	**Property**	**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	Strength	CTD (-65 °F)	(ksi)	65.47	67.37	75.88	58.44	54.25	60.58	110.0	104.5	117.9
		RTD (70 °F)		77.44	72.46	80.97	52.95	48.76	55.09	119.8	114.2	127.7
		ETD1 (180 °F)		79.86	74.87	83.39	50.90	39.99	52.78	116.8	102.4	135.2
		ETW1 (180 °F)		84.62	77.70	88.15	49.80	46.28	52.50	78.70	NA	151.5
		ETW2 (250 °F)		85.65	80.28	91.07	38.62	45.40	51.51	62.69	NA	166.3
OHC	Strength	CTD (-65 °F)	(ksi)	45.06	37.05	48.89	38.88	33.10	43.69	57.03	48.93	64.57
		RTD (70 °F)		41.10	38.56	43.04	35.48	32.99	37.42	52.67	50.43	57.23
		ETD1 (180 °F)		37.16	34.63	39.09	30.45	24.19	31.92	47.17	41.19	52.95
		ETW1 (180 °F)		35.73	NA	37.67	23.94	26.49	30.05	34.95	42.05	48.83
		ETW2 (250 °F)		30.93	28.97	32.87	23.78	22.41	25.42	39.17	37.35	42.37
UNT	Strength	CTD (-65 °F)	(ksi)	134.2	151.3	168.5	78.95	83.47	92.00	250.0	236.0	264.0
	Modulus		(Msi)			8.600			5.349			13.62
	Strength	RTD (70 °F)	(ksi)	162.5	152.4	169.7	71.79	77.15	85.68	257.2	243.2	271.1
	Modulus		(Msi)			8.254			4.933			13.14
	Strength	ETW1 (180 °F)	(ksi)	155.2	145.1	162.3	63.81	67.23	75.76	215.3	238.6	266.0
	Modulus		(Msi)			8.299			4.699			13.36
	Strength	ETW2 (250 °F)	(ksi)	127.9	140.1	157.4	58.98	62.34	70.87	220.7	241.0	269.0
	Modulus		(Msi)			8.128			4.480			13.59
UNC	Strength	CTD (-65 °F)	(ksi)	94.04	90.61	100.9	56.13	64.86	72.30	142.4	138.7	156.3
	Modulus		(Msi)			8.047			5.125			12.57
	Strength	RTD (70 °F)	(ksi)	79.95	76.57	86.75	56.61	53.54	60.99	124.3	120.6	138.3
	Modulus		(Msi)			7.882			4.865			12.41
	Strength	ETD1 (180 °F)	(ksi)	71.88	58.87	77.70	49.73	38.74	51.13	104.2	96.61	119.1
	Modulus		(Msi)			7.878			4.683			12.46
	Strength	ETW1 (180 °F)	(ksi)	53.83	56.83	65.48	39.53	37.99	43.29	78.88	78.88	97.71
	Modulus		(Msi)			7.545			4.411			11.98
	Strength	ETW2 (250 °F)	(ksi)	42.46	NA	57.80	24.27	NA	34.55	30.33	NA	73.87
	Modulus		(Msi)			7.446			4.216			12.06
FHT	Strength	CTD (-65 °F)	(ksi)	70.93	72.75	81.91	67.84	63.60	69.97	109.2	103.8	117.8
		RTD (70 °F)		74.90	75.13	84.29	52.40	53.91	60.28	117.4	112.0	126.0
		ETW1 (180 °F)		87.78	82.63	91.79	51.57	50.77	57.14	107.1	127.2	141.1
		ETW2 (250 °F)		80.52	82.39	91.56	51.78	48.38	54.75	112.0	132.1	146.2
FHC	Strength	CTD (-65 °F)	(ksi)	71.60	61.69	81.42	60.50	49.56	65.41	90.16	78.93	101.5
		RTD (70 °F)		64.52	61.82	68.03	50.47	50.21	55.34	78.33	76.20	83.98
		ETW1 (180 °F)		53.07	50.37	56.58	31.97	40.66*	45.84*	61.75	59.61	67.44
		ETW2 (250 °F)		45.65*	42.95	49.16	34.82*	32.05*	37.23*	51.03*	48.89	56.72

*** In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design.**

Table 3-4: Summary of B-Basis Values and B-Estimates for Laminate Tests - Part A

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
SSB Proc. C	2% Offset Strength	RTD (70 °F)	(ksi)	106.0	102.3	114.0	110.4	106.9	119.0	104.1	101.8	113.5
		ETW1 (180 °F)		99.70	96.01	107.7	94.49	91.01	103.1	87.46	85.16	96.88
		ETW2 (250 °F)		88.09	84.40	96.06	87.45	83.97	96.10	78.79	76.49	88.21
	Ultimate Strength	RTD (70 °F)	(ksi)	139.5	134.0	147.8	133.1	126.6	141.2	132.0	127.6	140.7
		ETW1 (180 °F)		115.5	110.0	123.8	113.6	107.0	121.7	105.8	101.5	114.6
		ETW2 (250 °F)		100.2	98.47	112.2	105.5	100.2	113.6	97.29	92.96	106.0
	Chord Stiffness	RTD (70 °F)	(Msi)			1.829			1.500			2.305
		ETW1 (180 °F)				1.721			1.397			2.211
		ETW2 (250 °F)				1.689			1.354			2.109
ILT*	Strength	CTD (-65 °F)	(ksi)			24.98						
		RTD (70 °F)				17.78						
		ETW1 (180 °F)				6.422						
	Curved Beam Strength	CTD (-65 °F)	(lb)			831.1						
		RTD (70 °F)				588.7						
		ETW1 (180 °F)				219.7						
CAI	Strength	CTD (-65 °F)	(ksi)	40.86	48.37	55.71			46.91			64.65
		RTD (70 °F)		29.76	NA	50.29			41.13			58.38

*The actual layup for ILT is [0]20, (50/0/50). The ILT property is reported as-measured

Table 3-5: Summary of B-Basis Values and B-Estimates for Laminate Tests - Part B

4 Individual Test Summaries, Statistics, Basis Values and Graphs

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

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

When a dataset fails the Anderson-Darling k-sample (ADK) test for batch-to-batch variation, an ANOVA analysis is required. In order for B-basis values 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 of CMH-17 Vol 1, found in section 8.4.4 of the Handbook.

4.1 Longitudinal Tension (LT)

Longitudinal Tension data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, the CTD, ETD1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions and the normal method was used for RTD and ETW1. Applying the modified CV, the CTD condition failed the ADK test, therefore modified CV basis values were not computed for CTD. The remaining conditions met all the requirements for pooling.

For the as-measured dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The remaining conditions met all the requirements for pooling. Applying the modified CV, the CTD and ETW conditions failed the ADK test, therefore modified CV basis values were not computed for these conditions. The remaining conditions met all the requirements for pooling.

There was one statistical outlier. The lowest value in batch A of the ETW2 conditions was a batch outlier in the as-measured dataset. It was retained for this analysis.

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

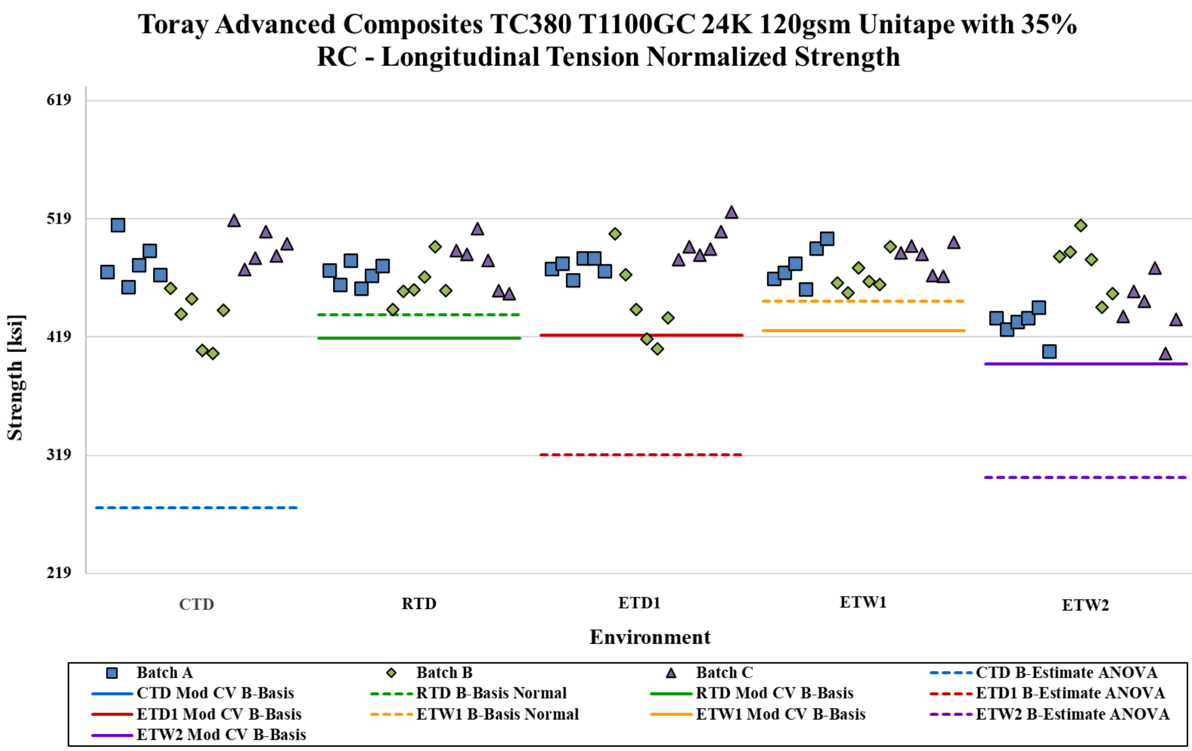

Figure 4-1: Batch Plot for LT Normalized Strength

LT Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	470.6	472.6	475.0	478.9	450.9	452.9	475.3	463.2	469.8	437.2
Stdev	32.63	17.56	31.04	14.81	29.48	31.11	19.15	22.79	12.64	28.73
CV	6.935	3.715	6.536	3.093	6.538	6.869	4.028	4.921	2.691	6.571
Mod CV	7.467	6.000	7.268	6.000	7.269	7.434	6.014	6.460	6.000	7.285
Min	405.0	442.4	408.7	456.6	405.2	389.2	440.4	421.6	444.0	390.4
Max	517.7	510.7	525.1	502.3	513.3	503.4	514.6	506.6	493.5	492.0
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates										
B-Basis Value		437.9		449.6			442.3	430.1	436.7	
B-Estimate	274.7		319.4		299.8	276.9				276.4
A-Estimate	134.9	413.4	208.4	428.9	192.1	151.3	420.2	408.1	414.7	161.7
Method	ANOVA	Normal	ANOVA	Normal	ANOVA	ANOVA	Pooled	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	NA	418.1	420.5	424.4	396.4	NA	424.1	412.0	418.6	NA
A-Estimate		382.2	384.6	388.5	360.5		390.0	377.9	384.5	
Method		Pooled	Pooled	Pooled	Pooled		Pooled	Pooled	Pooled	

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

LT Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	23.91	22.84	23.20	23.48	23.76	23.02	22.97	22.64	23.04	23.03
Stdev	0.6491	0.6679	0.7829	0.5901	0.4933	0.7512	0.7536	0.5695	0.4231	0.4763
CV	2.714	2.924	3.375	2.513	2.076	3.264	3.280	2.516	1.837	2.068
Min	22.92	21.30	21.34	22.09	23.12	21.79	21.53	21.78	22.15	22.35
Max	25.51	23.84	24.30	24.38	24.85	24.99	24.42	23.74	23.84	24.08
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18

Table 4-2: Statistics for LT Modulus Data

4.2 Transverse Tension (TT)

Transverse Tension data is not normalized. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The RTD, ETD1, and ETW1 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The ETW2 condition failed all the distributions tests, therefore the non-parametric method was used for that condition. The normal method was used for CTD. Applying the modified CV, the RTD, ETD1 and ETW1 conditions failed the ADK test and the ETW2 condition, with an original CV larger than 8% failed the normality test, therefore modified CV basis values were not computed for these conditions. The normal method was used for CTD.

There were no statistical outliers.

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

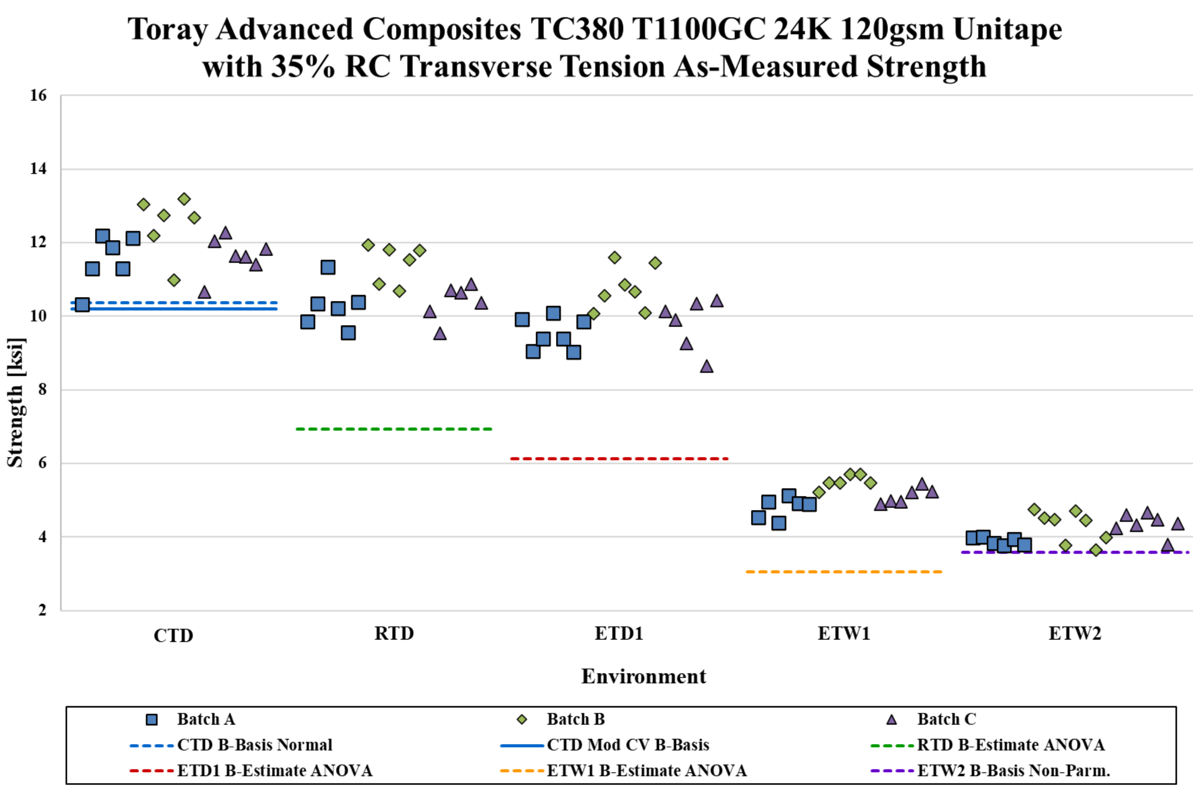

Figure 4-2: Batch Plot for TT As-Measured Strength

TT As-Measured Strength (ksi) Basis Values and Statistics					
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	11.86	10.70	10.04	5.145	4.199
Stdev	0.7669	0.7387	0.7761	0.3619	0.3623
CV	6.464	6.904	7.729	7.034	8.629
Mod CV	7.232	7.452	7.864	7.517	8.629
Min	10.32	9.548	8.654	4.380	3.654
Max	13.18	11.94	11.61	5.699	4.744
No. Batches	3	3	3	3	3
No. Spec.	19	18	20	18	21
Basis Values and Estimates					
B-Basis Value	10.37				3.581
B-Estimate		6.931	6.133	3.065	
A-Estimate	9.308	4.244	3.344	1.581	2.594
Method	Normal	ANOVA	ANOVA	ANOVA	Non-Parm.
Modified CV Basis Values and Estimates					
B-Basis Value	10.19	NA	NA	NA	NA
A-Estimate	9.005				
Method	Normal				

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

TT As-Measured Modulus (Msi) Statistics					
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	1.273	1.111	1.013	0.9254	0.7605
Stdev	0.04156	0.04320	0.01486	0.03138	0.02290
CV	3.264	3.888	1.467	3.391	3.011
Min	1.207	1.055	0.9859	0.8870	0.7302
Max	1.371	1.209	1.033	0.9795	0.8008
No. Batches	3	3	3	3	3
No. Spec.	18	18	20	18	21

Table 4-4: Statistics for TT Modulus Data

4.3 Longitudinal Compression (LC) Derived from UNC0

Longitudinal Compression data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength values were computed from UNC0 using the cross-ply backout factor. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, using the original CV and the modified CV, there were no diagnostic test failures, therefore all conditions were pooled.

For the as-measured dataset, the CTD, RTD, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions and the normal method was used for ETD1. Applying the modified CV, the ETW1 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The CTD, RTD and ETD1 conditions met all the requirements for pooling and the normal method was used for ETW2.

There were three statistical outliers. The lowest value in batch B of the CTD condition was a batch outlier in the normalized and as-measured datasets. The highest value in batch A of the ETD1 condition was a batch outlier in the normalized and as-measured datasets. The highest value in batch A of the ETW2 condition was a condition outlier in the normalized dataset. They were retained for this analysis.

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

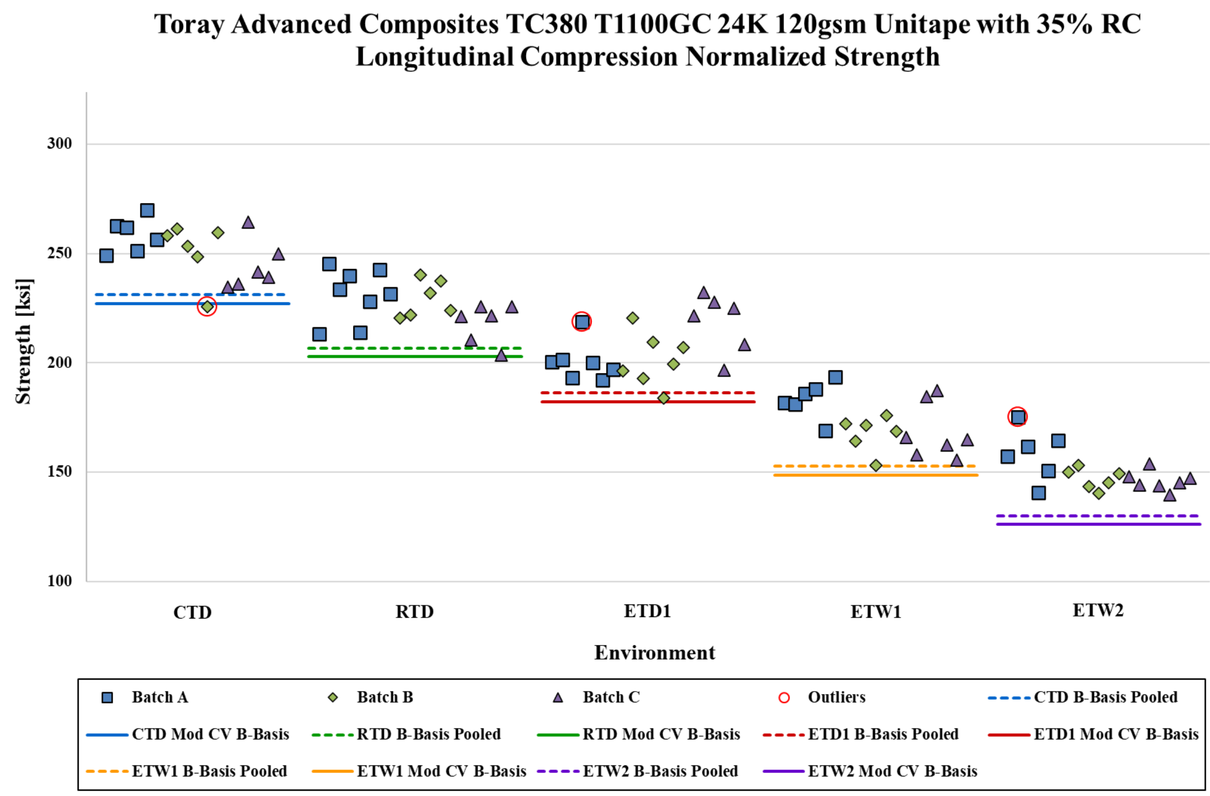

Figure 4-3: Batch Plot for LC Normalized Strength

LC Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	251.4	226.7	206.3	172.8	150.2	246.2	236.2	201.3	174.2	151.9
Stdev	11.96	11.33	13.66	11.92	9.198	13.90	11.98	13.93	13.06	8.914
CV	4.756	5.000	6.622	6.894	6.123	5.648	5.073	6.918	7.496	5.869
Mod CV	6.378	6.500	7.311	7.447	7.061	6.824	6.536	7.459	7.748	6.935
Min	225.7	203.5	183.9	153.3	139.8	221.3	211.1	176.6	151.6	134.5
Max	269.9	245.5	232.2	193.5	175.3	270.1	255.2	232.5	196.0	172.6
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	20	20	19	19	18	20	20	19	19
Basis Values and Estimates										
B-Basis Value	231.2	206.7	186.3	152.7	130.1			174.5		
B-Estimate						174.9	180.1		116.7	109.9
A-Estimate	218.0	193.5	173.0	139.5	116.9	124.0	140.1	155.4	75.67	79.92
Method	Pooled	Pooled	Pooled	Pooled	Pooled	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	227.3	202.8	182.4	148.8	126.2	218.4	208.7	173.9	NA	131.3
A-Estimate	211.5	187.0	166.6	133.1	110.4	200.0	190.2	155.4		116.8
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled		Normal

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

LC Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	21.66	20.85	21.44	21.44	21.25	21.13	20.83	20.79	20.96	21.23
Stdev	0.6616	0.4619	0.5170	0.5826	0.5194	0.6563	0.3728	0.5509	0.4674	0.8264
CV	3.054	2.215	2.412	2.717	2.445	3.105	1.790	2.650	2.230	3.892
Min	20.58	20.22	20.67	20.48	20.10	20.05	20.02	19.73	20.24	19.63
Max	23.04	21.87	22.25	22.27	21.97	22.20	21.59	21.61	21.81	22.88
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18

Table 4-6: Statistics for LC Modulus Data

4.4 Transverse Compression (TC)

Transverse Compression data is not normalized. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The CTD, RTD, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions and the normal method was used for ETD1. Applying the modified CV, pooling all conditions was not possible because the pooled dataset failed the Levene's test for equality of variances. However, the RTD ,ETD1 and ETW1 conditions met all the requirements for pooling and the normal method was used for the remaining conditions.

