# Syensqo PRISM™ EP2400 toughened epoxy resin with Tenax™ Reinforcement Fabrics, Material Allowables Statistical Analysis Report

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# 1. Introduction

This report contains statistical analysis of the Syensqo PRISM™ EP2400 toughened epoxy resin with Tenax™ Reinforcement Fabrics material property data published in NCAMP Test Report CAM-RP-2021-025 Rev N/C. The lamina and laminate material property data have been generated with NCAMP oversight through NCAMP Project Number NPN 072101 and also meet the requirements outlined in 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 241 family series. The qualification test panels were cured in accordance with NCAMP Process Specification NPS 82401 Rev -, dated December 6$^{th}$, 2022 using baseline cure cycle "C" for VARTM processing. The panels were fabricated at Fiber Dynamics, 3730 Midco, Wichita KS 67215. The NCAMP Test Plan NTP 2401Q1 was used for this qualification program. The testing was performed at the National Institute for Aviation Research (NIAR) in Wichita, Kansas.

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

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

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

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

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

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

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 241 family series. NMS 241 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 241.* NMS 241 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 |
|---|---|
| 0° Tension | 0TEN |
| 0° Compression | 0CLC |
| 90° Tension | 90TEN |
| 90° Compression | 90CLC |
| Flexural Strength | FLEX |
| 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** |
|---|---|
| 0° Tension Strength | $F_1^{tu}$ |
| 0° Tension Modulus | $E_1^{t}$ |
| 90° Tension Strength | $F_2^{tu}$ |
| 90° Tension Modulus | $E_2^{t}$ |
| 0° Compression Strength | $F_1^{cu}$ |
| 0° Compression Modulus | $E_1^{c}$ |
| 90° Compression Strength | $F_2^{cu}$ |
| 90° Compression Modulus | $E_2^{c}$ |
| 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 Ambient | CTA | −65 ± 5˚F |
| Room Temperature Ambient | RTA | 70 ± 10˚F |
| Elevated Temperature Ambient | ETA | 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 40/20/40 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-2024-020 Rev N/C.

## 1.2 Pooling Across Environments

When pooling across environments was possible, the pooled co-efficient of variation was used. CMH17 STATS (CMH17 Approved Statistical Analysis Program) was used to determine if pooling was possible 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: 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 section 8.4.4 of CMH-17-1H. 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-17-1H 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-17-1H requirements for a single point analysis, estimates are created by a variety of methods depending on which is most appropriate for the dataset available. Specific procedures used are presented in the individual sections where the data is presented.

## 2.1 CMH17 STATS Statistical Formulas and Computations

This section contains the details of the specific formulas CMH17 STATS uses in its computations.

### 2.1.1 Basic Descriptive Statistics

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

***Mean:***

$$\bar{X} = \sum_{i=1}^{N} \frac{x_i}{N} \qquad \text{Equation 1}$$

***Std. Dev.:***

$$S = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{X})^2} \qquad \text{Equation 2}$$

***% Co. Variation:***

$$\frac{S}{\bar{X}} \times 100 \qquad \text{Equation 3}$$

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.:***

$$S_p = \sqrt{\frac{\sum_{i=1}^{k}(n_i - 1)S_i^2}{\sum_{i=1}^{k}(n_i - 1)}} \qquad \text{Equation 4}$$

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.

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

### 2.1.3 Basis Value Computations

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

***Basis Values:***

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

#### 2.1.3.1 K-factor computations

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

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

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

Where

$r$ = the number of environments being pooled together
$n_j$ = number of data values for environment j
$N = \sum_{j=1}^{r} n_j$
$f = N - r$

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

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

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

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

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

### 2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

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

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

#### 2.1.4.1 Transformation of data based on Modified CV

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

To accomplish this requires a transformation in two steps:

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

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

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

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.

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

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

$$SSE^* = (N-1)(CV^* \cdot \bar{X})^2 - \sum_{i=1}^{k} n_i(\bar{x}_i - \bar{X})^2 \quad \text{Equation 21}$$

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

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

### 2.1.5 Determination of Outliers

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

$$MNR = \frac{\max\limits_{all\ i}|x_i - \bar{X}|}{S},\ i = 1 \ldots N \quad \text{Equation 23}$$

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

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:

$$\boldsymbol{ADK = \frac{N-1}{N^2(k-1)}\sum_{i=1}^{k}\left[\frac{1}{n_i}\sum_{j=1}^{L} h_j \frac{\left(NF_{ij}-n_iH_j\right)^2}{H_j\left(N-H_j\right)-\frac{Nh_j}{4}}\right]}$$ **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:

$$\boldsymbol{ADC = 1 + \sigma_N\left[z_\alpha + \frac{0.678}{\sqrt{k-1}} - \frac{0.362}{k-1}\right]}$$ **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.

$$\boldsymbol{\sigma_N^2 = VAR(ADK) = \frac{aN^3+bN^2+cN+d}{(N-1)(N-2)(N-3)(k-1)^2}}$$ **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:

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

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

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

$$z_{(i)} = \frac{x_{(i)} - \bar{X}}{S}, \quad for\ i = 1, \ldots, N \qquad \text{Equation 29}$$

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

The Anderson Darling test statistic (AD) is:

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

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

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

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:

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

If this computed F statistic is less than the critical value for the F-distribution having k-1 numerator and *N-k* denominator degrees of freedom at the 1-α level of confidence, then the data is not rejected as being too different in terms of the co-efficient of variation. CMH-17 STATS provides the appropriate critical values for F at α levels of 0.10, 0.05, 0.025, and 0.01. For more information on this procedure, see references 4, and 5.

### 2.1.9 Distribution Tests

In addition to testing for normality using the Anderson-Darling test (see 2.1.7), CMH17 STATS also tests to see if the Weibull or Lognormal distribution is a good fit for the data.

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

An observed significance level (*OSL*) based on the Anderson-Darling test statistic is computed for each test. The *OSL* measures the probability of observing an Anderson-Darling test statistic at least as extreme as the value calculated if the distribution under consideration is in fact the underlying distribution of the data. In other words, the *OSL* is the probability of obtaining a value of the test statistic at least as large as that obtained if the hypothesis that the data are actually from the distribution being tested is true. If the OSL is less than or equal to 0.05, then the assumption that the data are from the distribution being tested is rejected with at most a five percent risk of being in error.

If the normal distribution has an *OSL* greater than 0.05, then the data is assumed to be from a population with a normal distribution. If not, then if either the Weibull or lognormal distributions has an *OSL* greater than 0.05, then one of those can be used. If neither of these distributions has an *OSL* greater than 0.05, a non-parametric approach is used.

In what follows, unless otherwise noted, the sample size is denoted by $N$, the sample observations by $x_1, ..., x_N$ , and the sample observations ordered from least to greatest by $x_{(1)}, ..., x_{(N)}$.

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

The exact computation of $k_B$ values is $\frac{1}{\sqrt{N}}$ 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:

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

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

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

The exact computation of $k_A$ values is $\frac{1}{\sqrt{N}}$ 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, the following approximation to the $k_A$ values is used:

$$k_A \approx 2.326 + exp\{1.34 - 0.522\, ln(N) + \frac{3.87}{N}\}$$ **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

$$e^{-\left(\frac{a}{\alpha}\right)^{\beta}} - e^{-\left(\frac{b}{\alpha}\right)^{\beta}}$$ **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:

$$\hat{\alpha}\hat{\beta}N - \frac{\hat{\beta}}{\hat{\alpha}^{\hat{\beta}-1}}\sum_{i=1}^{N} x_i^{\hat{\beta}} = 0 \qquad \text{Equation 36}$$

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

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

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

The Anderson-Darling test statistic is

$$AD = \sum_{i=1}^{N} \frac{1-2i}{N}\left[\ln[1 - e^{-z_{(i)}}] - z_{(N+1-i)}\right] - N \qquad \text{Equation 39}$$

and the observed significance level is

$$OSL = \frac{1}{\{1+e^{-0.10+1.24\ln(AD^*)+4.48AD^*}\}} \qquad \text{Equation 40}$$

where

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

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 $OSL \leq 0.05$, 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

$$B = \hat{q}e^{\left(\frac{-V}{\hat{\beta}\sqrt{N}}\right)} \qquad \text{Equation 42}$$

where

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

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

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

V is the value in Table 2-1 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.

$$V_B \approx 3.803 + exp\left[1.79 - 0.516\, ln(N) + \frac{5.1}{N-1}\right]$$

**Equation 45**

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

**Equation 46**

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

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

**Table 2-1: Weibull Distribution Basis Value Factors**

### 2.1.9.4 Lognormal Distribution

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

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

#### 2.1.9.4.1 Goodness-of-fit test for the Lognormal distribution

In order to test the goodness-of-fit of the lognormal distribution, take the logarithm of the data and perform the Anderson-Darling test for normality from Section 2.1.7. Using the natural logarithm, replace Equation 29 above with Equation 47 below:

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

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 $OSL \leq 0.05$, 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:

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

For A-Basis values:

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

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

The B-basis value is the $r_B^{th}$ lowest observation in the data set, while the A-basis value is the $r_A^{th}$ lowest observation in the data set. For example, in a sample of size $N = 30$, the lowest $(r = 1)$ observation is the B-basis value. Further information on this procedure may be found in reference 7.

#### 2.1.10.2 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

The A-basis value is:

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

where $x_{(N)}$ is the largest data value, $x_{(1)}$ is the smallest, and $x_{(r)}$ is the $r^{th}$ largest data value. The values of $r$ and $k$ depend on $N$ and are listed in Table 2-2. 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-17-1H, 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 $(n_i, \bar{x}_i, s_i^2)$ 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:

$$SSB = \sum_{i=1}^{k} n_i \bar{x}_I^2 - N\bar{X}^2$$ **Equation 52**

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

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

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

Next, the mean sums of squares are computed:

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

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

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

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

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

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

Two k-factors are computed using the methodology of section 8.3.5 of CMH-17-1H 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 organization. Values computed in this manner are estimates only. It is used only when fewer than three batches are available and no valid B-basis value could be computed using any other method. The estimate is made using the mean of the data and setting the coefficient of variation to 8 percent if it was less than that. A modified standard deviation ($S_{adj}$) was computed by multiplying the mean by 0.08 and computing the A and B-basis values using this inflated value for the standard deviation.

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

## 2.3 Lamina Variability Method (LVM)

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

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

The LVM B-basis value is then computed as:

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

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

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

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 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **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 |
| **N1+N2-2** | **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 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 α = 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, let us assume the following:

$$x = \text{Some Material Strength Property}$$

$\overline{X} = \text{Mean of x}$
$S = \text{Standard Deviation of x}$

Then we define:

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

We compute these as the following:

$$\mathrm{W_{mean}} = \overline{X} - \mathrm{k}_N^{\mathrm{mean}}.\mathrm{S} \quad \textbf{Equation 64}$$
$$\mathrm{W_{min\ indiv}} = \overline{X} - \mathrm{k}_N^{\mathrm{min\ indiv}}.\mathrm{S} \quad \textbf{Equation 65}$$

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

$$\mathrm{W_{lower}} = \overline{X} - \mathrm{k.S} \quad \textbf{Equation 66}$$
$$\mathrm{W_{upper}} = \overline{X} + \mathrm{k.S} \quad \textbf{Equation 67}$$

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

$$k = t_c.\sqrt{(\frac{1}{N} + \frac{1}{n})} \quad \textbf{Equation 68}$$

and

$$t_c = t.INV(\alpha, N)) \quad \textbf{Equation 69}$$

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.

**Case study**

Consider a simple example using some fictitious data for illustration purposes, assuming we have a dataset with 3 batches, 6 specimens for each batch and two properties: Strength and Modulus. The specification limits may be computed using the equations described above. The input data, the intermediate results (k factors) and the final results (specification limits) are shown in Table 2-5 for Strength property and in Table 2-6 for Modulus property. The results including the data points for the Strength property with its corresponding specification limits are shown in Figure 2-1 and for the Modulus property with its corresponding specification limits are shown in Figure 2-2. Notice that specification limits for Mod CV are more "inclusive" for the data points.

| Specimen# | Strength [ksi] |
|---|---|
| 1 | 26.80 |
| 2 | 22.60 |
| 3 | 22.20 |
| 4 | 24.00 |
| 5 | 26.30 |
| 6 | 24.50 |
| 7 | 24.30 |
| 8 | 27.00 |
| 9 | 26.00 |
| 10 | 25.70 |
| 11 | 26.00 |
| 12 | 24.30 |
| 13 | 22.00 |
| 14 | 22.80 |
| 15 | 24.80 |
| 16 | 22.00 |
| 17 | 24.00 |
| 18 | 26.10 |
| **Mean Strength [ksi]** | 24.52 |
| **Std. Dev.** | 1.637 |
| **CV%** | 6.675 |
| **Min** | 22.00 |
| **Max** | 27.00 |
| **Count** | 18 |
| **Kmean** | 1.1425 |
| **Kmin** | 3.0715 |
| **Wmean** | 22.65 |
| **Wmin** | 19.49 |

**Table 2-5 Data and Specification Limits for Strength**

| Specimen# | Modulus [Msi] |
|---|---|
| 1 | 13.90 |
| 2 | 14.50 |
| 3 | 15.80 |
| 4 | 13.80 |
| 5 | 15.50 |
| 6 | 15.90 |
| 7 | 14.20 |
| 8 | 16.30 |
| 9 | 16.20 |
| 10 | 13.80 |
| 11 | 15.00 |
| 12 | 14.00 |
| 13 | 15.80 |
| 14 | 16.50 |
| 15 | 14.50 |
| 16 | 16.00 |
| 17 | 14.20 |
| 18 | 15.20 |
| **Mean Modulus [Msi]** | 15.06 |
| **Std. Dev.** | 0.9298 |
| **CV%** | 6.174 |
| **min** | 13.80 |
| **max** | 16.50 |
| **Count** | 18 |
| **Tc** | 2.8980 |
| **K** | 1.4650 |
| **W lower** | 13.70 |
| **W upper** | 16.42 |

**Table 2-6 Data and Specification Limits for Modulus**

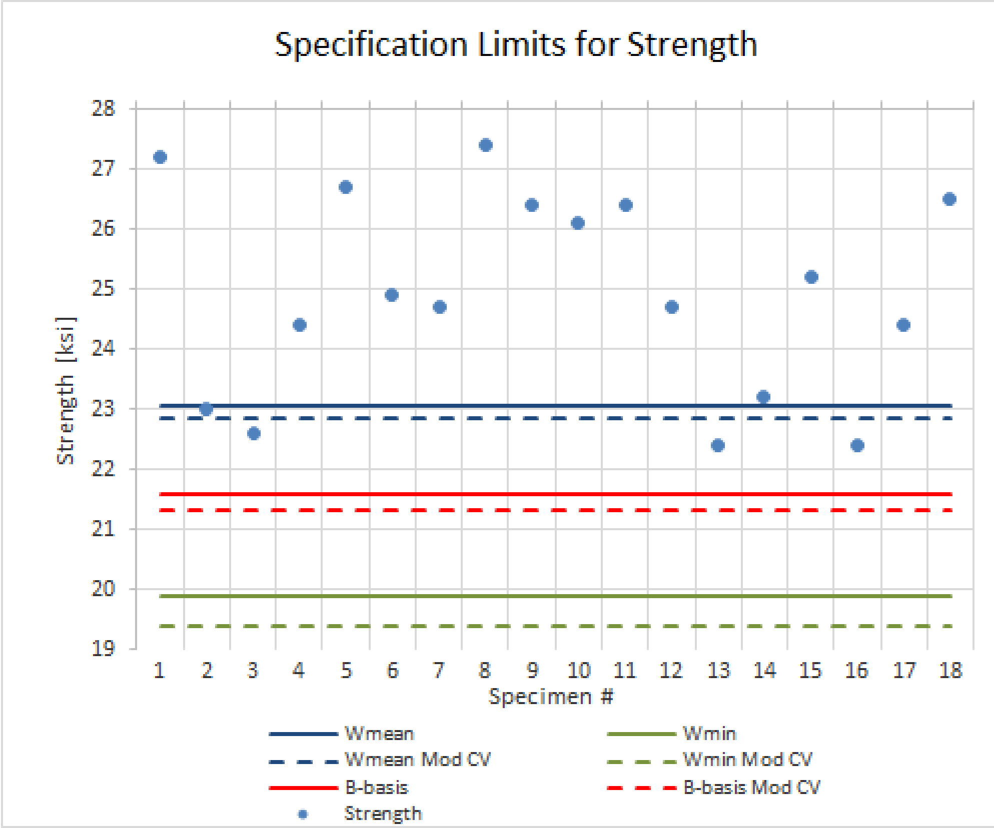


**Figure 2-1 Specification Limits for Strength**

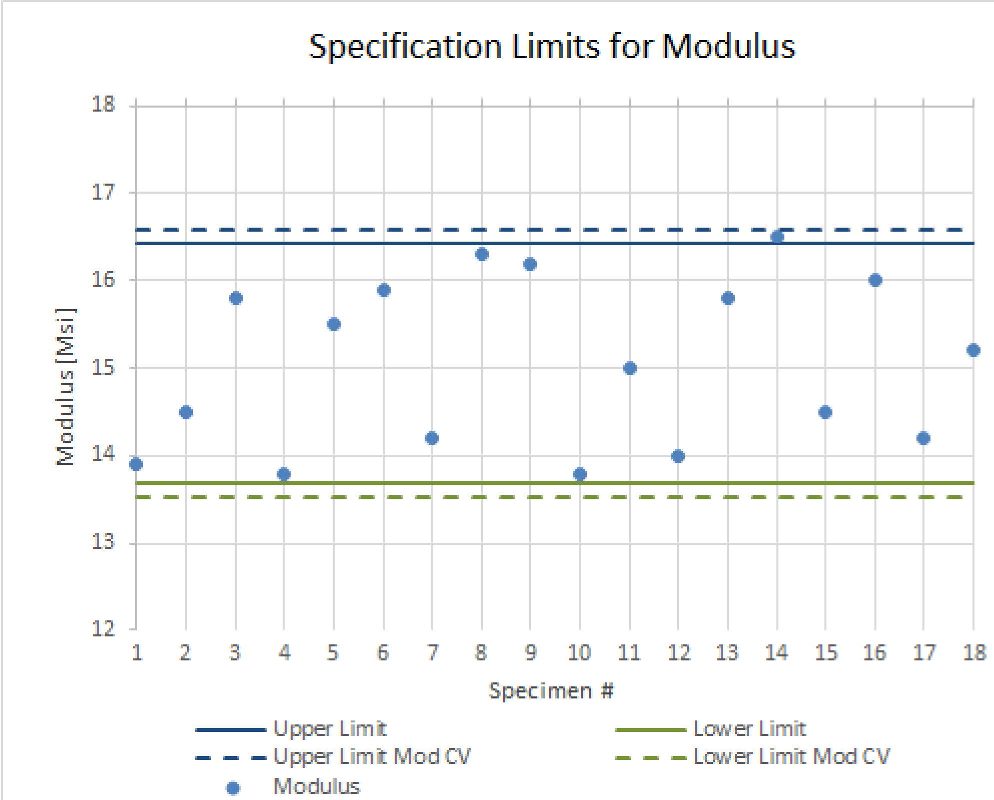


**Figure 2-2 Specification Limits for Modulus**

# 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-17-1H. 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-17-1H are shown in shaded boxes and labeled as estimates. Basis values computed with the modified coefficient of variation (CV) are presented whenever possible. Basis values and estimates computed without that modification are presented for all tests.

## 3.1 NCAMP Recommended B-basis Values

The following rules are used in determining what B-basis value, if any, is included in Table 3-1 (BA Lamina), Table 3-2 (BD Lamina), Table 3-3 (UD Lamina) and Table 3-4 (Laminate) of recommended values.

1. Recommended values are NEVER estimates. Only B-basis values that meet all requirements of CMH-17-1H 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-17-1H 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 STATS when the B-basis value is 90% or more of the average value. Such values will be indicated.
6. If the data appear questionable (e.g. when the CTA-RTA-ETW trend of the basis values is not consistent with the CTA-RTA-ETW trend of the average values), then the B-basis values will not be recommended.

**NCAMP Recommended B-Basis Values for**
**Syensqo PRISM™ EP2400 toughened epoxy resin**
**All B-Basis values in this table meet the standards for publication in CMH-17-1H Handbook**
**Values are for normalized data unless noted**

**Biaxial Lamina Strength Tests**

| Environment | Statistic | 0CLC | 0TEN | 90CLC | 90TEN | IPS* | | FLEX | SBS* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.2% Offset Strength | Strength at 5% Strain | | |
| CTA (-65°F) | B-basis | | 174.6 | | 199.6 | 7.187 | 12.10 | | 8.738 |
| | Mean | | 196.2 | | 214.1 | 8.139 | 13.73 | | 9.876 |
| | CV | | 6.000 | | 3.431 | 6.000 | 6.000 | | 6.565 |
| RTA (70°F) | B-basis | NA | 185.8 | 87.48 | NA: A | 5.216 | 9.244 | 127.3 | 8.868 |
| | Mean | 99.99 | 207.3 | 106.5 | 223.8 | 5.762 | 10.21 | 152.5 | 10.01 |
| | CV | 8.603 | 6.028 | 9.253 | 6.739 | 6.000 | 6.000 | 8.354 | 6.000 |
| ETA (180°F) | B-basis | 60.37 | 190.3 | 67.20 | 198.1 | 3.534 | 6.193 | | 6.458 |
| | Mean | 74.82 | 211.5 | 82.81 | 228.4 | 4.079 | 7.156 | | 7.313 |
| | CV | 10.02 | 6.000 | 8.983 | 6.805 | 6.000 | 6.000 | | 6.000 |
| ETW1 (180°F) | B-basis | 61.18 | 185.4 | NA: A | NA | 3.235 | 5.339 | | 5.569 |
| | Mean | 70.81 | 206.9 | 80.83 | 222.9 | 3.669 | 6.056 | | 6.317 |
| | CV | 6.891 | 6.000 | 8.195 | 6.000 | 6.000 | 6.000 | | 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 implies ANOVA with three batches.
ETW2 not included as there were no recommended B-Basis values.
* Data is as measured rather than normalized

**Table 3-1: NCAMP Recommended B-Basis Values for Biaxial Lamina Strength Tests**

**NCAMP Recommended B-Basis Values for**
**Syensqo PRISM™ EP2400 toughened epoxy resin**
**All B-Basis values in this table meet the standards for publication in CMH-17-1H**
**Values are for normalized data unless noted**

**Bidiagonal Lamina Strength Tests**

| Environment | Statistic | 0CLC | 0TEN | IPS* 0.2% Offset Strength | IPS* Strength at 5% Strain | FLEX | SBS* |
|---|---|---|---|---|---|---|---|
| CTA (-65°F) | B-basis | | 188.2 | 7.618 | 13.37 | | 9.900 |
| | Mean | | 210.4 | 8.658 | 15.16 | | 10.85 |
| | CV | | 6.113 | 6.087 | 6.000 | | 6.000 |
| RTA (70°F) | B-basis | 94.60 | 190.8 | 5.354 | 9.873 | 142.3 | 9.769 |
| | Mean | 104.8 | 213.1 | 6.101 | 10.78 | 161.4 | 10.72 |
| | CV | 6.569 | 6.157 | 6.281 | 6.059 | 6.000 | 6.000 |
| ETA (180°F) | B-basis | 68.53 | 188.3 | 3.827 | 6.680 | | 6.527 |
| | Mean | 78.70 | 210.7 | 4.341 | 7.590 | | 7.478 |
| | CV | 6.978 | 6.000 | 6.000 | 6.000 | | 6.000 |
| ETW1 (180°F) | B-basis | 65.34 | 180.1 | 3.479 | 5.567 | | 5.416 |
| | Mean | 75.45 | 202.4 | 3.946 | 6.477 | | 6.368 |
| | CV | 6.255 | 6.213 | 6.000 | 6.000 | | 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.
ETW2 not included as there were no recommended B-Basis values.
* Data is as measured rather than normalized

**Table 3-2: NCAMP Recommended B-Basis Values for Bidiagonal Lamina Strength Tests**

**NCAMP Recommended B-Basis Values for**
**Syensqo PRISM™ EP2400 toughened epoxy resin**
**All B-Basis values in this table meet the standards for publication in CMH-17-1H Handbook**
**Values are for normalized data unless noted**

**Unidirectional Lamina Strength Tests**

| Environment | Statistic | 0CLC | 0TEN | UNC0 | UNT0 | IPS* | | FLEX | SBS* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.2% Offset Strength | Strength at 5% Strain | | |
| CTA (-65°F) | B-basis | | 361.1 | | 186.9 | 7.538 | 12.74 | | 14.27 |
| | Mean | | 417.8 | | 209.3 | 8.551 | 14.45 | | 16.23 |
| | CV | | 6.866 | | 6.000 | 6.000 | 6.000 | | 6.102 |
| RTA (70°F) | B-basis | 130.1 | NA: A | 89.94 | 188.5 | NA | 9.649 | 139.3 | 10.30 |
| | Mean | 144.7 | 427.0 | 99.96 | 210.8 | 6.023 | 10.51 | 161.3 | 11.69 |
| | CV | 6.599 | 6.892 | 6.599 | 6.747 | 6.000 | 6.000 | 6.896 | 6.000 |
| ETA (180°F) | B-basis | NA: A | 359.5 | NA: A | 183.5 | 3.548 | 6.065 | | 6.148 |
| | Mean | 102.3 | 412.1 | 72.21 | 205.8 | 4.024 | 6.927 | | 6.974 |
| | CV | 5.552 | 6.462 | 6.776 | 6.000 | 6.000 | 6.000 | | 6.000 |
| ETW1 (180°F) | B-basis | 74.46 | NA: A | 50.42 | 178.8 | 3.231 | 5.029 | | 5.016 |
| | Mean | 89.05 | 391.6 | 60.44 | 201.2 | 3.659 | 5.896 | | 5.736 |
| | CV | 6.841 | 7.856 | 6.841 | 6.000 | 6.000 | 6.000 | | 6.353 |

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 implies ANOVA with three batches.
ETW2 not included as there were no recommended B-Basis values.
* Data is as measured rather than normalized

**Table 3-3: NCAMP Recommended B-Basis Values for Unidirectional Lamina Strength Tests**

**NCAMP Recommended B-Basis Values for**
**Syensqo PRISM™ EP2400 toughened epoxy resin**
**All B-Basis values in this table meet the standards for publication in CMH-17-1H Handbook**
**Values are for normalized data unless noted**

**Laminate Strength Tests**

| Layup | Environment | Statistic | UNT | UNC | SBS* | OHT | FHT | OHC | FHC | SSB 2% Offset Strength | SSB Ultimate Strength |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25/50/25 (Quasi) | CTA (-65°F) | B-basis | 117.1 | | | 77.86 | 76.98 | | | | |
| | | Mean | 131.6 | | | 87.33 | 86.04 | | | | |
| | | CV | 6.287 | | | 6.000 | 6.000 | | | | |
| | RTA (70°F) | B-basis | 123.1 | 78.11 | 8.442 | 82.25 | 76.62 | 43.49 | NA | 101.8 | 121.1 |
| | | Mean | 137.6 | 87.41 | 9.259 | 97.71 | 85.68 | 48.04 | 69.11 | 113.1 | 134.0 |
| | | CV | 6.000 | 7.303 | 6.000 | 6.000 | 6.000 | 6.212 | 6.129 | 6.000 | 6.000 |
| | ETA (180°F) | B-basis | 124.9 | 53.26 | 5.872 | 81.11 | 77.53 | 33.42 | 47.83 | 85.76 | 102.2 |
| | | Mean | 139.3 | 62.46 | 6.688 | 90.57 | 86.59 | 37.97 | 54.43 | 97.11 | 115.1 |
| | | CV | 6.000 | 8.385 | 6.431 | 6.000 | 6.000 | 6.491 | 6.142 | 6.508 | 6.000 |
| | ETW1 (180°F) | B-basis | 122.3 | 46.26 | 5.188 | 82.63 | 78.71 | 30.75 | 43.12 | 88.50 | 101.4 |
| | | Mean | 136.7 | 55.56 | 6.004 | 92.05 | 87.77 | 35.30 | 48.96 | 99.85 | 114.3 |
| | | CV | 6.000 | 6.959 | 6.321 | 6.000 | 6.000 | 6.218 | 6.042 | 6.118 | 6.000 |
| 12.5/75/12.5 (Soft) | CTA (-65°F) | B-basis | 82.68 | | | 52.80 | 62.12 | | | | |
| | | Mean | 91.74 | | | 59.01 | 68.77 | | | | |
| | | CV | 6.000 | | | 6.000 | 6.000 | | | | |
| | RTA (70°F) | B-basis | 79.42 | 55.11 | | 52.04 | 55.06 | 34.66 | 51.20 | 99.47 | 123.7 |
| | | Mean | 88.47 | 60.65 | | 58.25 | 61.70 | 38.48 | 56.38 | 112.4 | 137.5 |
| | | CV | 6.000 | 6.000 | | 6.000 | 6.000 | 6.000 | 6.061 | 6.000 | 6.000 |
| | ETW1 (180°F) | B-basis | 65.33 | 30.59 | | 51.82 | 49.95 | 25.68 | 33.56 | 83.29 | 99.34 |
| | | Mean | 74.38 | 36.13 | | 58.03 | 56.60 | 29.49 | 38.74 | 96.20 | 113.1 |
| | | CV | 6.000 | 6.339 | | 6.000 | 6.000 | 6.302 | 6.000 | 7.709 | 6.041 |
| 50/40/10 (Hard) | CTA (-65°F) | B-basis | 206.8 | | | NA | 114.6 | | | | |
| | | Mean | 232.6 | | | 146.7 | 128.6 | | | | |
| | | CV | 6.189 | | | 8.510 | 6.075 | | | | |
| | RTA (70°F) | B-basis | 213.0 | NA | | 136.4 | 115.0 | 55.99 | 73.34 | 92.61 | 117.1 |
| | | Mean | 238.8 | 109.6 | | 154.9 | 129.0 | 61.95 | 85.16 | 104.5 | 130.0 |
| | | CV | 6.296 | 11.55 | | 4.470 | 6.000 | 6.000 | 7.031 | 6.614 | 6.000 |
| | ETW1 (180°F) | B-basis | 192.9 | 54.70 | | 161.8 | 122.7 | 35.66 | NA | 76.13 | 92.32 |
| | | Mean | 218.7 | 65.88 | | 179.9 | 136.7 | 41.63 | 56.71 | 88.02 | 105.2 |
| | | CV | 6.542 | 8.599 | | 1.956 | 6.000 | 6.631 | 6.000 | 6.946 | 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.
ETW2 not included as there were no recommended B-Basis values.
* Data is as measured rather than normalized