There were no statistical outliers.

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

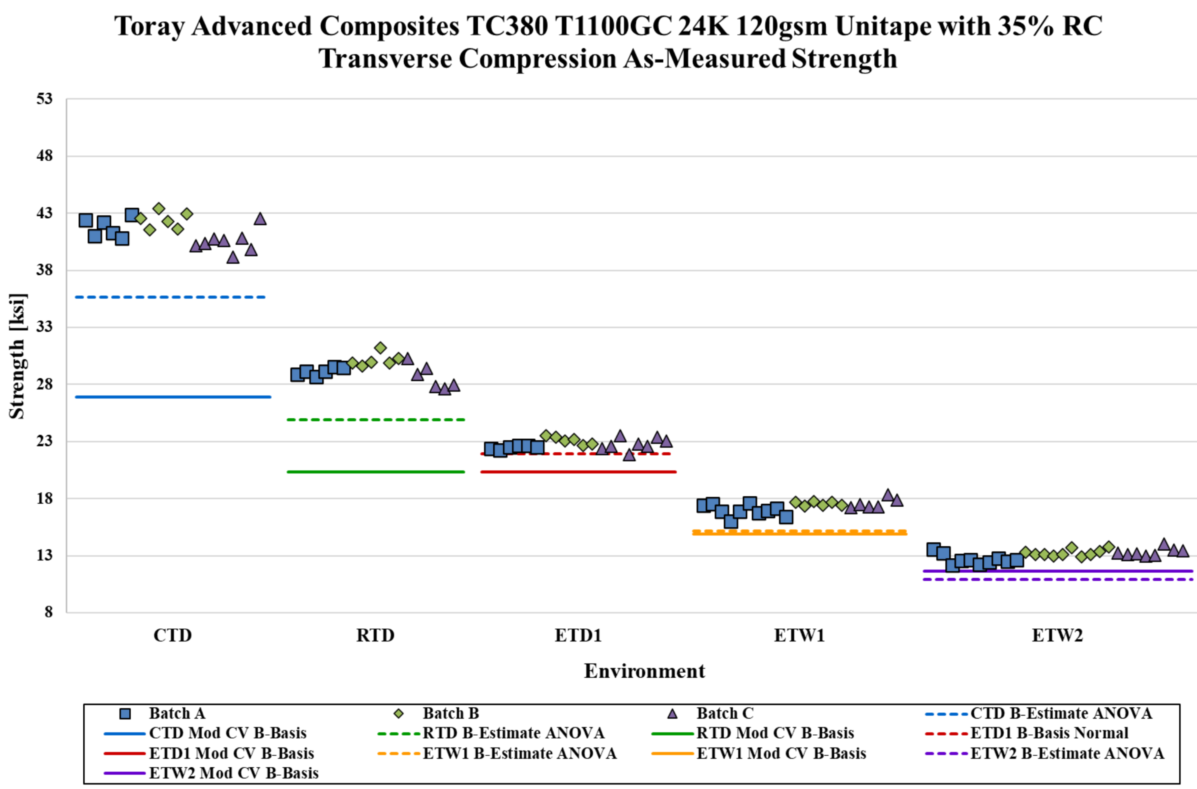

Figure 4-4: Batch Plot for TC As-Measured Strength

TC As-Measured Strength (ksi) Basis Values and Statistics					
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	41.47	29.33	22.78	17.29	13.07
Stdev	1.165	0.9245	0.4422	0.5055	0.4498
CV	2.809	3.153	1.941	2.923	3.442
Mod CV	6.000	6.000	6.000	6.000	6.000
Min	39.14	27.65	21.86	16.06	12.17
Max	43.42	31.24	23.53	18.32	14.02
No. Batches	3	3	3	3	3
No. Spec.	20	18	20	22	28
Basis Values and Estimates					
B-Basis Value			21.93		
B-Estimate	35.65	24.89		15.14	10.93
A-Estimate	31.51	21.73	21.33	13.59	9.397
Method	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates					
B-Basis Value	36.67	26.87	20.36	14.89	11.66
A-Estimate	33.27	25.24	18.72	13.25	10.64
Method	Normal	Pooled	Pooled	Pooled	Normal

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

TC As-Measured Modulus (Msi) Statistics					
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	1.313	1.198	1.098	1.030	0.8591
Stdev	0.03937	0.03523	0.03477	0.03275	0.02893
CV	2.997	2.941	3.167	3.179	3.368
Min	1.250	1.131	1.030	0.9537	0.8093
Max	1.411	1.242	1.173	1.080	0.9332
No. Batches	3	3	3	3	3
No. Spec.	20	18	20	22	28

Table 4-8: Statistics for TC Modulus Data

4.5 Unnotched Compression (0/90) (UNC0)

Unnotched Compression (0/90) data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, using the original CV and the modified CV, there were no diagnostic test failures, therefore all conditions were pooled.

For the as-measured dataset, the CTD, RTD, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions and the normal method was used for ETD1. Applying the modified CV, the ETW1 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The CTD, RTD and ETD1 conditions met all the requirements for pooling and the normal method was used for ETW2.

There were three statistical outliers. The lowest value in batch B of the CTD condition was a batch outlier in the normalized and as-measured datasets. The highest value in batch A of the ETD1 condition was a batch outlier in the normalized and as-measured datasets. The highest value in batch A of the ETW2 condition was a condition outlier in the normalized dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UNC0 strength data in Table 4-9 and for the modulus data in Table 4-10. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-5.

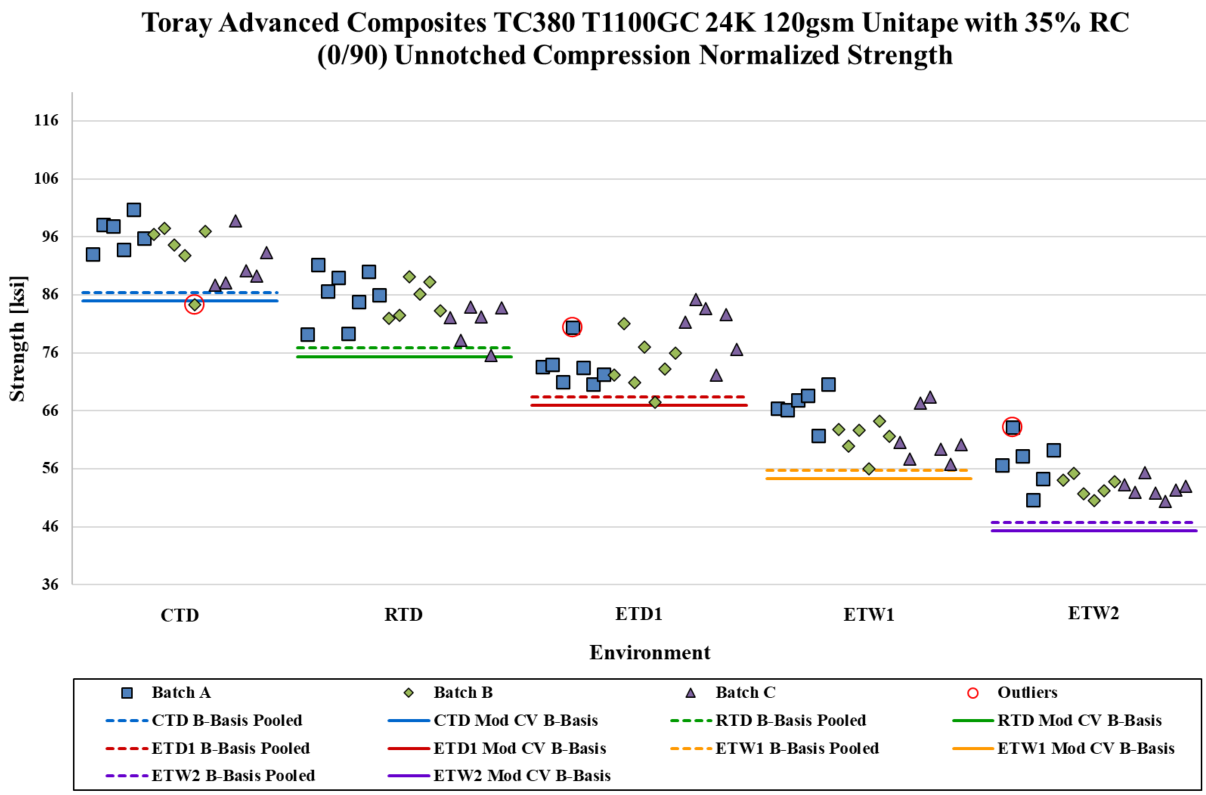

Figure 4-5: Batch Plot for UNC0 Normalized Strength

(0/90) UNC0 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	93.84	84.16	75.72	63.10	54.09	92.12	87.69	74.12	63.70	54.68
Stdev	4.462	4.208	5.014	4.350	3.312	5.203	4.448	5.128	4.775	3.209
CV	4.756	5.000	6.622	6.894	6.123	5.648	5.073	6.918	7.496	5.869
Mod CV	6.378	6.500	7.311	7.447	7.061	6.824	6.536	7.459	7.748	6.935
Min	84.26	75.57	67.52	55.98	50.34	82.83	78.37	65.02	55.44	48.43
Max	100.7	91.16	85.26	70.65	63.13	101.1	94.76	85.58	71.68	62.16
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	20	20	19	19	18	20	20	19	19
Basis Values and Estimates										
B-Basis Value	86.40	76.80	68.36	55.70	46.69			64.25		
B-Estimate						65.44	66.87		42.68	39.56
A-Estimate	81.54	71.93	63.50	50.84	41.83	46.41	52.02	57.22	27.68	28.78
Method	Pooled	Pooled	Pooled	Pooled	Pooled	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	84.94	75.35	66.92	54.25	45.24	81.82	77.49	63.93	NA	47.29
A-Estimate	79.13	69.53	61.10	48.44	39.43	74.97	70.62	57.06		42.04
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled		Normal

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

(0/90) UNC0 Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	7.818	7.729	7.858	7.760	7.688	7.671	8.079	7.627	7.829	7.762
Stdev	0.3319	0.2871	0.4283	0.2951	0.3465	0.3078	0.2939	0.4386	0.3836	0.5192
CV	4.245	3.715	5.450	3.803	4.507	4.013	3.638	5.751	4.900	6.689
Min	7.131	7.069	6.867	7.286	7.125	6.981	7.293	6.612	7.208	6.777
Max	8.283	8.249	8.433	8.351	8.348	8.085	8.595	8.129	8.473	8.964
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18

Table 4-10: Statistics for UNC0 Modulus Data

4.6 In-Plane Shear (IPS)

In Plane Shear data is not normalized. 0.2% offset strength, strength at 5% strain and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the 0.2% Offset Strength dataset, the CTD, ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The RTD and ETD1 conditions were not pooled because the pooled dataset failed the Levene's test for equality of variances, so the normal method was used for these conditions. Applying the modified CV, the CTD, ETW1, and ETW2 conditions failed the ADK test, therefore modified CV basis values were not computed for these conditions. The remaining conditions met all the requirements for pooling.

For the Strength at 5% strain dataset, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The remaining conditions met all the requirements for pooling. Applying the modified CV, the ETW1 and ETW2 conditions failed the ADK test, and the CTD condition failed the normality test, therefore modified CV basis values were not computed for these conditions. The RTD and ETD1 conditions met all the requirements for pooling.

There were two statistical outliers. The highest value in batch C of the CTD condition was a batch and condition outlier for both strength properties tested. The highest value in batch C of the ETW1 condition was a batch outlier in the 0.2% offset strength dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the IPS strength data in Table 4-11 and for the modulus data in Table 4-12. The as-measured data, B-basis values and B-estimates are shown graphically for 0.2% offset strength in Figure 4-6 and for strength at 5% strain in Figure 4-7.

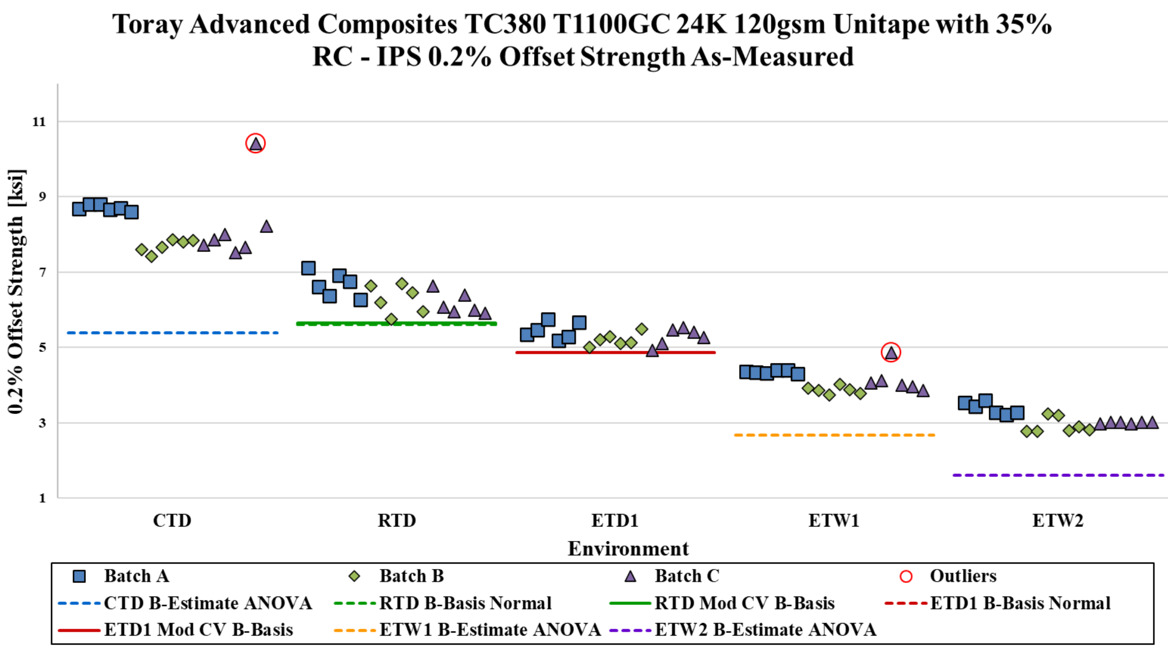

Figure 4-6: Batch Plot for IPS 0.2% Offset Strength As-Measured

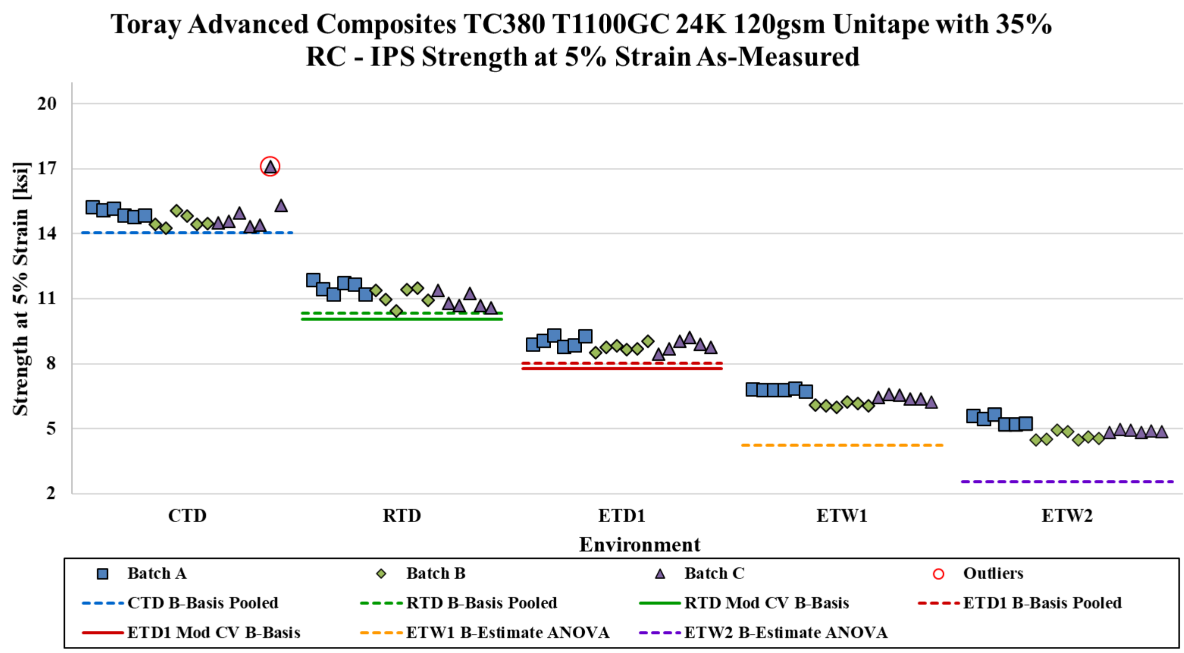

Figure 4-7: Batch Plot for IPS Strength at 5% Strain As-Measured

IPS As-Measured Basis Values and Statistics										
	0.2 % Offset Strength (ksi)					Strength at 5% Strain (ksi)				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	8.201	6.369	5.311	4.118	3.097	14.86	11.16	8.857	6.425	4.956
Stdev	0.7204	0.3874	0.2251	0.2919	0.2532	0.6309	0.4188	0.2527	0.3105	0.3642
CV	8.785	6.083	4.239	7.088	8.177	4.245	3.753	2.854	4.832	7.350
Mod CV	8.785	7.042	6.120	7.544	8.177	6.123	6.000	6.000	6.416	7.675
Min	7.419	5.754	4.920	3.730	2.764	14.23	10.44	8.427	5.960	4.461
Max	10.42	7.109	5.742	4.864	3.595	17.08	11.87	9.304	6.851	5.681
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	19	18	18	18	19	19	18	18	18	19
Basis Values and Estimates										
B-Basis Value		5.604	4.867			14.04	10.34	8.035		
B-Estimate	5.379			2.670	1.600				4.247	2.566
A-Estimate	3.368	5.062	4.552	1.638	0.5323	13.49	9.789	7.487	2.693	0.8611
Method	ANOVA	Normal	Normal	ANOVA	ANOVA	Pooled	Pooled	Pooled	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value		5.655	4.598				10.06	7.756		
A-Estimate	NA	5.170	4.113	NA	NA	NA	9.309	7.007	NA	NA
Method		Pooled	Pooled				Pooled	Pooled		

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

IPS As-Measured Modulus (Msi) Statistics					
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	0.6923	0.5740	0.4882	0.3900	0.3051
Stdev	0.08493	0.04105	0.02261	0.02073	0.02166
CV	12.27	7.152	4.632	5.315	7.100
Min	0.6154	0.5112	0.4481	0.3445	0.2718
Max	0.9841	0.6475	0.5218	0.4168	0.3462
No. Batches	3	3	3	3	3
No. Spec.	19	18	18	18	19

Table 4-12: Statistics for IPS Modulus Data

4.7 Lamina Short-Beam Strength (SBS)

The Short Beam Strength data is not normalized. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 dataset consist of a single batch with six specimens, therefore only estimates were computed for that condition.

The CTD, RTD, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions and the normal method was used for ETD1. The ETW2 A-Estimate was set to zero because the result was negative. Applying the modified CV, the ETW1 and ETW2 conditions failed the ADK test, therefore basis values were not computed for these conditions. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1.

There were no statistical outliers.

Statistics, basis values and estimates are given for the SBS data in Table 4-13. The as-measured data, B-estimates and B-basis values are shown graphically in Figure 4-8.

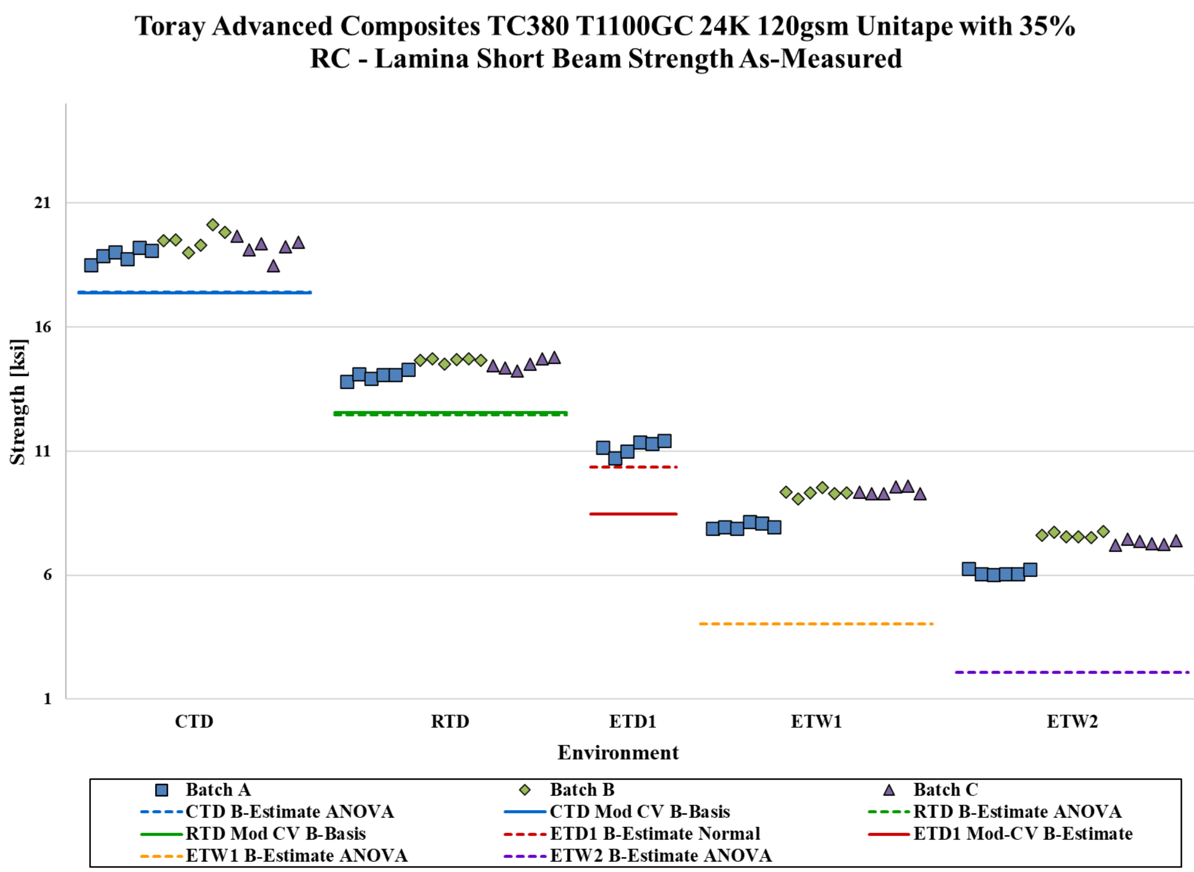

Figure 4-8: Batch Plot for SBS As-Measured

SBS Strength (ksi) As-Measured Basis Values and Statistics					
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	19.21	14.40	11.15	8.892	7.013
Stdev	0.4296	0.3081	0.2616	0.6794	0.6790
CV	2.236	2.139	2.345	7.641	9.682
Mod CV	6.000	6.000	8.000	7.820	9.682
Min	18.46	13.81	10.72	7.866	6.026
Max	20.11	14.79	11.41	9.590	7.760
No. Batches	3	3	1	3	3
No. Spec.	18	18	6	18	18
Basis Value Estimates					
B-Estimate	17.41	12.47	10.36	4.018	2.088
A-Estimate	16.12	11.09	9.798	0.5377	0.000
Method	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates					
B-Basis Value	17.36	12.55		NA	NA
B-Estimate			8.451		
A-Estimate	16.10	11.29	6.529		
Method	Pooled	Pooled	Normal		

Table 4-13: Statistics and Basis Values for SBS Data

4.8 "25/50/25" Open-Hole Tension (OHT1)

The OHT1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, the CTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTD, ETD1 and ETW1 conditions met all the requirements for pooling and the normal method was used for ETW2. Applying the modified CV, the CTD, RTD and ETD1 condition met all the requirements for pooling and the normal method was used for the remaining conditions.