**Table 3-4: NCAMP Recommended B-Basis Values for Laminate Strength Tests**

## 3.2 Summary Tables

| | | |
|---|---|---|
| **Reinforcement :** | Tenax™ Reinforcement Fabrics - DRNF IM BA | **Syensqo PRISM™ EP2400 with Tenax™ DRNF - Biaxial Lamina Properties Summary** |
| **Material Specification:** | NMS 241/1, NMS 241F/1 and NMS 241R/1 | |
| **Process Specification:** | NPS 82401 | |
| **Matrix:** | PRISM™ EP2400 | |
| **Tg(dry):** 314°F | **Tg(wet):** 275°F | **Tg METHOD:** ASTM D7028 |

| | |
|---|---|
| **Date of fiber manufacture** | Apr-Oct 2021 |
| **Date of resin manufacture** | 2022 and 2023 |
| **Date of composite manufacture** | Mar to Dec 2023 |
| **Date of testing** | July 2023 to July 2024 |
| **Date of analysis** | August 2024 |

**BIAXIAL LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY**

**Data reported: As measured followed by normalized values in parentheses, normalizing CPT: 0.014 in**

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

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

| Test Condition | CTA | | RTA | | ETA | | ETW1 | | ETW2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Property** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** |
| $F_1^{tu}$ [ksi] | 167.9 (183.1) | 160.3 (174.6) | 178.5 (190.2) | 170.9 (185.8) | 181.9 (196.9) | 174.4 (190.3) | 178.1 (192.9) | 170.5 (185.4) | | |
| $F_2^{tu}$ [ksi] | 149.7 (199.6) | NA | 150.8 (156.1) | NA | 188.1 (203.4) | 183.2 (198.1) | 177.4 (209.5) | 183.3 (196.2) | | |
| $F_1^{cu}$ [ksi] | | | 51.00 (82.76) | NA | 55.68 (60.37) | | 57.17 (49.35) | 55.67 (61.18) | 30.16 (34.69) | 30.23 (34.76) |
| $F_2^{cu}$ [ksi] | | | 83.84 (90.85) | (87.48) | 61.26 (67.20) | NA | 60.11 (49.87) | NA | 42.87 (48.32) | 39.41 (44.19) |
| $F_{12}^{s0.2\%}$ [ksi] | 7.095 | 7.187 | 5.472 | 5.216 | 3.790 | 3.534 | 3.306 | 3.235 | | |
| $F_{12}^{s5\%strain}$ [ksi] | 11.64 | 12.10 | 8.814 | 9.244 | 6.803 | 6.193 | 5.109 | 5.339 | | |
| FLEX | | | 114.3 (99.66) | (127.3) | | | | | | |
| SBS | 7.827 | 8.738 | 9.508 | 8.868 | 7.039 | 6.458 | 6.142 | 5.569 | 3.483 | 2.744 |

**Notes: NA means basis values were not computed for that combination of property/condition**
**Basis values are not computed for Interlaminar Tension properties**
**Shaded empty boxes mean that data was not available for that combination of property/condition**

**Table 3-5: Summary of B-Basis Values and Estimates for Biaxial Lamina Strength Tests**

| | | |
|---|---|---|
| **Reinforcement :** | Tenax™ Reinforcement Fabrics - DRNF IM BD | **Syensqo PRISM™ EP2400 with Tenax™ DRNF - Bidiagonal Lamina Properties Summary** |
| **Material Specification:** | NMS 241/2, NMS 241F/2 and NMS 241R/1 | |
| **Process Specification:** | NPS 82401 | |
| **Matrix:** | PRISM™ EP2400 | |
| **Tg(dry):** 314°F | **Tg(wet):** 274°F | **Tg METHOD:** ASTM D7028 |

| | |
|---|---|
| **Date of fiber manufacture** | Apr-Oct 2021 |
| **Date of resin manufacture** | 2022 and 2023 |
| **Date of composite manufacture** | Mar to Dec 2023 |
| **Date of testing** | July 2023 to July 2024 |
| **Date of analysis** | August 2024 |

**BIDIAGONAL LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY**

**Data reported: As measured followed by normalized values in parentheses, normalizing CPT: 0.014 in**

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

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

| Test Condition | CTA | | RTA | | ETA | | ETW1 | | ETW2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Property** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** |
| $F_1^{tu}$ [ksi] | 195.7 (193.1) | 186.1 (188.2) | 197.9 (162.8) | 188.4 (190.8) | 195.5 (170.4) | 185.9 (188.3) | 187.4 (148.2) | 177.8 (180.1) | | |
| $F_1^{cu}$ [ksi] | | | 92.71 (96.72) | 90.54 (94.60) | 68.11 (70.66) | 65.94 (68.53) | 64.88 (67.46) | 62.72 (65.34) | 47.52 (48.32) | 39.98 (41.26) |
| $F_{12}^{s0.2\%}$ [ksi] | 8.075 | 7.618 | 5.520 | 5.354 | 4.074 | 3.827 | 3.352 | 3.479 | | |
| $F_{12}^{s5\%strain}$ [ksi] | 11.63 | 13.37 | 9.914 | 9.873 | 7.209 | 6.680 | 5.282 | 5.567 | | |
| FLEX | | | 143.0 (149.3) | 135.9 (142.3) | | | | | | |
| SBS | 10.12 | 9.900 | 10.01 | 9.769 | 7.041 | 6.527 | 6.218 | 5.416 | 3.536 | 2.866 |

**Notes: Shaded empty boxes mean that data was not available for that combination of property/condition**
**Basis values are not computed for Interlaminar Tension properties**

**Table 3-6: Summary of B-Basis Values and Estimates for Bidiagonal Lamina Strength Tests**

| | | |
|---|---|---|
| **Reinforcement :** | Tenax™ Reinforcement Fabrics - DRWF IM UD | **Syensqo PRISM™ EP2400 with Tenax™ DRWF - IM UD Lamina Properties Summary** |
| **Material Specification:** | NMS 241/2, NMS 241F/2 and NMS 241R/1 | |
| **Process Specification:** | NPS 82401 | |
| **Matrix:** | PRISM™ EP2400 | |
| **Tg(dry):** 328°F | **Tg(wet):** 288°F | **Tg METHOD** ASTM D7028 |

| | |
|---|---|
| **Date of fiber manufacture** | Apr-Oct 2021 |
| **Date of resin manufacture** | 2022 and 2023 |
| **Date of composite manufacture** | Mar to Dec 2023 |
| **Date of testing** | July 2023 to July 2024 |
| **Date of analysis** | August 2024 |

**UNIDIRECTIONAL LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY**

**Data reported: As measured followed by normalized values in parentheses, normalizing CPT: 0.007 in**

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

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

| Test Condition | CTA | | RTA | | ETA | | ETW1 | | ETW2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Property** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** |
| **$F_1^{tu}$ [ksi]** | 276.3<br>(370.5) | NA<br>(361.1) | 267.6<br>(290.6) | NA | 290.6<br>(372.0) | NA<br>(359.5) | 223.7<br>(236.3) | NA | 320.3<br>(309.6) | 264.3<br>(265.8) |
| **$F_1^{cu}$ [ksi]** | | | 172.6<br>(140.1) | 168.0<br>(170.0) | 79.90<br>(92.66) | NA | 103.6<br>(105.2) | 99.01<br>(99.28) | 36.62<br>(34.67) | |
| **UNT0 Strength [ksi]** | 197.4<br>(179.0) | 188.3<br>(186.9) | 170.4<br>(162.5) | 190.1<br>(188.5) | 195.3<br>(187.4) | 185.1<br>(183.5) | 178.7<br>(173.6) | 180.3<br>(178.8) | | |
| **UNC0 Strength [ksi]** | | | 94.29<br>(74.02) | 91.80<br>(89.94) | 43.89<br>(49.63) | NA | 54.14<br>(53.66) | 51.65<br>(50.42) | 18.28<br>17.11 | |
| **$_{12}^{s0.2\%}$ [ksi]** | 7.792 | 7.538 | 5.848 | 5.319 | 3.590 | 3.548 | 3.301 | 3.231 | | |
| **$^{s5\%strain}$ [ksi]** | 12.45 | 12.74 | 9.134 | 9.536 | 6.125 | 5.951 | 5.624 | 5.187 | | |
| **FLEX** | | | 141.4<br>(142.8) | 139.3<br>(139.3) | | | | | | |
| **SBS** | 14.88 | 14.27 | 10.25 | 10.30 | 5.261 | 6.148 | 4.022 | 5.016 | 2.858 | 2.591 |

**Notes: NA means basis values were not computed for that combination of property/condition**
**Shaded empty boxes mean that data was not available for that combination of property/condition**

**Table 3-7: Summary of B-Basis Values and Estimates for Unidirectional Lamina Strength Tests**

| | | |
|---|---|---|
| **Reinforcement :** | Tenax™ Reinforcement Fabrics | **Syensqo PRISM™ EP2400 with Tenax™ DRNF & DRWF Laminate Properties Summary** |
| **Material Specification:** | NMS 241 series | |
| **Process Specification:** | NPS 82401 | |
| **Matrix:** | PRISM™ EP2400 | |
| **Tg(dry):** 319°F | **Tg(wet):** 281°F | **Tg METHOD:** ASTM D7028 |

| | |
|---|---|
| **Date of fiber manufacture** | Apr-Oct 2021 |
| **Date of resin manufacture** | 2022 and 2023 |
| **Date of composite manufacture** | Mar to Dec 2023 |
| **Date of testing** | July 2023 to July 2024 |
| **Date of analysis** | August 2024 |

**LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY**

**Data reported: As measured followed by normalized values in parentheses, normalizing CPT: 0.007 in**

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

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

| | **Layup** | **25/50/25 (Quasi)** | | **12.5/75/12.5 (Soft)** | | **50/40/10 (Hard)** | | **37.5/25/37.5** | |
|---|---|---|---|---|---|---|---|---|---|
| **Property** | **Test Condition** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** | **B-Basis** | **Modified CV B-Basis** |
| **UNC Strength** | **RTA** | 71.71<br>(78.75) | 71.52<br>(78.11) | 44.85<br>(57.03) | 50.70<br>(55.11) | 81.48<br>(84.26) | 82.41 | | |
| | **ETA** | 48.95<br>(53.90) | 48.75<br>(53.26) | | | | | | |
| | **ETW1** | 42.90<br>(46.91) | 42.71<br>(46.26) | 31.03<br>(32.52) | 30.01<br>(30.59) | 53.86<br>(54.70) | | | |
| | **ETW2** | 21.75<br>(23.18) | 20.99<br>(22.65) | | | | | | |
| **UNT Strength** | **CTA** | 97.22<br>(103.5) | 110.1<br>(117.1) | 62.66<br>(73.74) | 78.80<br>(82.68) | 214.6<br>(185.8) | 203.6<br>(206.8) | | |
| | **RTA** | 122.0<br>(129.7) | 115.8<br>(123.1) | 71.30<br>(84.60) | 75.75<br>(79.42) | 219.2<br>(190.5) | 208.7<br>(213.0) | | |
| | **ETA** | 123.7<br>(131.5) | 117.5<br>(124.9) | 66.76<br>(70.79) | 62.24<br>(65.33) | 199.5<br>(165.3) | 190.6<br>(192.9) | | |
| | **ETW1** | 121.2<br>(128.8) | 114.9<br>(122.3) | | | | | | |
| **FHT Strength** | **CTA** | 71.00<br>(82.79) | 72.38<br>(76.98) | 63.70<br>(58.85) | 59.18<br>(62.12) | 118.0<br>(120.4) | 113.8<br>(114.6) | | |
| | **RTA** | 76.46<br>(82.43) | 71.97<br>(76.62) | 57.26<br>(55.80) | 52.74<br>(55.06) | 106.9<br>(120.8) | 113.8<br>(115.0) | | |
| | **ETA** | 60.65<br>(68.81) | 73.04<br>(77.53) | 52.29<br>(53.69) | 47.78<br>49.95) | 127.6<br>(128.6) | 121.9<br>(122.7) | | |
| | **ETW1** | 78.89<br>(84.52) | 74.41<br>(78.71) | | | | | | |
| **OHT Strength** | **CTA** | 77.88<br>(82.64) | 72.71<br>(77.86) | 50.73<br>(57.54) | 50.45<br>(52.80) | 78.40<br>(90.76) | NA | | |
| | **RTA** | 82.25<br>(87.02) | NA<br>(82.25) | 45.51<br>(52.27) | 49.98<br>(52.04) | 104.5<br>(121.2) | 132.9<br>(136.4) | 82.61<br>(92.22) | 70.25<br>(76.46) |
| | **ETA** | 80.59<br>(85.88) | 75.44<br>(81.11) | | | | | | |
| | **ETW1** | 82.42<br>(87.38) | 77.16<br>(82.63) | 52.58<br>(55.83) | 49.66<br>(51.82) | 148.8<br>(163.3) | 158.9<br>(161.8) | 89.13<br>(101.1) | 87.03<br>(93.87) |

| | Layup | 25/50/25 (Quasi) | | 12.5/75/12.5 (Soft) | | 50/40/10 (Hard) | | 37.5/25/37.5 | |
|---|---|---|---|---|---|---|---|---|---|
| **Property** | **Test Condition** | B-Basis | Modified CV B-Basis | B-Basis | Modified CV B-Basis | B-Basis | Modified CV B-Basis | B-Basis | Modified CV B-Basis |
| **FHC Strength** | **RTA** | 59.08 (63.22) | 56.95 (60.63) | 49.03 (52.93) | 47.27 (51.20) | 73.95 (74.97) | 72.41 (73.34) | | |
| | **ETA** | 47.19 (49.83) | 45.17 (47.83) | | | | | | |
| | **ETW1** | 42.43 (45.02) | 40.53 (43.12) | 34.39 (35.29) | 32.71 (33.56) | 53.18 (53.41) | NA | | |
| **OHC Strength** | **RTA** | 41.43 (44.37) | 40.55 (43.49) | 33.98 (35.96) | 33.15 (34.66) | 47.84 (57.89) | 54.81 (55.99) | 35.36 (37.83) | 33.12 (36.25) |
| | **ETA** | 31.99 (34.30) | 31.11 (33.42) | | | | | | |
| | **ETW1** | 26.36 (26.50) | 28.74 (30.75) | 23.71 (22.00) | 24.39 (25.68) | 36.93 (37.56) | 34.96 (35.66) | 31.28 (32.27) | 26.47 (28.85) |
| | **ETW2** | 20.99 (23.40) | 17.26 (18.64) | | | | | | |
| **SBS1 Strength [ksi]** | **RTA** | 8.529 | 8.442 | | | | | | |
| | **ETA** | 4.918 | 5.872 | | | | | | |
| | **ETW1** | 5.490 | 5.188 | | | | | | |
| **SSB 2% Offset Strength** | **RTA** | 100.1 (105.1) | 96.98 (101.8) | 101.2 (105.4) | 96.03 (99.47) | 92.64 (94.79) | 90.49 (92.61) | | |
| | **ETA** | 85.25 (89.08) | 82.11 (85.76) | | | | | | |
| | **ETW1** | 86.64 (91.82) | 83.50 (88.50) | 60.12 (63.70) | 79.98 (83.29) | 76.47 (78.31) | 74.31 (76.13) | | |
| **SSB Ultimate Strength [ksi]** | **RTA** | 122.2 (128.3) | 115.4 (121.1) | 126.2 (130.1) | 119.2 (123.7) | 120.9 (123.9) | 114.4 (117.1) | | |
| | **ETA** | 104.7 (109.4) | 97.81 (102.2) | | | | | | |
| | **ETW1** | 102.5 (108.7) | 95.70 (101.4) | 102.1 (105.8) | 95.16 (99.34) | 96.55 (99.14) | 90.05 (92.32) | | |
| **Notes:** | **NA means basis values were not computed for that combination of property/condition<br>Basis values are not computed for Compression After Impact properties<br>Shaded empty boxes mean that data was not available for that combination of property/condition** | | | | | | | | |

**Table 3-8: Summary of B-Basis Values and Estimates for Laminate Strength Tests**

# 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-17-1H section 8.4.4.

## 4.1 Biaxial 0° Tension (BA - 0TEN)

Biaxial 0° Tension data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA and ETW1.

For the normalized dataset, every acceptable condition combination for pooling failed either the Anderson darling test for normality or the Levene's test for equality of variances, therefore, the single point normal method was used to compute basis values for CTA, ETA and ETW1, and the single point Weibull method was used for RTA. Applying the modified CV, there were no diagnostic test failures so all conditions were pooled.

For the as measured dataset, there were no diagnostic test failures so all conditions were pooled using both the as measured CV and the modified CV.

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

Statistics, estimates, and basis values are given for the BA 0TEN strength data in Table 4-1 and Table 4-2 and for the modulus data in Table 4-3. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-1.

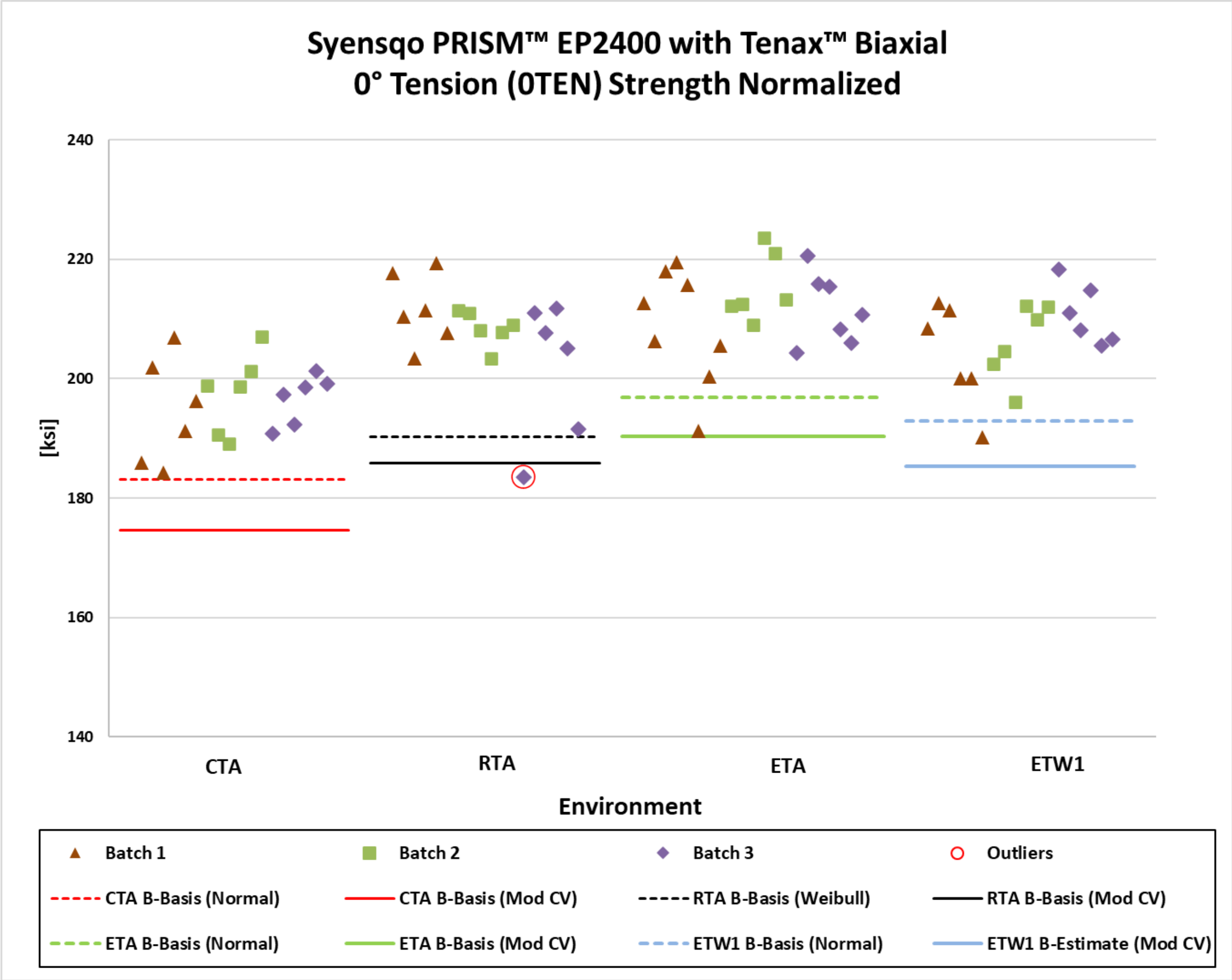


**Figure 4-1: Batch Plot for BA 0TEN Normalized Strength**

| Normalized Biaxial 0TEN Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 196.2 | 207.3 | 211.5 | 206.9 |
| Stdev | 6.606 | 8.407 | 7.677 | 7.071 |
| CV | 3.368 | 4.055 | 3.629 | 3.418 |
| Mod CV | 6.000 | 6.028 | 6.000 | 6.000 |
| Min | 184.2 | 183.5 | 191.3 | 190.2 |
| Max | 207.0 | 219.4 | 223.6 | 218.3 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 21 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 183.1 | 190.2 | 196.9 | 192.9 |
| A-Estimate | 173.9 | 172.3 | 186.5 | 183.1 |
| Method | Normal | Weibull | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 174.6 | 185.8 | 190.3 | 185.4 |
| A-Estimate | 160.5 | 171.6 | 176.1 | 171.2 |
| Method | Pooled | Pooled | Pooled | Pooled |

**Table 4-1: Normalized Statistics, B-Basis Values and Estimates for BA 0TEN Strength Data**

| As Measured Biaxial 0TEN Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 180.1 | 190.7 | 193.9 | 190.3 |
| Stdev | 6.631 | 7.977 | 6.677 | 6.680 |
| CV | 3.681 | 4.183 | 3.443 | 3.509 |
| Mod CV | 6.000 | 6.091 | 6.000 | 6.000 |
| Min | 170.2 | 169.4 | 179.7 | 177.0 |
| Max | 192.1 | 205.5 | 204.3 | 202.8 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 21 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 167.9 | 178.5 | 181.9 | 178.1 |
| A-Estimate | 159.9 | 170.5 | 173.9 | 170.1 |
| Method | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 160.3 | 170.9 | 174.4 | 170.5 |
| A-Estimate | 147.2 | 157.8 | 161.3 | 157.4 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-2: As Measured Statistics, B-Basis Values and Estimates for BA 0TEN Strength Data

| Biaxial 0TEN Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | CTA | RTA | ETA | ETW1 | CTA | RTA | ETA | ETW1 |
| Mean | 12.49 | 12.49 | 12.17 | 12.22 | 11.47 | 11.50 | 11.16 | 11.24 |
| Stdev | 0.4962 | 0.3928 | 0.09238 | 0.1058 | 0.5465 | 0.4751 | 0.1852 | 0.2216 |
| CV | 3.972 | 3.144 | 0.7590 | 0.8655 | 4.763 | 4.132 | 1.659 | 1.971 |
| Min | 11.74 | 11.63 | 12.05 | 12.08 | 10.68 | 10.72 | 10.65 | 10.97 |
| Max | 13.32 | 12.99 | 12.45 | 12.52 | 12.30 | 12.26 | 11.44 | 11.82 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 21 | 18 | 18 | 18 | 21 | 18 |

Table 4-3: Statistics for BA 0TEN Modulus Data

## 4.2 Biaxial 0° Compression (BA-0CLC)

Biaxial 0° Compression data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA, ETW1 and ETW2.

The RTA condition consists of three batches with seventeen specimens, therefore only estimates were computed for RTA. The ETW2 condition consists of one batch with six specimens, therefore only estimates were computed for ETW2.

For the normalized dataset, the ETW1 condition failed the ADK test for batch equivalency, ANOVA was used to compute estimates for ETW1, the single point normal method was used for the remaining environments. Applying the modified CV, ETA resulted in the same values as the as measured CV is greater than 8%. The normal method for modified CV was used for the remaining conditions.

For the as measured dataset, the RTA condition failed the ADK test for batch equivalency, therefore, pooling all conditions was not possible. ANOVA was used to compute estimates for RTA and the single point normal method was used for the remaining conditions. Applying the modified CV, RTA failed the ADK test, therefore pooling across conditions was not possible and basis values could not be calculated for RTA, ETA resulted in the same values as the as measured CV is greater than 8%, and the normal method for modified CV was used for the remaining conditions.

There were no statistical outliers.

Statistics, estimates and basis values are given for the 0CLC strength data in Table 4-4 and Table 4-5 and for the modulus data in Table 4-6. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-2.

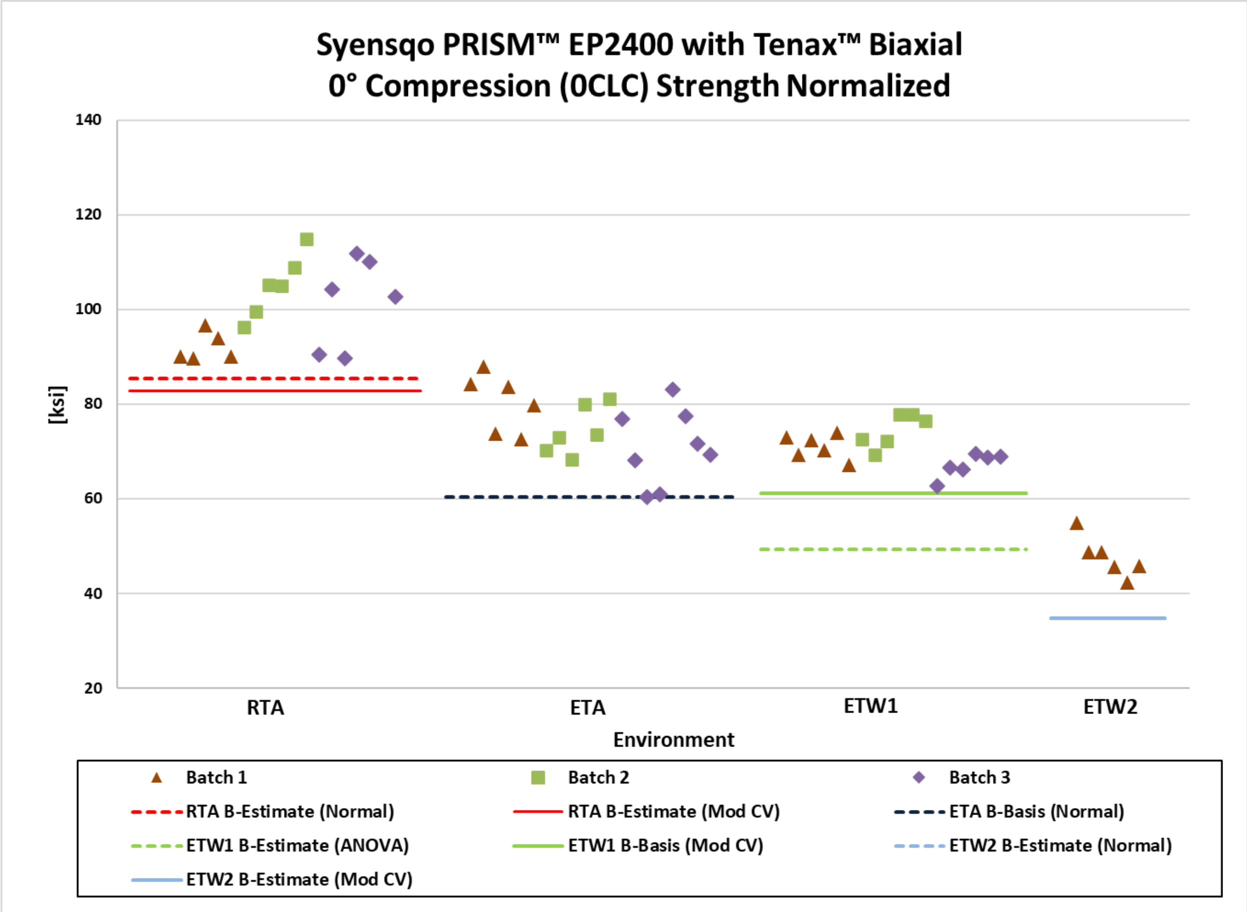


**Figure 4-2: Batch Plot for BA 0CLC Normalized Strength**

| Normalized Biaxial 0CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 99.99 | 74.82 | 70.81 | 47.68 |
| Stdev | 8.602 | 7.500 | 4.095 | 4.290 |
| CV | 8.603 | 10.02 | 5.783 | 8.996 |
| Mod CV | 8.603 | 10.02 | 6.891 | 8.996 |
| Min | 89.63 | 60.37 | 62.66 | 42.29 |
| Max | 114.8 | 87.89 | 77.76 | 54.92 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 17 | 20 | 18 | 6 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 60.37 | | |
| B-Estimate | 82.76 | | 49.35 | 34.69 |
| A-Estimate | 70.58 | 50.10 | 34.05 | 25.45 |
| Method | Normal | Normal | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | | | 61.18 | |
| B-Estimate | 82.77 | | | 34.76 |
| A-Estimate | 70.61 | | 54.36 | 25.92 |
| Method | Normal | | Normal | Normal |

**Table 4-4: Normalized Statistics, B-Basis Values and Estimates for BA 0CLC Strength Data**

| As Measured Biaxial 0CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 90.30 | 68.09 | 64.32 | 42.76 |
| Stdev | 7.897 | 6.439 | 3.624 | 4.159 |
| CV | 8.745 | 9.457 | 5.635 | 9.728 |
| Mod CV | 8.745 | 9.457 | 6.817 | 9.728 |
| Min | 79.15 | 55.93 | 57.79 | 37.54 |
| Max | 103.3 | 80.31 | 70.93 | 49.34 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 17 | 20 | 18 | 6 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 55.68 | 57.17 | |
| B-Estimate | 51.00 | | | 30.16 |
| A-Estimate | 22.98 | 46.86 | 52.10 | 21.20 |
| Method | ANOVA | Normal | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | NA | | 55.67 | |
| B-Estimate | | | | 30.23 |
| A-Estimate | | | 49.54 | 21.66 |
| Method | | | Normal | Normal |

Table 4-5: As Measured Statistics, B-Basis Values and Estimates for BA 0CLC Strength Data

| Biaxial 0CLC Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | RTA | ETA | ETW1 | ETW2 | RTA | ETA | ETW1 | ETW2 |
| Mean | 11.20 | 11.08 | 11.35 | 11.20 | 10.12 | 10.07 | 10.32 | 10.04 |
| Stdev | 0.2885 | 0.3362 | 0.7030 | 0.3348 | 0.2631 | 0.2749 | 0.6924 | 0.3930 |
| CV | 2.576 | 3.034 | 6.192 | 2.990 | 2.599 | 2.729 | 6.711 | 3.916 |
| Min | 10.65 | 10.42 | 10.38 | 10.78 | 9.715 | 9.561 | 9.369 | 9.500 |
| Max | 11.92 | 11.54 | 12.95 | 11.62 | 10.46 | 10.63 | 11.96 | 10.56 |
| No. Batches | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 6 | 18 | 18 | 18 | 6 |

Table 4-6: Statistics for BA 0CLC Modulus Data

## 4.3 Biaxial 90° Tension (BA-90TEN)

Biaxial 90° Tension data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW1.

The ETW1 condition consists of three batches with seventeen specimens, therefore only estimates were computed for ETW1.

For the normalized dataset the RTA condition failed the ADK test for batch equivalency, therefore, pooling all conditions was not possible. ANOVA was used to compute estimates for RTA and the single point normal method was used for the remaining conditions. Applying the modified CV, RTA failed the ADK test, therefore pooling all conditions was not possible and basis values could not be calculated for RTA and the modified CV normal method was used for the remaining conditions.

For the as measured dataset, CTA, RTA and ETW1 failed the ADK test for batch equivalency, therefore pooling across conditions was not acceptable. ANOVA was used to compute estimates for CTA, RTA and ETW1 and the single point normal method was used for ETA. Applying the modified CV, CTA and RTA failed the ADK test, so pooling all conditions was not acceptable and basis values could not be computed for CTA and RTA, and the modified CV normal method was used for ETA and ETW1.

There were two statistical outliers. The lowest normalized value in batch one of the CTA condition was an outlier for the batch but not for the condition. It was an outlier in the normalized dataset and in the as measured dataset. The lowest normalized value in batch three of the CTA condition was an outlier for the environment and for the batch. It was an outlier in the normalized dataset and in the as measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the BA 90TEN strength data in Table 4-7 and Table 4-8 and for the modulus data in Table 4-9. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-3.

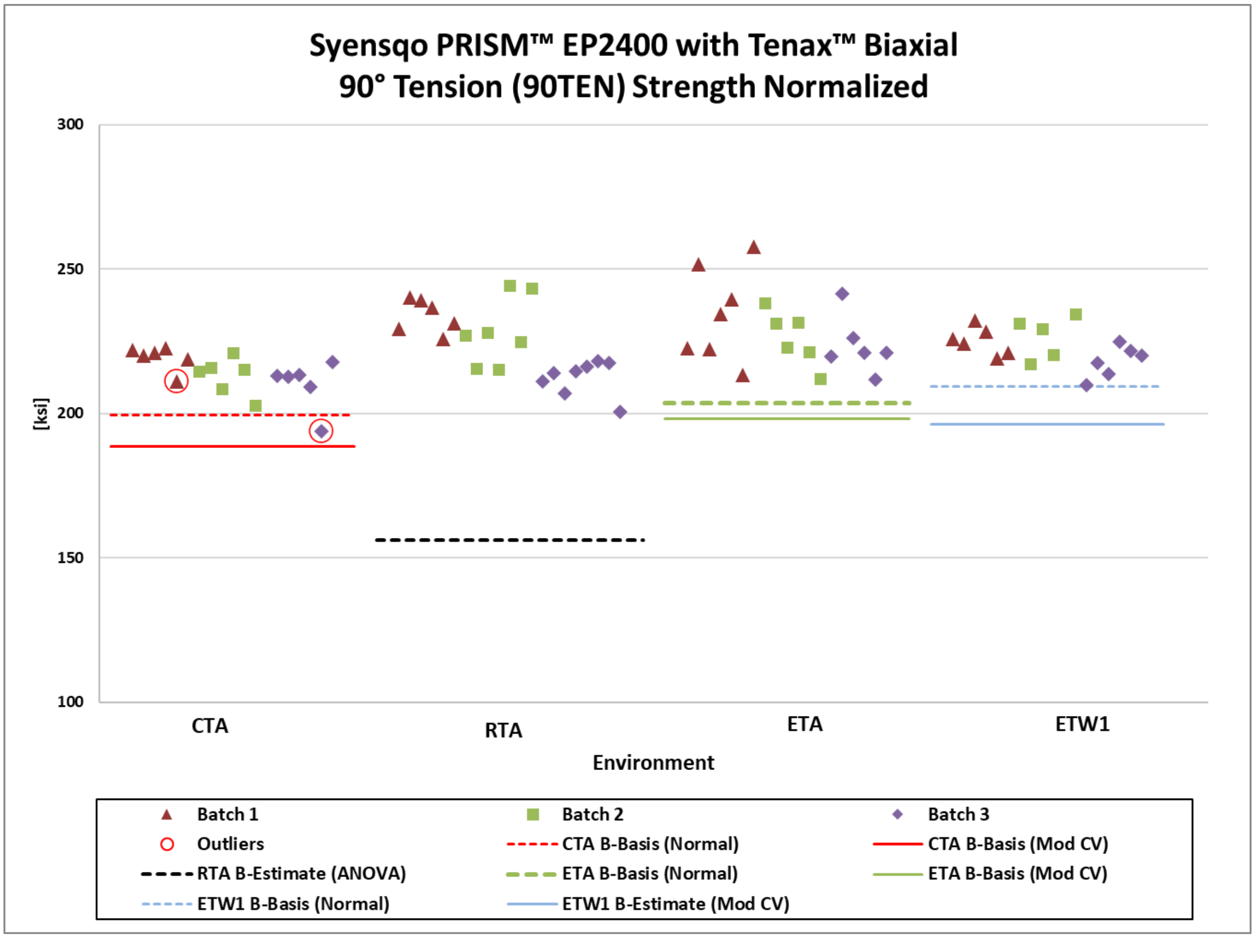


**Figure 4-3: Batch Plot for BA 90TEN Normalized Strength**

| Normalized Biaxial 90 TEN Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 214.1 | 223.8 | 228.4 | 222.9 |
| Stdev | 7.345 | 12.26 | 12.82 | 6.723 |
| CV | 3.431 | 5.477 | 5.611 | 3.016 |
| Mod CV | 6.000 | 6.739 | 6.805 | 6.000 |
| Min | 193.9 | 200.7 | 211.7 | 209.7 |
| Max | 222.7 | 244.3 | 257.8 | 234.3 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 21 | 19 | 17 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 199.6 | | 203.4 | |
| B-estimate | | 156.1 | | 209.5 |
| A-Estimate | 189.3 | 107.8 | 185.7 | 200.0 |
| Method | Normal | ANOVA | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 188.7 | NA | 198.1 | |
| B-estimate | | | | 196.2 |
| A-Estimate | 170.8 | | 176.6 | 177.3 |
| Method | Normal | | Normal | Normal |

Table 4-7: Normalized Statistics, B-Basis Values and Estimates for BA 90TEN Strength Data

| As Measured Biaxial 90 TEN Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 198.8 | 208.6 | 211.3 | 208.4 |
| Stdev | 8.857 | 10.29 | 11.91 | 6.812 |
| CV | 4.455 | 4.934 | 5.638 | 3.269 |
| Mod CV | 6.227 | 6.467 | 6.819 | 6.000 |
| Min | 183.2 | 193.8 | 191.3 | 193.8 |
| Max | 210.1 | 228.7 | 237.5 | 218.2 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 21 | 19 | 17 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | | 188.1 | |
| B-estimate | 149.7 | 150.8 | | 177.4 |
| A-Estimate | 114.7 | 109.6 | 171.6 | 155.3 |
| Method | ANOVA | ANOVA | Normal | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | NA | NA | 183.2 | |
| B-estimate | | | | 183.3 |
| A-Estimate | | | 163.3 | 165.7 |
| Method | | | Normal | Normal |

Table 4-8: As Measured Statistics, B-Basis Values and Estimates for BA 90TEN Strength

| Biaxial 90TEN Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | CTA | RTA | ETA | ETW1 | CTA | RTA | ETA | ETW1 |
| Mean | 12.74 | 12.74 | 12.50 | 12.52 | 11.84 | 11.85 | 11.56 | 11.67 |
| Stdev | 0.6298 | 0.6594 | 0.4835 | 0.3724 | 0.7297 | 0.6787 | 0.5060 | 0.3078 |
| CV | 4.942 | 5.175 | 3.868 | 2.974 | 6.165 | 5.728 | 4.376 | 2.637 |
| Min | 11.88 | 11.93 | 11.84 | 12.03 | 10.93 | 10.84 | 10.62 | 11.05 |
| Max | 14.07 | 14.06 | 13.65 | 13.56 | 13.36 | 13.59 | 12.57 | 12.20 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 19 | 19 | 18 | 18 | 19 | 19 | 18 |

**Table 4-9: Statistics for BA 90TEN Modulus Data**

## 4.4 Biaxial 90° Compression (BA-90CLC)

Biaxial 90° Compression data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with seven specimens, therefore only estimates were computed for ETW2.

For the normalized data, the ETW1 condition failed the ADK test for batch equivalency. RTA and ETA were pooled, ANOVA was used to compute estimates for ETW1, and the single point normal method was used for ETW2. Applying the modified CV, ETA and ETW1 failed the ADK test, therefore, basis values could not be computed. The normal method for modified CV was used to compute values and estimates for the remaining conditions.

For the as measured dataset, there were no diagnostic test failures so RTA, ETA and ETW1 were pooled, the modified CV section is grayed out because there was no change to the as measured CV. The normal method was used to compute estimates for ETW2.

There was one statistical outlier. The highest as measured value in batch two of the ETW1 condition was an outlier for the batch but not for the condition. It was an outlier in the as measured dataset, but not in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the BA 90CLC strength data in Table 4-10 and Table 4-11 and for the modulus data in Table 4-12. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-4.

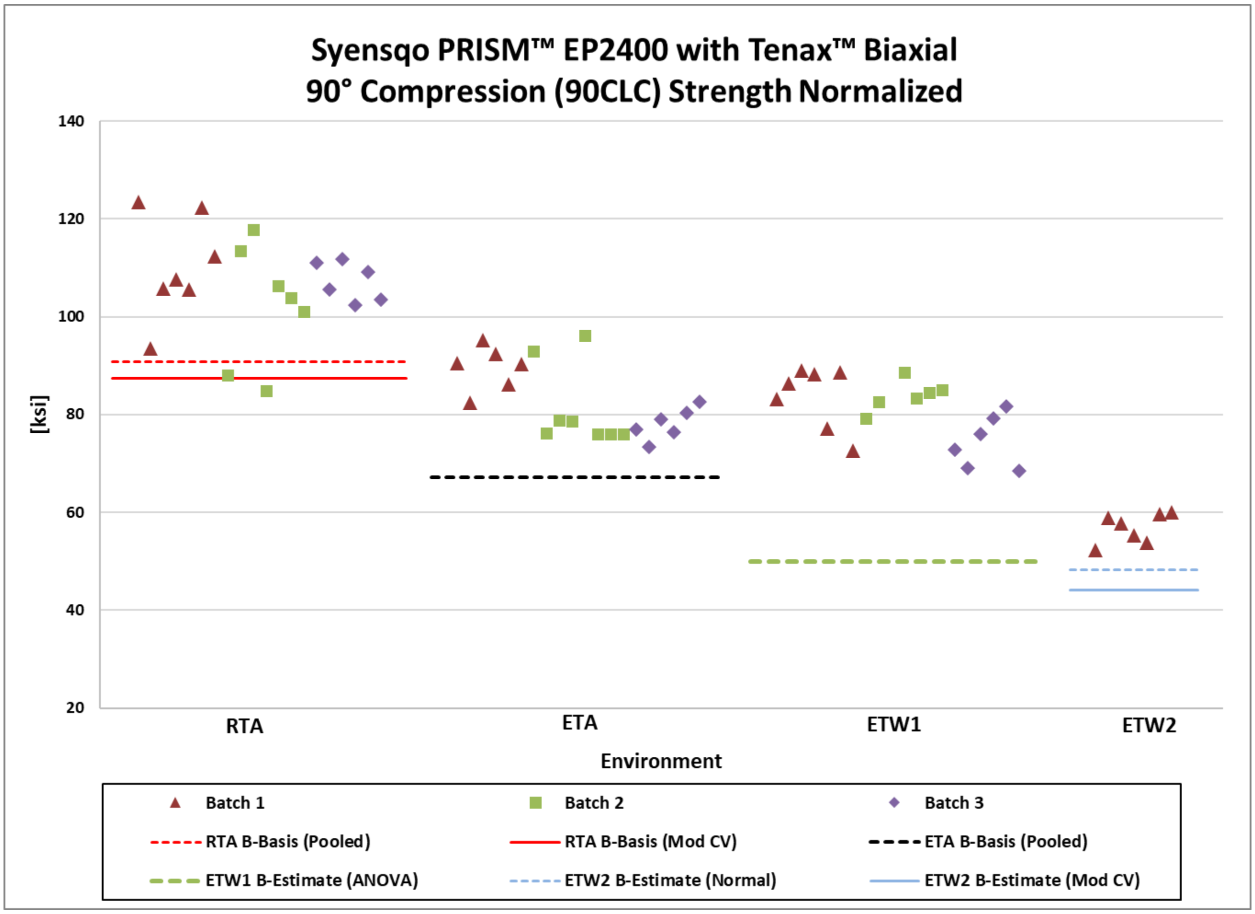


**Figure 4-4: Batch Plot for BA 90CLC Normalized Strength**

| Normalized Biaxial 90 CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 106.5 | 82.81 | 80.83 | 56.81 |
| Stdev | 9.850 | 7.439 | 6.624 | 3.059 |
| CV | 9.253 | 8.983 | 8.195 | 5.384 |
| Mod CV | 9.253 | 8.983 | 8.195 | 8.000 |
| Min | 84.80 | 73.43 | 68.48 | 52.31 |
| Max | 123.4 | 96.13 | 89.05 | 60.00 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 20 | 20 | 19 | 7 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 90.85 | 67.20 | | |
| B-estimate | | | 49.87 | 48.32 |
| A-Estimate | 80.16 | 56.51 | 27.79 | 42.34 |
| Method | Pooled | Pooled | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 87.48 | NA | NA | |
| B-estimate | | | | 44.19 |
| A-Estimate | 74.00 | | | 35.31 |
| Method | Normal | | | Normal |

Table 4-10: Normalized Statistics, B-Basis Values and Estimates for BA 90CLC Strength Data

| As Measured Biaxial 90 CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 96.44 | 73.86 | 72.78 | 50.66 |
| Stdev | 8.826 | 6.511 | 5.964 | 2.807 |
| CV | 9.152 | 8.814 | 8.195 | 5.541 |
| Mod CV | 9.152 | 8.814 | 8.195 | 8.000 |
| Min | 76.87 | 64.97 | 61.06 | 46.24 |
| Max | 112.2 | 84.50 | 81.65 | 53.59 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 20 | 20 | 19 | 7 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 83.84 | 61.26 | 60.11 | |
| B-estimate | | | | 42.87 |
| A-Estimate | 75.35 | 52.78 | 51.64 | 37.38 |
| Method | Pooled | Pooled | Pooled | Normal |
| Modified CV Estimates | | | | |
| B-estimate | | | | 39.41 |
| A-Estimate | | | | 31.49 |
| Method | | | | Normal |

Table 4-11: As Measured Statistics, B-Basis Values and Estimates for BA 90CLC Strength Data

| Bixial 90CLC Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | RTA | ETA | ETW1 | ETW2 | RTA | ETA | ETW1 | ETW2 |
| Mean | 11.36 | 11.98 | 11.71 | 11.07 | 10.30 | 10.71 | 10.55 | 9.901 |
| Stdev | 0.4605 | 0.9228 | 0.4270 | 0.7324 | 0.4216 | 0.7921 | 0.4965 | 0.4962 |
| CV | 4.053 | 7.702 | 3.645 | 6.617 | 4.092 | 7.397 | 4.708 | 5.012 |
| Min | 10.72 | 10.99 | 11.22 | 10.32 | 9.707 | 9.587 | 10.01 | 9.333 |
| Max | 12.73 | 14.33 | 12.74 | 12.04 | 11.19 | 12.82 | 11.66 | 10.69 |
| No. Batches | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 19 | 18 | 6 | 18 | 19 | 18 | 6 |

Table 4-12: Statistics for BA 90CLC Modulus Data

## 4.5 Biaxial In-Plane Shear (BA-IPS)

In Plane Shear data is not normalized. Test results were available for 0.2% offset strength and strength at 5% strain in the following environmental conditions: CTA, RTA, ETA, and ETW1.

For the 0.2% Offset Strength dataset, the CTA and ETW1 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for CTA and ETW1. Batches for RTA and ETA were pooled. Applying the modified CV, the normal method for modified CV was used for CTA and ETW1 and RTA and ETA were pooled.

For the Strength at 5% Strain dataset, CTA, RTA, and ETW1 failed the ADK test for batch equivalency. ANOVA was used to compute estimates for CTA, RTA and ETW1. The single point normal method was used for ETA. Applying the modified CV, the normal method for modified CV was used for CTA and ETW1, and RTA and ETA were pooled.

There were no statistical outliers.

Statistics, basis values and estimates are given for the BA IPS strength data in Table 4-13 and Table 4-14 and for the modulus data in Table 4-15. The as measured data, B-basis values and B-estimates are shown graphically for Strength at 5% Strain in Figure 4-5 and for 0.2% Offset Strength in Figure 4-6.

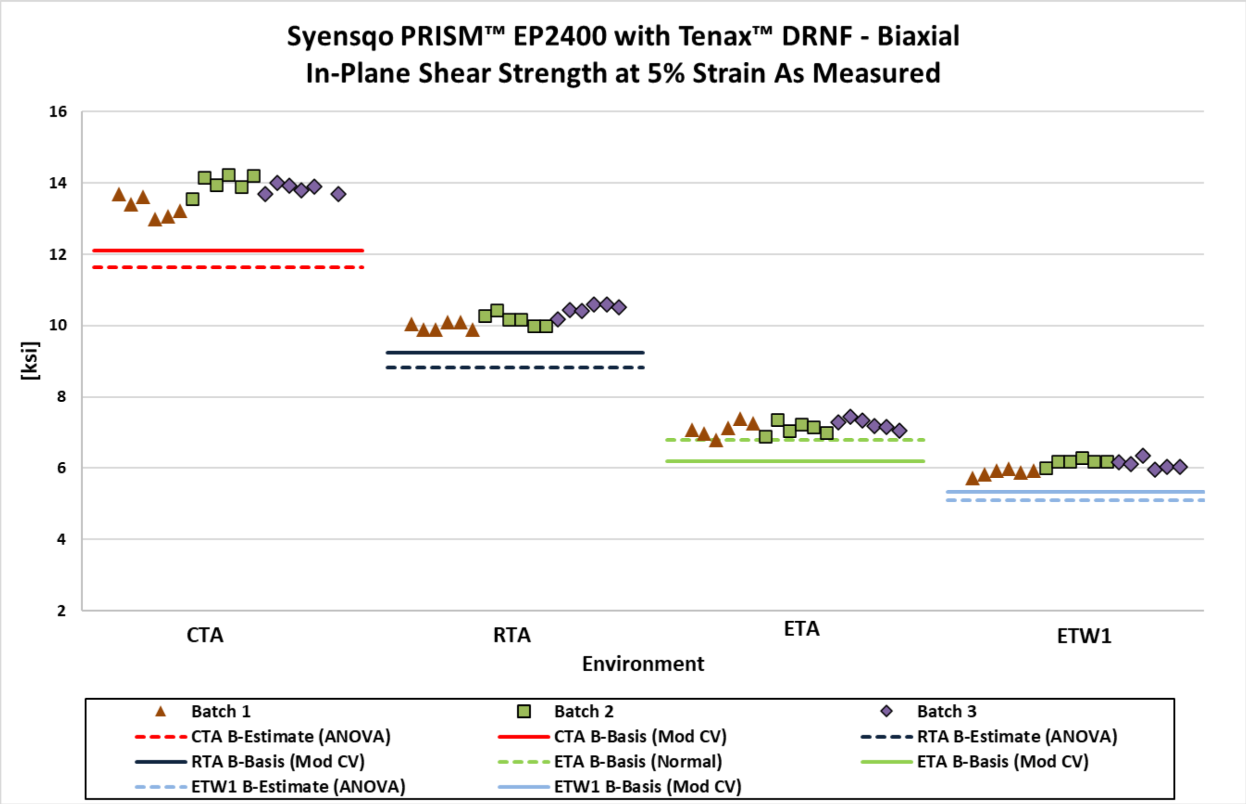


**Figure 4-5: Batch Plot for BA IPS As Measured Strength at 5% Strain**

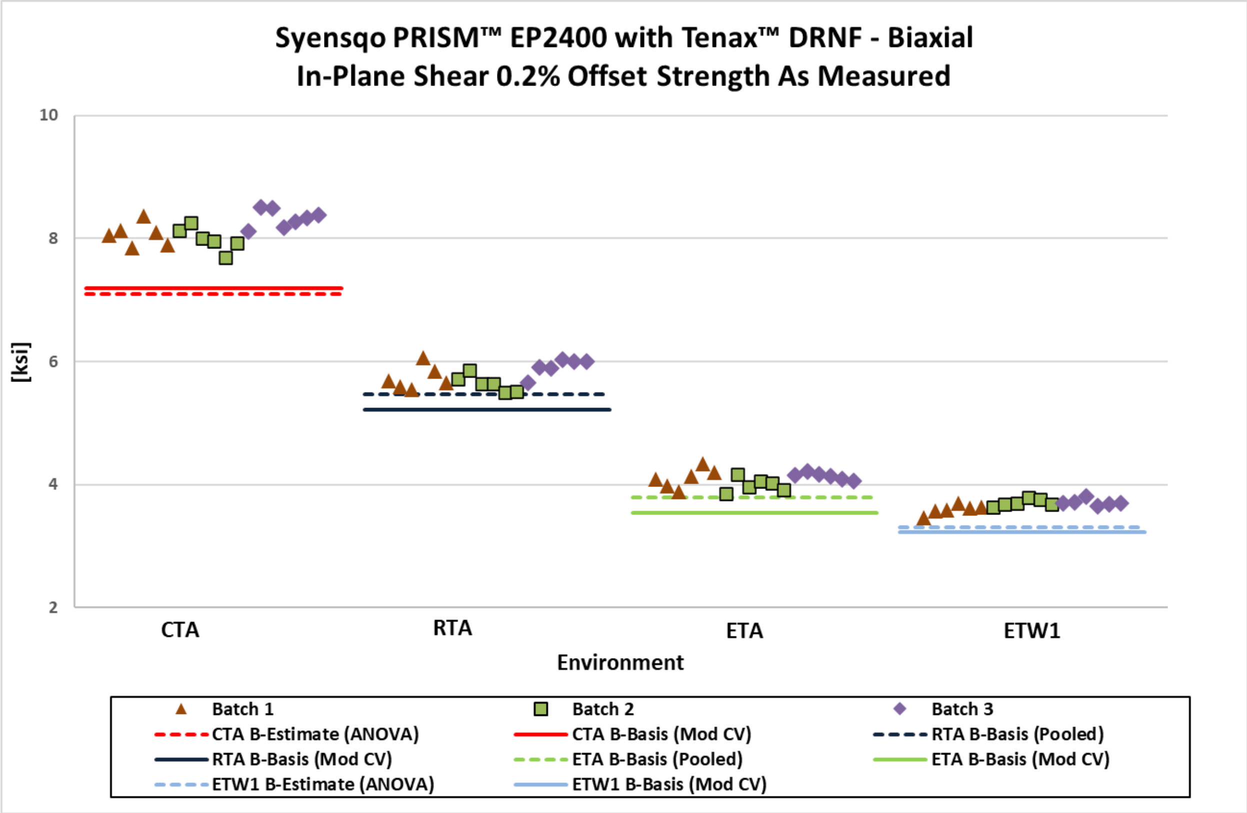


**Figure 4-6: Batch Plot for BA IPS 0.2% Offset As Measured Strength**

| Biaxial IPS 0.2 % Offset Strength Basis Values and Statistics As Measured Values | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 8.139 | 5.762 | 4.079 | 3.669 |
| Stdev | 0.2226 | 0.1873 | 0.1244 | 0.07952 |
| CV | 2.735 | 3.251 | 3.051 | 2.167 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 7.692 | 5.494 | 3.858 | 3.467 |
| Max | 8.508 | 6.061 | 4.345 | 3.808 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 19 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 5.472 | 3.790 | |
| B-Estimate | 7.095 | | | 3.306 |
| A-Estimate | 6.351 | 5.275 | 3.593 | 3.048 |
| Method | ANOVA | Pooled | Pooled | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 7.187 | 5.216 | 3.534 | 3.235 |
| A-Estimate | 6.512 | 4.845 | 3.163 | 2.927 |
| Method | Normal | Pooled | Pooled | Normal |

**Table 4-13: Statistics, B-Basis Values and Estimates for BA IPS 0.2% Offset Strength Data**

| Biaxial IPS Strength at 5% Strain Basis Values and Statistics As Measured Values | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 13.73 | 10.21 | 7.156 | 6.056 |
| Stdev | 0.3671 | 0.2398 | 0.1787 | 0.1675 |
| CV | 2.674 | 2.350 | 2.497 | 2.765 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 13.00 | 9.890 | 6.790 | 5.714 |
| Max | 14.23 | 10.60 | 7.434 | 6.347 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | | 6.803 | |
| B-Estimate | 11.64 | 8.814 | | 5.109 |
| A-Estimate | 10.15 | 7.820 | 6.553 | 4.433 |
| Method | ANOVA | ANOVA | Normal | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 12.10 | 9.244 | 6.193 | 5.339 |
| A-Estimate | 10.95 | 8.589 | 5.537 | 4.832 |
| Method | Normal | Pooled | Pooled | Normal |

**Table 4-14: Statistics, B-Basis Values and Estimates for BA IPS Strength at 5% Strain Data**

| Biaxial IPS Modulus Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 0.7199 | 0.5770 | 0.4282 | 0.3935 |
| Stdev | 0.02102 | 0.02193 | 0.01512 | 0.01109 |
| CV | 2.920 | 3.801 | 3.531 | 2.818 |
| Min | 0.6798 | 0.5406 | 0.4030 | 0.3628 |
| Max | 0.7552 | 0.6106 | 0.4583 | 0.4085 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 19 | 18 | 18 | 18 |

**Table 4-15: Statistics for BA IPS Modulus Data**

## 4.6 Biaxial Lamina Short Beam Strength (BA-SBS)

The Short Beam Strength data is not normalized. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with six specimens, therefore only estimates were computed for ETW2.

The CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for CTA. The single point normal method was used to compute values and estimates for the remaining conditions. Applying the modified CV, CTA and RTA were pooled and the normal method for modified CV was used for the remaining conditions.

There was one statistical outlier. The lowest value in batch one in the ETW1 condition was an outlier for the condition but not for the batch. It was retained for this analysis.

Statistics, basis values and estimates are given for the BA Lamina SBS strength data in Table 4-16. The as measured data, B-basis values and B-estimates are shown graphically in Figure 4-7.