For the as-measured dataset, the CTD, ETW1, and ETW2 conditions failed the ADK test. ANOVA was used to compute estimates for these conditions. The RTD and ETD1 conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There was one statistical outlier. The highest value in batch B of the ETW2 condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHT1 strength data in Table 4-14. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-9.

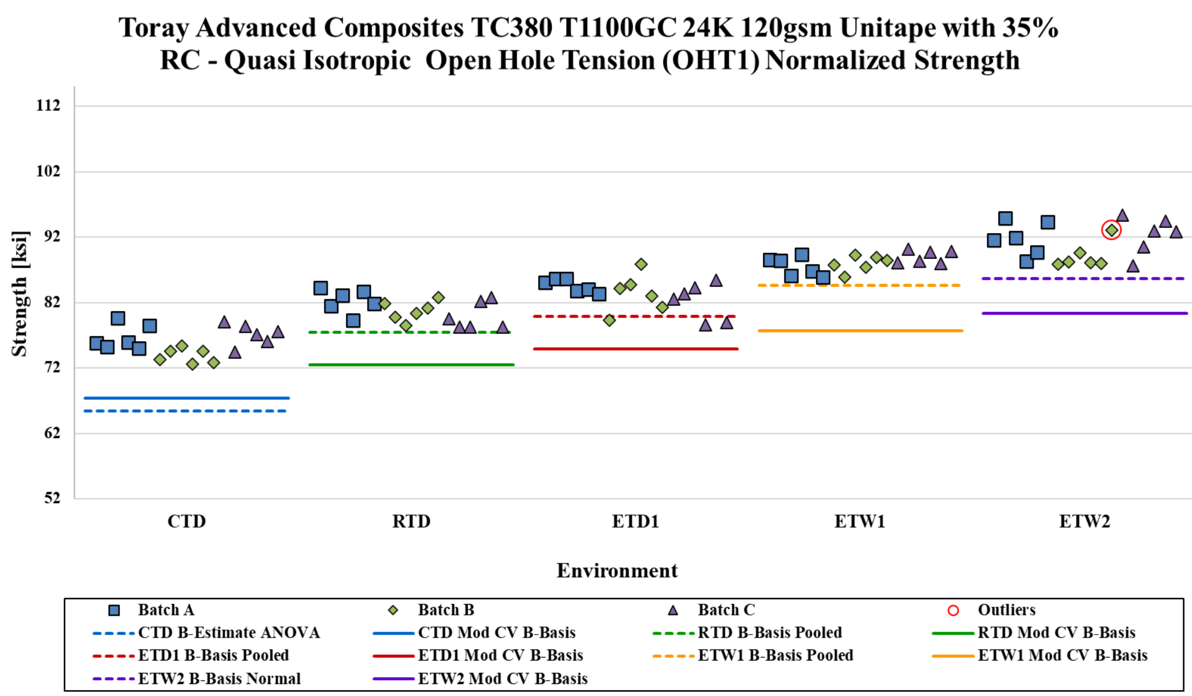

Figure 4-9: Batch Plot for OHT1 Normalized Strength

OHT1 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	75.88	80.97	83.39	88.15	91.07	73.46	79.56	81.61	85.26	88.13
Stdev	2.114	1.990	2.496	1.317	2.745	3.278	3.853	3.956	1.916	3.706
CV	2.786	2.458	2.993	1.494	3.015	4.462	4.843	4.847	2.247	4.206
Mod CV	6.000	6.000	6.000	6.000	6.000	6.231	6.421	6.424	6.000	6.103
Min	72.57	78.26	78.60	85.92	87.67	68.30	72.58	73.28	81.14	82.43
Max	79.62	84.27	87.82	90.20	95.41	78.76	86.41	87.71	88.71	93.71
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates										
B-Basis Value		77.44	79.86	84.62	85.65		72.45	74.50		
B-Estimate	65.47					52.35			75.02	66.57
A-Estimate	58.05	75.09	77.50	82.26	81.80	37.29	67.61	69.66	67.71	51.18
Method	ANOVA	Pooled	Pooled	Pooled	Normal	ANOVA	Pooled	Pooled	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	67.37	72.46	74.87	77.70	80.28	64.65	70.76	72.80	76.45	79.32
A-Estimate	61.69	66.78	69.19	70.30	72.63	58.89	65.00	67.04	70.69	73.56
Method	Pooled	Pooled	Pooled	Normal	Normal	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-14: Statistics and Basis Values for OHT1 Strength Data

4.9 “10/80/10” Open-Hole Tension (OHT2)

The OHT2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

The results are identical for the normalized and as-measured datasets. The ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for the remaining conditions. Applying the modified CV, the CTD and RTD conditions met all the requirements for pooling and the normal method was used for the remaining conditions.

There was one statistical outlier. The highest value in batch C of the ETW2 condition was a batch outlier in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHT2 strength data in Table 4-15. The normalized data and B-basis values are shown graphically in Figure 4-10.

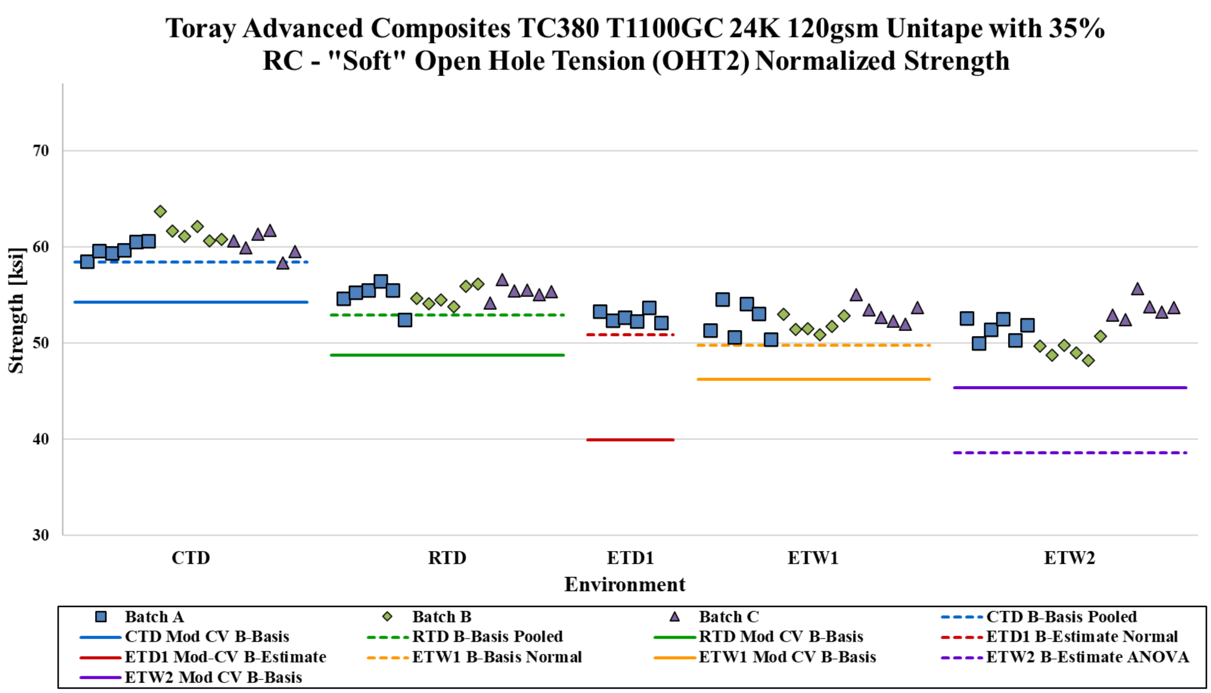

Figure 4-10: Batch Plot for OHT2 Normalized Strength

OHT2 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	60.58	55.09	52.78	52.50	51.51	58.99	53.86	52.61	51.54	50.45
Stdev	1.315	1.023	0.6183	1.365	2.031	1.301	1.659	1.225	1.995	2.249
CV	2.171	1.857	1.172	2.600	3.943	2.205	3.081	2.329	3.871	4.457
Mod CV	6.000	6.000	8.000	6.000	6.000	6.000	6.000	8.000	6.000	6.229
Min	58.41	52.51	52.16	50.40	48.25	56.66	50.66	51.02	47.55	46.98
Max	63.74	56.62	53.72	55.03	55.68	61.45	56.61	54.11	55.35	54.68
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	18	18	6	18	18	18	18	6	18	18
Basis Values and Estimates										
B-Basis Value	58.44	52.95		49.80		56.28	51.15		47.61	
B-Estimate			50.90		38.62			48.90		35.80
A-Estimate	56.98	51.49	49.57	47.89	29.42	54.43	49.30	46.26	44.81	25.34
Method	Pooled	Pooled	Normal	Normal	ANOVA	Pooled	Pooled	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	54.25	48.76		46.28	45.40	52.82	47.69		45.44	44.25
B-Estimate			39.99					39.86		
A-Estimate	49.95	44.46	30.89	41.87	41.08	48.62	43.49	30.80	41.11	39.85
Method	Pooled	Pooled	Normal	Normal	Normal	Pooled	Pooled	Normal	Normal	Normal

Table 4-15: Statistics and Basis Values for OHT2 Strength Data

4.10 "50/40/10" Open-Hole Tension (OHT3)

The OHT3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1. Applying the modified CV, the ETW1 and ETW2 conditions failed the ADK test, therefore modified CV basis values were not computed for these conditions. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1.

For the as-measured dataset, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVAS was used to compute estimates for these conditions. The normal method was used for the remaining conditions. Applying the modified CV, the ETW1 and ETW2 conditions failed the ADK test, therefore modified CV basis values were not computed for these conditions. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1.

There was one statistical outlier. The highest value in batch B of the ETW1 condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHT3 strength data in Table 4-16. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-11.

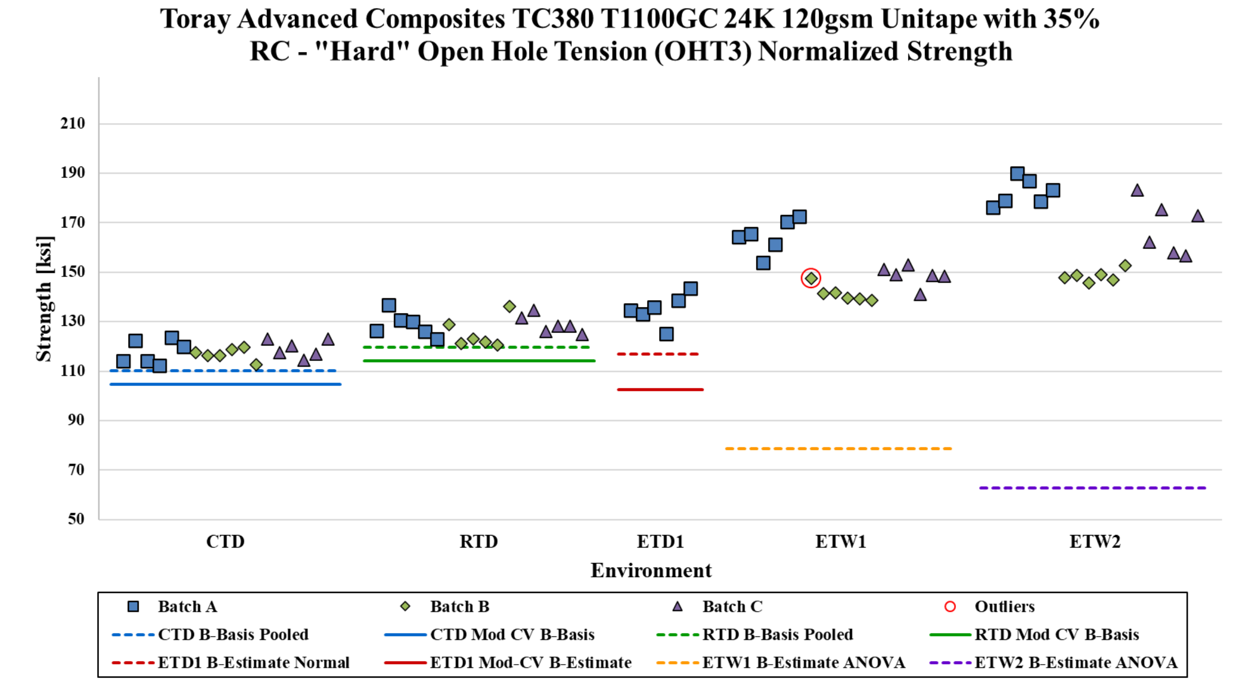

Figure 4-11: Batch Plot for OHT3 Normalized Strength

OHT3 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	117.9	127.7	135.2	151.5	166.3	114.3	124.6	134.5	148.6	162.6
Stdev	3.623	4.956	6.084	11.03	15.74	4.357	6.805	8.243	13.27	17.56
CV	3.072	3.882	4.501	7.279	9.467	3.810	5.462	6.130	8.933	10.80
Mod CV	6.000	6.000	8.000	7.640	9.467	6.000	6.731	8.000	8.933	10.80
Min	112.3	120.6	125.2	138.8	145.8	106.5	113.7	123.3	129.6	140.3
Max	123.6	136.7	143.4	172.4	190.0	123.5	134.2	147.6	174.6	186.9
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	18	18	6	18	18	18	18	6	18	18
Basis Values and Estimates										
B-Basis Value	110.0	119.8				105.7	111.2			
B-Estimate			116.8	78.70	62.69			109.5	64.81	43.35
A-Estimate	104.6	114.4	103.6	26.70	0.000	99.65	101.6	91.74	5.005	0.000
Method	Pooled	Pooled	Normal	ANOVA	ANOVA	Normal	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	104.5	114.2		NA	NA	100.4	110.6		NA	NA
B-Estimate			102.4					101.9		
A-Estimate	95.36	105.1	79.13			90.89	101.1	78.71		
Method	Pooled	Pooled	Normal			Pooled	Pooled	Normal		

Table 4-16: Statistics and Basis Values for OHT3 Strength Data

4.11 “25/50/25” Open-Hole Compression (OHC1)

The OHC1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The CTD condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the normal method was used for CTD and the remaining conditions met all the requirements for pooling. Applying the modified CV, the ETW1 condition failed the normality test, therefore modified CV basis values were not computed for that condition. The RTD and ETD1 conditions met all the requirements for pooling and the normal method was used for the remaining conditions.

For the as-measured dataset, the ETD1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for CTD and the remaining condition met all the requirements for pooling.

There were no statistical outliers.

Statistics, basis values and estimates are given for the OHC1 strength data in Table 4-17. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-12.

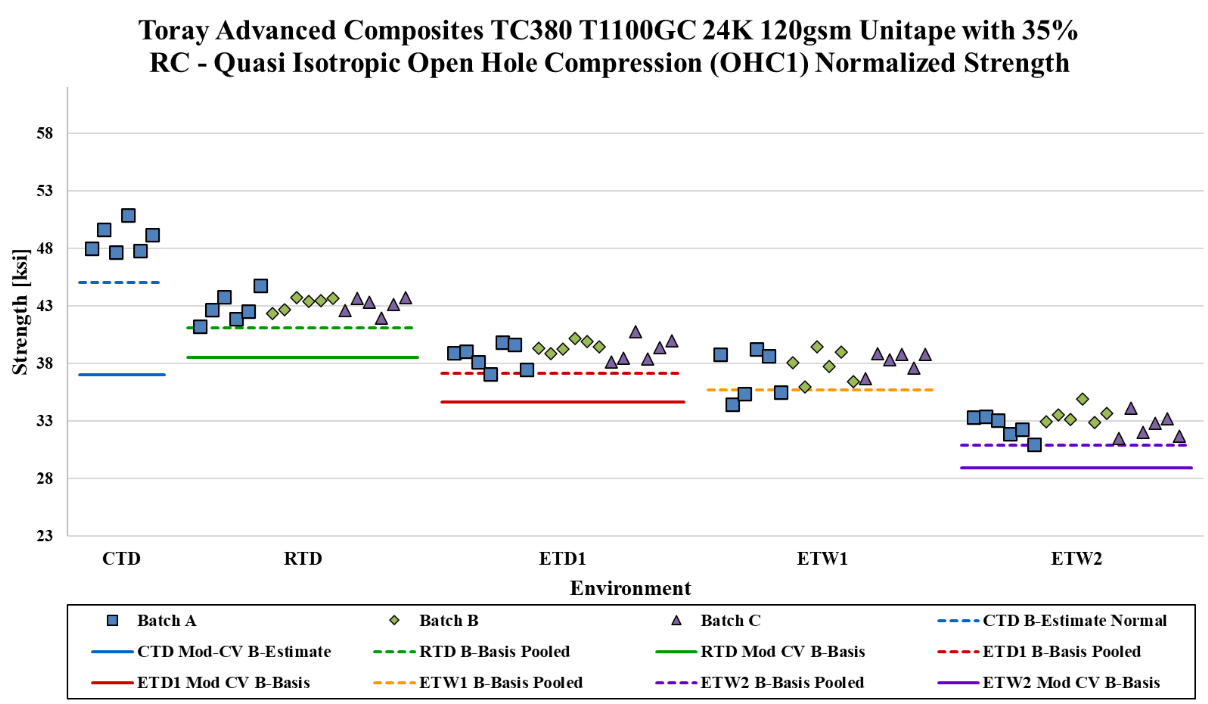

Figure 4-12: Batch Plot for OHC1 Normalized Strength

OHC1 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	48.89	43.04	39.09	37.67	32.87	48.90	42.29	38.10	37.04	32.10
Stdev	1.265	0.8586	0.9375	1.541	0.9854	1.306	1.010	0.7749	1.812	0.9729
CV	2.586	1.995	2.398	4.090	2.998	2.672	2.387	2.034	4.892	3.031
Mod CV	8.000	6.000	6.000	6.045	6.000	8.000	6.000	6.000	6.446	6.000
Min	47.70	41.25	37.12	34.44	30.95	47.68	40.85	36.55	34.07	30.22
Max	50.89	44.77	40.76	39.48	34.92	50.99	44.19	39.30	40.02	33.36
No. Batches	1	3	3	3	3	1	3	3	3	3
No. Spec.	6	18	19	18	18	6	18	19	18	18
Basis Values and Estimates										
B-Basis Value		41.10	37.16	35.73	30.93		40.30		33.47	30.18
B-Estimate	45.06					44.94		34.66		
A-Estimate	42.34	39.82	35.88	34.46	29.65	42.13	38.89	32.21	30.93	28.82
Method	Normal	Pooled	Pooled	Pooled	Pooled	Normal	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates										
B-Basis Value		38.56	34.63	NA	28.97		38.29	34.11	33.04	28.10
B-Estimate	37.05					37.05				
A-Estimate	28.62	35.52	31.59		26.21	28.62	35.65	31.47	30.40	25.46
Method	Normal	Pooled	Pooled		Normal	Normal	Pooled	Pooled	Pooled	Pooled

Table 4-17: Statistics and Basis Values for OHC1 Strength Data

4.12 “10/80/10” Open-Hole Compression (OHC2)

The OHC2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The CTD and ETD1 conditions consist of a single batch with six specimens, therefore only estimates were computed for these conditions.

For the normalized dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTD condition failed all the distributions tests, therefore the non-parametric method was use for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for all the conditions.

For the as-measured dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for all the conditions.

There were two statistical outliers. The highest value in batch B of the RTD condition was a condition outlier in the normalized dataset. The highest value in batch C of the RTD condition was a batch outlier in the normalized dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the OHC2 strength data in Table 4-18. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-13.

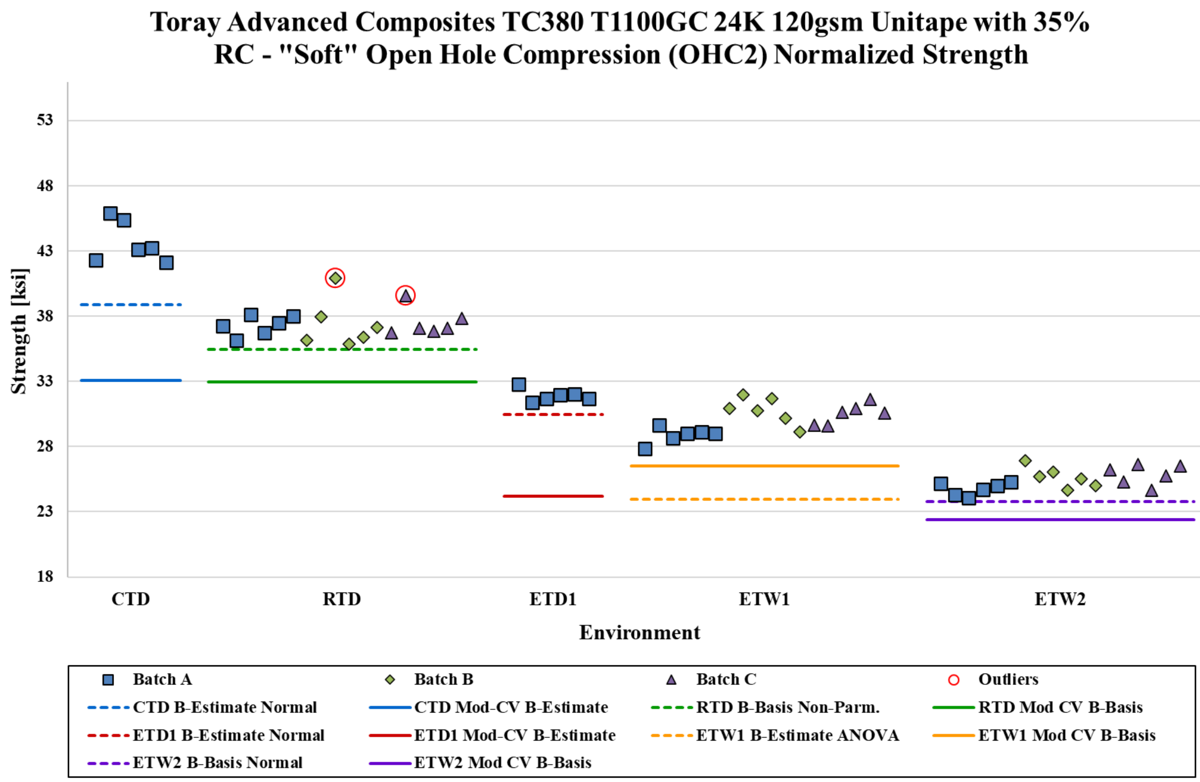

Figure 4-13: Batch Plot for OHC2 Normalized Strength

OHC2 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	43.69	37.42	31.92	30.05	25.42	43.94	36.93	31.77	29.51	24.75
Stdev	1.586	1.246	0.4864	1.163	0.8271	1.652	1.113	0.5865	1.040	0.6830
CV	3.631	3.331	1.524	3.869	3.254	3.759	3.015	1.846	3.525	2.759
Mod CV	8.000	6.000	8.000	6.000	6.000	8.000	6.000	8.000	6.000	6.000
Min	42.12	35.90	31.37	27.83	24.07	42.24	35.58	30.92	27.82	23.88
Max	45.90	40.90	32.78	32.00	26.94	46.24	39.19	32.56	31.20	26.27
No. Batches	1	3	1	3	3	1	3	1	3	3
No. Spec.	6	18	6	18	18	6	18	6	18	18
Basis Values and Estimates										
B-Basis Value		35.48			23.78		34.73			23.40
B-Estimate	38.88		30.45	23.94		38.94		29.99	24.66	
A-Estimate	35.47	29.52	29.40	19.58	22.63	35.38	33.18	28.73	21.21	22.45
Method	Normal	Non-Parm.	Normal	ANOVA	Normal	Normal	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates										
B-Basis Value		32.99		26.49	22.41		32.56		26.01	21.82
B-Estimate	33.10		24.19			33.29		24.07		
A-Estimate	25.57	29.84	18.69	23.97	20.27	25.72	29.46	18.60	23.54	19.74
Method	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-18: Statistics and Basis Values for OHC2 Strength Data

4.13 “50/40/10” Open-Hole Compression (OHC3)

The OHC3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The CTD and ETD1 conditions consist of a single batch with seven or less specimens, therefore only estimates were computed for these conditions.

For the normalized dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for all the conditions.

For the as-measured dataset, the RTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for all the conditions.

There were no statistical outliers.

Statistics, basis values and estimates are given for the OHC3 strength data in Table 4-19. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-14.

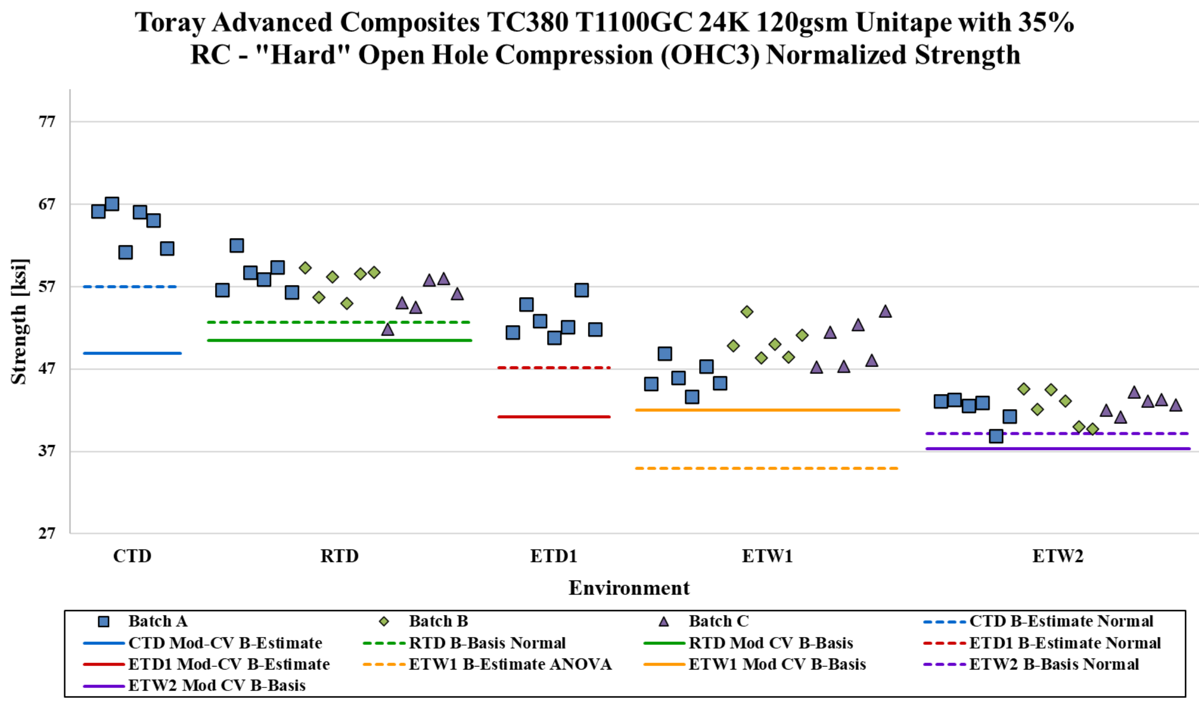

Figure 4-14: Batch Plot for OHC3 Normalized Strength

OHC3 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	64.57	57.23	52.95	48.83	42.37	63.89	56.29	52.73	47.57	40.92
Stdev	2.489	2.308	2.081	2.961	1.620	2.524	2.615	1.631	2.876	1.562
CV	3.855	4.033	3.930	6.065	3.824	3.951	4.646	3.092	6.046	3.817
Mod CV	8.000	6.017	8.000	7.032	6.000	8.000	6.323	8.000	7.023	6.000
Min	61.23	51.89	50.83	43.65	38.88	60.74	52.11	50.74	42.34	38.32
Max	67.11	62.01	56.64	54.05	44.59	66.75	60.99	55.01	53.93	43.13
No. Batches	1	3	1	3	3	1	3	1	3	3
No. Spec.	6	18	7	18	18	6	18	7	18	18
Basis Values and Estimates										
B-Basis Value		52.67			39.17				41.89	37.84
B-Estimate	57.03		47.17	34.95		56.24	44.94	48.20		
A-Estimate	51.67	49.44	43.11	25.05	36.90	50.80	36.85	45.02	37.87	35.65
Method	Normal	Normal	Normal	ANOVA	Normal	Normal	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates										
B-Basis Value		50.43		42.05	37.35		49.26		40.97	36.07
B-Estimate	48.93		41.19			48.40		41.02		
A-Estimate	37.80	45.61	32.91	37.24	33.79	37.40	44.28	32.78	36.30	32.64
Method	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-19: Statistics and Basis Values for OHC3 Strength Data

4.14 "25/50/25" Unnotched Tension (UNT1)

The UNT1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTA, RTD, ETW1, and ETW2.

For the normalized dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The RTD and ETW1 conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD, RTD, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The ETW1 condition failed all the distributions tests, therefore the non-parametric method was used for that condition. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were two statistical outliers. The highest value in batch B of the RTD condition was a batch outlier in the normalized dataset. The highest value in batch A of the ETW1 condition was a batch outlier in the as-measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UNT1 strength data in Table 4-20 and for the modulus data in Table 4-21. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-15.

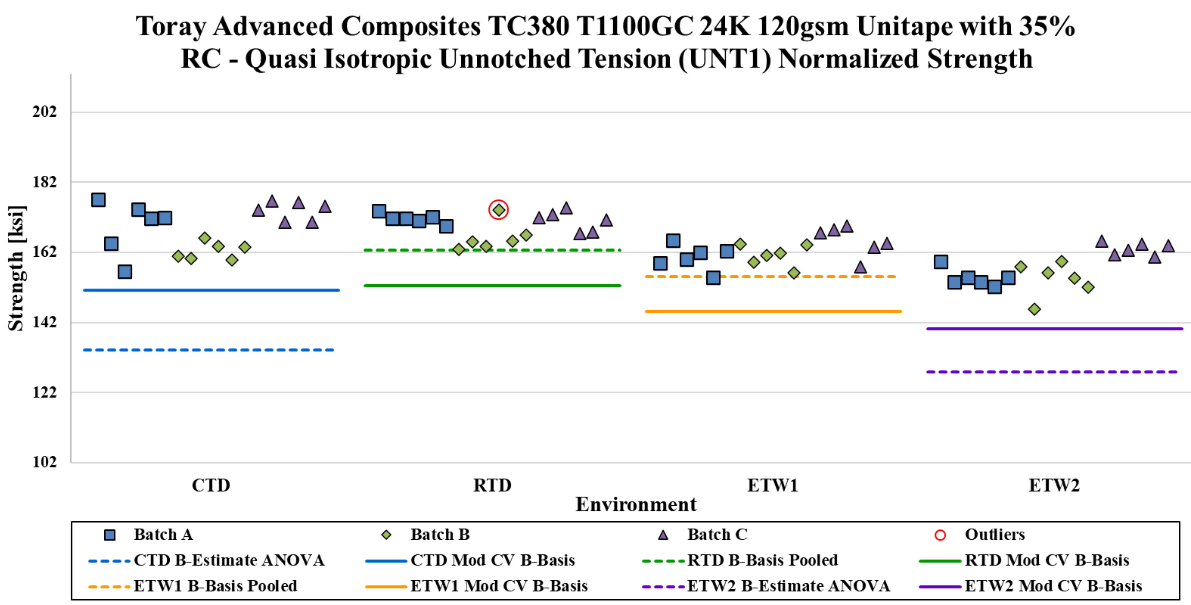

Figure 4-15: Batch Plot for UNT1 Normalized Strength

UNT1 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	168.5	169.7	162.3	157.4	166.1	169.6	164.8	152.6
Stdev	6.630	3.725	4.093	5.156	6.963	6.742	4.927	5.557
CV	3.934	2.196	2.522	3.277	4.192	3.974	2.990	3.640
Mod CV	6.000	6.000	6.000	6.000	6.096	6.000	6.000	6.000
Min	156.7	162.9	154.8	145.9	156.6	160.0	157.3	138.6
Max	177.0	174.8	169.6	165.1	182.4	183.6	176.6	161.5
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		162.5	155.2				155.2	
B-Estimate	134.2			127.9	126.4	131.7		120.8
A-Estimate	109.7	157.7	150.3	107.0	98.14	104.6	132.3	98.05
Method	ANOVA	Pooled	Pooled	ANOVA	ANOVA	ANOVA	Non-Parm.	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value	151.3	152.4	145.1	140.1	148.9	152.5	147.6	135.5
A-Estimate	139.9	141.1	133.7	128.8	137.6	141.1	136.3	124.1
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-20: Statistics and Basis Values for UNT1 Strength Data

UNT1 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	8.600	8.254	8.299	8.128	8.481	8.254	8.426	7.888
Stdev	0.1685	0.1655	0.08121	0.1276	0.3449	0.3565	0.2256	0.2991
CV	1.959	2.005	0.9786	1.570	4.067	4.319	2.677	3.792
Min	8.316	7.937	8.162	7.949	8.053	7.723	8.071	7.518
Max	8.926	8.599	8.474	8.329	9.198	9.079	8.806	8.421
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18

Table 4-21: Statistics for UNT1 Modulus Data

4.15 “10/80/10” Unnotched Tension (UNT2)

The UNT2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, all the conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for all conditions. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD, ETW1 and ETW2 conditions failed the ADK test. ANOVA was used to compute estimates for these conditions. The normal method was used for RTD. Applying the modified CV, there were no diagnostic test failures therefore all the conditions were pooled.

There were two statistical outliers. The lowest value in batch A of the RTD condition was a batch outlier in the normalized dataset. The lowest value in batch B of the RTD condition was a batch and condition outlier in the normalized dataset. They were retained for this analysis,

Statistics, basis values and estimates are given for the UNT2 strength data in Table 4-22 and for the modulus data in Table 4-23. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-16.

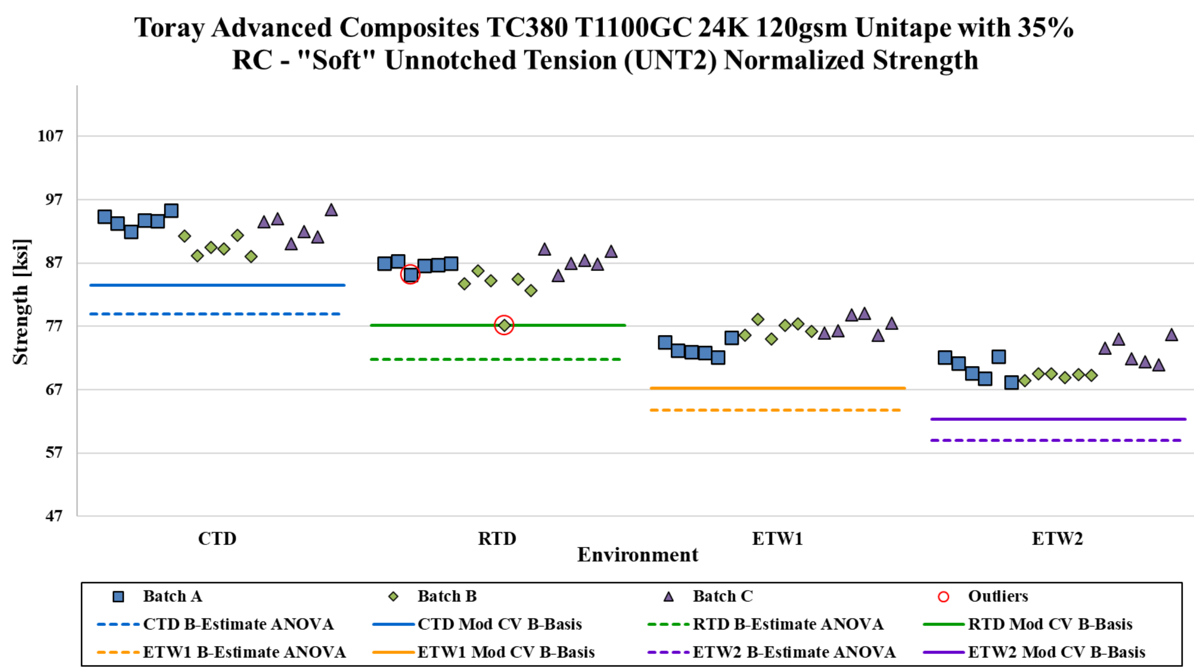

Figure 4-16: Batch Plot for UNT2 Normalized Strength

UNT2 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	92.00	85.68	75.76	70.87	91.53	88.03	77.54	69.14
Stdev	2.347	2.728	2.060	2.215	3.833	3.400	1.958	2.785
CV	2.551	3.184	2.719	3.125	4.187	3.862	2.525	4.028
Mod CV	6.000	6.000	6.000	6.000	6.094	6.000	6.000	6.014
Min	88.00	77.16	72.14	68.14	86.72	81.96	74.38	65.55
Max	95.41	89.21	79.07	75.67	97.82	95.43	81.48	73.90
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						81.32		
B-Estimate	78.95	71.79	63.81	58.98	66.41		67.58	52.49
A-Estimate	69.64	61.89	55.28	50.49	48.48	76.56	60.48	40.61
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value	83.47	77.15	67.23	62.34	82.89	79.39	68.90	60.50
A-Estimate	77.84	71.52	61.60	56.71	77.20	73.70	63.21	54.81
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-22: Statistics and Basis Values for UNT2 Strength Data

UNT2 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	5.349	4.933	4.699	4.480	5.322	5.070	4.811	4.371
Stdev	0.1216	0.1264	0.05543	0.1131	0.2163	0.2241	0.1258	0.1675
CV	2.274	2.562	1.180	2.524	4.064	4.420	2.615	3.832
Min	5.188	4.710	4.572	4.306	5.025	4.667	4.594	4.146
Max	5.581	5.192	4.762	4.685	5.696	5.508	4.966	4.734
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18

Table 4-23: Statistics for UNT2 Modulus Data

4.16 “50/40/10” Unnotched Tension (UNT3)

The UNT3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The CTD and RTD conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The RTD and ETW1 conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were three statistical outliers. The lowest value in batch B of the RTD condition was a condition outlier in the normalized dataset. The lowest value in batch B of the ETW1 condition was a condition outlier in the normalized dataset. The highest value in batch C of the RTD condition was a batch outlier in the as-measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UNT3 strength data in Table 4-24 and for the modulus data in Table 4-25. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-17.

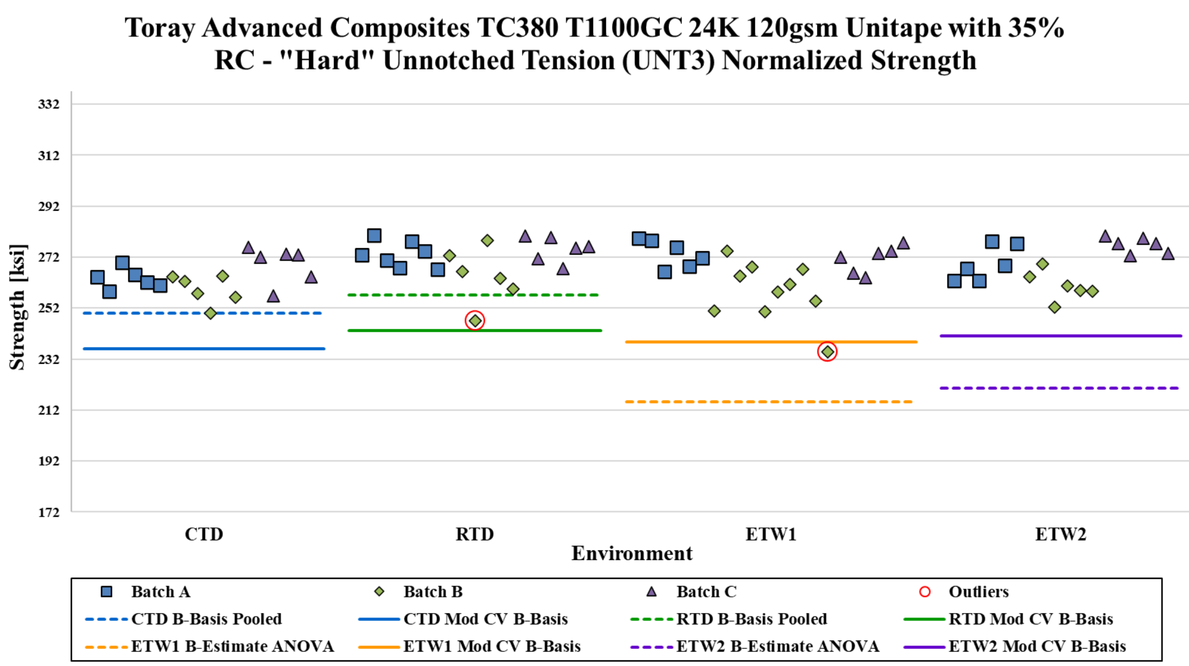

Figure 4-17: Batch Plot for UNT3 Normalized Strength

UNT3 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	264.0	271.1	266.0	269.0	261.2	275.1	267.2	260.9
Stdev	6.872	8.348	10.89	8.479	8.056	12.51	15.73	9.330
CV	2.603	3.079	4.094	3.152	3.084	4.549	5.887	3.576
Mod CV	6.000	6.000	6.047	6.000	6.000	6.275	6.944	6.000
Min	249.9	247.0	234.9	252.5	243.4	246.7	224.8	241.2
Max	275.9	280.6	279.5	280.3	273.8	295.4	292.5	274.0
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	19	22	18	18	19	22	18
Basis Values and Estimates								
B-Basis Value	250.0	257.2				249.4	241.9	
B-Estimate			215.3	220.7	226.5			200.5
A-Estimate	240.6	247.7	179.1	186.2	201.8	231.9	224.3	157.3
Method	Pooled	Pooled	ANOVA	ANOVA	ANOVA	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value	236.0	243.2	238.6	241.0	231.7	245.8	238.3	231.5
A-Estimate	217.6	224.8	220.1	222.6	212.3	226.4	218.9	212.1
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-24: Statistics and Basis Values for UNT3 Strength Data

UNT3 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	13.62	13.14	13.36	13.59	13.48	13.34	13.40	13.18
Stdev	0.2637	0.3809	0.6136	0.6255	0.3997	0.5422	0.7240	0.5740
CV	1.936	2.898	4.592	4.603	2.965	4.065	5.401	4.356
Min	13.10	12.41	12.70	12.93	12.93	12.16	12.15	12.44
Max	13.96	13.79	15.14	15.51	14.21	14.23	15.34	14.84
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	19	20	18	18	19	20	18

Table 4-25: Statistics for UNT3 Modulus Data

4.17 "25/50/25" Unnotched Compression (UNC1)

The UNC1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The ETW1 condition failed all the distributions tests, therefore the non-parametric method was used for that condition. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1. Applying the modified CV, the ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1 and ETW1.

For the as-measured dataset, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1. Applying the modified CV, the ETW21 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETD1 and ETW2.

There was one statistical outlier. The lowest value in batch B of the ETW2 condition was a batch outlier in the normalized dataset. It was retained for this analysis,

Statistics, basis values and estimates are given for the UNC1 strength data in Table 4-26 and for the modulus data in Table 4-27. The normalized data and B-basis values are shown graphically in Figure 4-18.