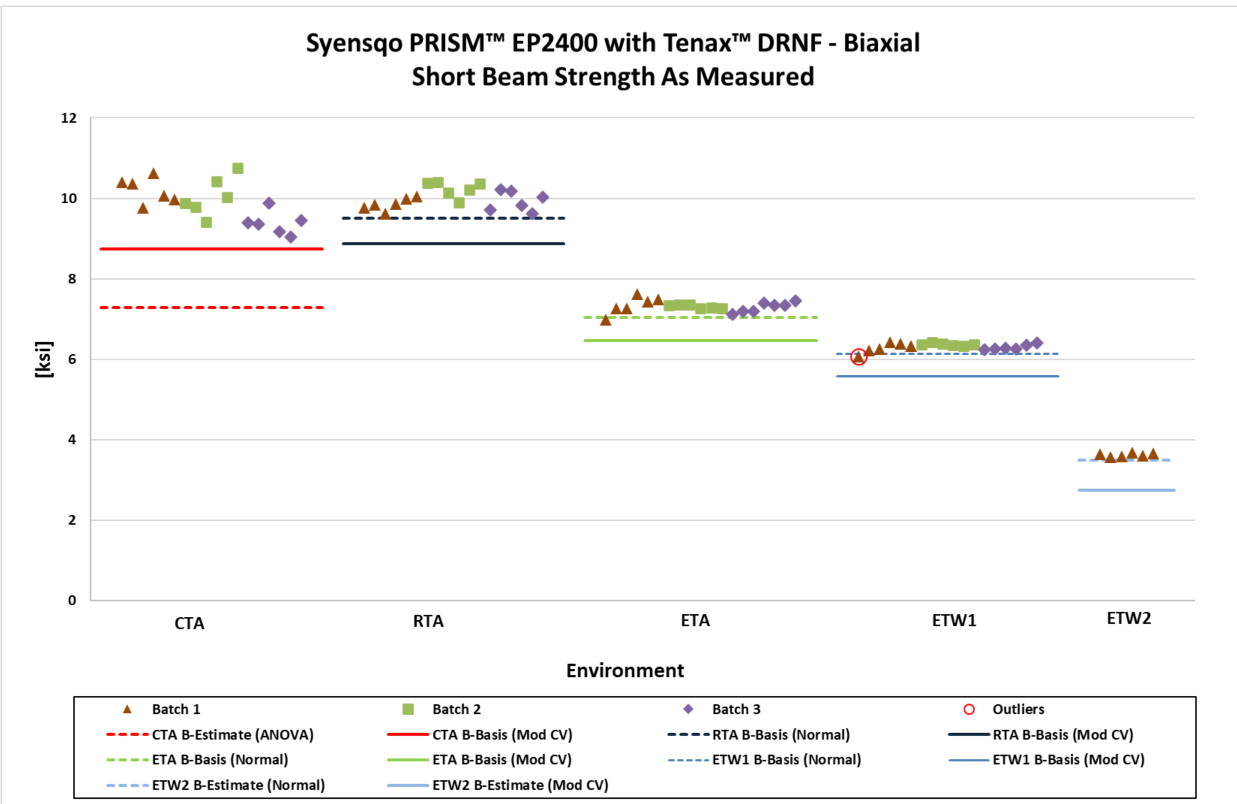

**Figure 4-7: Batch Plot for BA SBS As Measured Strength**

| Biaxial Short Beam Strength (SBS) As Measured Basis Values and Statistics | | | | | |
|---|---|---|---|---|---|
| **Env** | **CTA** | **RTA** | **ETA** | **ETW1** | **ETW2** |
| **Mean** | 9.876 | 10.01 | 7.313 | 6.317 | 3.622 |
| **Stdev** | 0.5066 | 0.2527 | 0.1408 | 0.08882 | 0.04565 |
| **CV** | 5.130 | 2.526 | 1.926 | 1.406 | 1.261 |
| **Mod CV** | 6.565 | 6.000 | 6.000 | 6.000 | 6.000 |
| **Min** | 9.042 | 9.626 | 6.989 | 6.075 | 3.569 |
| **Max** | 10.76 | 10.41 | 7.624 | 6.428 | 3.684 |
| **No. Batches** | 3 | 3 | 3 | 3 | 1 |
| **No. Spec.** | 18 | 18 | 19 | 18 | 6 |
| **Basis Value and Estimates** | | | | | |
| **B-Basis Value** | | 9.508 | 7.039 | 6.142 | |
| **B-Estimate** | 7.287 | | | | 3.483 |
| **A-Estimate** | 5.441 | 9.154 | 6.844 | 6.017 | 3.385 |
| **Method** | ANOVA | Normal | Normal | Normal | Normal |
| **Modified CV Basis Value and Estimates** | | | | | |
| **B-Basis Value** | 8.738 | 8.868 | 6.458 | 5.569 | |
| **B-Estimate** | | | | | 2.744 |
| **A-Estimate** | 7.963 | 8.094 | 5.852 | 5.039 | 2.120 |
| **Method** | Pooled | Pooled | Normal | Normal | Normal |

**Table 4-16: Statistics, B-Basis Values and Estimates for BA SBS Strength Data**

## 4.7 Biaxial Flexural Strength (BA-FLEX)

The Biaxial FLEX data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Test were conducted in the following environmental condition: RTA.

For both normalized and as measured dataset, the single point normal method was used to compute basis values and estimates. Applying the modified CV, the normal method for modified CV was used to compute basis values and estimates.

There were no statistical outliers.

Statistics, basis values and estimates are given for the BA FLEX strength data in Table 4-17. The normalized data and B-basis values are shown graphically in Figure 4-8.

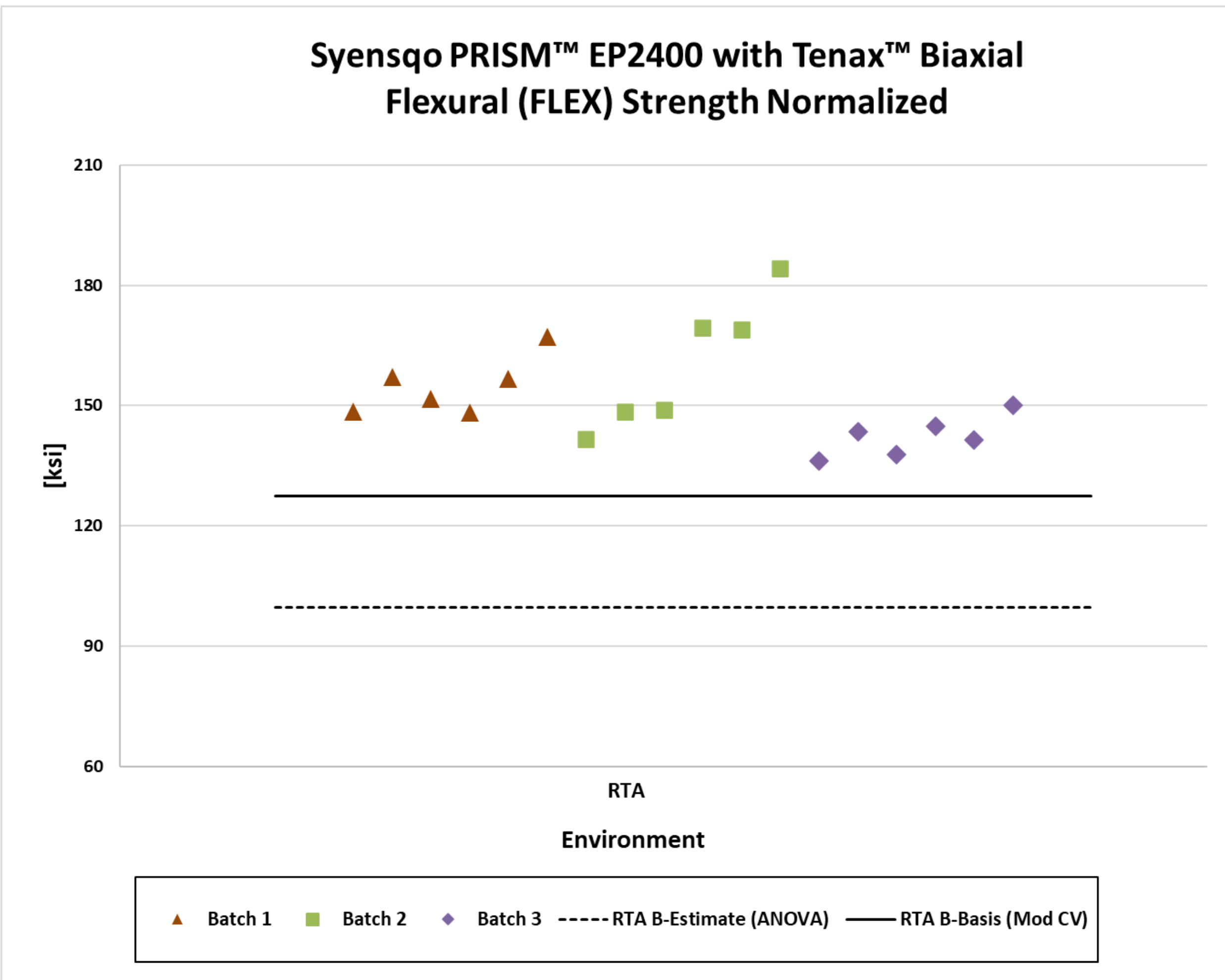


**Figure 4-8: Batch Plot for BA FLEX Normalized Strength**

| Biaxial FLEX Strength Basis Values and Statistics | | |
|---|---|---|
| | Normalized | As-Measured |
| Env | RTA | RTA |
| Mean | 152.5 | 136.3 |
| Stdev | 12.74 | 11.16 |
| CV | 8.354 | 8.185 |
| Mod CV | 8.354 | 8.185 |
| Min | 136.3 | 122.7 |
| Max | 184.3 | 164.9 |
| No. Batches | 3 | 3 |
| No. Spec. | 18 | 18 |
| Basis Values and Estimates | | |
| B-Basis Value | | 114.3 |
| B-Estimate | 99.66 | |
| A-Estimate | 62.04 | 98.67 |
| Method | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | |
| B-Basis Value | 127.3 | |
| A-Estimate | 109.5 | |
| Method | Normal | |

**Table 4-17: Statistics, B-Basis Values and Estimates for BA FLEX Strength Data**

## 4.8 Bidiagonal 0° Tension (BD-0TEN)

The BD 0° Tension data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW1.

For the normalized dataset, the RTA, ETA and ETW1 conditions failed the ADK test for batch equivalency, therefore pooling all conditions was not possible. ANOVA was used to compute estimates for RTA, ETA and ETW1, and the single point normal method was used for CTA. Applying the modified CV, there were no diagnostic test failures so all the conditions were pooled.

For the as measured dataset, there were no diagnostic test failures so all the conditions were pooled.

There was one statistical outlier. The highest normalized value of batch one in the ETW1 condition was an outlier for the batch but nor for the condition. It was an outlier in the normalized dataset but not in the as measured dataset.

Statistics, estimates, and basis values are given for the BD 0TEN strength data in Table 4-18 and Table 4-19 and for the modulus data in Table 4-20. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-9.

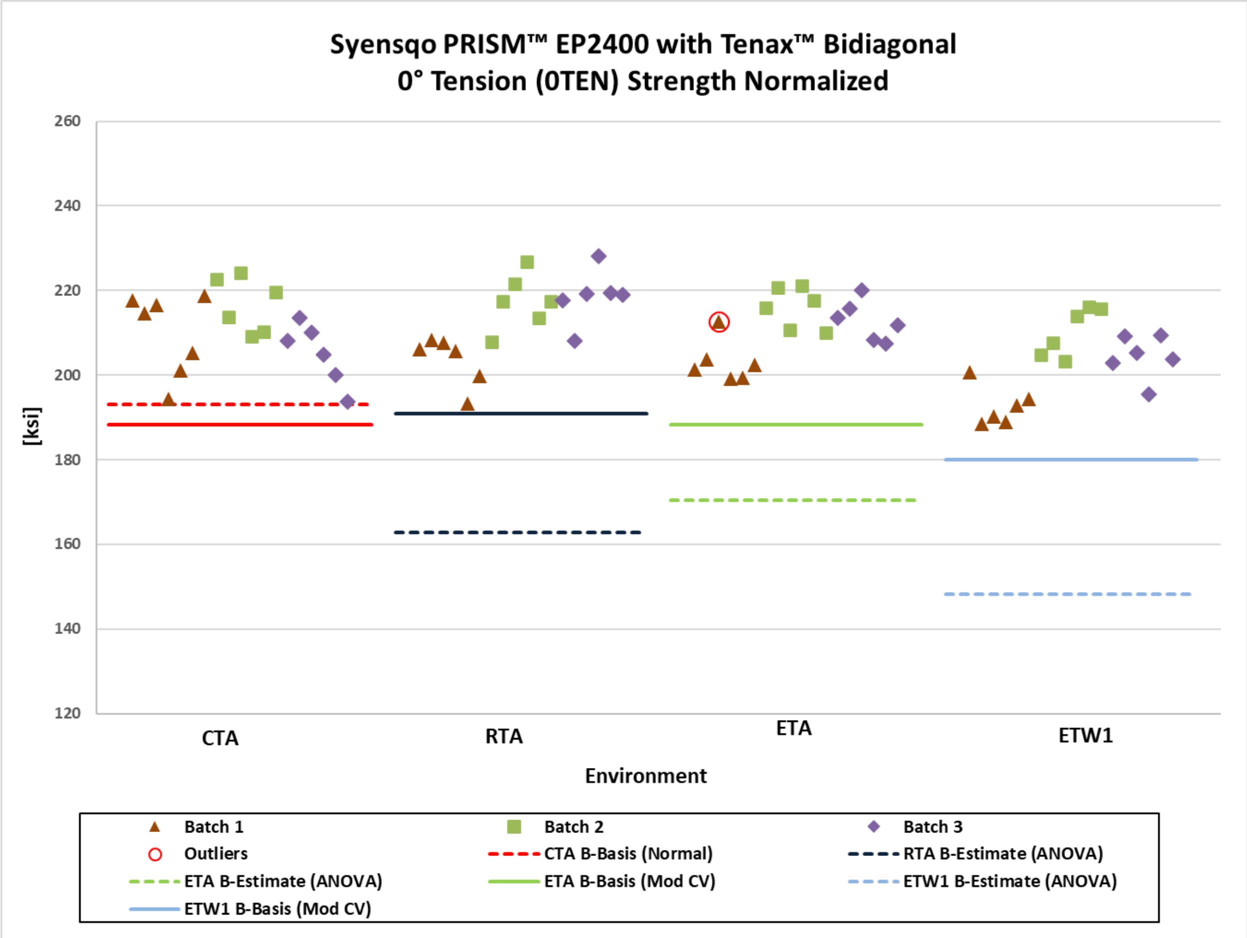


**Figure 4-9: Batch Plot for BD 0TEN Normalized Strength**

| Normalized Bidiagonal 0TEN Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 210.4 | 213.1 | 210.7 | 202.4 |
| Stdev | 8.893 | 9.194 | 7.270 | 8.958 |
| CV | 4.226 | 4.313 | 3.451 | 4.426 |
| Mod CV | 6.113 | 6.157 | 6.000 | 6.213 |
| Min | 193.7 | 193.2 | 199.1 | 188.5 |
| Max | 224.2 | 228.0 | 221.2 | 216.0 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 19 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 193.1 | | | |
| B-Estimate | | 162.8 | 170.4 | 148.2 |
| A-Estimate | 180.8 | 127.0 | 141.7 | 109.6 |
| Method | Normal | ANOVA | ANOVA | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 188.2 | 190.8 | 188.3 | 180.1 |
| A-Estimate | 173.5 | 176.1 | 173.6 | 165.4 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-18: Normalized Statistics, B-Basis Values and Estimates for BD 0TEN Strength Data

| As Measured Bidiagonal 0TEN Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 207.8 | 210.1 | 207.7 | 199.6 |
| Stdev | 8.991 | 7.437 | 5.363 | 5.310 |
| CV | 4.327 | 3.539 | 2.582 | 2.661 |
| Mod CV | 6.164 | 6.000 | 6.000 | 6.000 |
| Min | 192.5 | 193.2 | 199.1 | 190.7 |
| Max | 221.3 | 224.0 | 215.6 | 206.3 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 19 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 195.7 | 197.9 | 195.5 | 187.4 |
| A-Estimate | 187.6 | 189.9 | 187.5 | 179.4 |
| Method | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 186.1 | 188.4 | 185.9 | 177.8 |
| A-Estimate | 171.8 | 174.0 | 171.6 | 163.5 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-19: As Measured Statistics, B-Basis Values and Estimates for BD 0TEN Strength Data

| Bidiagonal 0TEN Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | CTA | RTA | ETA | ETW1 | CTA | RTA | ETA | ETW1 |
| Mean | 12.37 | 12.20 | 12.22 | 12.33 | 12.22 | 12.03 | 12.05 | 12.17 |
| Stdev | 0.5797 | 0.3589 | 0.2183 | 0.2160 | 0.6495 | 0.5053 | 0.3085 | 0.2464 |
| CV | 4.686 | 2.943 | 1.787 | 1.751 | 5.314 | 4.200 | 2.560 | 2.025 |
| Min | 11.62 | 11.43 | 11.89 | 11.99 | 11.37 | 10.95 | 11.49 | 11.68 |
| Max | 14.10 | 12.75 | 12.61 | 12.77 | 14.22 | 12.80 | 12.56 | 12.55 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |

**Table 4-20: Statistics for BD 0TEN Modulus Data**

## 4.9 Bidiagonal 0° Compression (BD-0CLC)

Bidiagonal 0° Compression data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA, ETW1 and ETW2.

ETW2 consists of one batch with six specimens, therefore only estimates were computed for ETW2.

For both the normalized and as measured datasets, the RTA, ETA, and ETW1 conditions were pooled using the as measured CV and modified CV, and the normal method was used for ETW2.

There was one statistical outliers. The highest normalized value in batch one of the ETW1 condition was an outlier for the batch but not for the condition. It was an outlier in both the normalized and the as measured dataset. It was retained for this analysis.

Statistics, estimates and basis values are given for the BD 0CLC strength data in Table 4-21 and Table 4-22, and for the modulus data in Table 4-23. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-10.

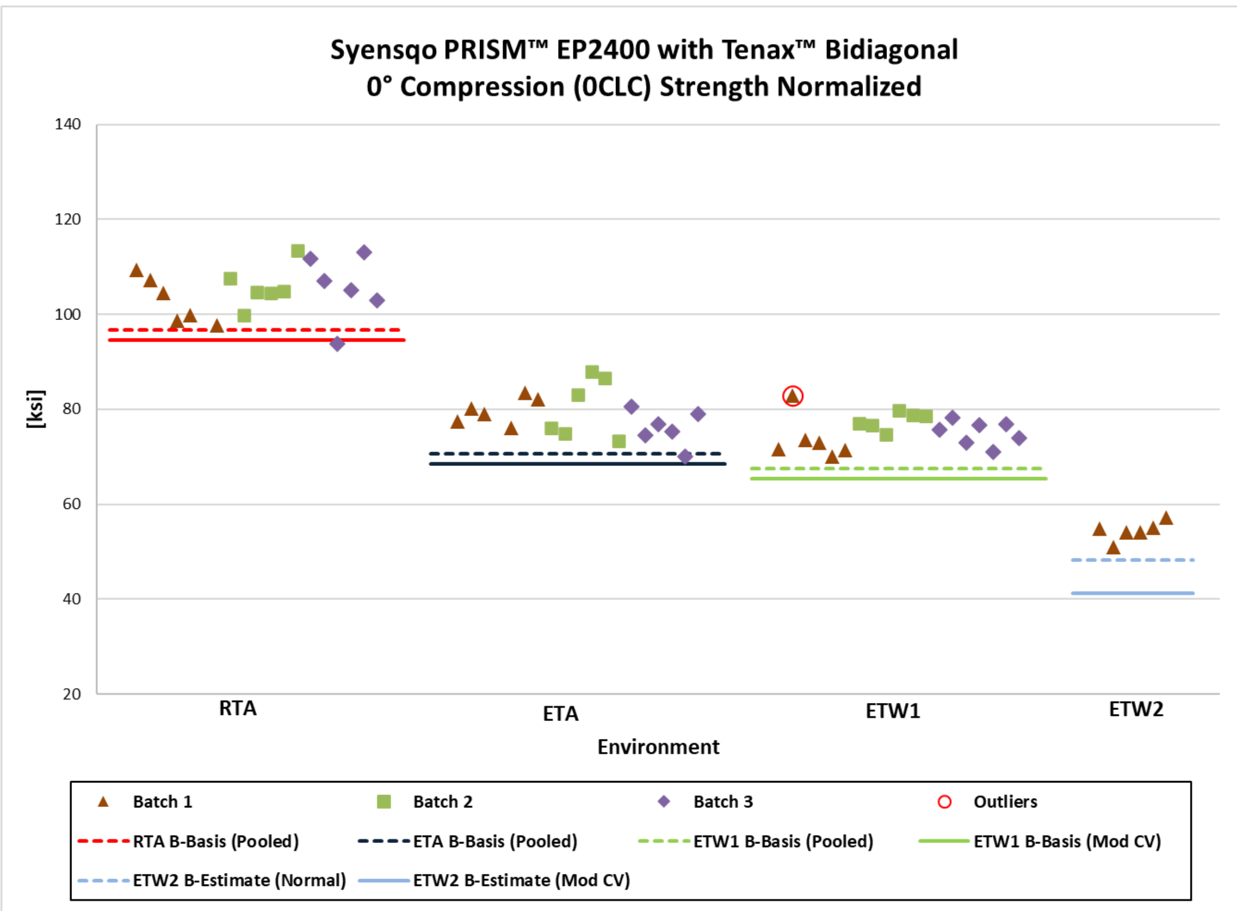


**Figure 4-10: Batch Plot for BD 0CLC Normalized Strength**

| Normalized Bidiagonal 0CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 104.8 | 78.70 | 75.45 | 54.36 |
| Stdev | 5.384 | 4.688 | 3.402 | 1.995 |
| CV | 5.139 | 5.957 | 4.509 | 3.669 |
| Mod CV | 6.569 | 6.978 | 6.255 | 6.000 |
| Min | 93.76 | 70.08 | 70.00 | 51.04 |
| Max | 113.4 | 87.96 | 82.82 | 57.18 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 19 | 6 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 96.72 | 70.66 | 67.46 | |
| B-Estimate | | | | 48.32 |
| A-Estimate | 91.36 | 65.30 | 62.09 | 44.02 |
| Method | Pooled | Pooled | Pooled | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 94.60 | 68.53 | 65.34 | |
| B-Estimate | | | | 41.26 |
| A-Estimate | 87.82 | 61.75 | 58.55 | 32.30 |
| Method | Pooled | Pooled | Pooled | Normal |

**Table 4-21: Normalized Statistics, B-Basis Values and Estimates for BD 0CLC Strength Data**

| As Measured Bidiagonal 0CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 100.2 | 75.56 | 72.29 | 52.67 |
| Stdev | 5.244 | 3.887 | 3.332 | 1.702 |
| CV | 5.236 | 5.144 | 4.609 | 3.231 |
| Mod CV | 6.618 | 6.572 | 6.305 | 6.000 |
| Min | 88.87 | 68.35 | 66.14 | 50.35 |
| Max | 109.7 | 82.11 | 80.97 | 55.35 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 19 | 6 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 92.71 | 68.11 | 64.88 | |
| B-Estimate | | | | 47.52 |
| A-Estimate | 87.74 | 63.14 | 59.90 | 43.85 |
| Method | Pooled | Pooled | Pooled | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 90.54 | 65.94 | 62.72 | |
| B-Estimate | | | | 39.98 |
| A-Estimate | 84.12 | 59.52 | 56.29 | 31.29 |
| Method | Pooled | Pooled | Pooled | Normal |

**Table 4-22: As Measured Statistics, B-Basis Values and Estimates for BD CLC Strength Data**

| Bidiagonal 0CLC Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | RTA | ETA | ETW1 | ETW2 | RTA | ETA | ETW1 | ETW2 |
| Mean | 11.43 | 11.56 | 11.88 | 11.44 | 10.93 | 11.11 | 11.38 | 11.08 |
| Stdev | 0.3455 | 0.5938 | 0.5223 | 0.4224 | 0.4544 | 0.6668 | 0.5994 | 0.3318 |
| CV | 3.024 | 5.134 | 4.397 | 3.692 | 4.158 | 6.003 | 5.266 | 2.993 |
| Min | 11.08 | 10.40 | 10.99 | 10.85 | 10.49 | 10.02 | 10.66 | 10.60 |
| Max | 12.28 | 12.29 | 12.62 | 11.89 | 12.05 | 12.39 | 12.58 | 11.51 |
| No. Batches | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 19 | 18 | 6 | 18 | 19 | 18 | 6 |

Table 4-23: Statistics for BD 0CLC Modulus Data

## 4.10 Bidiagonal In-Plane Shear (BD-IPS)

In Plane Shear data is not normalized. Test results were available for 0.2% offset strength and strength at 5% strain in the following environmental conditions: CTA, RTA, ETA, and ETW1.

For the 0.2% Offset Strength dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for ETW1. The single point normal method was used for ETA, and the remaining conditions were pooled. Applying the modified CV, every acceptable combination for pooling failed either the test for normality or the test for equality of variances so the normal method for modified CV was used to compute values for all conditions.

For the Strength at 5% Strain dataset, CTA and ETW1 failed the ADK test for batch equivalency. ANOVA was used to compute estimates for CTA and ETW1, and the single point normal method was used for RTA and ETA, as pooling both failed the equality of variances test. Applying the modified CV, the normal method for modified CV was used for CTA, and the remaining conditions were pooled.

There were two statistical outliers. The lowest values in batch three of the ETW1 condition for 0.2% offset strength dataset was an outlier for the condition but not for the batch. The lowest value in batch three of the ETW1 condition for the strength at 5% strain dataset was an outlier for the condition but not for the batch. They were retained for this analysis.

Statistics, basis values and estimates are given for the BD IPS strength data in Table 4-24 and Table 4-25 and for the modulus data in Table 4-26. The as measured data, B-basis values and B-estimates are shown graphically for Strength at 5% Strain in Figure 4-11 and for 0.2% Offset Strength in Figure 4-12.