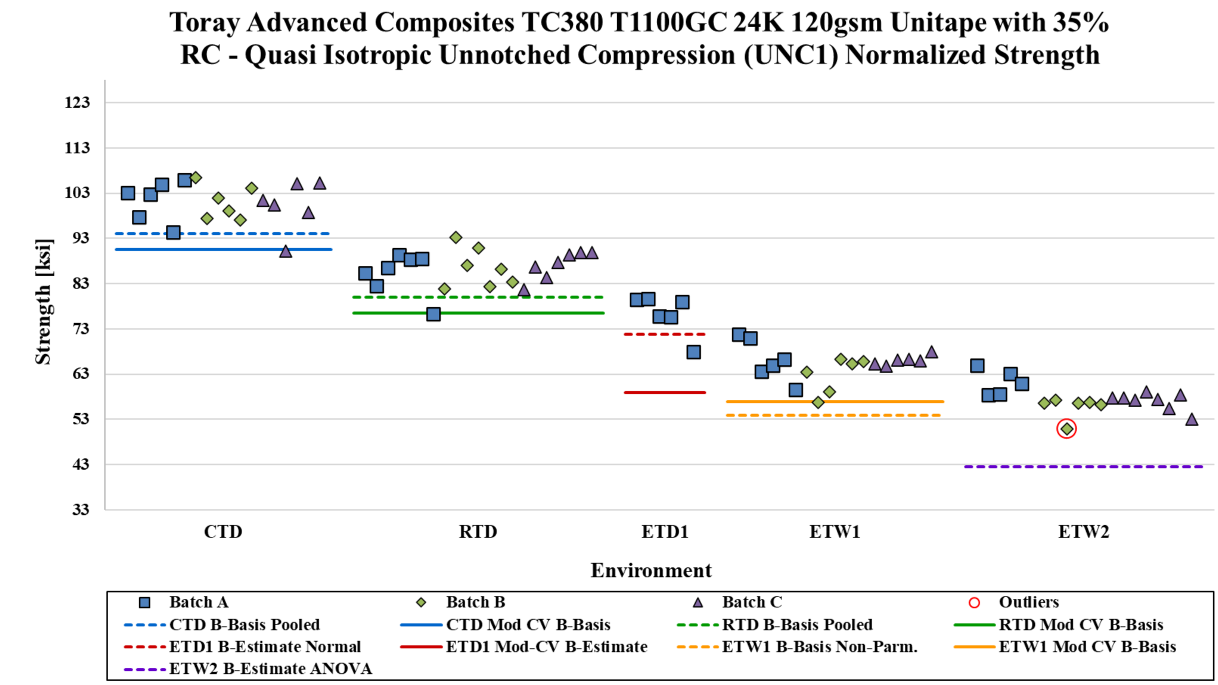

Figure 4-18: Batch Plot for UNC1 Normalized Strength

UNC1 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	100.9	86.75	77.70	65.48	57.80	100.6	89.70	78.42	64.97	58.99
Stdev	4.412	3.208	1.919	3.529	3.050	4.250	4.458	1.878	4.944	3.303
CV	4.372	3.698	2.470	5.389	5.277	4.226	4.970	2.395	7.611	5.598
Mod CV	6.186	6.000	8.000	6.695	6.638	6.113	6.485	8.000	7.805	6.799
Min	90.18	81.77	75.66	56.74	50.88	92.45	78.67	76.61	54.40	53.58
Max	106.5	93.29	79.75	71.87	64.90	107.2	98.90	80.40	74.08	65.94
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	18	21	6	18	20	18	21	6	18	20
Basis Values and Estimates										
B-Basis Value	94.04	79.95		53.83		92.67	81.91			
B-Estimate			71.88		42.46			72.73	39.55	42.80
A-Estimate	89.37	75.26	67.75	39.83	31.52	87.33	76.54	68.69	21.42	31.25
Method	Pooled	Pooled	Normal	Non-Parm.	ANOVA	Pooled	Pooled	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	90.61	76.57		56.83	NA	89.76	79.04		NA	51.27
B-Estimate			58.87					59.42		
A-Estimate	83.62	69.54	45.48	50.70		82.45	71.69	45.91		45.77
Method	Pooled	Pooled	Normal	Normal		Pooled	Pooled	Normal		Normal

Table 4-26: Statistics and Basis Values for UNC1 Strength Data

UNC1 Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	8.047	7.882	7.878	7.545	7.446	8.021	8.191	7.952	7.488	7.579
Stdev	0.2333	0.1476	0.1826	0.2973	0.2890	0.3063	0.2689	0.1869	0.5359	0.2947
CV	2.900	1.873	2.318	3.940	3.882	3.818	3.283	2.351	7.157	3.888
Min	7.635	7.603	7.645	6.974	6.942	7.440	7.715	7.688	6.687	7.094
Max	8.516	8.099	8.185	8.071	8.017	8.568	8.547	8.252	8.466	8.124
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	18	18	6	18	18	18	18	6	18	18

Table 4-27: Statistics for UNC1 Modulus Data

4.18 “10/80/10” Unnotched Compression (UNC2)

The UNC2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

The results were identical for the normalized and as-measured datasets, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for the remaining conditions. Applying the modified CV, the ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for the remaining conditions.

There were three statistical outlies. The lowest value in batch C of the CTD condition was a batch and condition outlier in the normalized and as-measured datasets. The lowest value in batch C of the RTD condition was a batch outlier in the normalized dataset. The highest value in batch C of the ETW2 condition was a batch outlier in the normalized dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UNC2 strength data in Table 4-28 and for the modulus data in Table 4-29. The normalized data and B-basis values are shown graphically in Figure 4-19.

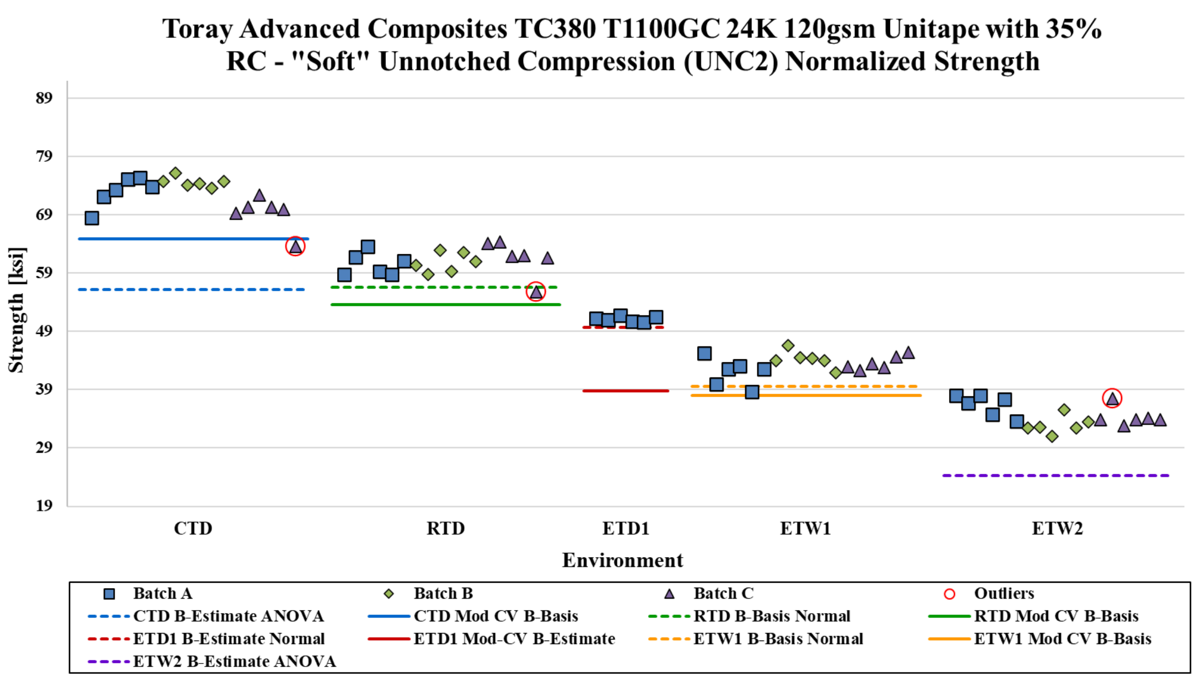

Figure 4-19: Batch Plot for UNC2 Normalized Strength

UNC2 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	72.30	60.99	51.13	43.29	34.55	71.28	63.93	51.74	42.95	34.97
Stdev	3.162	2.217	0.4603	1.903	2.151	3.520	2.455	0.5514	1.996	2.296
CV	4.373	3.635	0.9003	4.397	6.226	4.938	3.841	1.066	4.647	6.567
Mod CV	6.187	6.000	8.000	6.199	7.113	6.469	6.000	8.000	6.324	7.284
Min	63.61	55.78	50.57	38.67	31.07	61.25	58.46	51.00	39.31	31.61
Max	76.17	64.31	51.73	46.60	38.06	76.18	69.12	52.33	47.49	39.18
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	18	18	6	18	18	18	18	6	18	18
Basis Values and Estimates										
B-Basis Value		56.61		39.53			59.08		39.01	
B-Estimate	56.13		49.73		24.27	52.00		50.07		21.81
A-Estimate	44.60	53.51	48.74	36.86	16.93	38.25	55.65	48.88	36.21	12.43
Method	ANOVA	Normal	Normal	Normal	ANOVA	ANOVA	Normal	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	64.86	53.54		37.99	NA	63.56	56.20		37.59	NA
B-Estimate			38.74					39.20		
A-Estimate	59.80	48.48	29.93	34.23		58.30	50.95	30.29	33.79	
Method	Pooled	Pooled	Normal	Normal		Pooled	Pooled	Normal	Normal	

Table 4-28: Statistics and Basis Values for UNC2 Strength Data

UNC2 Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	5.125	4.865	4.683	4.411	4.216	5.055	5.101	4.740	4.383	4.267
Stdev	0.1326	0.1060	0.07516	0.1340	0.1716	0.2164	0.1576	0.07971	0.2723	0.2054
CV	2.588	2.179	1.605	3.038	4.071	4.282	3.090	1.682	6.213	4.815
Min	4.881	4.642	4.561	4.106	3.913	4.743	4.882	4.600	3.916	4.011
Max	5.305	5.004	4.759	4.580	4.460	5.417	5.370	4.828	4.778	4.630
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	18	18	6	18	18	18	18	6	18	18

Table 4-29: Statistics for UNC2 Modulus Data

4.19 "50/40/10" Unnotched Compression (UNC3)

The UNC3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with ten specimens, therefore only estimates were computed for that condition.

The results are identical for the normalized and as-measured datasets. The ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The A-estimate for ETW2 was set to zero because their results were negative. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for the remaining conditions. Applying the modified CV, the ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for the remaining conditions. The ETW1 condition has an original CV that is greater than 8%, therefore no modifications were made and the modified CV results are the same as those of the original CV. The batch plot below only shows the modified CV line for ETW1.

There was one statistical outlier. The highest value in batch C of the ETW2 condition was a batch outlier in the normalized dataset. It was retained for this analysis,

Statistics, basis values and estimates are given for the UNC3 strength data in Table 4-30 and for the modulus data in Table 4-31. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-20.

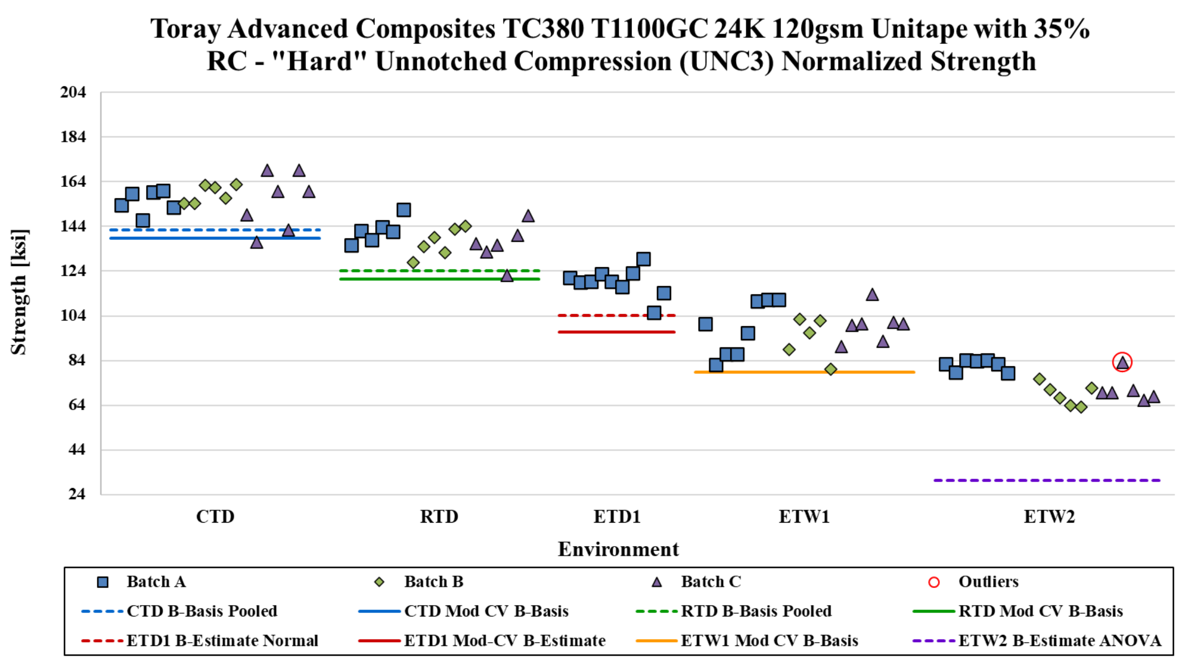

Figure 4-20: Batch Plot for UNC3 Normalized Strength

UNC3 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	156.3	138.3	119.1	97.71	73.87	154.8	142.4	119.4	97.46	75.28
Stdev	8.243	7.100	6.302	9.773	7.388	7.669	5.945	6.119	10.29	7.269
CV	5.273	5.133	5.289	10.00	10.00	4.955	4.174	5.124	10.56	9.656
Mod CV	6.637	6.567	8.000	10.00	10.00	6.478	6.087	8.000	10.56	9.656
Min	136.9	122.2	105.4	80.21	63.16	135.2	129.5	105.8	80.21	65.94
Max	169.2	151.5	129.5	113.8	84.20	166.6	154.4	129.3	113.4	87.32
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	19	18	10	20	21	19	18	10	20	21
Basis Values and Estimates										
B-Basis Value	142.4	124.3		78.88		142.3	129.9		77.64	
B-Estimate			104.2		30.33			104.9		28.20
A-Estimate	132.8	114.8	93.84	65.49	0.000	133.8	121.4	94.84	63.54	0.000
Method	Pooled	Pooled	Normal	Normal	ANOVA	Pooled	Pooled	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates										
B-Basis Value	138.7	120.6		78.88	NA	137.8	125.4		77.64	NA
B-Estimate			96.61					96.82		
A-Estimate	126.6	108.5	80.86	65.49		126.2	113.8	81.04	63.54	
Method	Pooled	Pooled	Normal	Normal		Pooled	Pooled	Normal	Normal	

Table 4-30: Statistics and Basis Values for UNC3 Strength Data

UNC3 Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	12.57	12.41	12.46	11.98	12.06	12.46	12.97	12.50	11.90	12.27
Stdev	0.3739	0.3335	0.2350	0.5753	0.4411	0.4595	0.4891	0.2553	0.7624	0.6036
CV	2.974	2.687	1.885	4.801	3.658	3.687	3.770	2.043	6.407	4.920
Min	11.85	11.85	12.19	10.86	11.44	11.47	11.92	12.24	10.47	11.54
Max	13.30	13.13	12.90	12.96	12.88	13.24	13.91	13.03	13.21	13.35
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Spec.	18	19	9	20	18	18	19	9	20	18

Table 4-31: Statistics for UNC3 Modulus Data

4.20 "25/50/25" Filled-Hole Tension (FHT1)

The FHT1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For both the normalized dataset, the CTD, RTD, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for ETW1. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used for these conditions. The remaining conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were no statistical outliers.

Statistics, basis values and estimates are given for the FHT1 strength data in Table 4-32. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-21.

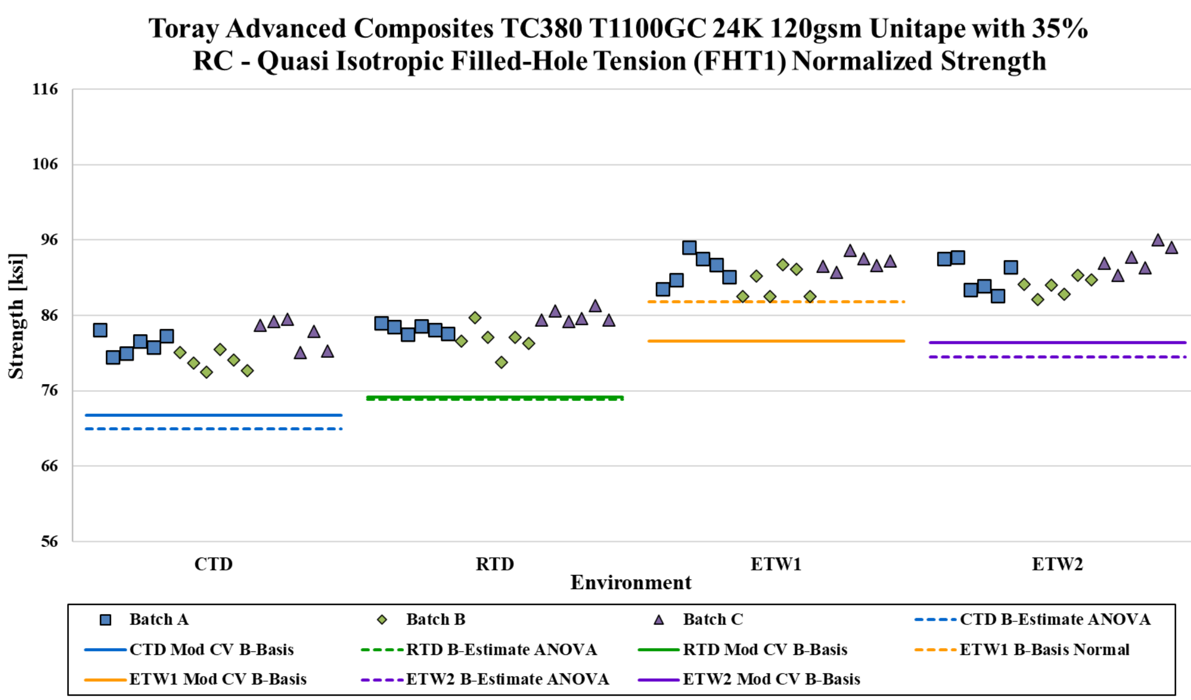

Figure 4-21: Batch Plot for FHT1 Normalized Strength

FHT1 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	81.91	84.29	91.79	91.56	79.72	82.78	90.63	89.52
Stdev	2.139	1.772	2.030	2.302	3.396	3.407	4.345	3.086
CV	2.611	2.102	2.212	2.514	4.260	4.116	4.795	3.448
Mod CV	6.000	6.000	6.000	6.000	6.130	6.058	6.397	6.000
Min	78.46	79.74	88.48	88.09	73.56	76.27	82.59	84.68
Max	85.46	87.27	95.05	96.07	84.75	88.16	96.08	94.73
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			87.78			75.66	83.51	
B-Estimate	70.93	74.90		80.52	57.84			70.87
A-Estimate	63.10	68.20	84.94	72.66	42.23	70.83	78.68	57.55
Method	ANOVA	ANOVA	Normal	ANOVA	ANOVA	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value	72.75	75.13	82.63	82.39	70.50	73.56	81.41	80.31
A-Estimate	66.71	69.09	76.59	76.35	64.43	67.49	75.34	74.24
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-32: Statistics and Basis Values for FHT1 Strength Data

4.21 “10/80/10” Filled-Hole Tension (FHT2)

The FHT2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, the RTD and ETW1 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The CTD condition failed the normality test, but the Weibull distribution was a fit for the dataset. The normal method was used for ETW2. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The remaining conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were two statistical outliers. The highest value in batch A of the CTD condition was a batch outlier in the as-measured dataset. The highest value in batch A of the ETW2 condition was a batch outlier in the as-measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the FHT2 strength data in Table 4-33. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-22.

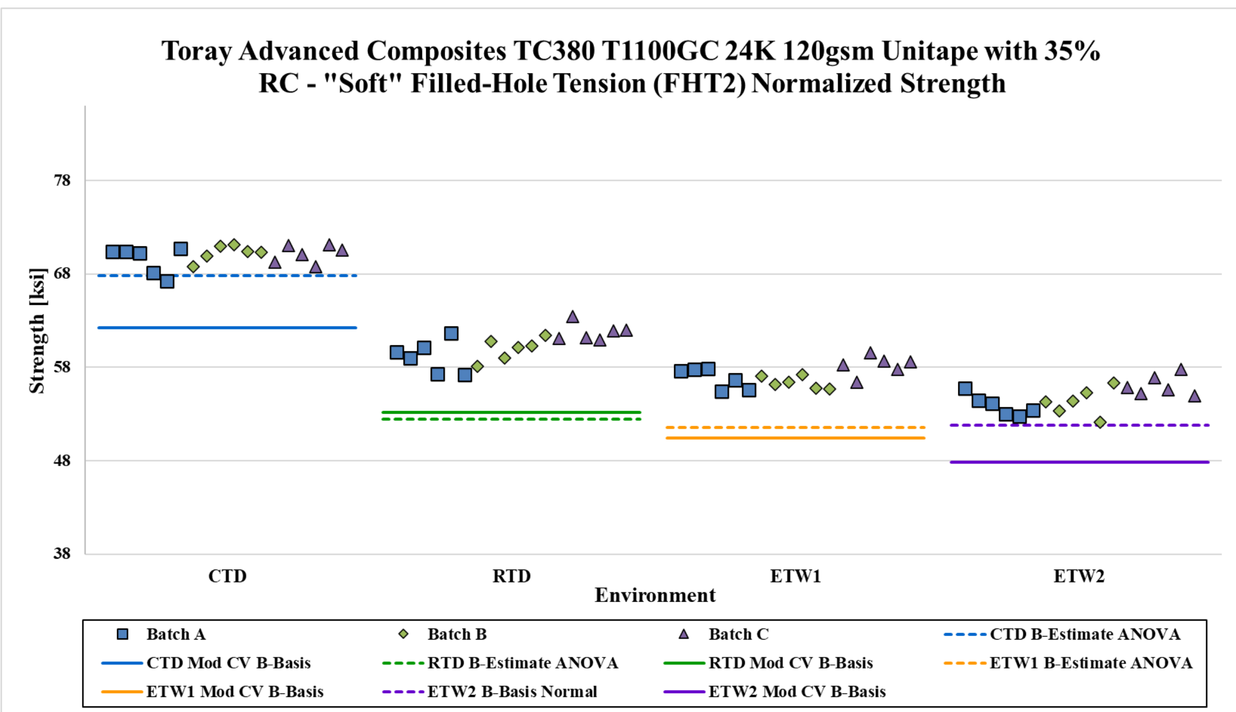

Figure 4-22: Batch plot for FHT2 Normalized Strength

FHT2 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	69.97	60.28	57.14	54.75	68.50	59.45	56.72	54.07
Stdev	1.097	1.685	1.204	1.505	1.771	1.853	1.836	1.570
CV	1.567	2.795	2.107	2.749	2.586	3.116	3.237	2.904
Mod CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
Min	67.24	57.19	55.41	52.08	65.98	55.69	53.70	50.64
Max	71.12	63.44	59.55	57.79	73.03	62.58	59.65	56.65
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	67.84			51.78		56.09	53.36	
B-Estimate		52.40	51.57		58.41			45.56
A-Estimate	65.42	46.79	47.61	49.67	51.22	53.81	51.08	39.49
Method	Weibull	ANOVA	ANOVA	Normal	ANOVA	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value	63.60	53.91	50.77	48.38	62.22	53.17	50.45	47.79
A-Estimate	59.41	49.71	46.57	44.18	58.08	49.04	46.31	43.66
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-33: Statistics and Basis Values for FHT2 Strength Data

4.22 "50/40/10" Filled-Hole Tension (FHT3)

The FHT3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The results are identical for the normalized and as-measured datasets. The ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The remaining conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures , therefore all the conditions were pooled.

There were no statistical outliers.

Statistics, basis values and estimates are given for the FHT3 strength data in Table 4-34. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-23.

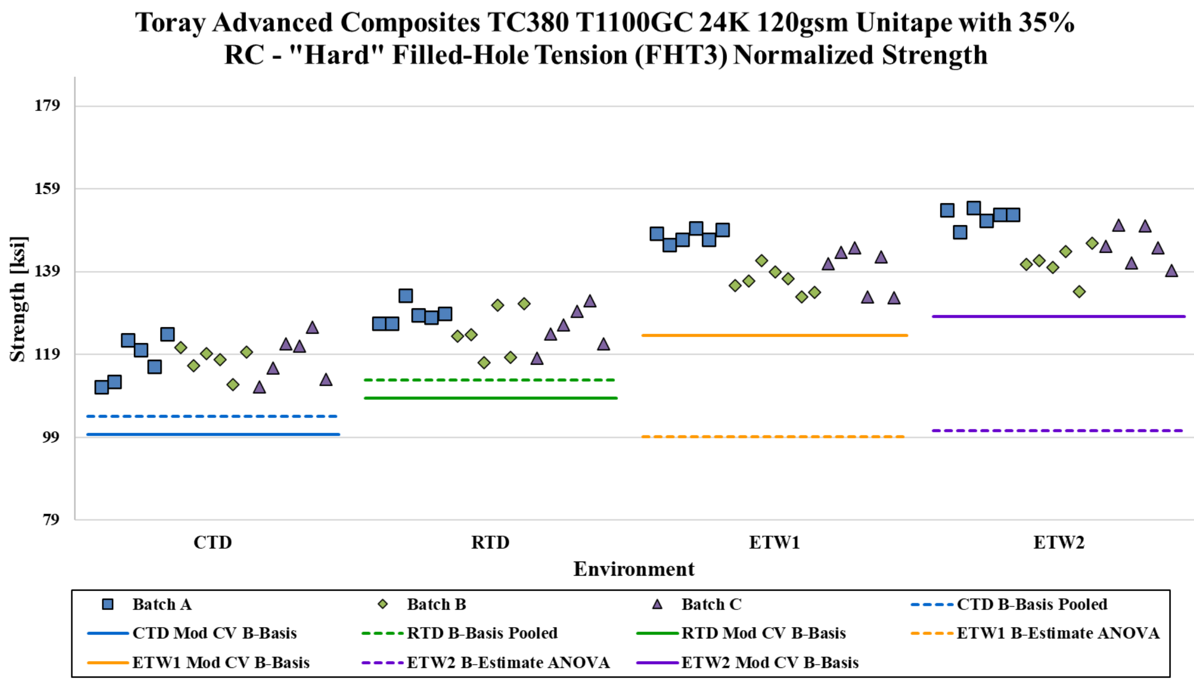

Figure 4-23: Batch plot for FHT3 Normalized Strength

FHT3 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	117.8	126.0	141.1	146.2	114.5	123.1	138.3	143.0
Stdev	4.546	4.895	5.838	5.893	4.716	6.503	7.613	6.721
CV	3.860	3.885	4.137	4.032	4.119	5.281	5.506	4.700
Mod CV	6.000	6.000	6.069	6.016	6.059	6.641	6.753	6.350
Min	111.2	117.0	132.7	134.3	106.9	109.8	126.1	131.5
Max	125.6	133.4	149.5	154.4	122.8	133.0	149.5	152.8
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	19	18	18	18	19	18
Basis Values and Estimates								
B-Basis Value	109.2	117.4			104.2	112.8		
B-Estimate			107.1	112.0			99.17	100.7
A-Estimate	103.3	111.5	82.82	87.54	97.12	105.7	71.28	70.45
Method	Pooled	Pooled	ANOVA	ANOVA	Pooled	Pooled	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value	103.8	112.0	127.2	132.1	99.77	108.4	123.6	128.3
A-Estimate	94.54	102.8	117.9	122.9	90.06	98.69	113.9	118.6
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-34: Statistics and Basis Values for FHT3 Strength Data

4.23 “25/50/25” Filled-Hole Compression (FHC1)

The FHC1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the results are identical using the original CV and the modified CV, the normal method was used for CTD and the remaining conditions met all the requirements for pooling.

For the as-measured dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for CTD and the remaining conditions met all the requirements for pooling. Applying the modified CV, the ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The normal method was used for CTD and the remaining conditions met all the requirements for pooling.

There were two statistical outliers. The lowest value in batch B of the ETW1 condition was a batch outlier in the normalized dataset. The highest value in batch C of the ETW1 condition was a batch outlier in the as-measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the FHC1 strength data in Table 4-35. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-24.

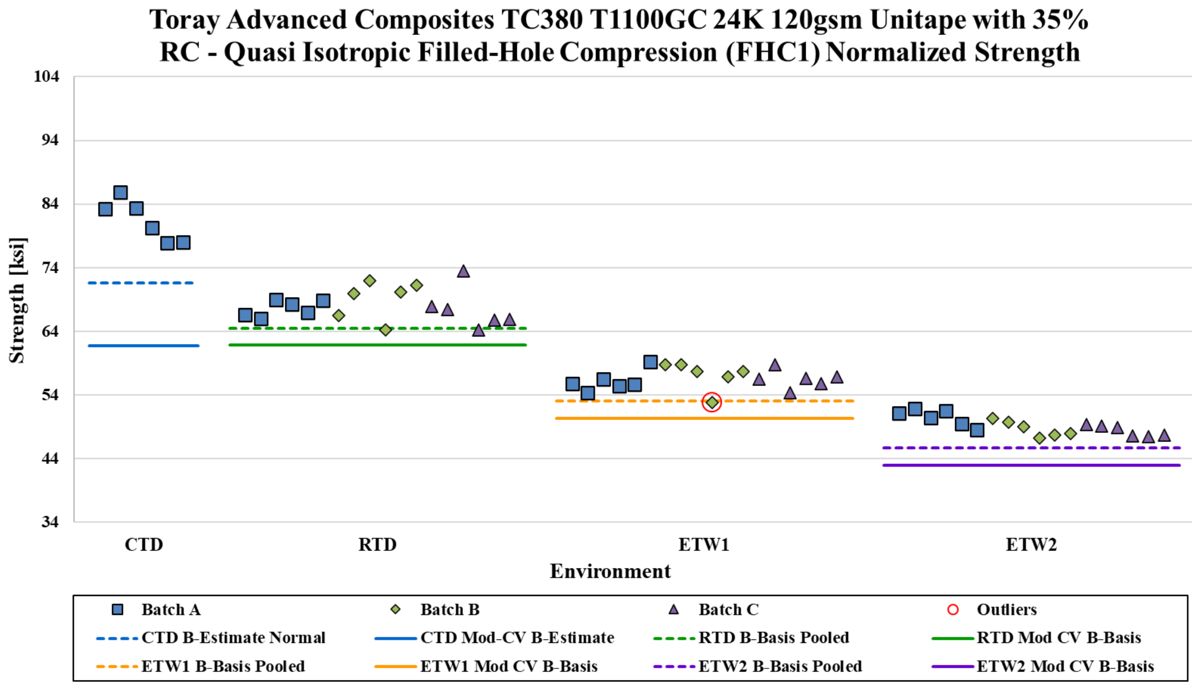

Figure 4-24: Batch plot for FHC1 Normalized Strength

FHC1 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	81.42	68.03	56.58	49.16	81.92	66.91	55.65	47.54
Stdev	3.243	2.586	1.740	1.447	3.020	2.461	2.217	2.378
CV	3.983	3.801	3.075	2.944	3.686	3.678	3.983	5.001
Mod CV	8.000	6.000	6.000	6.000	8.000	6.000	6.000	6.501
Min	77.86	64.26	52.79	47.26	78.62	62.19	50.00	44.84
Max	85.89	73.45	59.23	51.83	86.29	70.25	59.19	51.91
No. Batches	1	3	3	3	1	3	3	3
No. Spec.	6	18	18	18	6	18	18	18
Basis Values and Estimates								
B-Basis Value		64.52	53.07	45.65*		62.65	51.39*	
B-Estimate	71.60				72.78			32.18
A-Estimate	64.61	62.17	50.72	43.30	66.27	59.74	48.48	21.21
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value		61.82	50.37	42.95		60.19	48.93	NA
B-Estimate	61.69				62.07			
A-Estimate	47.66	57.68	46.23	38.81	47.96	55.61	44.35	
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	

* In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design.

Table 4-35: Statistics and Basis Values for FHC1 Strength Data

4.24 “10/80/10” Filled-Hole Compression (FHC2)

The FHC2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design. These values where marked with an asterisk in the summary table below.

The CTD condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for CTD and the remaining conditions met all the requirements for pooling.

For the as-measured dataset, the ETW1 and ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for CTD and the remaining conditions met all the requirements for pooling.

There was one statistical outlier. The highest value in batch A of the ETW2 condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics are given for the FHC2 strength data in Table 4-36. The normalized data are shown graphically in Figure 4-25.

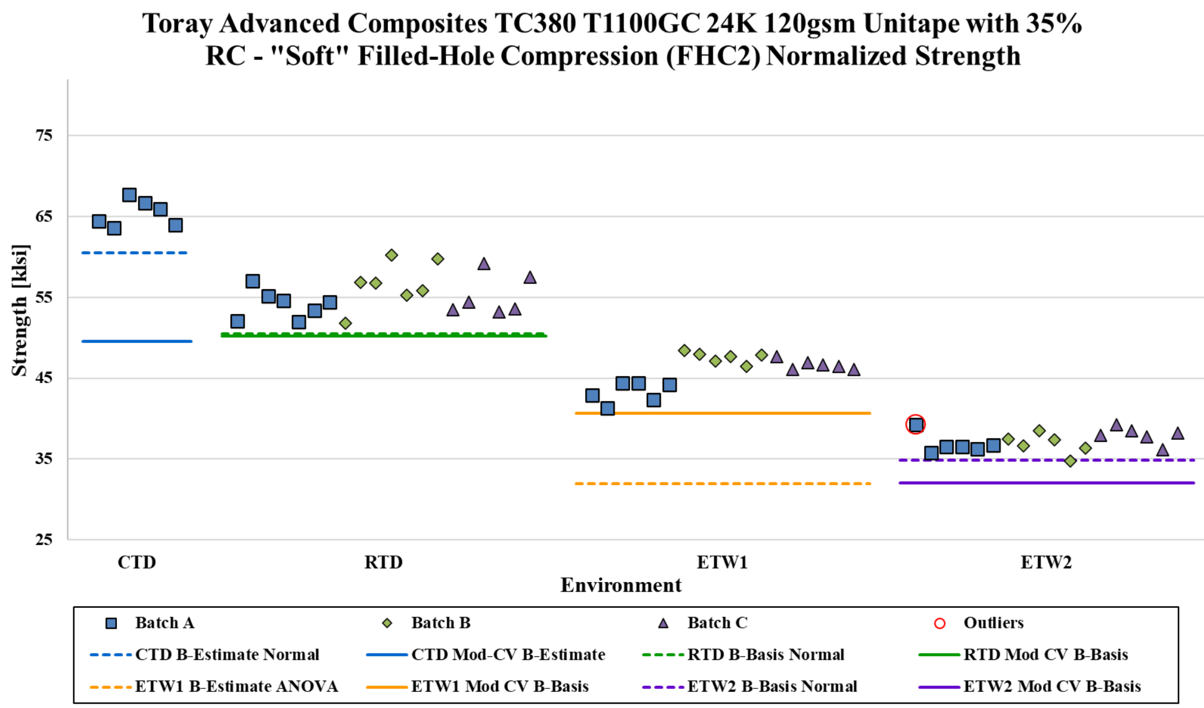

Figure 4-25: Batch plot for FHC2 Normalized Strength

FHC2 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	65.41	55.34	45.84*	37.23*	65.94	54.61	45.23*	36.37*
Stdev	1.621	2.527	2.093	1.225	1.733	1.681	1.692	1.523
CV	2.478	4.567	4.566	3.290	2.628	3.079	3.740	4.187
Mod CV	8.000	6.284	6.283	6.000	8.000	6.000	6.000	6.094
Min	63.63	51.78	41.32	34.77	63.62	51.59	42.00	32.88
Max	67.69	60.21	48.46	39.25	67.82	57.21	48.85	39.36
No. Batches	1	3	3	3	1	3	3	3
No. Spec.	6	20	18	18	6	20	18	18
Basis Values and Estimates								
B-Basis Value		50.47		34.82*		51.37		
B-Estimate	60.50		31.97		60.69		35.82	28.75*
A-Estimate	57.01	47.01	22.07	33.10	56.96	49.07	29.10	23.33
Method	Normal	Normal	ANOVA	Normal	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value		50.21	40.66*	32.05*		49.73	40.30*	31.44
B-Estimate	49.56				49.96			
A-Estimate	38.29	46.75	37.21	28.60	38.60	46.44	37.01	28.15
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	Pooled

* In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design.

Table 4-36: Statistics and Basis Values for FHC2 Strength Data

4.25 “50/40/10” Filled-Hole Compression (FHC3)

The FHC3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design. These values where marked with an asterisk in the summary table below.

The CTD condition consists of a single batch with seven specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the results were identical using the original CV and the modified CV, the normal method was used for CTD and the remaining condition met all the requirements for pooling.

For the as-measured dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was use for CTD and the remaining conditions met all the requirements for pooling. Applying the modified CV, the normal method was used for CTD and the remaining condition met all the requirements for pooling.

There was one statistical outlier. The lowest value in batch A of the ETW2 condition was a batch outlier in the normalized and as-measured datasets. It was retained for this analysis.

Statistics, basis values and estimates are given for the FHC3 strength data in Table 4-37. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-26.

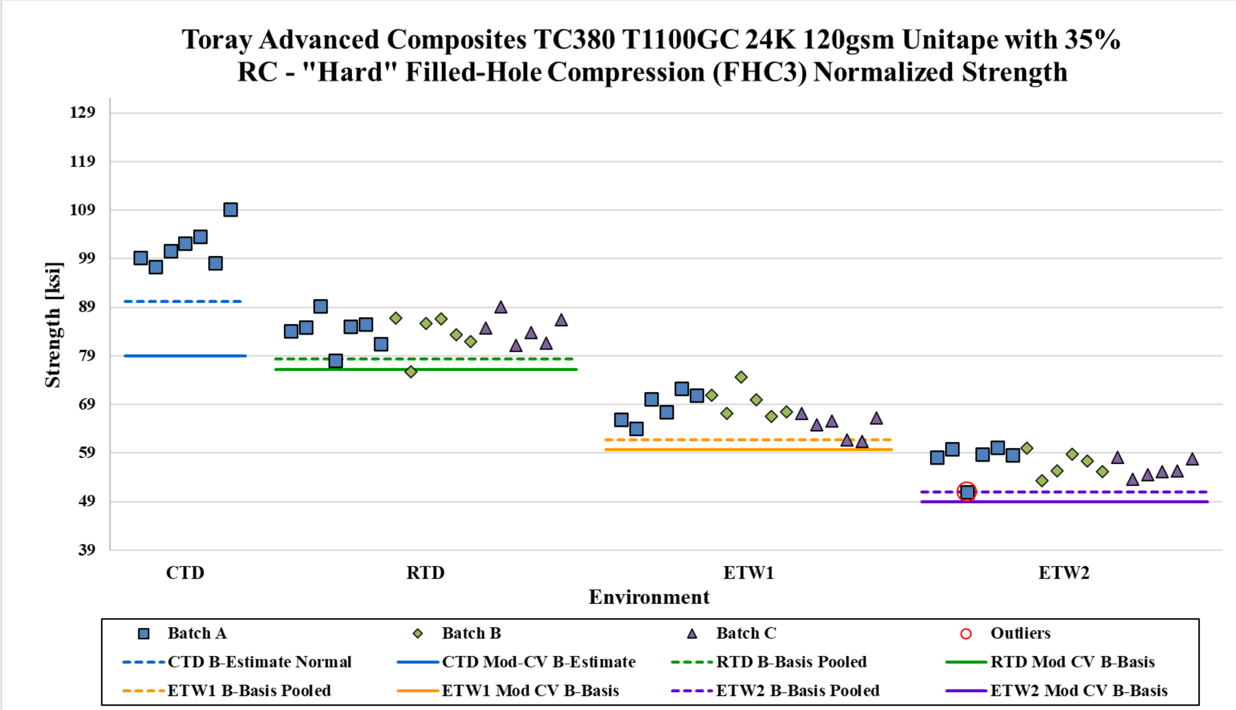

Figure 4-26: Batch Plot for FHC3 Normalized Strength

FHC3 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	101.5	83.98	67.44	56.72	100.8	82.84	66.15	55.08
Stdev	4.072	3.433	3.489	2.634	4.107	4.517	4.025	3.087
CV	4.014	4.088	5.174	4.643	4.073	5.453	6.086	5.605
Mod CV	8.000	6.044	6.587	6.322	8.000	6.727	7.043	6.803
Min	97.29	75.72	61.44	50.95	96.78	73.39	58.76	49.96
Max	109.2	89.26	74.60	60.08	108.6	88.66	74.41	59.84
No. Batches	1	3	3	3	1	3	3	3
No. Spec.	7	19	18	18	7	19	18	18
Basis Values and Estimates								
B-Basis Value		78.33	61.75	51.03*		75.09	58.36	
B-Estimate	90.16				89.42			43.63*
A-Estimate	82.20	74.53	57.96	47.25	81.40	69.79	53.07	35.47
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates								
B-Basis Value		76.20	59.61	48.89		74.50	57.77	46.71
B-Estimate	78.93				78.43			
A-Estimate	63.07	70.98	54.40	43.68	62.67	68.91	52.19	41.12
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	Pooled

* In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational prposes only and is not appropriate for design.

Table 4-37: Statistics and Basis Values for FHC3 Strength Data

4.26 "25/50/25" Single-Shear Bearing Proc. C (SSB1)

The SSB1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. 2% offset strength, ultimate strength and chord stiffness tests were conducted in the following environmental conditions: RTD, ETW1, and ETW2.

For the normalized datasets, for the 2% offset strength dataset, the results were identical using the original CV and the modified CV. There were no diagnostic test failures, therefore all the conditions were pooled. For the ultimate strength dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTD and ETW1 conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured datasets, for the 2% offset strength dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTD and ETW1 conditions met all the requirements for pooling. Applying the modified CV, the ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The remaining conditions met all the requirements for pooling. For the ultimate strength dataset, the results were identical using the original CV and the modified CV. There were no diagnostic test failures, therefore all the conditions were pooled.

There was one statistical outlier. The highest value in batch C of the ETW1 condition was a condition outlier in the normalized ultimate strength dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the SSB1 Proc. C strength data in Table 4-38 and for chord stiffness in Table 4-39. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-27 and Figure 4-28.