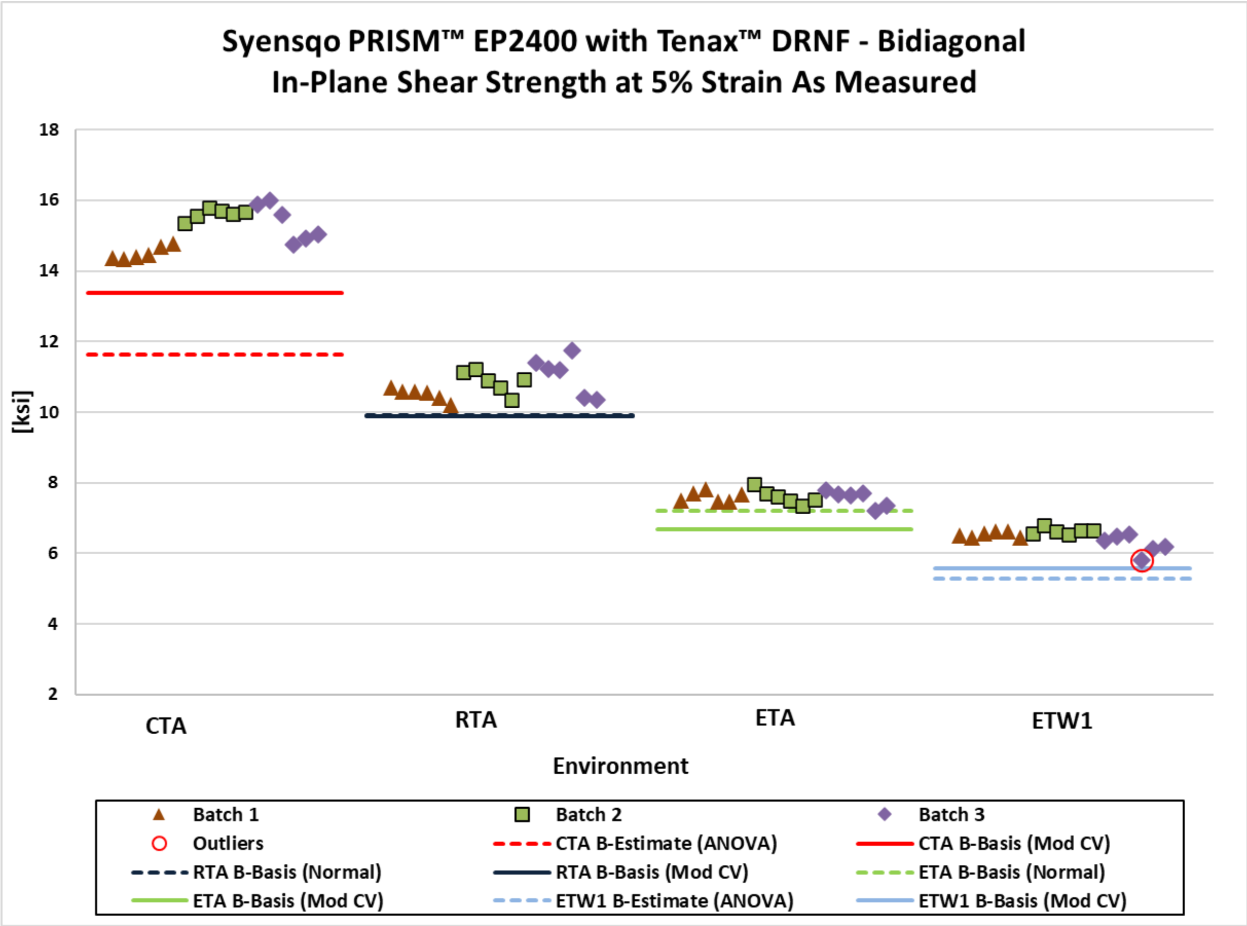


**Figure 4-11: Batch Plot for BD IPS As Measured Strength at 5% Strain**

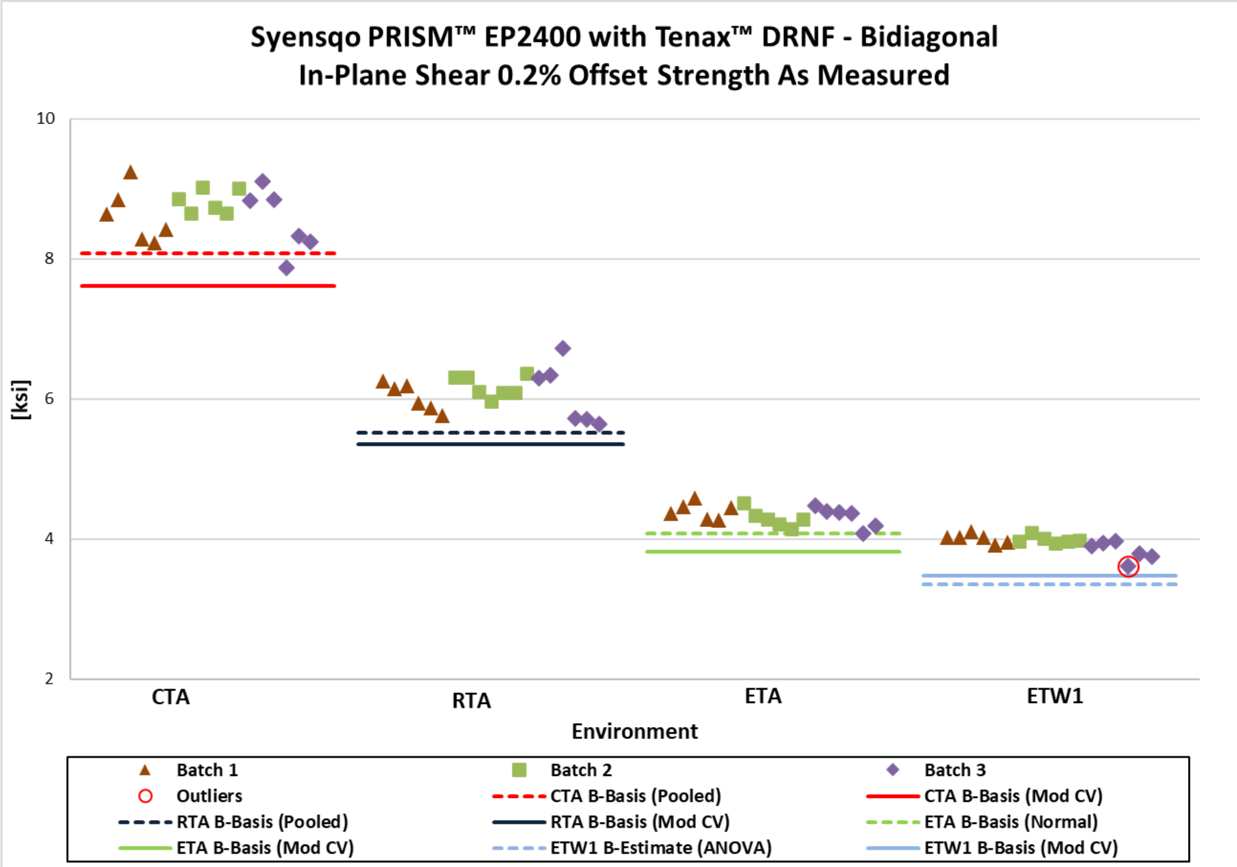


Figure 4-12: Batch Plot for BD IPS As Measured 0.2% Offset Strength

| Bidiagonal IPS 0.2% Offset Strength Basis Values and Statistics - As Measured Values | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 8.658 | 6.101 | 4.341 | 3.946 |
| Stdev | 0.3613 | 0.2783 | 0.1351 | 0.1213 |
| CV | 4.173 | 4.561 | 3.112 | 3.073 |
| Mod CV | 6.087 | 6.281 | 6.000 | 6.000 |
| Min | 7.878 | 5.649 | 4.075 | 3.610 |
| Max | 9.239 | 6.731 | 4.592 | 4.111 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 19 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 8.075 | 5.520 | 4.074 | |
| B-estimate | | | | 3.352 |
| A-Estimate | 7.678 | 5.123 | 3.885 | 2.929 |
| Method | Pooled | Pooled | Normal | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 7.618 | 5.354 | 3.827 | 3.479 |
| A-Estimate | 6.882 | 4.825 | 3.463 | 3.148 |
| Method | Normal | Normal | Normal | Normal |

Table 4-24: Statistics, B-Basis Values and Estimates for BD IPS 0.2% Offset Strength Data

| Bidiagonal IPS Strength at 5% Strain Basis Values and Statistics - As Measured Values | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 15.16 | 10.78 | 7.590 | 6.477 |
| Stdev | 0.5834 | 0.4438 | 0.1928 | 0.2342 |
| CV | 3.848 | 4.118 | 2.540 | 3.615 |
| Mod CV | 6.000 | 6.059 | 6.000 | 6.000 |
| Min | 14.35 | 10.20 | 7.195 | 5.803 |
| Max | 16.00 | 11.75 | 7.967 | 6.798 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 19 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 9.914 | 7.209 | |
| B-estimate | 11.63 | | | 5.282 |
| A-Estimate | 9.115 | 9.299 | 6.940 | 4.430 |
| Method | ANOVA | Normal | Normal | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 13.37 | 9.873 | 6.680 | 5.567 |
| A-Estimate | 12.10 | 9.266 | 6.073 | 4.960 |
| Method | Normal | Pooled | Pooled | Pooled |

**Table 4-25: Statistics, B-Basis Values and Estimates for BD IPS Strength a 5% Strain Data**

| Bidiagonal IPS Modulus Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 0.7740 | 0.6197 | 0.4582 | 0.4262 |
| Stdev | 0.04848 | 0.03640 | 0.01643 | 0.01439 |
| CV | 6.264 | 5.873 | 3.587 | 3.377 |
| Min | 0.6681 | 0.5509 | 0.4204 | 0.3870 |
| Max | 0.8277 | 0.6869 | 0.4833 | 0.4462 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 19 | 18 | 18 |

**Table 4-26: Statistics for BD IPS Modulus Data**

## 4.11 Bidiagonal Lamina Short Beam Strength (BD-SBS)

The Bidiagonal Short Beam Strength data is not normalized. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with six specimens, therefore only estimates were computed for ETW2.

The single point non parametric method was used to compute values and estimates for ETA and the single point normal method was used for the remaining conditions. Applying the modified CV, the normal method for modified CV was used to compute estimates for ETW2 and the remaining conditions were pooled.

There were three statistical outliers. The lowest value in batch one of the RTA condition was an outlier for the batch for not for the condition. The highest value in batch one of the ETA condition was an outlier for the batch and for the condition. The highest value in batch one of the ETW2 condition was an outlier for the batch and for the condition. They were retained for this analysis.

Statistics, basis values and estimates are given for the BD Lamina SBS strength data in Table 4-27. The as measured data, B-basis values and B-estimates are shown graphically in Figure 4-13.

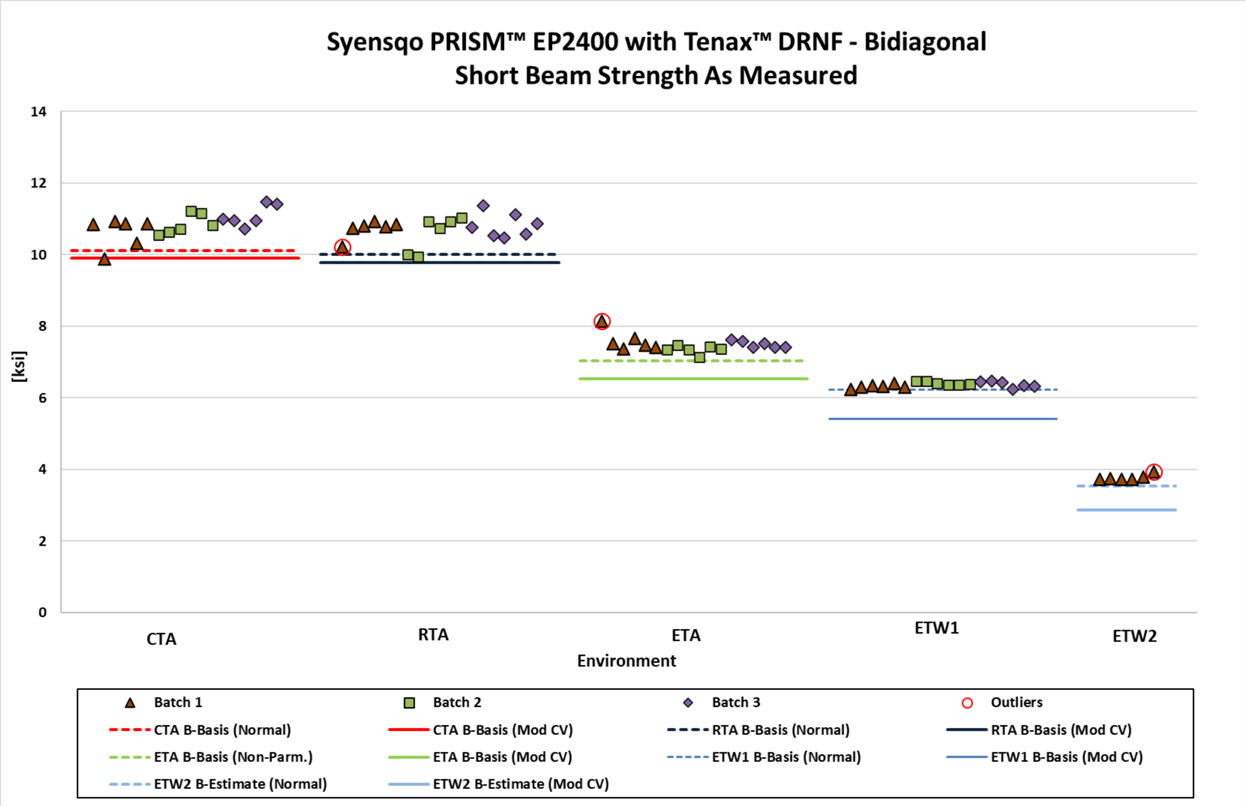


**Figure 4-13: Batch Plot for BD As Measured SBS**

| Bidiagonal Short Beam Strength (SBS) As Measured Basis Values and Statistics | | | | | |
|---|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 | ETW2 |
| Mean | 10.85 | 10.72 | 7.478 | 6.368 | 3.776 |
| Stdev | 0.3723 | 0.3604 | 0.2028 | 0.07579 | 0.07909 |
| CV | 3.431 | 3.364 | 2.711 | 1.190 | 2.095 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 9.884 | 9.944 | 7.138 | 6.232 | 3.723 |
| Max | 11.47 | 11.37 | 8.136 | 6.474 | 3.929 |
| No. Batches | 3 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 19 | 18 | 18 | 6 |
| Basis Values and Estimates | | | | | |
| B-Basis Value | 10.12 | 10.01 | 7.041 | 6.218 | |
| B-Estimate | | | | | 3.536 |
| A-Estimate | 9.596 | 9.514 | 5.868 | 6.112 | 3.366 |
| Method | Normal | Normal | Non-Parm. | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | | |
| B-Basis Value | 9.900 | 9.769 | 6.527 | 5.416 | |
| B-Estimate | | | | | 2.866 |
| A-Estimate | 9.273 | 9.141 | 5.899 | 4.789 | 2.243 |
| Method | Pooled | Pooled | Pooled | Pooled | Normal |

Table 4-27: Statistics, B-Basis Values and Estimates for BD SBS Strength Data

## 4.12 Bidiagonal Flexural Strength (BD-Flex)

The Bidiagonal FLEX data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Test were conducted in the following environmental condition: RTA.

For both the normalized dataset and the as measured dataset, the single point normal method was used to compute basis values and estimates. Applying the modified CV, the normal method for modified CV was used to compute basis values and estimates.

There were no statistical outliers.

Statistics, basis values and estimates are given for the BD-FLEX strength data in Table 4-28. The normalized data and B-basis values are shown graphically in Figure 4-14.

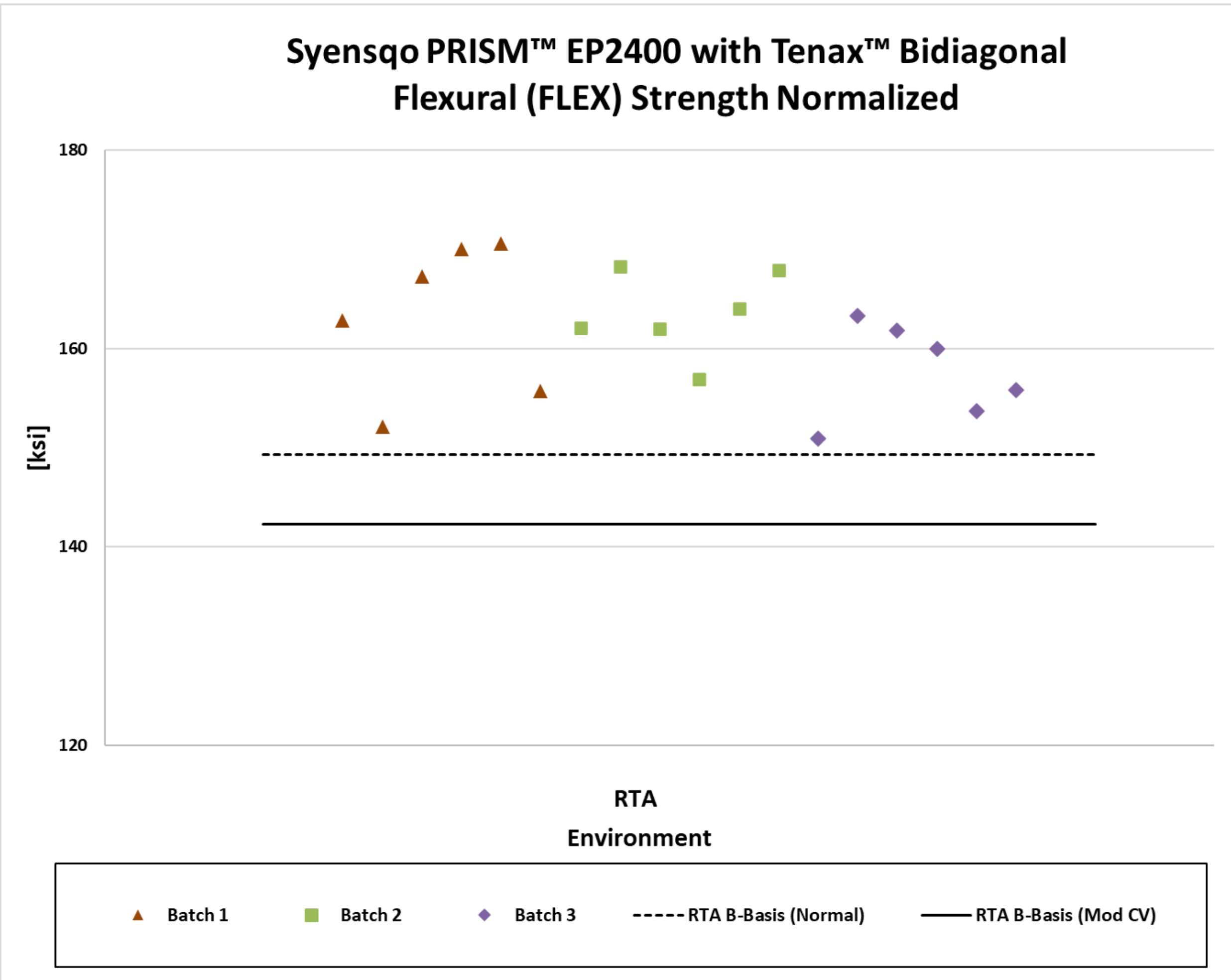


**Figure 4-14: Batch Plot for BD FLEX Normalized Strength**

| Bidiagonal FLEX Strength Basis Values and Statistics | | |
|---|---|---|
| | Normalized | As-Measured |
| Env | RTA | RTA |
| Mean | 161.4 | 154.2 |
| Stdev | 6.127 | 5.664 |
| CV | 3.797 | 3.674 |
| Mod CV | 6.000 | 6.000 |
| Min | 150.9 | 143.8 |
| Max | 170.5 | 163.6 |
| No. Batches | 3 | 3 |
| No. Spec. | 18 | 18 |
| Basis Values and Estimates | | |
| B-Basis Value | 149.3 | 143.0 |
| A-Estimate | 140.7 | 135.1 |
| Method | Normal | Normal |
| Modified CV Basis Values and Estimates | | |
| B-Basis Value | 142.3 | 135.9 |
| A-Estimate | 128.7 | 123.0 |
| Method | Normal | Normal |

**Table 4-28: Statistics, B-Basis Values and Estimates for BD FLEX Strength Data**

## 4.13 UD Woven 0/90° Unnotched Tension (UD-UNT0)

The UD-UNT0 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW1.

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 so all conditions were pooled.

For the as measured dataset, RTA and ETW1 failed the ADK test for batch equivalency. ANOVA was used to compute estimates for RTA and ETW1, the single point Weibull method was used for CTA and the single point normal method was used for ETA. Applying the modified CV, there were no diagnostic test failures so all conditions were pooled.

There were three statistical outliers. The lowest normalized value in batch one for the CTA condition was an outlier for the condition but not for the batch. It was an outlier in the normalized dataset and in the as measured dataset. The lowest as measured value in batch two for the RTA condition was an outlier for the batch but not for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. The highest normalized value in batch four for the ETW1 condition was an outlier for the batch but not for the condition. It was an outlier in the normalized dataset but not in the as measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UD-UNT0 strength data in Table 4-29 and 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 4-15.

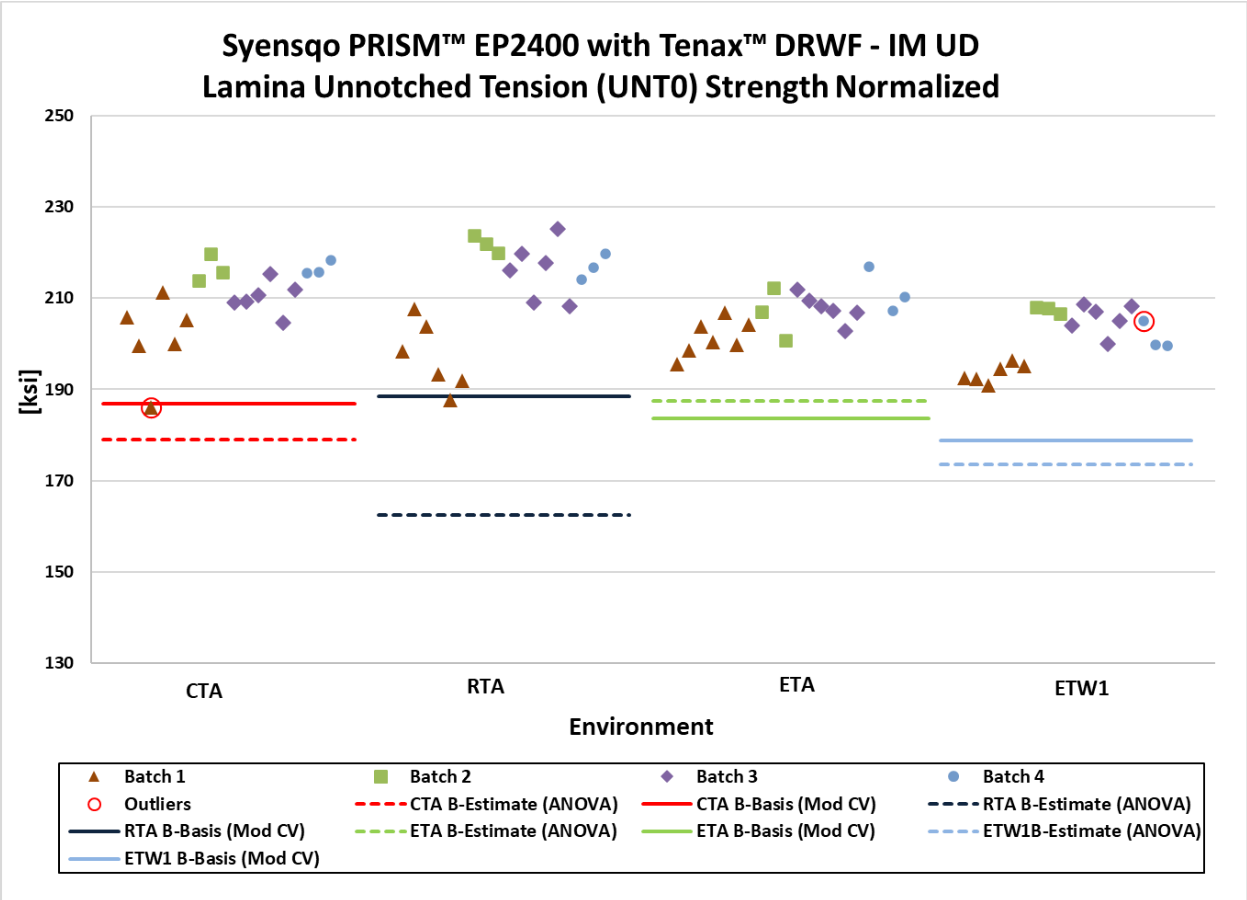


**Figure 4-15: Batch Plot UD UNT0 Normalized Strength**

| Normalized Unidirectional UNT0 Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 209.3 | 210.8 | 205.8 | 201.2 |
| Stdev | 8.228 | 11.58 | 5.348 | 6.257 |
| CV | 3.932 | 5.493 | 2.599 | 3.110 |
| Mod CV | 6.000 | 6.747 | 6.000 | 6.000 |
| Min | 186.0 | 187.6 | 195.5 | 190.9 |
| Max | 219.6 | 225.1 | 216.9 | 208.5 |
| No. Batches | 4 | 4 | 4 | 4 |
| No. Spec. | 18 | 18 | 19 | 18 |
| Basis Values and Estimates | | | | |
| B-Estimate | 179.0 | 162.5 | 187.4 | 173.6 |
| A-Estimate | 157.9 | 128.9 | 174.6 | 154.4 |
| Method | ANOVA | ANOVA | ANOVA | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 186.9 | 188.5 | 183.5 | 178.8 |
| A-Estimate | 172.2 | 173.7 | 168.8 | 164.1 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-29: Normalized Statistics, B-Basis Values and Estimates for UD UNT0 Strength Data

| As Measured Unidirectional UNT0 Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 210.5 | 212.3 | 207.2 | 202.5 |
| Stdev | 6.879 | 10.33 | 6.115 | 6.276 |
| CV | 3.267 | 4.865 | 2.951 | 3.099 |
| Mod CV | 6.000 | 6.433 | 6.000 | 6.000 |
| Min | 189.2 | 192.4 | 192.6 | 191.6 |
| Max | 219.5 | 229.9 | 216.0 | 212.7 |
| No. Batches | 4 | 4 | 4 | 4 |
| No. Spec. | 18 | 18 | 19 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 197.4 | | 195.3 | |
| B-Estimate | | 170.4 | | 178.7 |
| A-Estimate | 183.2 | 141.3 | 186.8 | 162.2 |
| Method | Weibull | ANOVA | Normal | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 188.3 | 190.1 | 185.1 | 180.3 |
| A-Estimate | 173.7 | 175.4 | 170.5 | 165.7 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-30: As Measured Statistics, B-Basis Values and Estimates for UD UNT0 Strength Data

| Unidirectional UNT0 Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | CTA | RTA | ETA1 | ETW1 | CTA | RTA | ETA1 | ETW1 |
| Mean | 12.15 | 12.06 | 11.95 | 11.98 | 12.23 | 12.14 | 12.01 | 12.06 |
| Stdev | 0.2572 | 0.1756 | 0.1807 | 0.1279 | 0.3120 | 0.2599 | 0.3129 | 0.2293 |
| CV | 2.116 | 1.456 | 1.512 | 1.068 | 2.551 | 2.140 | 2.604 | 1.901 |
| Min | 11.76 | 11.77 | 11.71 | 11.82 | 11.55 | 11.59 | 11.37 | 11.66 |
| Max | 12.62 | 12.39 | 12.39 | 12.25 | 12.71 | 12.54 | 12.59 | 12.48 |
| No. Batches | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| No. Spec. | 18 | 18 | 20 | 18 | 18 | 18 | 20 | 18 |

Table 4-31: Statistics for UD UNT0 Modulus Data

## 4.14 UD Woven 0/90° Unnotched Compression (UD-UNC0)

The UD-UNC0 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with ten specimens, therefore only estimates were computed for ETW2.

For the normalized dataset, RTA and ETA failed the ADK test for batch equivalency, ANOVA was used to compute estimates for RTA and ETA and the single point normal method was used for the remaining conditions. Applying the modified CV, ETA failed the ADK test so values were not computed for ETA, RTA and ETW1 were pooled, and the normal method for modified CV was used for ETW2.

For the as measured dataset, the ETA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for ETA, and RTA and ETW1 were pooled, and the single point normal method was used for ETW2. Applying the modified CV, ETA failed the ADK test, so values were not computed for ETA. RTA and ETW1 were pooled, and the normal method for modified CV was used for ETW2.

There was one statistical outlier. The highest normalized value in batch one for the ETA condition was an outlier for the batch for not for the condition. It was an outlier in the normalized dataset but not in the as measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UD-UNC0 normalized strength data in Table 4-32 and Table 4-33 and for the modulus data in Table 4-34. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-16.

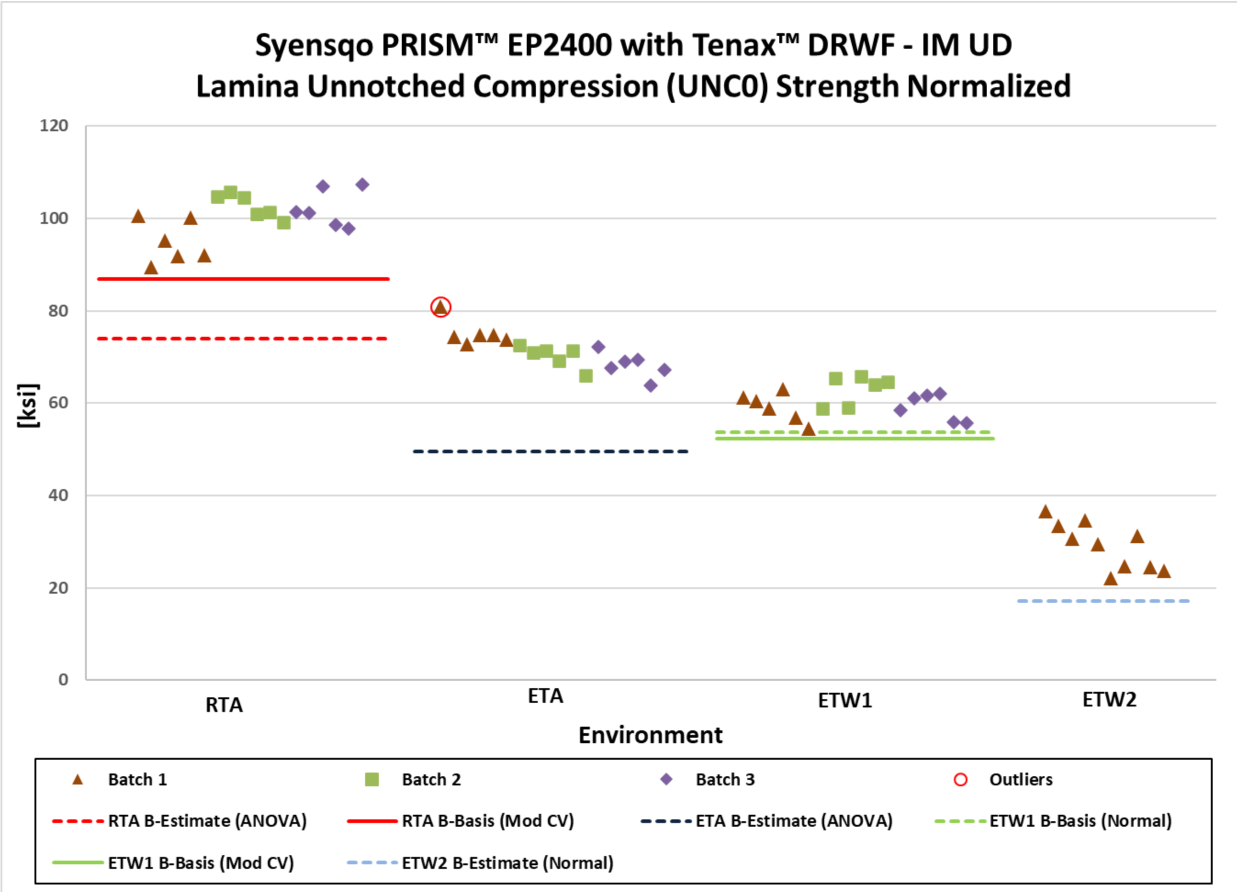


**Figure 4-16: Batch Plot for UD UNC0 Normalized Strength**

| Normalized Unidirectional UNC0 Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 99.96 | 71.21 | 60.44 | 29.12 |
| Stdev | 5.196 | 3.954 | 3.435 | 5.079 |
| CV | 5.198 | 5.552 | 5.683 | 17.44 |
| Mod CV | 6.599 | 6.776 | 6.841 | 17.44 |
| Min | 89.40 | 63.78 | 54.40 | 22.20 |
| Max | 107.4 | 81.01 | 65.90 | 36.68 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 10 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | | 53.66 | |
| B-Estimate | 74.02 | 49.63 | | 17.11 |
| A-Estimate | 55.52 | 34.23 | 48.86 | 8.718 |
| Method | ANOVA | ANOVA | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 86.94 | NA | 52.28 | |
| A-Estimate | 77.71 | | 46.49 | |
| Method | Normal | | Normal | |

Table 4-32: Normalized Statistics, B-Basis Values and Estimates for UD UNC0 Strength Data

| As Measured Unidirectional UNC0 Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 101.5 | 72.38 | 61.36 | 29.72 |
| Stdev | 4.528 | 4.597 | 3.310 | 4.841 |
| CV | 4.460 | 6.351 | 5.393 | 16.29 |
| Mod CV | 6.230 | 7.175 | 6.697 | 16.29 |
| Min | 91.39 | 64.82 | 56.20 | 23.25 |
| Max | 110.2 | 82.04 | 66.34 | 37.15 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 10 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 92.58 | | 54.83 | |
| B-Estimate | | 43.89 | | 18.28 |
| A-Estimate | 86.24 | 23.56 | 50.20 | 10.28 |
| Method | Normal | ANOVA | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 89.03 | NA | 53.25 | |
| A-Estimate | 80.18 | | 47.50 | |
| Method | Normal | | Normal | |

Table 4-33: As Measured Statistics, B-Basis Values and Estimates for UD UNC0 Strength Data

| Unidirectional UNC0 Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | RTA | ETA | ETW1 | ETW2 | RTA | ETA | ETW1 | ETW2 |
| Mean | 11.05 | 11.24 | 10.89 | 10.34 | 11.21 | 11.42 | 11.06 | 10.56 |
| Stdev | 0.2912 | 0.5050 | 0.4250 | 0.9894 | 0.3046 | 0.4374 | 0.4578 | 0.8624 |
| CV | 2.636 | 4.492 | 3.902 | 9.569 | 2.717 | 3.831 | 4.138 | 8.164 |
| Min | 10.55 | 10.49 | 10.12 | 9.296 | 10.62 | 10.60 | 10.19 | 9.629 |
| Max | 11.58 | 12.23 | 11.68 | 12.12 | 11.67 | 12.29 | 11.90 | 12.08 |
| No. Batches | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 10 | 18 | 18 | 18 | 10 |

Table 4-34: Statistics for UD UNC0 Modulus Data

## 4.15 UD Woven 0° Tabbed Tension (UD-0TEN)

The Unidirectional 0° Tabbed Tension data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with six specimens, therefore only estimates were computed for ETW2.