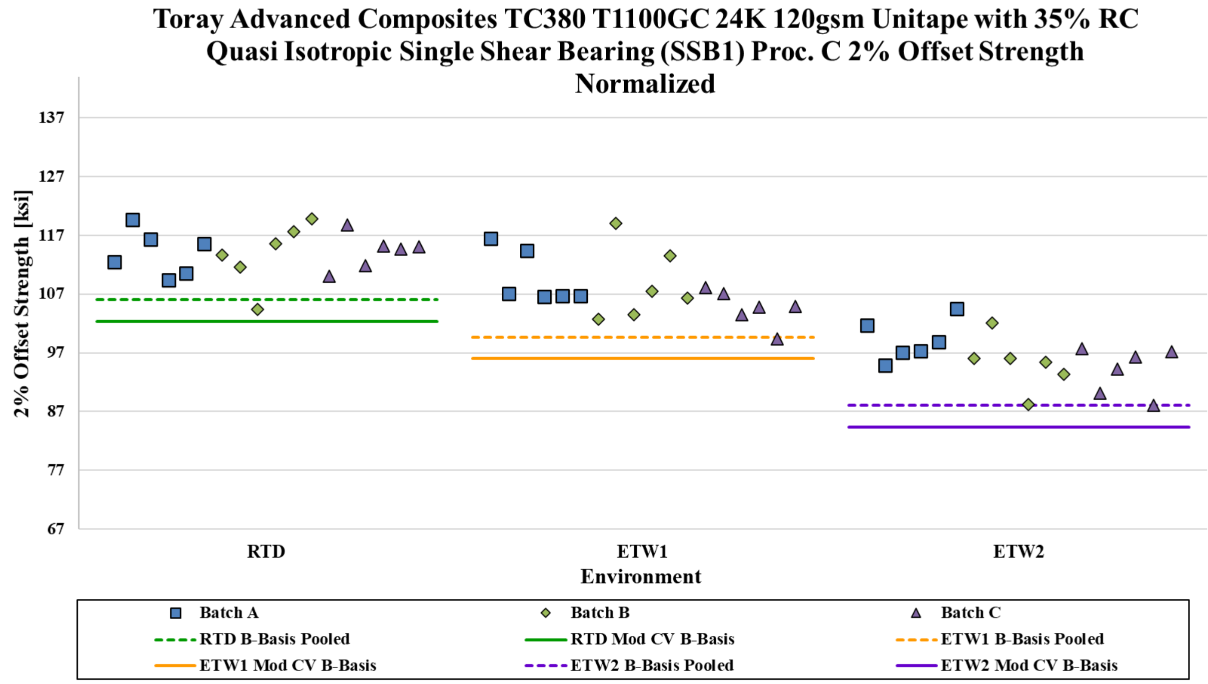

Figure 4-27: Batch Plot for SSB1 Proc. C Normalized 2% Offset Strength

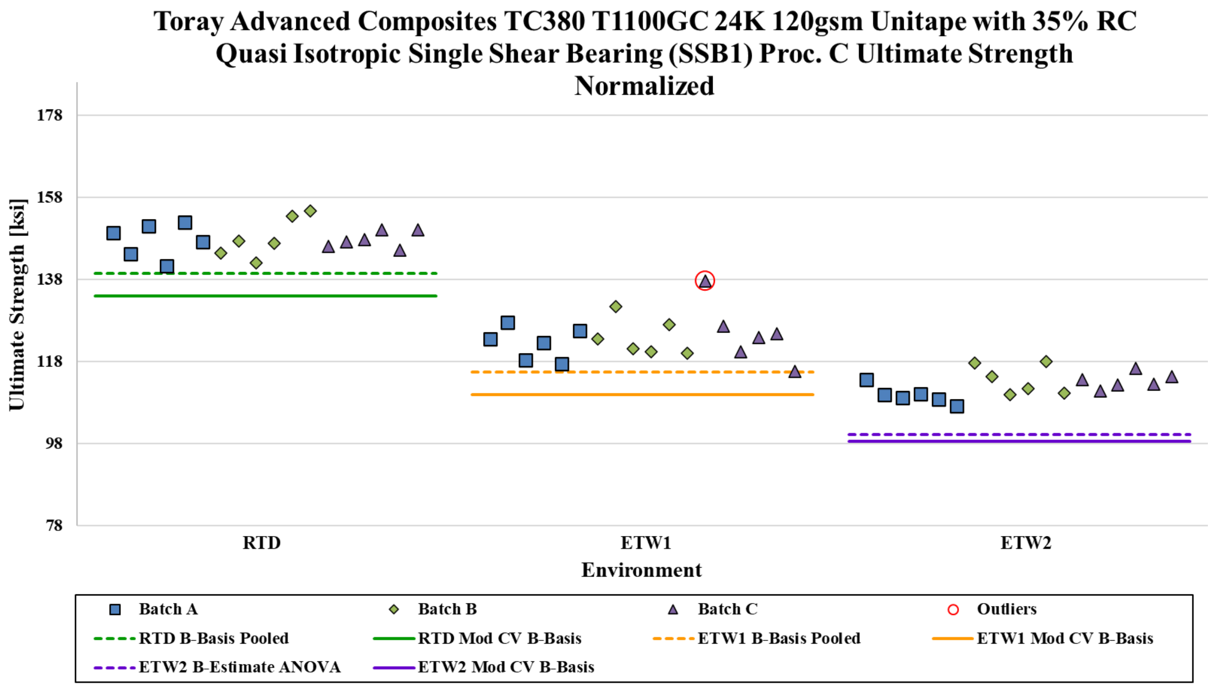

Figure 4-28: Batch Plot for SSB1 Proc. C Normalized Ultimate Strength

SSB1 Proc. C Strength (ksi) Basis Values and Statistics												
	Normalized						As-Measured					
Property	2% Offset Strength			Ultimate Strength			2% Offset Strength			Ultimate Strength		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	114.0	107.7	96.06	147.8	123.8	112.2	118.8	111.9	93.47	154.1	128.6	109.1
Stdev	3.965	5.079	4.390	3.693	5.255	3.054	4.293	5.632	6.053	4.342	4.917	2.671
CV	3.479	4.717	4.569	2.499	4.247	2.721	3.612	5.031	6.475	2.818	3.823	2.448
Mod CV	6.000	6.359	6.285	6.000	6.123	6.000	6.000	6.516	7.238	6.000	6.000	6.000
Min	104.4	99.33	88.04	141.3	115.6	107.2	108.5	100.5	83.51	147.7	120.9	104.8
Max	119.7	119.1	104.5	154.6	137.7	117.9	125.8	124.1	106.2	160.5	139.7	113.4
No. Batches	3	3	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates												
B-Basis Value	106.0	99.70	88.09	139.5	115.5		109.7	102.8		146.9	121.4	101.9
B-Estimate						100.2			60.29			
A-Estimate	100.7	94.38	82.77	133.9	109.9	91.63	103.5	96.62	36.62	142.0	116.6	97.03
Method	Pooled	Pooled	Pooled	Pooled	Pooled	ANOVA	Pooled	Pooled	ANOVA	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates												
B-Basis Value	102.3	96.01	84.40	134.0	110.0	98.47	105.7	98.81	NA	140.1	114.6	95.09
A-Estimate	94.54	88.23	76.62	124.8	100.8	89.29	96.77	89.87		130.7	105.3	85.74
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled		Pooled	Pooled	Pooled

Table 4-38: Statistics and Basis Values for SSB1 Proc. C Strength Data

SSB1 Proc. C Chord Stiffness (Msi) Statistics						
	Normalized			As-Measured		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	1.829	1.721	1.689	1.907	1.789	1.640
Stdev	0.04276	0.1082	0.1195	0.06095	0.1151	0.09349
CV	2.338	6.288	7.075	3.196	6.432	5.700
Min	1.738	1.538	1.465	1.821	1.594	1.463
Max	1.919	1.868	1.892	2.032	1.940	1.817
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-39: Statistics for SSB1 Proc. C Chord Stiffness Data

4.27 “10/80/10” Single-Shear Bearing Proc. C (SSB2)

The SSB2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. 2% offset strength, ultimate strength and stiffness tests were conducted in the following environmental conditions: RTD, ETW1, and ETW2.

For the normalized datasets, the results are identical for both properties using the original CV and the modified CV. There were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured datasets, for the 2% offset strength dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The remaining conditions met all the requirements for pooling. For the ultimate strength dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The ETW1 condition failed all the distributions tests, therefore the non-parametric method was use for that condition. The normal method was used for RTD. Applying the modified CV, the ETW1 condition failed the normality test, therefore modified CV basis values were not computed for that condition. The normal method was used for the remaining conditions.

There were two statistical outliers. The lowest value in batch A of the RTD condition was a batch outlier in the normalized and as-measured 2% offset strength datasets. The highest value in batch B of the ETW2 condition was a batch outlier in the normalized and as-measured 2% offset strength datasets. They were retained for this analysis.

Statistics, basis values and estimates are given for the SSB2 strength data in Table 4-40 and for chord stiffness in Table 4-41. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-29 and Figure 4-30.

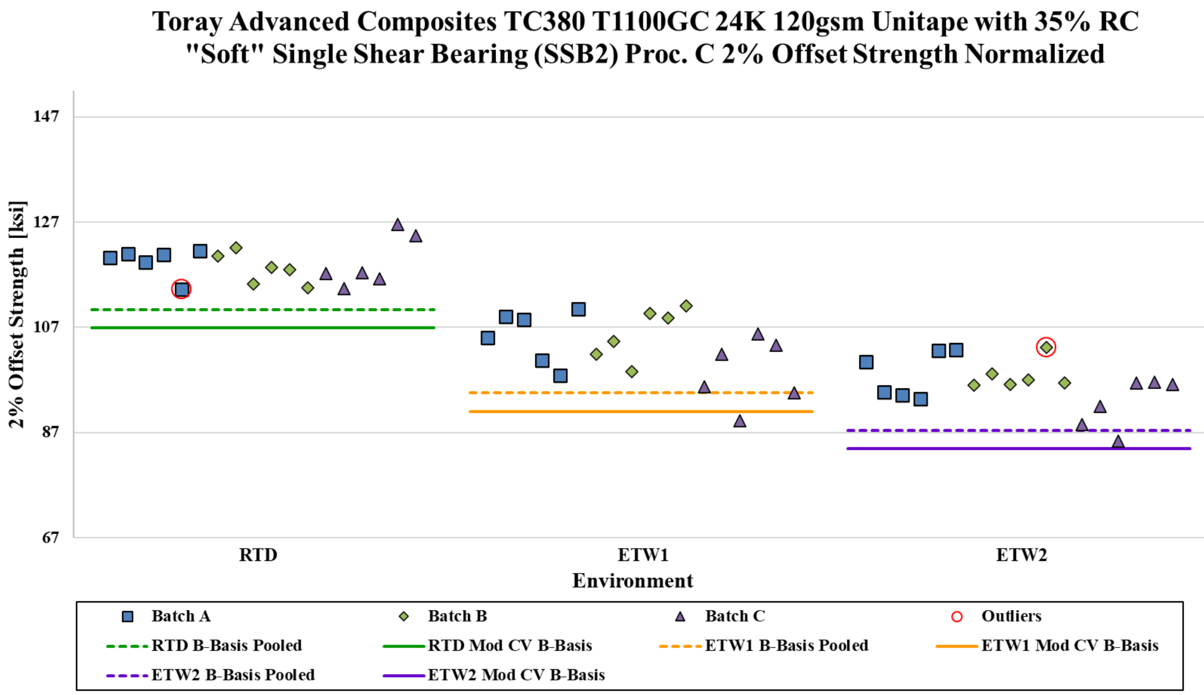

Figure 4-29: Batch Plot for SSB2 Proc. C Normalized 2% Offset Strength

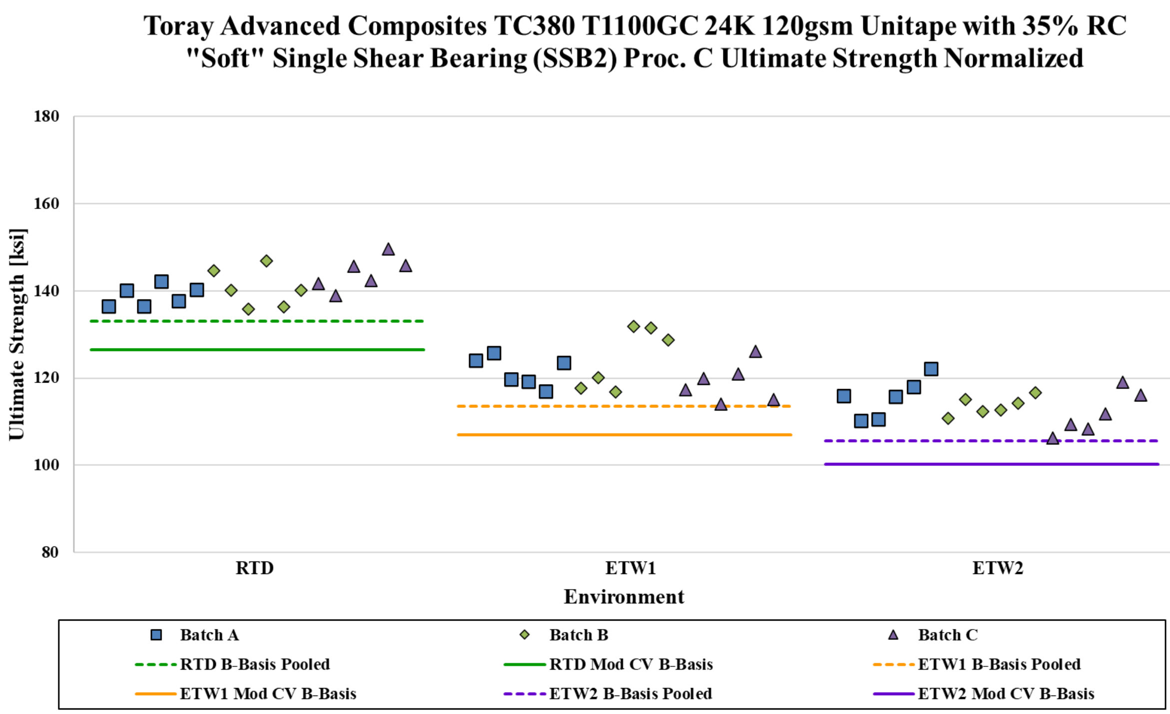

Figure 4-30: Batch Plot for SSB2 Proc. C Normalized Ultimate Strength

SSB2 Proc. C Strength (ksi) Basis Values and Statistics												
	Normalized						As-Measured					
Property	2% Offset Strength			Ultimate Strength			2% Offset Strength			Ultimate Strength		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	119.0	103.1	96.10	141.2	121.7	113.6	123.7	107.3	93.64	146.8	126.6	110.7
Stdev	3.495	6.161	4.630	4.073	5.382	4.104	3.451	6.596	5.636	4.318	5.827	5.522
CV	2.937	5.973	4.818	2.884	4.424	3.612	2.790	6.145	6.018	2.942	4.602	4.988
Mod CV	6.000	6.986	6.409	6.000	6.212	6.000	6.000	7.073	7.009	6.000	6.301	6.494
Min	114.3	89.23	85.32	135.8	114.0	106.2	118.5	95.53	82.06	140.0	119.5	102.8
Max	126.5	111.0	103.2	149.7	131.9	122.1	128.1	118.4	103.1	158.0	137.3	121.9
No. Batches	3	3	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates												
B-Basis Value	110.4	94.49	87.45	133.1	113.6	105.5	116.9	94.32		138.2	115.6	
B-Estimate									61.61			77.87
A-Estimate	104.6	88.72	81.68	127.7	108.2	100.2	112.1	85.09	38.75	132.2	108.5	54.45
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Normal	Normal	ANOVA	Normal	Log Normal	ANOVA
Modified CV Basis Values and Estimates												
B-Basis Value	106.9	91.01	83.97	126.6	107.0	100.2	110.0	93.67		129.4		96.51
A-Estimate	98.78	82.92	75.87	116.6	97.08	90.62	100.7	84.37	NA	117.1	NA	86.45
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Normal	Pooled	Pooled		Normal		Normal

Table 4-40: Statistics and Basis Values for SSB2 Proc. C Strength Data

SSB2 Proc. C Chord Stiffness (Msi) Statistics						
	Normalized			As-Measured		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	1.500	1.397	1.354	1.560	1.454	1.318
Stdev	0.04235	0.07826	0.07305	0.06571	0.08089	0.05566
CV	2.824	5.601	5.393	4.213	5.563	4.222
Min	1.426	1.292	1.253	1.392	1.352	1.204
Max	1.567	1.507	1.480	1.645	1.596	1.423
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-41: Statistics for SSB2 Proc. C Chord Stiffness Data

4.28 "50/40/10" Single-Shear Bearing Proc. C (SSB3)

The SSB3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. 2% offset strength, ultimate strength and stiffness tests were conducted in the following environmental conditions: RTD, ETW1, and ETW2.

For both properties, the results are identical for the normalized and as-measured datasets, using the original CV and the modified CV. There were no diagnostic test failures, therefore all the conditions were pooled for every scenario.

The were no statistical outliers.

Statistics, basis values and estimates are given for the SSB3 strength data in Table 4-42 and for chord stiffness in Table 4-43. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-31 and Figure 4-32.

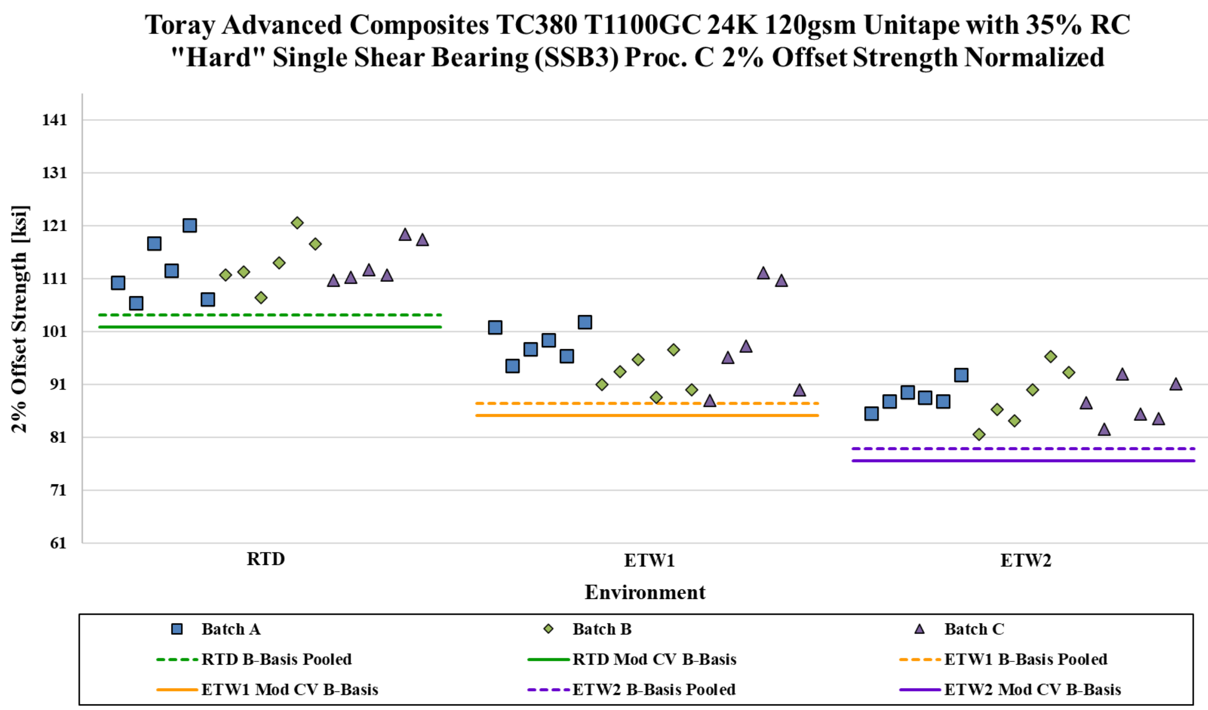

Figure 4-31: Batch Plot for SSB3 Proc. C Normalized 2% Offset Strength

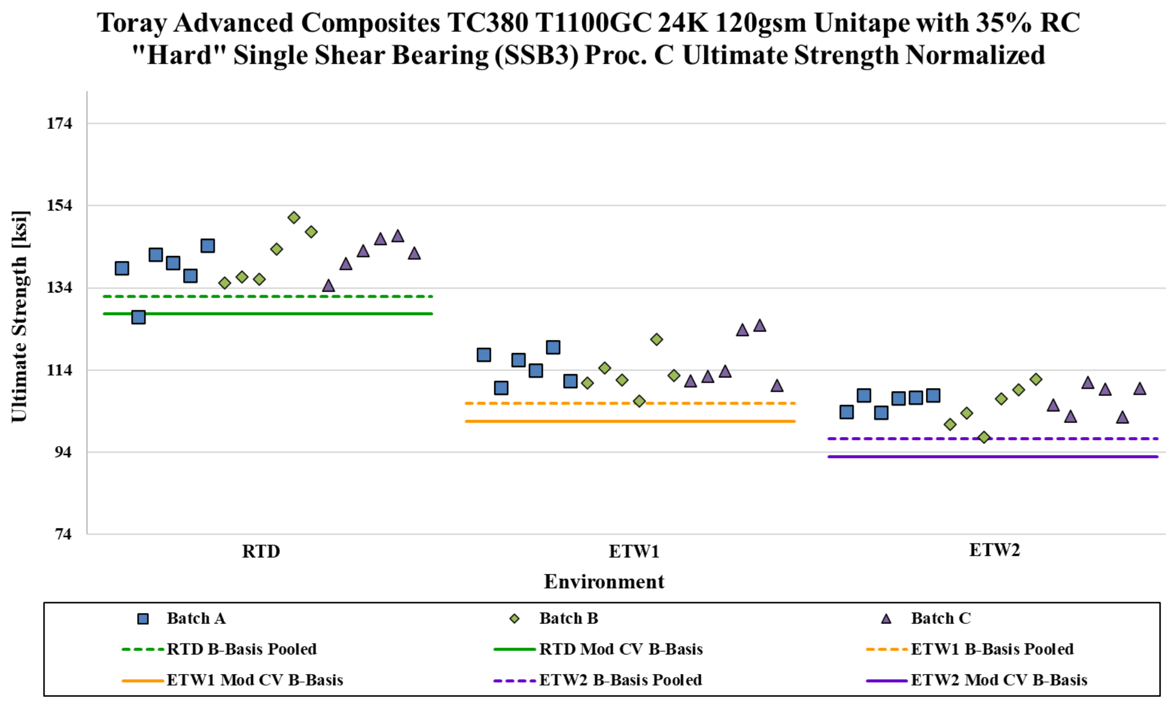

Figure 4-32: Batch Plot for SSB3 Proc. C Normalized Ultimate Strength

SSB3 Proc. C Strength (ksi) Basis Values and Statistics												
	Normalized						As-Measured					
Property	2% Offset Strength			Ultimate Strength			2% Offset Strength			Ultimate Strength		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	113.5	96.88	88.21	140.7	114.6	106.0	119.3	100.6	86.05	147.9	119.0	103.5
Stdev	4.697	6.827	4.017	5.770	5.106	3.754	5.126	6.248	4.351	6.676	4.973	4.390
CV	4.137	7.047	4.555	4.100	4.455	3.540	4.297	6.212	5.056	4.515	4.178	4.243
Mod CV	6.069	7.523	6.277	6.050	6.228	6.000	6.148	7.106	6.528	6.257	6.089	6.122
Min	106.4	87.91	81.50	126.9	106.4	97.62	110.3	91.47	77.92	132.2	110.7	93.26
Max	121.6	112.1	96.23	151.2	124.9	111.7	128.3	115.3	92.67	159.6	130.1	108.8
No. Batches	3	3	3	3	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates												
B-Basis Value	104.1	87.46	78.79	132.0	105.8	97.29	109.9	91.20	76.66	138.3	109.4	93.83
A-Estimate	97.85	81.18	72.51	126.1	99.99	91.44	103.6	84.94	70.40	131.8	103.0	87.41
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates												
B-Basis Value	101.8	85.16	76.49	127.6	101.5	92.96	107.3	88.64	74.10	134.2	105.4	89.80
A-Estimate	94.01	77.35	68.68	118.9	92.78	84.23	99.38	80.67	66.14	125.1	96.27	80.70
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-42: Statistics and Basis Values for SSB3 Proc. C Strength Data

SSB3 Proc. C Chord Stiffness (Msi) Statistics						
	Normalized			As-Measured		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	2.305	2.211	2.109	2.421	2.296	2.055
Stdev	0.05743	0.1599	0.1443	0.06550	0.1679	0.1152
CV	2.492	7.235	6.844	2.705	7.310	5.603
Min	2.206	1.890	1.890	2.321	1.972	1.836
Max	2.392	2.383	2.418	2.536	2.522	2.312
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-43: Statistics for SSB3 Proc. C Chord Stiffness Data

4.29 Interlaminar Tension Strength (ILT)

The ILT data is not normalized. Strength and curved beam strength tests were conducted in the following environmental conditions: CTD, RTD, and ETW1. Bais values were not computed.