For the normalized dataset, the RTA and ETW1 conditions failed the ADK test for batch equivalency, therefore, pooling all environments was not possible. ANOVA was used to compute estimates for RTA and ETW1, and the single point normal method was used for the remaining conditions. Applying the modified CV, RTA and ETW1 failed the ADK test so values were not computed for those conditions. The normal method for modified CV was used for the remaining conditions,

For the as measured dataset, CTA, RTA, ETA and ETW1 failed the ADK test for batch equivalency, therefore, pooling all environments was not possible. The single point normal method was used to compute estimates for ETW2 and ANOVA was used to compute estimates for the remaining conditions. Applying the modified CV, CTA, RTA, ETA and ETW1 failed the ADK test so values were not computed for those conditions, and the normal method for modified CV was used for ETW2.

There were no statistical outliers.

Statistics, basis values and estimates are given for the UD-0TEN strength data in Table 4-35 and Table 4-36,  and for the modulus data in Table 4-37. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-17.

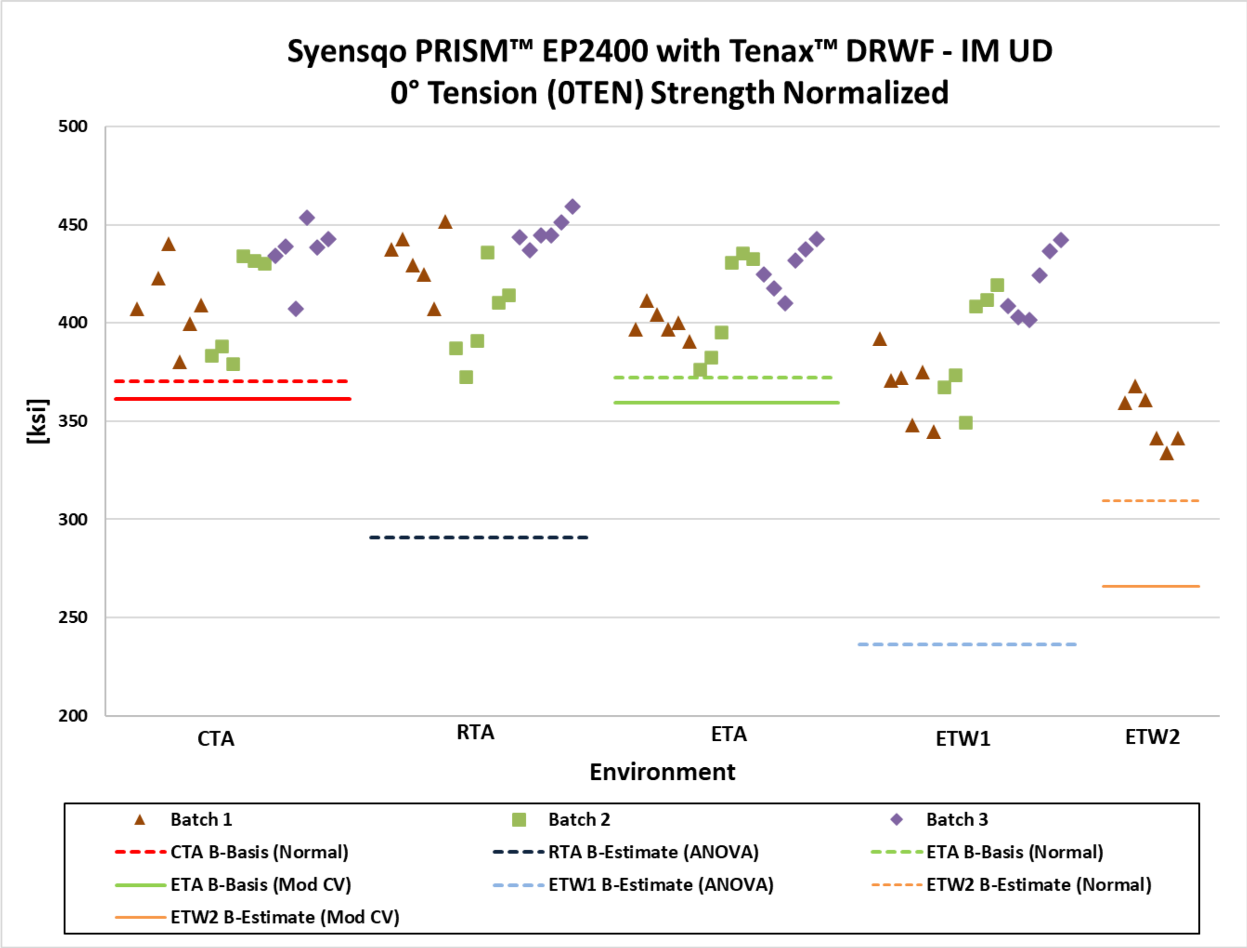


**Figure 4-17: Batch Plot for UD 0TEN Normalized Strength**

| Normalized Unidirectional 0TEN Strength Basis Values and Statistics | | | | | |
|---|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 | ETW2 |
| Mean | 417.8 | 427.0 | 412.1 | 391.6 | 350.8 |
| Stdev | 23.95 | 24.69 | 20.29 | 30.20 | 13.60 |
| CV | 5.733 | 5.784 | 4.924 | 7.713 | 3.878 |
| Mod CV | 6.866 | 6.892 | 6.462 | 7.856 | 8.000 |
| Min | 379.1 | 372.4 | 376.5 | 344.8 | 334.0 |
| Max | 453.5 | 459.4 | 442.5 | 442.4 | 367.7 |
| No. Batches | 3 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 18 | 6 |
| Basis Values and Estimates | | | | | |
| B-Basis Value | 370.5 | | 372.0 | | |
| B-Estimate | | 290.6 | | 236.3 | 309.6 |
| A-Estimate | 337.0 | 193.3 | 343.6 | 125.5 | 280.3 |
| Method | Normal | ANOVA | Normal | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | | |
| B-Basis Value | 361.1 | NA | 359.5 | NA | |
| B-Estimate | | | | | 265.8 |
| A-Estimate | 321.1 | | 322.3 | | 205.3 |
| Method | Normal | | Normal | | Normal |

Table 4-35: Normalized Statistics, B-Basis Values and Estimates for UD 0TEN Strength Data

| As Measured Unidirectional 0TEN Strength Estimates and Statistics | | | | | |
|---|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 | ETW2 |
| Mean | 415.6 | 421.9 | 409.8 | 390.4 | 348.9 |
| Stdev | 25.42 | 26.15 | 20.09 | 29.58 | 9.417 |
| CV | 6.117 | 6.198 | 4.902 | 7.576 | 2.699 |
| Mod CV | 7.058 | 7.099 | 6.451 | 7.788 | 8.000 |
| Min | 374.5 | 371.6 | 376.7 | 344.3 | 338.6 |
| Max | 464.4 | 455.1 | 438.1 | 440.8 | 361.0 |
| No. Batches | 3 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 18 | 6 |
| Estimates | | | | | |
| B-Estimate | 276.3 | 267.6 | 290.6 | 223.7 | 320.3 |
| A-Estimate | 177.0 | 157.5 | 205.6 | 104.8 | 300.1 |
| Method | ANOVA | ANOVA | ANOVA | ANOVA | Normal |
| Modified CV Estimates | | | | | |
| B-Estimate | NA | NA | NA | NA | 264.3 |
| A-Estimate | | | | | 204.2 |
| Method | | | | | Normal |

Table 4-36: As Measured Statistics, B-Basis Values and Estimates for UD 0TEN Strength Data

| Unidirectional 0TEN Modulus Statistics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | | As-Measured | | | | |
| Env | CTA | RTA | ETA | ETW1 | ETW2 | CTA | RTA | ETA | ETW1 | ETW2 |
| Mean | 23.39 | 23.08 | 23.19 | 23.80 | 23.34 | 23.26 | 22.80 | 23.06 | 23.73 | 23.22 |
| Stdev | 0.7917 | 0.5988 | 0.5887 | 0.8723 | 1.008 | 0.7897 | 0.8205 | 0.7878 | 0.8932 | 0.9114 |
| CV | 3.385 | 2.595 | 2.539 | 3.666 | 4.319 | 3.395 | 3.598 | 3.416 | 3.764 | 3.925 |
| Min | 22.60 | 22.15 | 22.25 | 22.46 | 22.18 | 22.41 | 21.35 | 21.96 | 22.46 | 22.33 |
| Max | 26.08 | 24.34 | 24.26 | 25.24 | 24.44 | 25.01 | 24.84 | 24.83 | 25.20 | 24.38 |
| No. Batches | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 18 | 6 | 18 | 18 | 18 | 18 | 6 |

**Table 4-37: Statistics for UD 0TEN Modulus Data**

## 4.16 UD Woven 0° Compression Modulus (UD-0CLC)

The Unidirectional Woven 0° Compression strength normalized and as measured data was computed using the backout factor from UNC0. Both normalized and as measured statistics are provided. Tests were performed in the following environmental conditions: RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with ten specimens, therefore only estimates were computed for ETW2.

For the normalized dataset, the RTA and ETA conditions failed the ADK test for batch equivalency, therefore pooling was not possible. ANOVA was used to compute estimates for RTA and ETA and the single point normal method was used for the remaining environments. Using the modified CV, the ETA condition failed the ADK test, therefore basis values were not computed for ETA. RTA and ETW1 were pooled and the normal method for modified CV was used for ETW2.

For the as measured dataset, the ETA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for ETA, RTA and ETW1 were pooled and the single point normal method was used for ETW2. Similarly, using the modified CV, the ETA condition failed the ADK test, therefore basis values were not computed for ETA. RTA and ETW1 were pooled and the normal method for modified CV was used for ETW2.

There was one statistical outlier. The highest normalized value in batch for of the ETA condition was an outlier for the batch but not for the condition. It was an outlier in the normalized dataset but not in the as measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UD 0CLC strength data in Table 4-38 and Table 4-39, and for the modulus data in Table 4-40 the normalized data, B-Basis values and B-estimates are shown graphically in Figure 4-18.

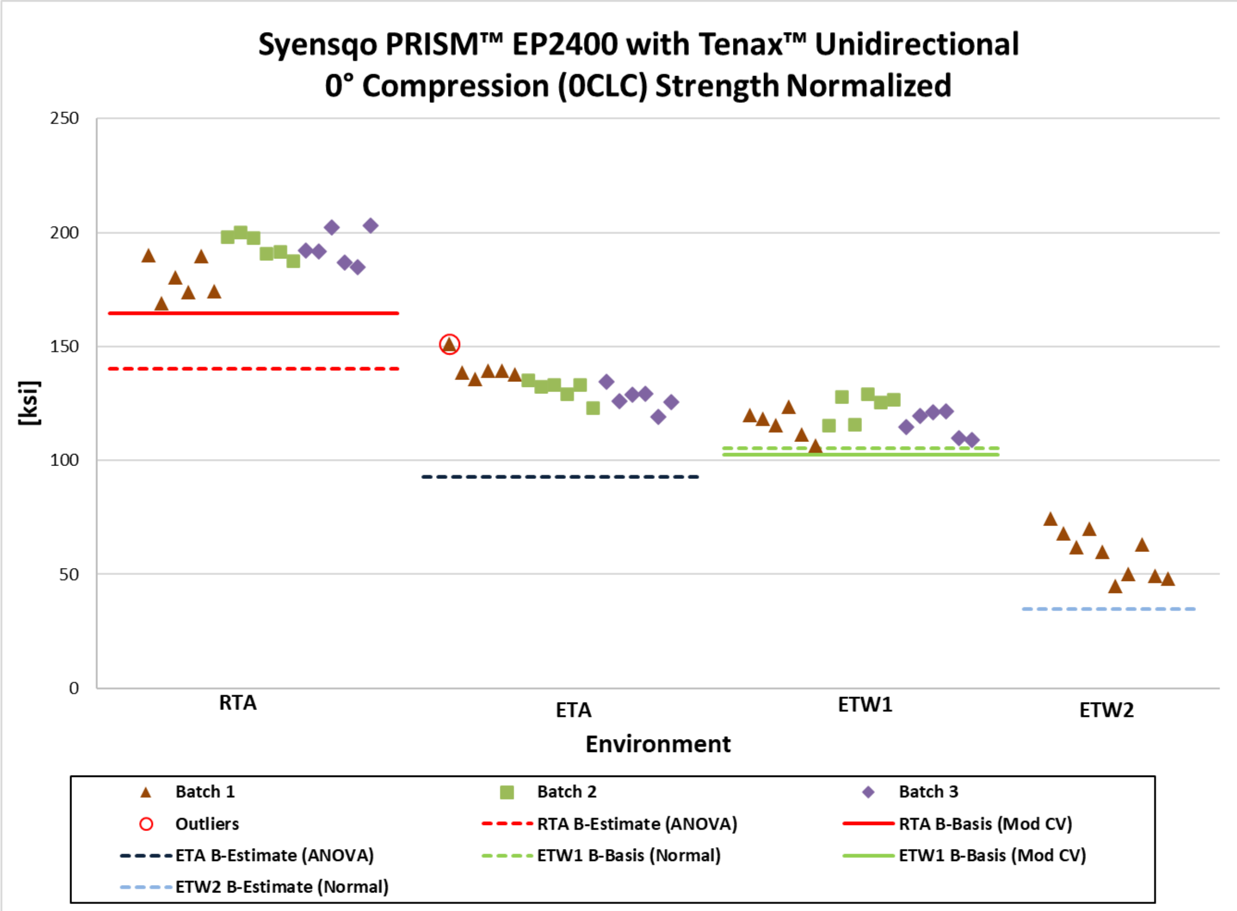


**Figure 4-18: Batch Plot for UD 0CLC Normalized Strength**

| Normalized Unidirectional 0CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 189.2 | 133.0 | 118.4 | 59.02 |
| Stdev | 9.832 | 7.382 | 6.731 | 10.29 |
| CV | 5.198 | 5.552 | 5.683 | 17.44 |
| Mod CV | 6.599 | 6.776 | 6.841 | 17.44 |
| Min | 169.2 | 119.1 | 106.6 | 45.00 |
| Max | 203.2 | 151.3 | 129.1 | 74.35 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 10 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | | 105.2 | |
| B-estimate | 140.1 | 92.66 | | 34.67 |
| A-Estimate | 105.1 | 63.92 | 95.74 | 17.67 |
| Method | ANOVA | ANOVA | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 164.5 | NA | 102.5 | |
| A-Estimate | 147.1 | | 91.11 | |
| Method | Normal | | Normal | |

Table 4-38: Normalized Statistics, B-Basis Values and Estimates for 0CLC Strength Data

| As Measured Unidirectional 0CLC Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 186.1 | 131.8 | 117.0 | 59.55 |
| Stdev | 8.298 | 8.368 | 6.312 | 9.698 |
| CV | 4.460 | 6.351 | 5.393 | 16.29 |
| Mod CV | 6.230 | 7.175 | 6.697 | 16.29 |
| Min | 167.5 | 118.0 | 107.2 | 46.57 |
| Max | 202.0 | 149.4 | 126.5 | 74.42 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 10 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 169.7 | | 104.6 | |
| B-estimate | | 79.90 | | 36.62 |
| A-Estimate | 158.1 | 42.89 | 95.74 | 20.60 |
| Method | Normal | ANOVA | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 163.2 | NA | 101.56 | |
| A-Estimate | 147.0 | | 90.60 | |
| Method | Normal | | Normal | |

Table 4-39: As Measured Statistics B-Basis Values and Estimates for 0CLC Strength Data

| Unidirectional 0CLC Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | RTA | ETA | ETW1 | ETW2 | RTA | ETA | ETW1 | ETW2 |
| Mean | 20.91 | 20.99 | 21.35 | 20.96 | 20.55 | 20.79 | 21.10 | 21.16 |
| Stdev | 0.3784 | 0.6052 | 0.4889 | 0.7887 | 0.9729 | 0.9365 | 1.274 | 0.9636 |
| CV | 1.810 | 2.883 | 2.290 | 3.763 | 4.734 | 4.505 | 6.041 | 4.553 |
| Min | 20.08 | 19.99 | 20.39 | 19.85 | 18.41 | 18.57 | 18.14 | 19.68 |
| Max | 21.60 | 22.23 | 22.47 | 22.03 | 21.99 | 22.47 | 23.03 | 22.68 |
| No. Batches | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 1 |
| No. Spec. | 18 | 18 | 18 | 6 | 18 | 18 | 18 | 6 |

Table 4-40: Statistics for UD 0CLC Modulus Data

## 4.17 UD Woven In-Plane Shear (UD-IPS)

In Plane Shear data is not normalized. Test results were available for 0.2% offset strength and strength at 5% strain in the following environmental conditions: CTA, RTA, ETA, and ETW1.

For the 0.2% Offset Strength dataset, CTA, ETA, and ETW1 failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The single point non-parametric method was used for RTA. Applying the modified CV,  CTA, RTA, and ETA were pooled and the normal method for modified CV was used for ETW1.

For the Strength at 5% Strain dataset, the ETW1 condition consists of three batches with 17 specimens, therefore only estimates were computed for ETW1. CTA, RTA and ETA failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions and the single point normal method was used to compute estimates for ETW1. Applying the modified CV, RTA and ETA were pooled, and the normal method for modified was used for the remaining conditions.

There were two statistical outliers. The highest value in batch three for the RTA condition of the 0.2% offset strength dataset was an outlier for the condition but not for the batch. The highest value in batch three for the RTA condition of the strength at 5% strain dataset was an outlier for the condition but not for the batch. They were retained for this analysis.

Statistics, basis values and estimates are given for the UD-IPS strength data in Table 4-41 and Table 4-42, and  for the modulus data in Table 4-43. The as measured data, B-basis values and B-estimates are shown graphically for Strength at 5% Strain in Figure 4-19 and for 0.2% Offset Strength in Figure 4-20.

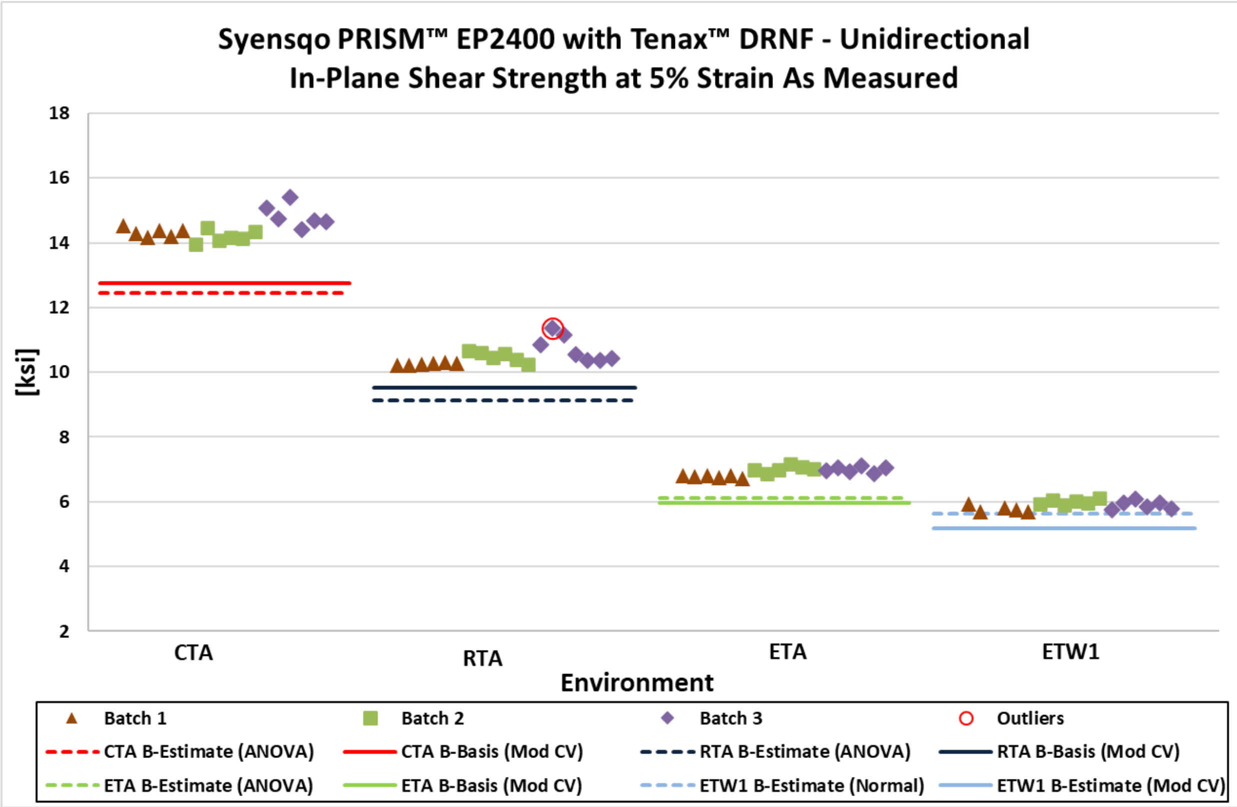


**Figure 4-19: Batch Plot for UD IPS As Measured Strength at 5% Strain**

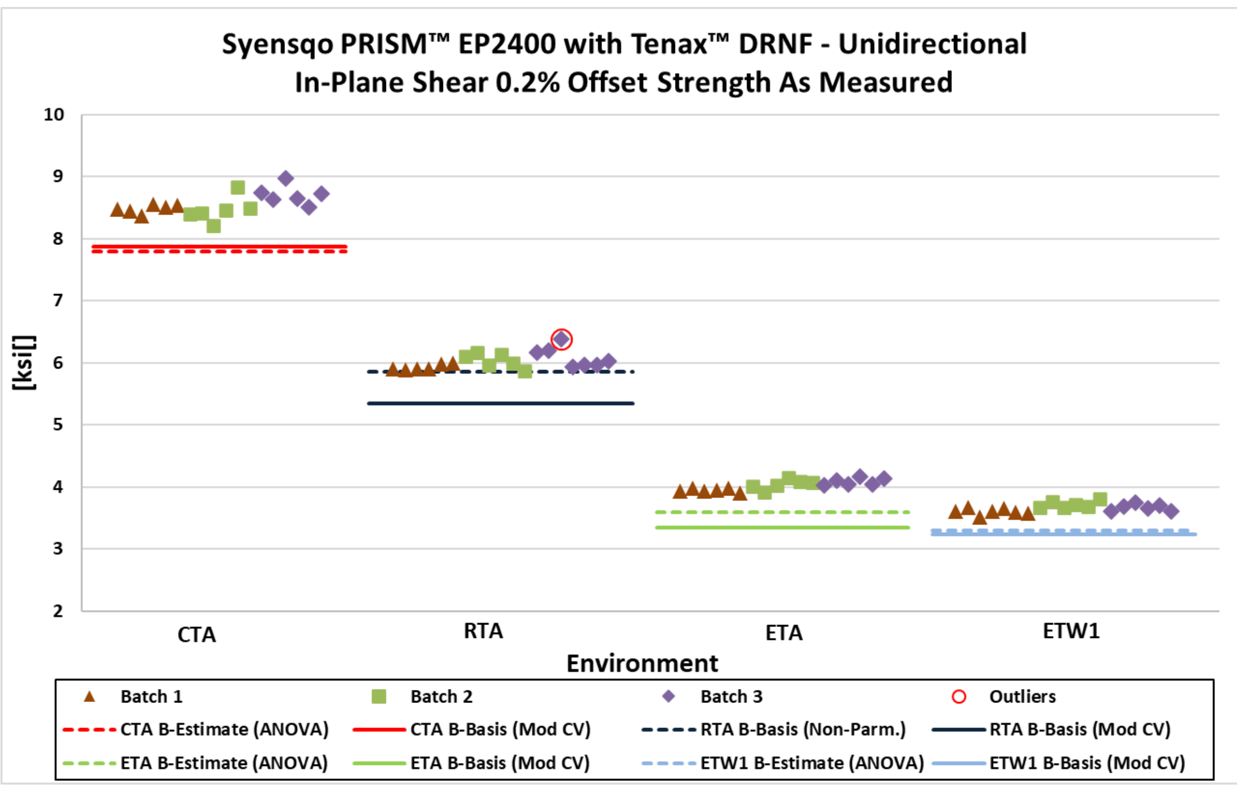


**Figure 4-20: Batch Plot for UD IPS As Measured 0.2% Offset Strength**

| Unidirectional IPS 0.2 % Offset Strength Basis Values and Statistics - As Measured Values | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 8.551 | 6.023 | 4.024 | 3.659 |
| Stdev | 0.1828 | 0.1344 | 0.08309 | 0.07062 |
| CV | 2.138 | 2.231 | 2.065 | 1.930 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 8.207 | 5.876 | 3.898 | 3.515 |
| Max | 8.969 | 6.387 | 4.172 | 3.809 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 19 | 18 | 19 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 5.848 | | |
| B-estimate | 7.792 | | 3.590 | 3.301 |
| A-Estimate | 7.251 | 5.217 | 3.279 | 3.045 |
| Method | ANOVA | Non-Parm. | ANOVA | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 7.865 | 5.341 | 3.338 | 3.231 |
| A-Estimate | 7.408 | 4.883 | 2.881 | 2.928 |
| Method | Pooled | Pooled | Pooled | Normal |

Table 4-41: Statistics, B-Basis Values and Estimates for UD IPS 0.2% Offset Strength Data

| Unidirectional IPS Strength at 5% Strain Basis Values and Statistics - As Measured Values | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 14.45 | 10.51 | 6.927 | 5.896 |
| Stdev | 0.3610 | 0.3165 | 0.1354 | 0.1358 |
| CV | 2.498 | 3.012 | 1.954 | 2.304 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 13.97 | 10.21 | 6.706 | 5.683 |
| Max | 15.39 | 11.37 | 7.164 | 6.100 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 19 | 18 | 17 |
| Estimates | | | | |
| B-Estimate | 12.45 | 9.134 | 6.125 | 5.624 |
| A-Estimate | 11.03 | 8.154 | 5.552 | 5.431 |
| Method | ANOVA | ANOVA | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 12.74 | 9.536 | 5.951 | |
| B-Estimate | | | | 5.187 |
| A-Estimate | 11.53 | 8.872 | 5.289 | 4.688 |
| Method | Normal | Pooled | Pooled | Normal |

Table 4-42: Statistics, B-Basis Values and Estimates for UD IPS Strength at 5% Strain Data

| Unidirectional IPS Modulus Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 0.7621 | 0.6100 | 0.4282 | 0.3980 |
| Stdev | 0.01448 | 0.01341 | 0.008769 | 0.007975 |
| CV | 1.899 | 2.198 | 2.048 | 2.004 |
| Min | 0.7410 | 0.5926 | 0.4135 | 0.3830 |
| Max | 0.7977 | 0.6489 | 0.4466 | 0.4143 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 19 | 18 | 19 |

Table 4-43: Statistics for UD IPS Modulus Data

## 4.18 UD Woven Lamina Short Beam Strength (UD-SBS)

The Bidiagonal Short Beam Strength data is not normalized. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with six specimens, therefore only estimates were computed for ETW2. The RTA, ETA and ETW1 conditions failed the ADK test for batch equivalency, therefore pooling was not possible. ANOVA was used to compute estimates for RTA, ETA and ETW1, and the single point normal method was used for CTA and ETW2. Applying the modified CV, the normal method for modified CV was used to compute values and estimates for all conditions.