Summary statistics are presented in Table 4-44 and the as-measured datasets are displayed graphically in Figure 4-33 and Figure 4-34.

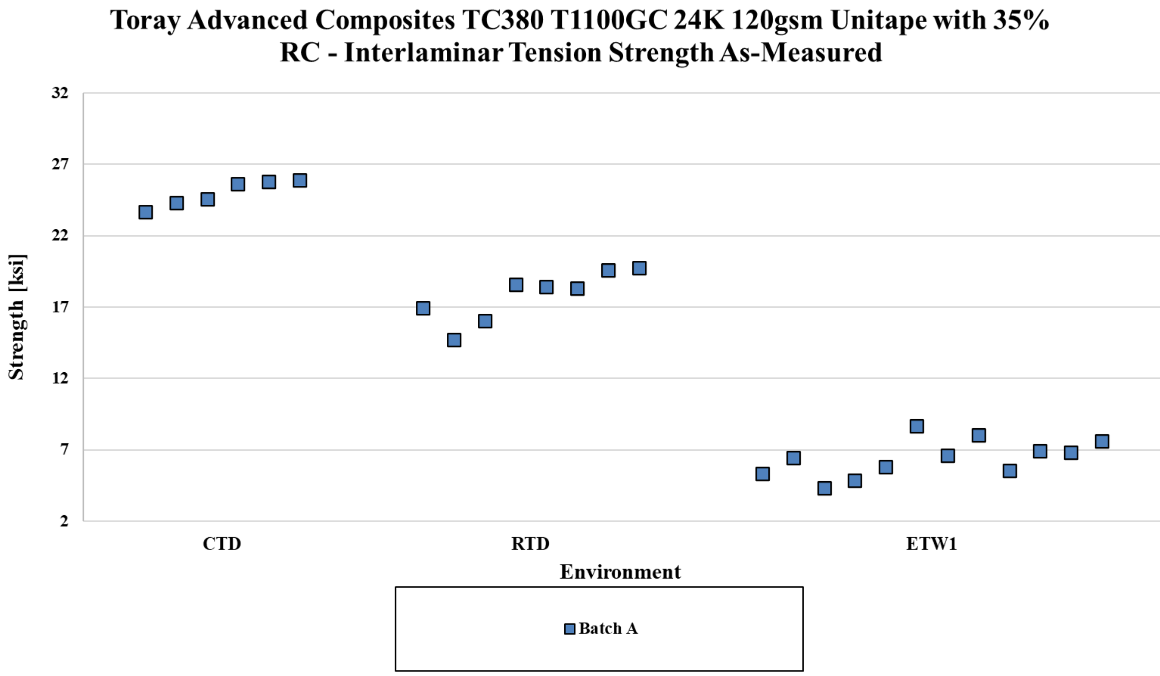

Figure 4-33: Batch Plot for ILT Strength

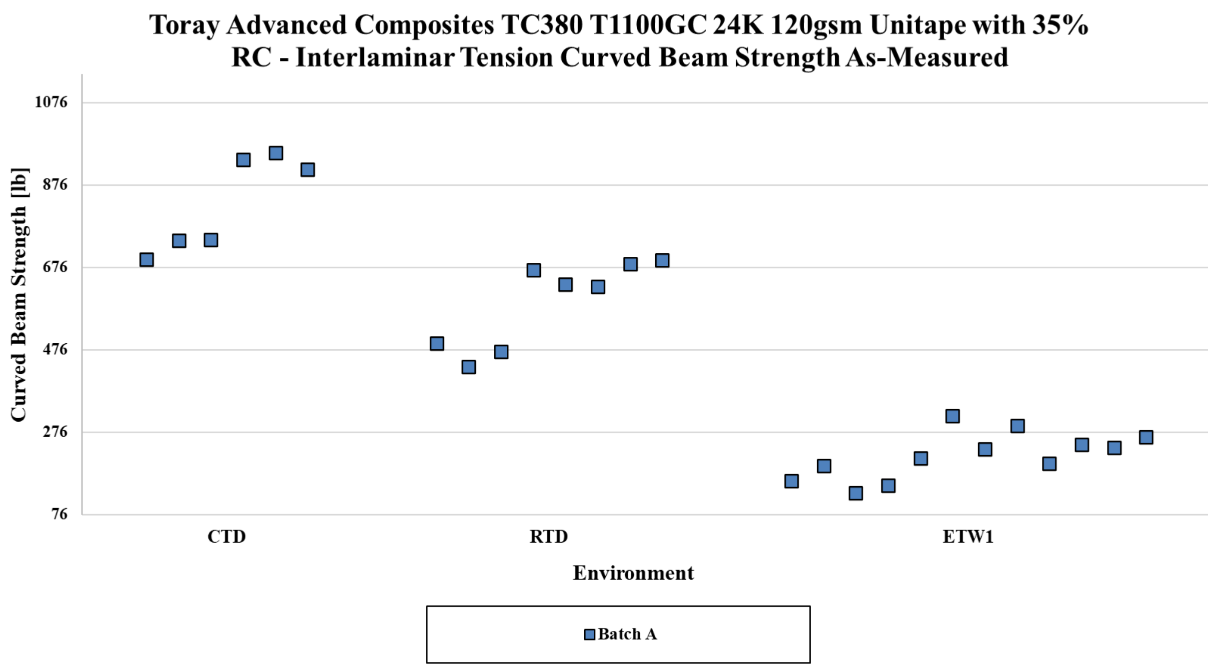

Figure 4-34: Batch Plot for ILT Curved Beam Strength

ILT As-Measured Statistics						
	ILT Strength (ksi)			Curved Beam Strength (lb)		
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)
Mean	24.98	17.78	6.422	831.1	588.7	219.7
Stdev	0.9241	1.750	1.305	116.3	105.2	57.47
CV	3.699	9.839	20.33	13.99	17.86	26.15
Min	23.69	14.73	4.340	695.0	434.5	128.2
Max	25.92	19.74	8.681	953.8	693.8	316.4
No. Batches	1	1	1	1	1	1
No. Spec.	6	8	12	6	8	12

Table 4-44: Statistics for ILT Strength Data

4.30 “25/50/25” Compression After Impact (CAI1)

The CAI1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD and RTD.

For the normalized dataset, both condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for both conditions. Applying the modified CV, the RTD condition failed the ADK test, therefore modified CV basis values where not computed for that condition. The normal method was used for CTD.

For the as-measured dataset, the RTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for CTD. Applying the modified CV, the RTD condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The normal method was used for CTD.

There was one statistical outlier. The lowest value in batch C of the CTD condition was a batch outlier in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are presented in Table 4-45 and the data are displayed graphically in Figure 4-35.

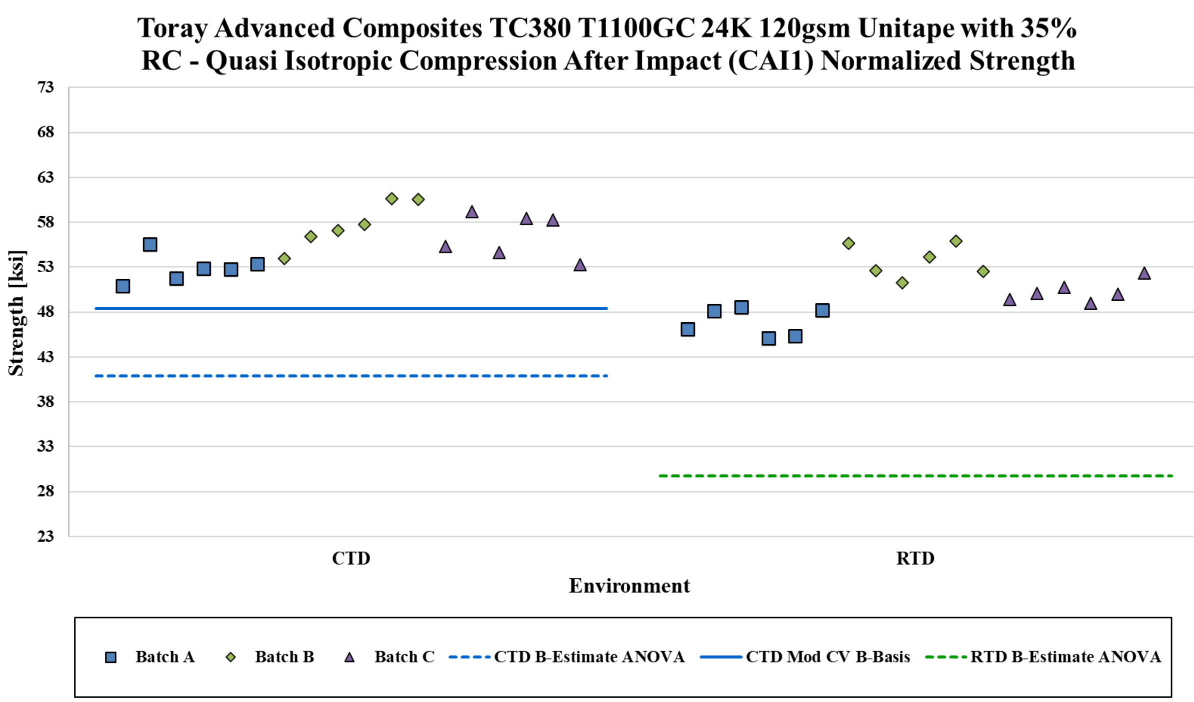

Figure 4-35: Batch Plot for CAI1 Normalized Strength

CAI1 Strength (ksi) Basis Values and Statistics				
	Normalized		As-Measured	
Environment	CTD (-65 °F)	RTD (70 °F)	CTD (-65 °F)	RTD (70 °F)
Mean	55.71	50.29	54.94	50.28
Stdev	2.981	3.198	2.364	2.699
CV	5.350	6.358	4.302	5.369
Mod CV	6.675	7.179	6.151	6.684
Min	50.94	45.10	50.94	45.78
Max	60.60	55.93	60.27	55.69
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis Value			50.27	
B-Estimate	40.86	29.76		34.78
A-Estimate	30.28	15.12	46.97	23.72
Method	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis Value	48.37	NA	48.27	NA
A-Estimate	43.16		43.54	
Method	Normal		Normal	

Table 4-45: Statistics and Basis Values for CAI1 Strength Data

4.31 "10/80/10" Compression After Impact (CAI2)

The CAI2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Testing was done in the following environmental conditions: CTD and RTD. Basis values were not computed.

Summary statistics are presented in Table 4-45 and the datasets are displayed graphically in Figure 4-35.

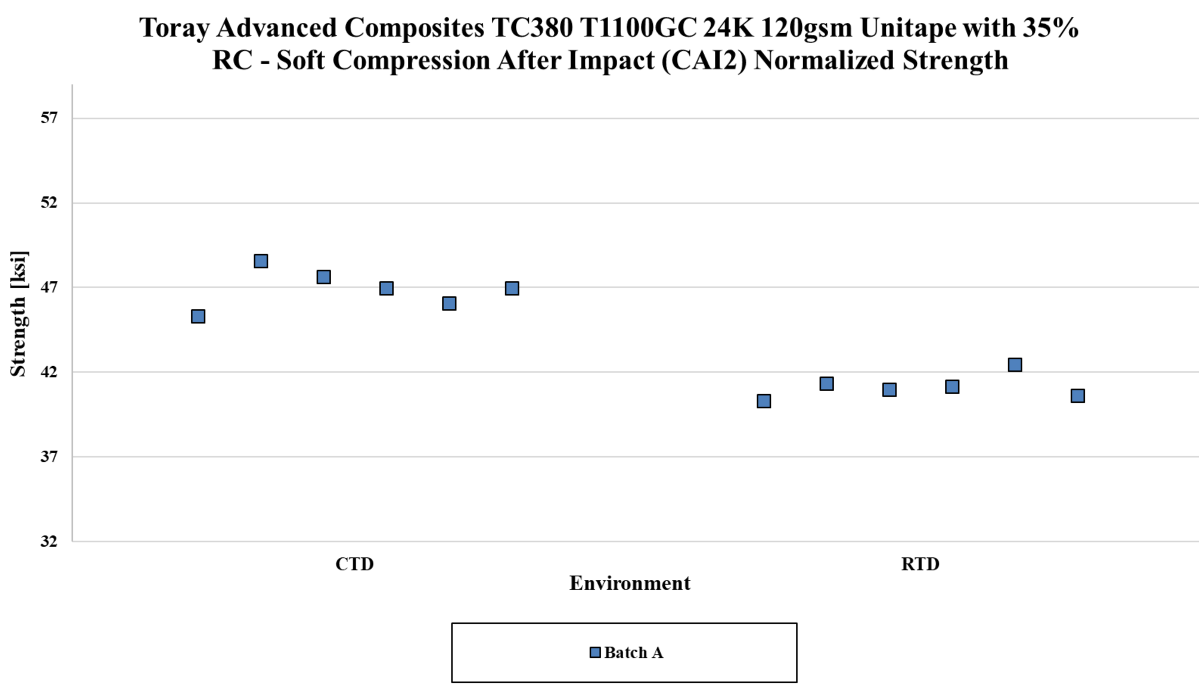

Figure 4-36: Plot for CAI2 Normalized Strength

CAI2 Strength (ksi) Statistics				
	Normalized		As-Measured	
Environment	CTD (-65 °F)	RTD (70 °F)	CTD (-65 °F)	RTD (70 °F)
Mean	46.91	41.13	47.53	41.99
Stdev	1.148	0.7449	1.132	0.6724
CV	2.448	1.811	2.382	1.601
Min	45.30	40.31	46.08	41.05
Max	48.57	42.46	49.05	42.98
No. Batches	1	1	1	1
No. Spec.	6	6	6	6

Table 4-46: Statistics for CAI2 Strength Data

4.32 "50/40/10" Compression After Impact (CAI3)

The CAI3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Testing was done in the following environmental conditions: CTD and RTD. Basis values were not computed.

Summary statistics are presented in Table 4-45 and the datasets are displayed graphically in Figure 4-35.

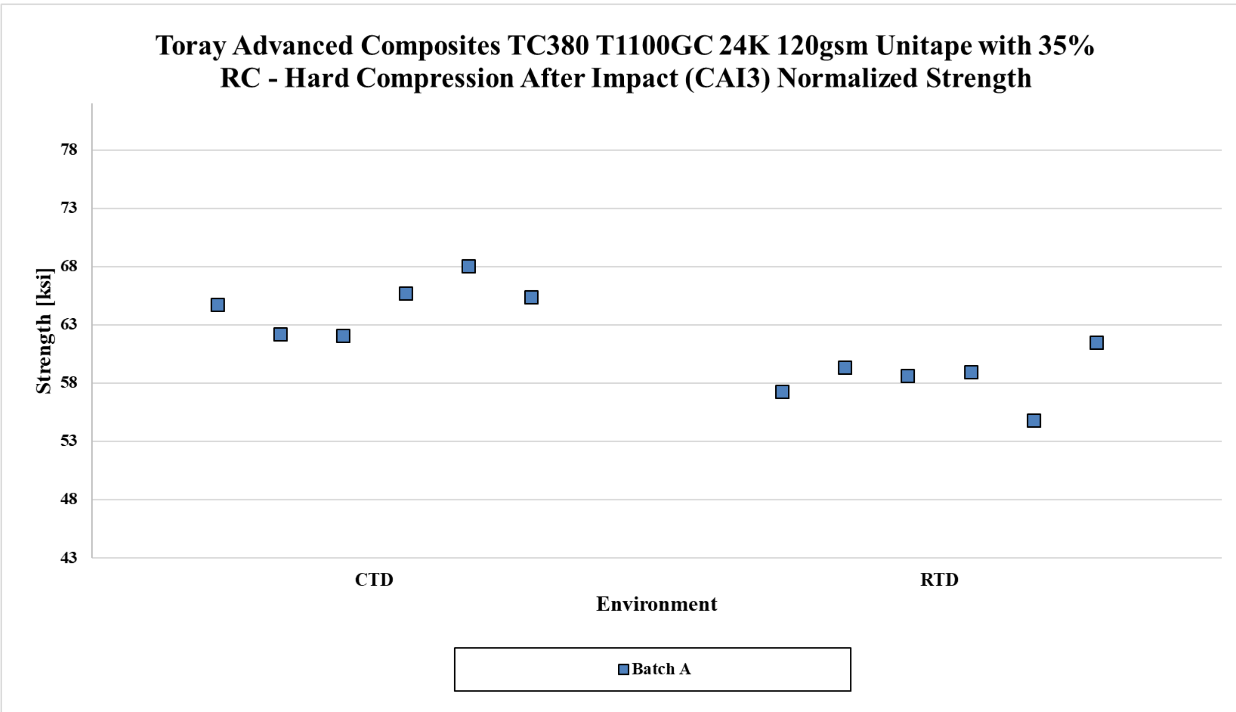

Figure 4-37: Plot for CAI3 Normalized Strength

CAI3 Strength (ksi) Statistics				
	Normalized		As-Measured	
Environment	CTD (-65 °F)	RTD (70 °F)	CTD (-65 °F)	RTD (70 °F)
Mean	64.65	58.38	63.48	58.31
Stdev	2.268	2.248	2.602	2.123
CV	3.508	3.851	4.098	3.641
Min	62.03	54.74	60.16	54.73
Max	68.01	61.47	66.51	61.07
No. Batches	1	1	1	1
No. Spec.	6	6	6	6

Table 4-47: Statistics for CAI3 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 the CMH-17 Vol 1 Handbook. 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-2025-021 Rev –. Outliers for which no causes could be identified are listed in Table 5-1 and Table 5-2. These outliers were included in the analysis for their respective test properties.

Lamina Test	Property	Condition	Batch	Specimen No.	Value	Type	Outlier		
							High/Low	Batch	Condition
LT	Strength	ETW2 (250 °F)	A	TCDJA213E	392.6	As-Measured	Low	Yes	No
LC from UNC0	Strength	CTD (-65 °F)	B	TCDRB312B	225.7	Normalized	Low	Yes	No
					221.3	As-Measured			
		ETD1 (180 °F)	A	TCDRA211C	218.8	Normalized	High	Yes	No
					217.5	As-Measured			
		ETW2 (250 °F)	A	TCDRA112E	175.3	Normalized	High	No	Yes
UNC0	Strength	CTD (-65 °F)	B	TCDRB312B	84.26	Normalized	Low	Yes	No
					82.83	As-Measured			
		ETD1 (180 °F)	A	TCDRA211C	80.32	Normalized	High	Yes	No
					80.08	As-Measured			
		ETW2 (250 °F)	A	TCDRA112E	63.13	Normalized	High	No	Yes
IPS	0.2% Offset Strength	CTD (-65 °F)	C	TCDNC213B	10.42	As-Measured	High	Yes	Yes
			C	TCDNC113D	4.864	As-Measured	High	Yes	No
IPS	Strength at 5% Strain	CTD (-65 °F)	C	TCDNC213B	17.08	As-Measured	High	Yes	Yes

Table 5-1: List of Outliers - Lamina Tests

Laminate Test	Property	Condition	Batch	Specimen No.	Value	Type	Outlier High/Low	Outlier Batch	Outlier Condition
UNT1	Strength	RTD (70 °F)	B	TCDAB211A	174.1	Normalized	High	Yes	No
		ETW1 (180 °F)	A	TCDAA112D	173.9	As-Measured	High	Yes	No
UNT2	Strength	RTD (70 °F)	A	TCDBA113A	85.13	Normalized	Low	Yes	No
		RTD (70 °F)	B	TCDBB211A	77.16	Normalized	Low	Yes	Yes
UNT3	Strength	RTD (70 °F)	B	TCDCB113A	247.0	Normalized	Low	No	Yes
		ETW1 (180 °F)	B	TCDCB215D	234.9	Normalized	Low	No	Yes
		RTD (70 °F)	C	TCDCC111A	295.4	As-Measured	High	Yes	No
UNC1	Strength	ETW2 (250 °F)	B	TCDWB113E	50.88	Normalized	Low	Yes	No
UNC2	Strength	CTD (-65 °F)	C	TCDXC213B	63.61	Normalized	Low	Yes	Yes
					61.25	As-Measured			
		RTD (70 °F)	C	TCDXC212A	55.78	Normalized	Low	Yes	No
		ETW2 (250 °F)	C	TCDXC112E	37.50	Normalized	High	Yes	No
UNC3	Strength	ETW2 (250 °F)	C	TCDYC114E	83.25	Normalized	High	Yes	No
OHT1	Strength	ETW2 (250 °F)	B	TCDDB213E	93.10	Normalized	High	Yes	No
OHT2	Strength	ETW2 (250 °F)	C	TCDEC113E	54.68	As-Measured	High	Yes	No
OHT3	Strength	ETW1 (180 °F)	B	TCDFB111D	147.5	Normalized	High	Yes	No
FHT2	Strength	CTD (-65 °F)	A	TCD5A313B	73.03	As-Measured	High	Yes	No
		ETW2 (250 °F)	A	TCD5A211E	56.65	As-Measured	High	Yes	No
OHC2	Strength	RTD (70 °F)	B	TCDHB113A	40.90	Normalized	High	No	Yes
		RTD (70 °F)	C	TCDHC112A	39.62	Normalized	High	Yes	No
FHC1	Strength	ETW1 (180 °F)	B	TCD7B211D	52.79	Normalized	Low	Yes	No
		ETW1 (180 °F)	C	TCD7C213D	57.98	As-Measured	High	Yes	No
FHC2	Strength	ETW2 (250 °F)	A	TCD8A111E	39.25	Normalized	High	Yes	No
FHC3	Strength	ETW2 (250 °F)	A	TCD9A113E	50.95	Normalized	Low	Yes	No
					50.69	As-Measured			
SSB1 Proc. C Ult. Strength	Ultimate Strength	ETW1 (180 °F)	C	TCD1C111D	137.7	Normalized	High	No	Yes
SSB2 Proc. C 2% Offset	2% Offset Strength	RTD (70 °F)	A	TCD2A212A	114.3	Normalized	Low	Yes	No
					119.5	As-Measured			
		ETW2 (250 °F)	B	TCD2B212E	103.2	Normalized	High	Yes	No
					97.71	As-Measured			
CAI1	Strength	CTD (-65 °F)	C	TCDKC213B	50.94	As-Measured	Low	Yes	No

Table 5-2: List of Outliers - Laminate Tests

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