There were no statistical outliers.

Statistics, basis values and estimates are given for the UD-SBS strength data in Table 4-44. The as measured data, B-basis values and B-estimates are shown graphically in Figure 4-21.

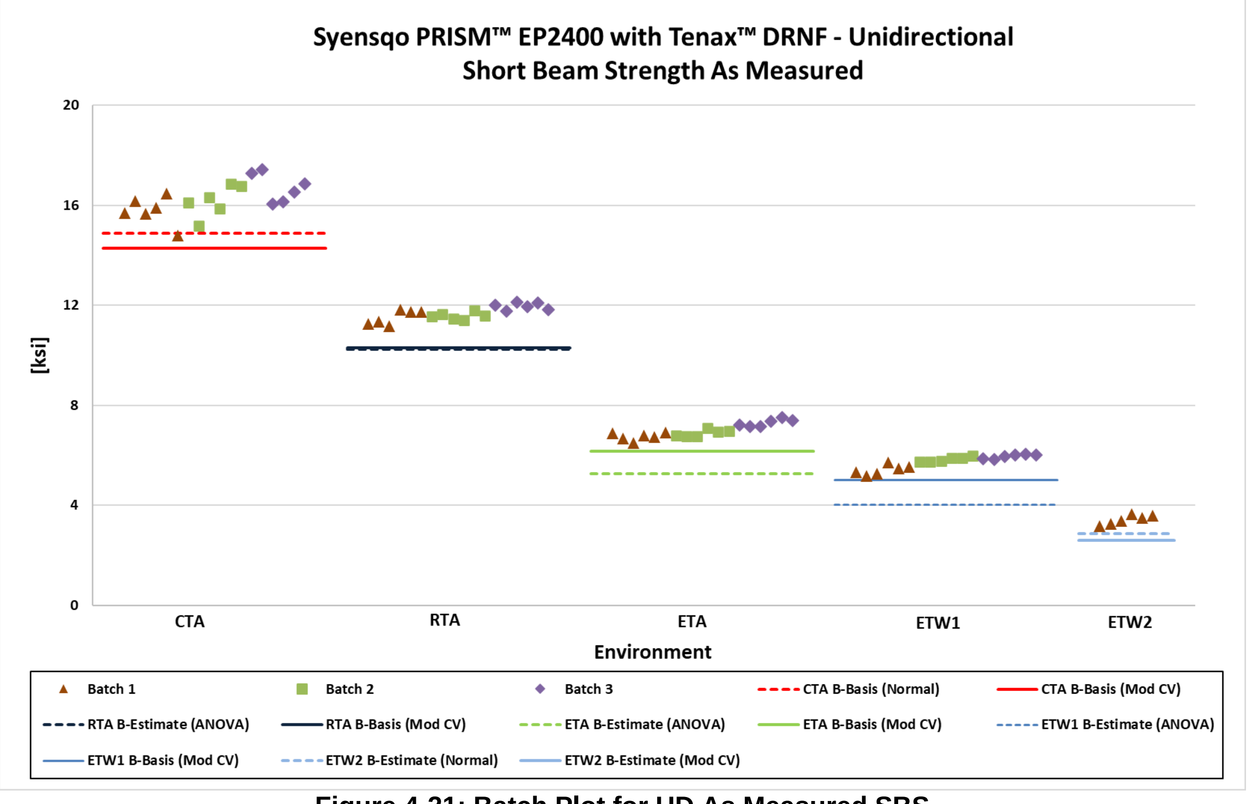


**Figure 4-21: Batch Plot for UD As Measured SBS**

| Unidirectional Short Beam Strength (SBS) As Measured Basis Values and | | | | | |
|---|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 | ETW2 |
| Mean | 16.23 | 11.69 | 6.974 | 5.736 | 3.419 |
| Stdev | 0.6821 | 0.2748 | 0.2728 | 0.2700 | 0.1853 |
| CV | 4.203 | 2.351 | 3.911 | 4.707 | 5.419 |
| Mod CV | 6.102 | 6.000 | 6.000 | 6.353 | 8.000 |
| Min | 14.79 | 11.17 | 6.497 | 5.185 | 3.175 |
| Max | 17.43 | 12.11 | 7.503 | 6.047 | 3.650 |
| No. Batches | 3 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 18 | 6 |
| Basis Values and Estimates | | | | | |
| B-Basis Value | 14.88 | | | | |
| B-Estimate | | 10.25 | 5.261 | 4.022 | 2.858 |
| A-Estimate | 13.93 | 9.228 | 4.038 | 2.798 | 2.459 |
| Method | Normal | ANOVA | ANOVA | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | | |
| B-Basis Value | 14.27 | 10.30 | 6.148 | 5.016 | |
| B-Estimate | | | | | 2.591 |
| A-Estimate | 12.89 | 9.323 | 5.563 | 4.507 | 2.002 |
| Method | Normal | Normal | Normal | Normal | Normal |

**Table 4-44: Statistics, B-Basis Values and Estimates for UD SBS Strength Data**

## 4.19 UD Woven Flexural Strength (UD-FLEX)

The Unidirectional FLEX data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Test were conducted in the following environmental condition: RTA.

For both normalized and as measured dataset, the single point normal method was used to compute basis values. Applying the modified CV, the normal method for modified CV was used to compute basis values.

There were no statistical outliers.

Statistics, basis values and estimates are given for the BD-FLEX strength data in Table 4-45. The normalized data and B-basis values are shown graphically in Figure 4-22.

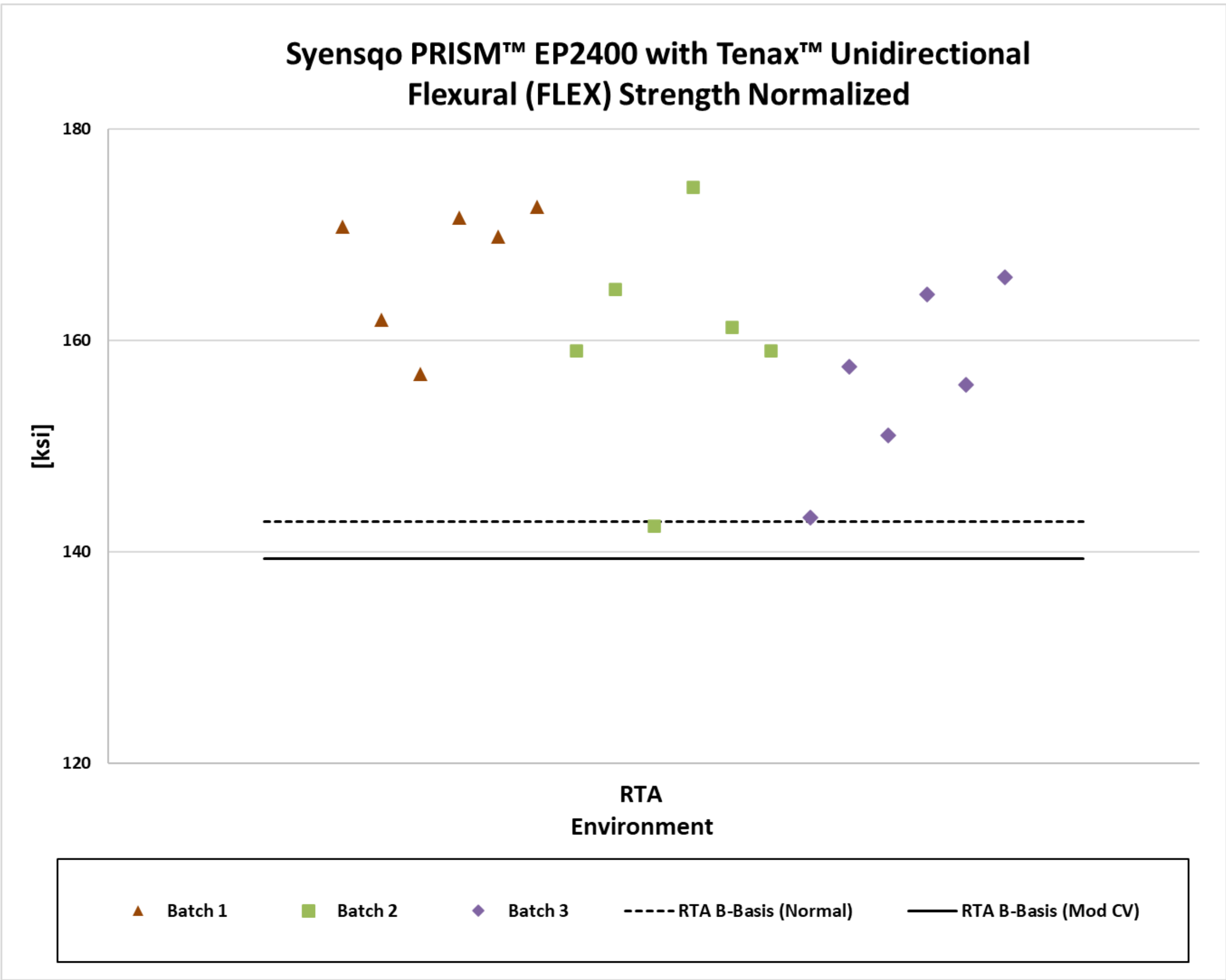


**Figure 4-22: Batch Plot for UD FLEX Normalized Strength**

| Unidirectional FLEX Strength Basis Values and Statistics | | |
|---|---|---|
| | Normalized | As-Measured |
| Env | RTA | RTA |
| Mean | 161.3 | 162.9 |
| Stdev | 9.340 | 10.87 |
| CV | 5.792 | 6.675 |
| Mod CV | 6.896 | 7.337 |
| Min | 142.4 | 141.7 |
| Max | 174.6 | 178.0 |
| No. Batches | 3 | 3 |
| No. Spec. | 18 | 18 |
| Basis Values and Estimates | | |
| B-Basis Value | 142.8 | 141.4 |
| A-Estimate | 129.8 | 126.2 |
| Method | Normal | Normal |
| Modified CV Basis Values and Estimates | | |
| B-Basis Value | 139.3 | 139.3 |
| A-Estimate | 123.8 | 122.6 |
| Method | Normal | Normal |

**Table 4-45: Statistics, B-Basis Values and Estimates for UD FLEX Strength Data**

## 4.20 Unnotched Tension 1 (UNT1)

The UNT1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW1.

For both the normalized and the as measured datasets, the CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for CTA. The RTA, ETA and ETW1 conditions were pooled. Applying the modified CV, all conditions were pooled

There were no statistical outliers.

Statistics, basis values and estimates are given for the UNT1 strength data in Table 4-46 and Table 4-47 and for the modulus data in Table 4-48. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-23.

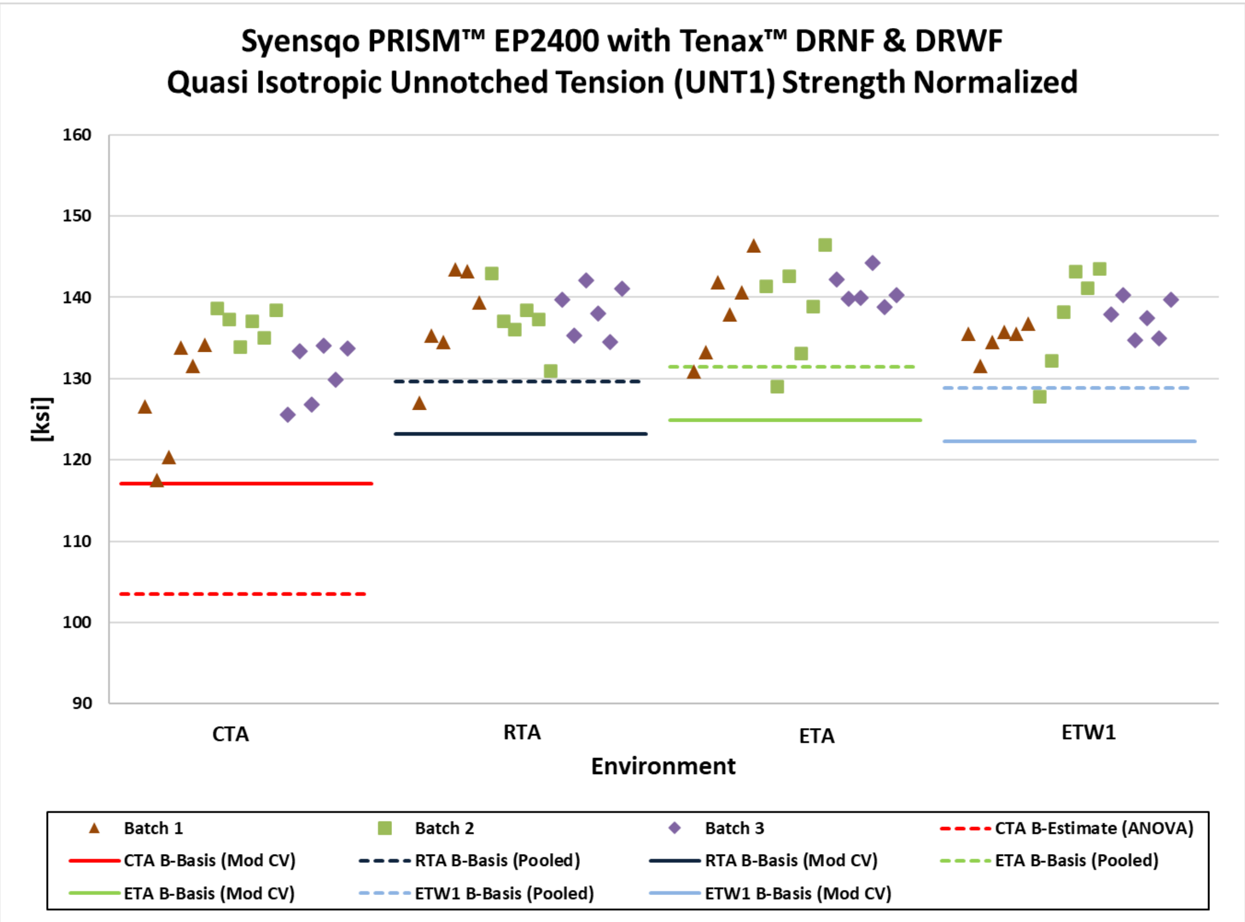


**Figure 4-23: Batch Plot for UNT1 Normalized Strength**

| Normalized Unnotched Tension 1 (UNT1) Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 131.6 | 137.6 | 139.3 | 136.7 |
| Stdev | 6.017 | 4.373 | 4.924 | 4.022 |
| CV | 4.574 | 3.178 | 3.534 | 2.941 |
| Mod CV | 6.287 | 6.000 | 6.000 | 6.000 |
| Min | 117.5 | 127.0 | 129.1 | 127.8 |
| Max | 138.7 | 143.5 | 146.5 | 143.5 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 129.7 | 131.5 | 128.8 |
| B-Estimate | 103.5 | | | |
| A-Estimate | 83.57 | 124.4 | 126.2 | 123.6 |
| Method | ANOVA | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 117.1 | 123.1 | 124.9 | 122.3 |
| A-Estimate | 107.6 | 113.6 | 115.4 | 112.8 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-46: Normalized Statistics, B-Basis Values and Estimates for UNT1 Strength Data

| As Measured Unnotched Tension 1 (UNT1) Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 123.6 | 129.3 | 131.0 | 128.5 |
| Stdev | 5.381 | 4.048 | 4.426 | 3.888 |
| CV | 4.352 | 3.132 | 3.377 | 3.026 |
| Mod CV | 6.176 | 6.000 | 6.000 | 6.000 |
| Min | 113.5 | 121.4 | 121.9 | 120.3 |
| Max | 132.2 | 135.4 | 137.9 | 136.3 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 122.0 | 123.7 | 121.2 |
| B-Estimate | 97.22 | | | |
| A-Estimate | 78.37 | 117.1 | 118.9 | 116.3 |
| Method | ANOVA | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 110.1 | 115.8 | 117.5 | 114.9 |
| A-Estimate | 101.2 | 106.8 | 108.6 | 106.0 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-47: As Measured Statistics, B-Basis Values and Estimates for UNT1 Strength Data

| Unnotched Tension 1 (UNT1) Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | CTA | RTA | ETA | ETW1 | CTA | RTA | ETA | ETW1 |
| Mean | 8.875 | 8.669 | 8.480 | 8.459 | 8.342 | 8.145 | 7.975 | 7.948 |
| Stdev | 0.2061 | 0.1488 | 0.1479 | 0.1738 | 0.1905 | 0.1368 | 0.1422 | 0.1620 |
| CV | 2.322 | 1.716 | 1.744 | 2.055 | 2.284 | 1.680 | 1.783 | 2.039 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 8.504 | 8.452 | 8.275 | 8.277 | 7.859 | 7.787 | 7.753 | 7.786 |
| Max | 9.267 | 9.046 | 8.740 | 8.930 | 8.753 | 8.335 | 8.195 | 8.422 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |

**Table 4-48: Statistics for UNT1 Modulus Data**

## 4.21 Unnotched Tension 2 (UNT2)

The UNT2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, and ETW1.

For the normalized dataset, the CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for CTA. The single point Weibull method was used for RTA and the single point non-parametric method was used for ETW1. Applying the modified CV, all conditions were pooled.

For the as measured dataset, the CTA and RTA conditions failed the ADK test for batch equivalency, therefore pooling was not possible. ANOVA was used to compute estimates for CTA and RTA, and the single point log normal method was used for ETW1. Applying the modified CV, all conditions were pooled.

There was one outlier. The highest normalized value in batch three of the ETW1 condition was an outlier for the batch and for the environment. It was an outlier in the normalized dataset and in the as measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNT2 strength data in Table 4-49 and for the modulus data in Table 4-50. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-24.

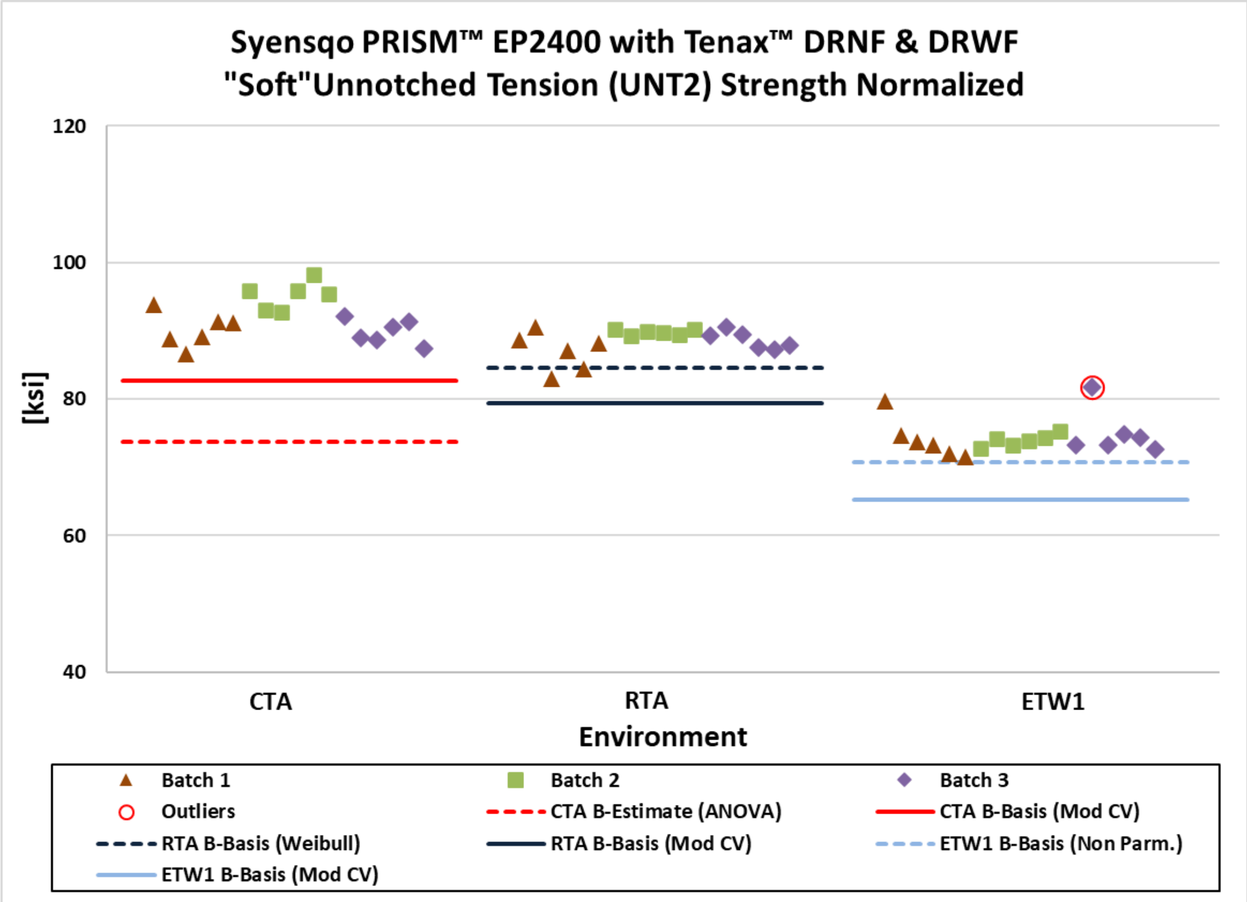


**Figure 4-24: Batch Plot for UNT2 Normalized Strength**

| Unnotched Tension 2 (UNT2) Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 91.74 | 88.47 | 74.38 | 87.67 | 84.63 | 71.12 |
| Stdev | 3.234 | 2.080 | 2.508 | 4.198 | 2.473 | 2.296 |
| CV | 3.525 | 2.351 | 3.372 | 4.788 | 2.922 | 3.228 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.394 | 6.000 | 6.000 |
| Min | 86.59 | 83.00 | 71.55 | 81.01 | 80.14 | 68.17 |
| Max | 98.23 | 90.59 | 81.70 | 96.13 | 88.57 | 76.41 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-Basis Value | | 84.60 | 70.79 | | | 66.76 |
| B-Estimate | 73.74 | | | 62.66 | 71.30 | |
| imate | 60.90 | 80.28 | 58.66 | 44.81 | 61.79 | 63.86 |
| Method | ANOVA | Weibull | Non-Parm. | ANOVA | ANOVA | Log Normal |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | 82.68 | 79.42 | 65.33 | 78.80 | 75.75 | 62.24 |
| A-Estimate | 76.65 | 73.38 | 59.29 | 72.87 | 69.83 | 56.32 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |

Table 4-49: Statistics, B-Basis Values and Estimates for UNT2 Strength Data

| Unnotched Tension 2 (UNT2) Modulus Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 6.426 | 6.117 | 5.717 | 6.139 | 5.851 | 5.466 |
| Stdev | 0.09540 | 0.08344 | 0.1906 | 0.1410 | 0.1211 | 0.1745 |
| CV | 1.485 | 1.364 | 3.334 | 2.296 | 2.070 | 3.192 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 6.230 | 5.963 | 5.507 | 5.872 | 5.618 | 5.230 |
| Max | 6.565 | 6.264 | 6.214 | 6.443 | 6.036 | 5.812 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |

Table 4-50: Statistics for UNT2 Modulus Data

## 4.22 Unnotched Tension 3 (UNT3)

The UNT3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETW1.

For the normalized dataset, all conditions fail the ADK test for batch equivalency, therefore pooling was not possible. ANOVA was used to compute estimates for all conditions. Applying the modified CV, all conditions were pooled.

For the as measured dataset, the single point normal method was used to compute values for CTA, and the RTA and ETW1 conditions were pooled. Applying the modified CV, the normal method for modified CV was used to compute values for all conditions.

There were no statistical outliers.

Statistics, basis values and estimates are given for the UNT3 strength data in Table 4-51 and for the modulus data in Table 4-52. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-25.

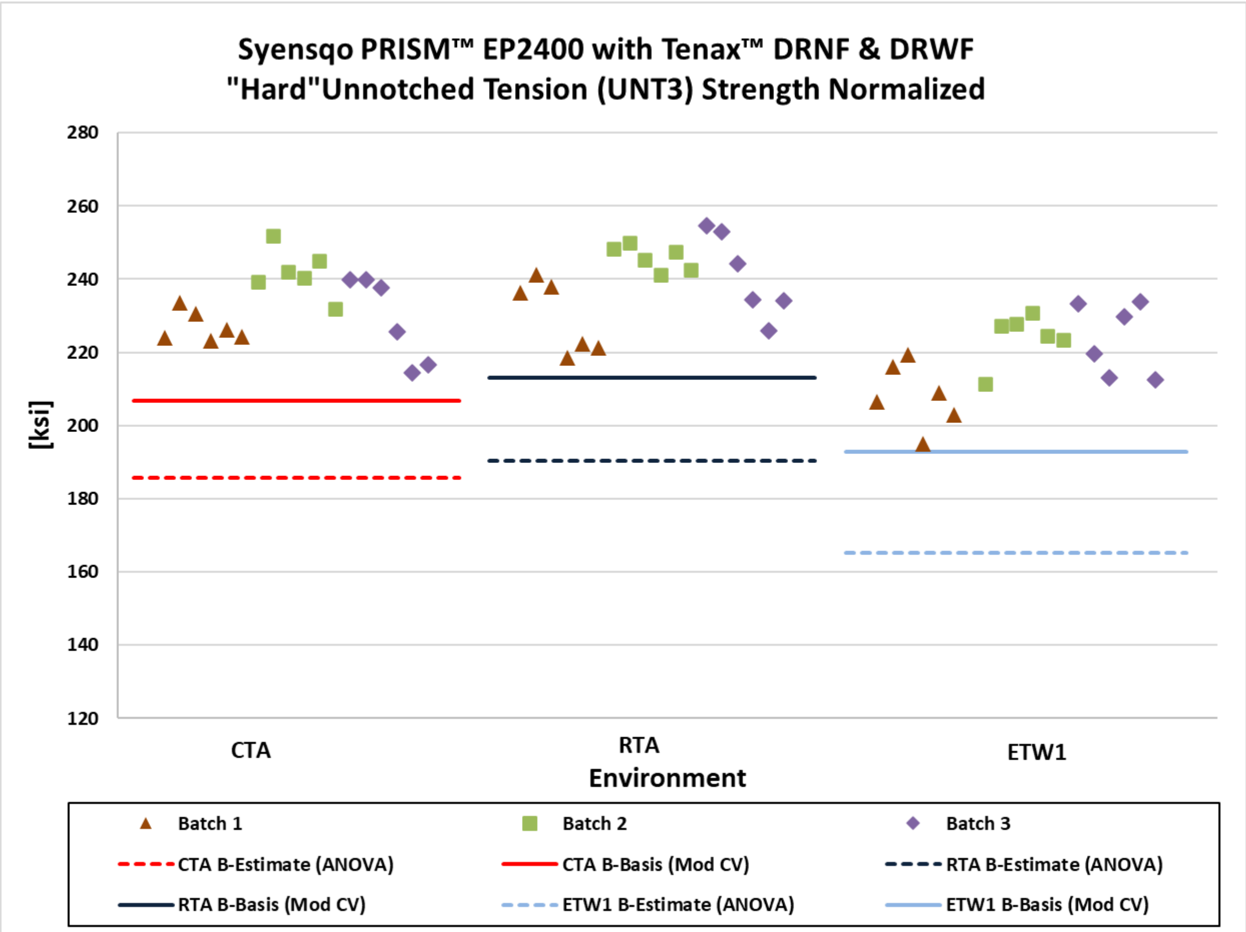


**Figure 4-25: Batch Plot for UNT3 Normalized Strength**

| Unnotched Tension 3 (UNT3) Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 232.6 | 238.8 | 218.7 | 231.0 | 237.2 | 217.5 |
| Stdev | 10.18 | 10.97 | 11.12 | 8.319 | 9.898 | 9.830 |
| CV | 4.377 | 4.592 | 5.083 | 3.602 | 4.173 | 4.519 |
| Mod CV | 6.189 | 6.296 | 6.542 | 6.000 | 6.087 | 6.260 |
| Min | 214.5 | 218.4 | 195.1 | 216.4 | 219.5 | 198.0 |
| Max | 251.9 | 254.5 | 233.8 | 246.2 | 252.2 | 232.5 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-Basis Value | | | | 214.6 | 219.2 | 199.5 |
| B-Estimate | 185.8 | 190.5 | 165.3 | | | |
| A-Estimate | 152.4 | 156.1 | 127.2 | 202.9 | 207.0 | 187.3 |
| Method | ANOVA | ANOVA | ANOVA | Normal | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | 206.8 | 213.0 | 192.9 | 203.6 | 208.7 | 190.6 |
| A-Estimate | 189.5 | 195.8 | 175.6 | 184.3 | 188.5 | 171.6 |
| Method | Pooled | Pooled | Pooled | Normal | Normal | Normal |

Table 4-51: Statistics, B-Basis Values and Estimates for UNT3 Strength Data

| Unnotched Tension 3 (UNT3) Modulus Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 13.80 | 13.63 | 13.09 | 13.71 | 13.54 | 13.01 |
| Stdev | 0.5346 | 0.4089 | 0.2856 | 0.5489 | 0.4228 | 0.3963 |
| CV | 3.873 | 3.000 | 2.182 | 4.003 | 3.123 | 3.047 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.001 | 6.000 | 6.000 |
| Min | 13.12 | 13.12 | 12.43 | 13.01 | 12.58 | 12.12 |
| Max | 14.76 | 14.54 | 13.49 | 14.89 | 14.28 | 13.56 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| o. Spec. | 18 | 18 | 19 | 18 | 18 | 19 |

Table 4-52: Statistics for UNT3 Modulus Data

## 4.23 Unnotched Compression 1 (UNC1)

The UNC1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA, ETW1, and ETW2.

The ETW2 condition consists of one batch with ten specimens. The single point normal method was used to compute estimates for the ETW2 condition for both the normalized and as measured datasets.

There were no diagnostic test failures within the remaining conditions, therefore the RTA, ETA, and ETW1 conditions were pooled in both the normalized and as measured datasets.

There were two statistical outliers. The lowest normalized value in batch two of the RTA condition was an outlier for the batch but no for the condition. It was an outlier in the normalized dataset and in the as measured dataset. The lowest as measured value in batch three of the RTA condition was an outlier for the batch but not for the environment. It was an outlier in the as measured dataset but not in the normalized dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UNC1 strength data in Table 4-53 and Table 4-54, and for the modulus data in Table 4-55. The normalized data and B-basis values are shown graphically in Figure 4-26.

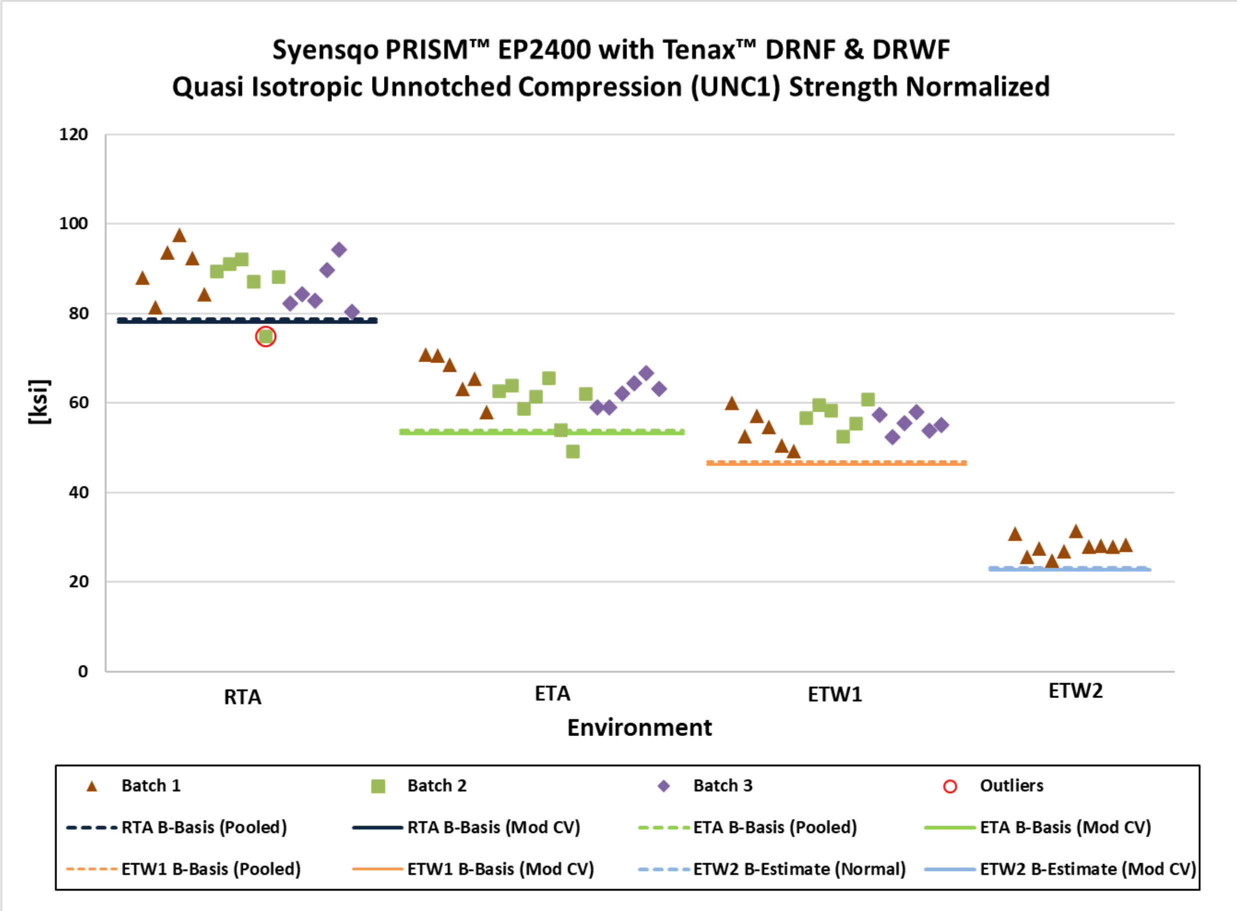


**Figure 4-26: Batch Plot for UNC1 Normalized Strength**

| Normalized Unnotched Compression 1 (UNC1) Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 87.41 | 62.46 | 55.56 | 27.94 |
| Stdev | 5.774 | 5.237 | 3.288 | 2.012 |
| CV | 6.606 | 8.385 | 5.918 | 7.202 |
| Mod CV | 7.303 | 8.385 | 6.959 | 8.000 |
| Min | 75.00 | 49.28 | 49.30 | 24.83 |
| Max | 97.56 | 70.83 | 60.90 | 31.39 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 20 | 18 | 10 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 78.75 | 53.90 | 46.91 | |
| B-Estimate | | | | 23.18 |
| A-Estimate | 72.99 | 48.11 | 41.14 | 19.86 |
| Method | Pooled | Pooled | Pooled | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 78.11 | 53.26 | 46.26 | |
| B-Estimate | | | | 22.65 |
| A-Estimate | 71.91 | 47.05 | 40.07 | 18.96 |
| Method | Pooled | Pooled | Pooled | Normal |

Table 4-53: Normalized Statistics, B-Basis Values and Estimates for UNC1 Strength Data

| As Measured Unnotched Compression 1 (UNC1) Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 80.39 | 57.54 | 51.58 | 25.89 |
| Stdev | 6.265 | 4.413 | 3.768 | 1.751 |
| CV | 7.793 | 7.670 | 7.305 | 6.764 |
| Mod CV | 7.896 | 7.835 | 7.652 | 8.000 |
| Min | 67.46 | 46.02 | 46.18 | 23.15 |
| Max | 90.38 | 64.68 | 57.65 | 28.75 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 20 | 18 | 10 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 71.71 | 48.95 | 42.90 | |
| B-Estimate | | | | 21.75 |
| A-Estimate | 65.93 | 43.15 | 37.12 | 18.85 |
| Method | Pooled | Pooled | Pooled | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 71.52 | 48.75 | 42.71 | |
| B-Estimate | | | | 20.99 |
| A-Estimate | 65.61 | 42.83 | 36.80 | 17.57 |
| Method | Pooled | Pooled | Pooled | Normal |

Table 4-54: As Measured Statistics, B-Basis Values and Estimates for UNC1 Strength Data

| Unnotched Compression 1 (UNC1) Modulus Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normalized | | | | As-Measured | | | |
| Env | RTA | ETA | ETW1 | ETW2 | RTA | ETA | ETW1 | ETW2 |
| Mean | 7.974 | 7.811 | 7.551 | 6.141 | 7.335 | 7.185 | 7.018 | 5.689 |
| Stdev | 0.1905 | 0.5572 | 0.4160 | 0.4983 | 0.3735 | 0.6815 | 0.5827 | 0.4288 |
| CV | 2.389 | 7.133 | 5.509 | 8.114 | 5.092 | 9.485 | 8.303 | 7.537 |
| Min | 7.566 | 7.068 | 6.824 | 5.341 | 6.466 | 6.026 | 5.860 | 4.998 |
| Max | 8.307 | 9.402 | 8.447 | 6.758 | 7.777 | 8.714 | 8.144 | 6.158 |
| No. Batches | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 10 | 18 | 18 | 18 | 10 |

Table 4-55: Statistics for UNC1 Modulus Data

## 4.24 Unnotched Compression 2 (UNC2)

The UNC2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

For the normalized dataset, there were no diagnostic test failures, therefore both conditions were pooled. Similarly, applying the modified CV, both conditions were pooled.

Fort the as measured dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for RTA and the single point normal method was used for ETW1. Applying the modified CV, pooling was not possible because the pooled dataset failed the test for equality of variances so the normal method for modified CV was used to compute values for both conditions.

There were no statistical outlies.

Statistics, basis values and estimates are given for the UNC2 strength data in Table 4-56 and for the modulus data in Table 4-57. The normalized data and B-basis values are shown graphically in Figure 4-27.

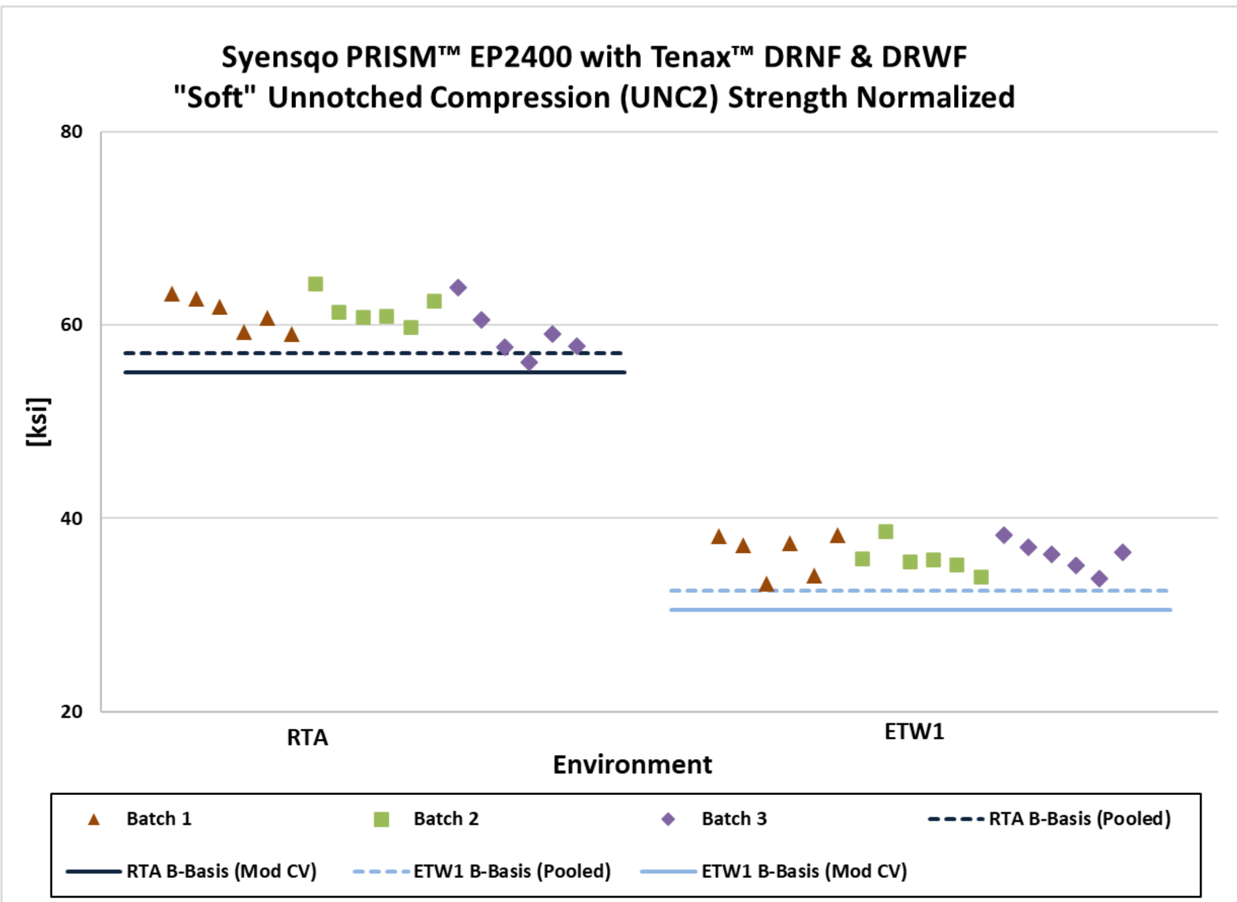


**Figure 4-27: Batch Plot for UNC2 Normalized Strength**

| Unnotched Compression 2 (UNC2) Basis Values and Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 60.65 | 36.13 | 57.56 | 34.43 |
| Stdev | 2.239 | 1.690 | 2.348 | 1.724 |
| CV | 3.691 | 4.679 | 4.079 | 5.006 |
| Mod CV | 6.000 | 6.339 | 6.039 | 6.503 |
| Min | 56.10 | 33.26 | 52.74 | 31.62 |
| Max | 64.28 | 38.72 | 61.94 | 37.62 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 57.03 | 32.52 | | 31.03 |
| B-Estimate | | | 44.85 | |
| A-Estimate | 54.58 | 30.06 | 35.79 | 28.62 |
| Method | Pooled | Pooled | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 55.11 | 30.59 | 50.70 | 30.01 |
| A-Estimate | 51.34 | 26.83 | 45.84 | 26.89 |
| Method | Pooled | Pooled | Normal | Normal |

Table 4-56: Statistics, B-Basis Values and Estimates for UNC2 Strength Data

| Unnotched Compression 2 (UNC2) Modulus Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 5.684 | 5.496 | 5.394 | 5.236 |
| Stdev | 0.1255 | 0.1881 | 0.1489 | 0.1577 |
| CV | 2.208 | 3.422 | 2.761 | 3.012 |
| Min | 5.505 | 5.176 | 5.159 | 4.828 |
| Max | 5.977 | 5.793 | 5.756 | 5.501 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |

Table 4-57: Statistics for UNC2 Modulus Data

## 4.25 Unnotched Compression 3 (UNC3)

The UNC3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

The RTA condition consists of three batches with seventeen specimens. Therefore, the values computed for RTA are estimates.

For the normalized and the as measured dataset, both conditions have coefficients of variation larger than 8% therefore, modified CV results are the same as as measured CV results.

For the normalized dataset, pooling both conditions was not possible because the pooled dataset failed the test for equality of variances so the single point normal method was used to compute estimates and values for both conditions.

For the as measured dataset, pooling both conditions was not possible because the pooled dataset failed the test for equality of variances so the single point Weibull method was used to compute estimates for RTA and the single point normal method was used for ETW1.

There were no statistical outliers.

Statistics, basis values and estimates are given for the UNC3 strength data in Table 4-58 and for the modulus data in Table 4-59. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-28.

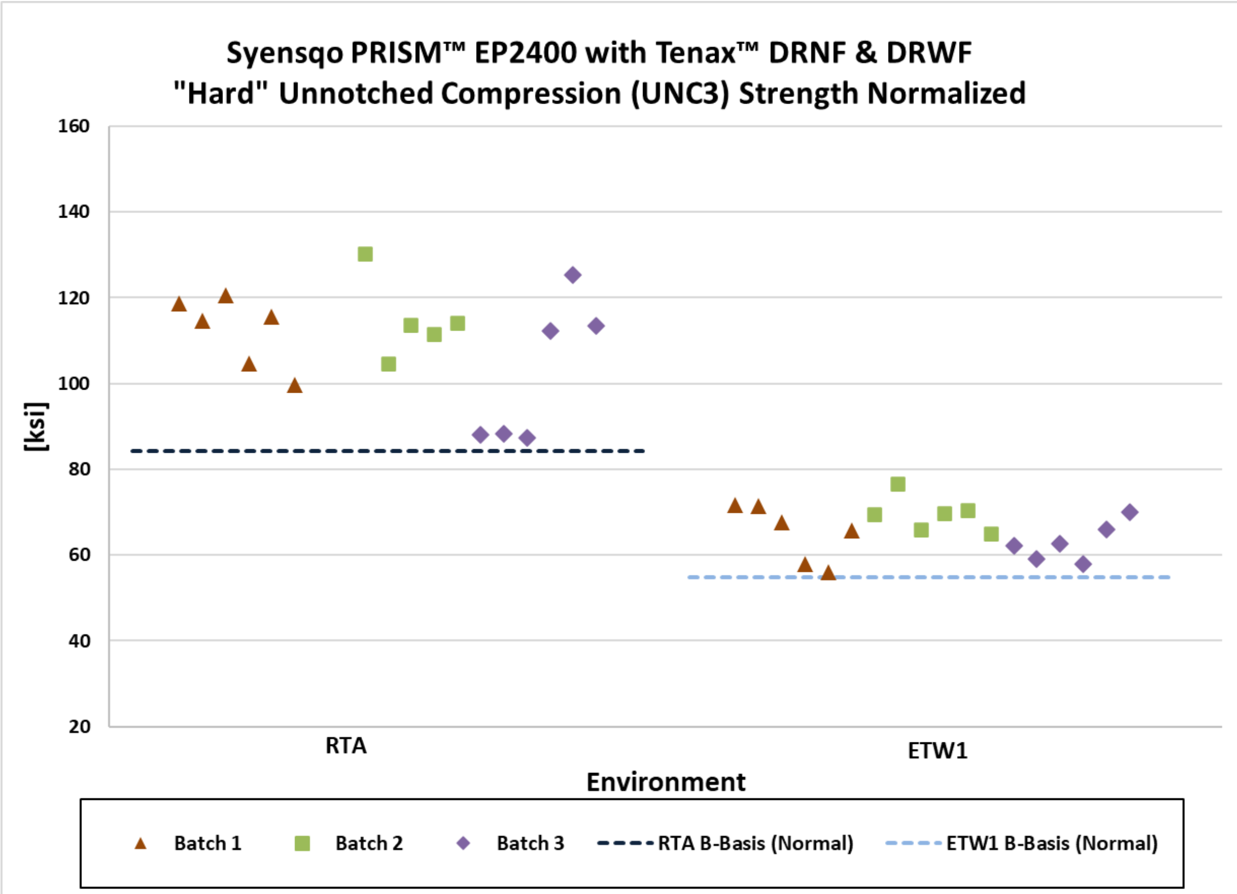


**Figure 4-28: Batch Plot for UNC3 Normalized Strength**

| Unnotched Compression 3 (UNC3) Basis Values and Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 109.6 | 65.88 | 107.8 | 64.91 |
| Stdev | 12.66 | 5.665 | 12.66 | 5.598 |
| CV | 11.55 | 8.599 | 11.75 | 8.624 |
| Mod CV | 11.55 | 8.599 | 11.75 | 8.624 |
| Min | 87.42 | 56.11 | 85.54 | 54.91 |
| Max | 130.3 | 76.64 | 126.3 | 74.23 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 17 | 18 | 17 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 54.70 | | 53.86 |
| B-Estimate | 84.26 | | 81.48 | |
| A-Estimate | 66.33 | 46.77 | 59.45 | 46.03 |
| Method | Normal | Normal | Weibull | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | | 54.70 | | 53.86 |
| B-Estimate | 84.26 | | 82.41 | |
| A-Estimate | 66.38 | 46.79 | 64.52 | 46.04 |
| Method | Normal | Normal | Normal | Normal |

**Table 4-58: Statistics, B-Basis Values and Estimates for UNC3 Strength Data**

| Unnotched Compression 3 (UNC3) Modulus Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 12.42 | 12.55 | 12.20 | 12.36 |
| Stdev | 0.5001 | 0.5647 | 0.5696 | 0.6312 |
| CV | 4.025 | 4.501 | 4.669 | 5.105 |
| Mod CV | 6.012 | 6.251 | 6.335 | 6.552 |
| Min | 12.05 | 11.58 | 11.67 | 11.34 |
| Max | 13.58 | 13.44 | 13.75 | 13.48 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |

**Table 4-59: Statistics for UNC3 Modulus Data**

## 4.26 Laminate Short-Beam Strength (SBS1)

The Laminate Short Beam Strength data is not normalized. Tests were conducted in the following environmental conditions: RTA, ETA and ETW1.

The ETA condition failed the ADK test for batch equivalency. The single point normal method was used for RTA, ANOVA was used to compute estimates for ETA and the single point Weibull method was used for ETW1. Applying the modified CV, there were no diagnostic test failures so all conditions were pooled.

There were two statistical outliers. The lowest value in batch one of the RTA condition was an outlier for the condition but not for the batch. The lowest value in batch two of the ETW1 condition was an outlier for the condition but not for the batch. They were retained for this analysis.

Statistics, basis values and estimates are given for the SBS1 data in Table 4-60. The as measured data, B-estimates and B-basis values are shown graphically in Figure 4-29.

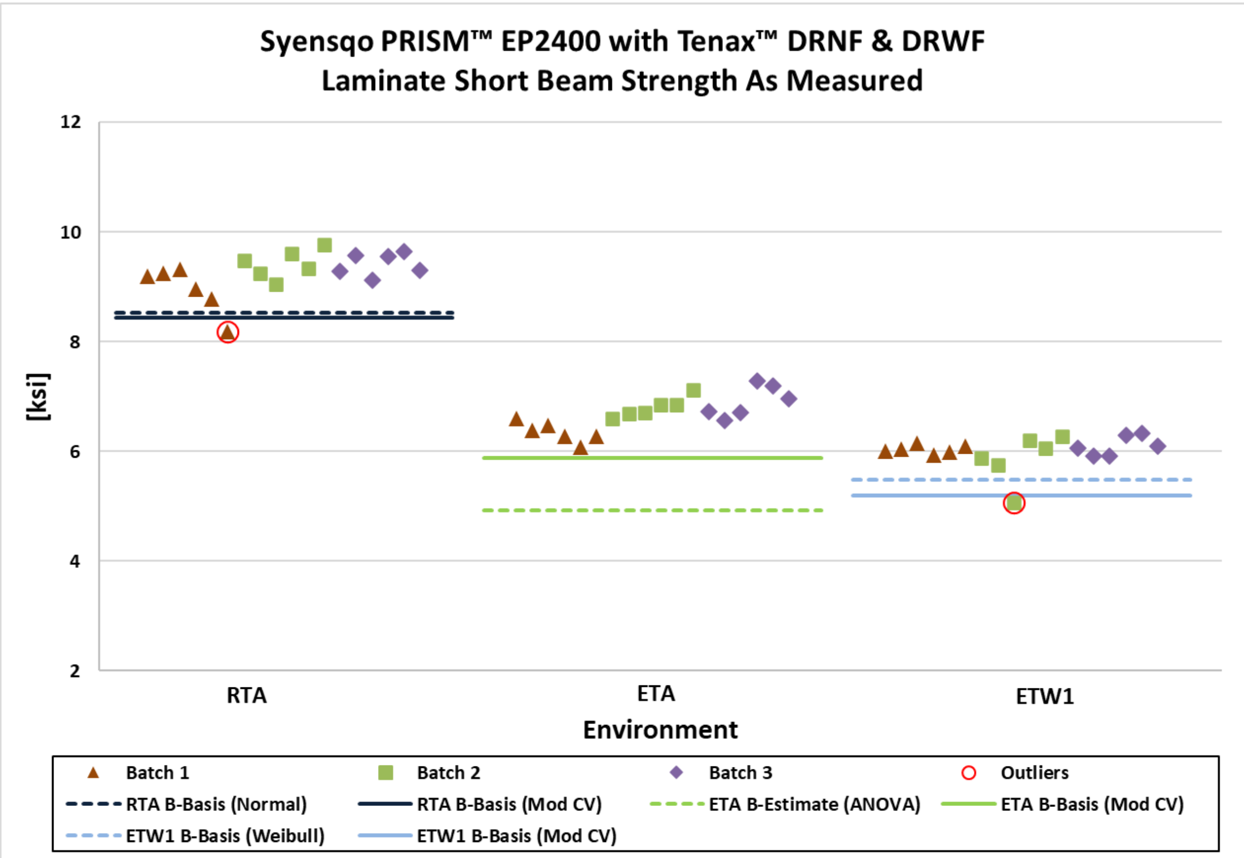


**Figure 4-29: Batch Plot for As Measured SBS1**

| Laminate Short Beam Strength (SBS1) As Measured Basis Values and Statistics | | | |
|---|---|---|---|
| Env | RTA | ETA | ETW1 |
| Mean | 9.259 | 6.688 | 6.004 |
| Stdev | 0.3696 | 0.3251 | 0.2787 |
| CV | 3.992 | 4.861 | 4.642 |
| Mod CV | 6.000 | 6.431 | 6.321 |
| Min | 8.179 | 6.084 | 5.073 |
| Max | 9.767 | 7.283 | 6.338 |
| No. Batches | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 |
| Basis Values and Estimates | | | |
| B-Basis Value | 8.529 | | 5.490 |
| B-Estimate | | 4.918 | |
| A-Estimate | 8.012 | 3.655 | 4.951 |
| Method | Normal | ANOVA | Weibull |
| Modified CV Basis Values and Estimates | | | |
| B-Basis Value | 8.442 | 5.872 | 5.188 |
| A-Estimate | 7.898 | 5.327 | 4.643 |
| Method | Pooled | Pooled | Pooled |

Table 4-60: Statistics, B-Basis Values and Estimates for SBS1 Strength Data

## 4.27 Open-Hole Tension 1 (OHT1)

The OHT1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW1.

There were no diagnostic test failures in either the normalized dataset nor the as measured dataset using the as measured CV so all conditions were pooled. Applying the modified CV, all conditions were pooled for the normalized dataset, but for the as measured dataset, the RTA condition failed the normality test, therefore basis values were not computed for it and the normal method for modified CV was used for the remaining conditions.

There were three statistical outliers. The lowest as measured value in batch one of the RTA condition was an outlier for the batch but not for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. The highest as measured value in batch five of the ETA condition was an outlier for the batch but not for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. The highest as measured value in batch one of the ETW1 condition was an outlier for the batch but no for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the OHT1 strength data in Table 4-61 and Table 4-62. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-30.

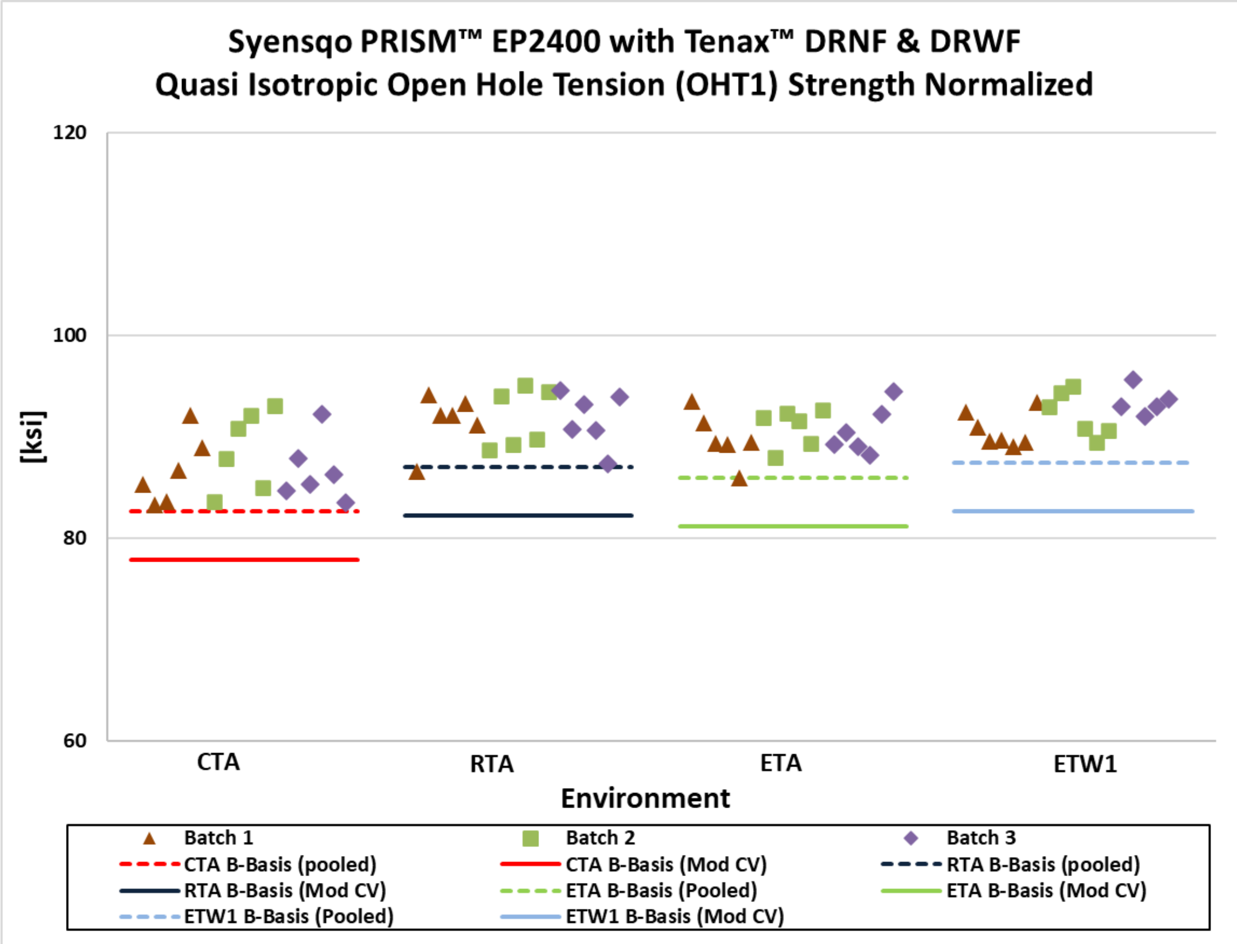


**Figure 4-30: Batch Plot for OHT1 Normalized Strength**

| Normalized Open Hole Tension 1 (OHT1) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 87.33 | 91.71 | 90.57 | 92.05 |
| Stdev | 3.418 | 2.613 | 2.481 | 2.100 |
| CV | 3.914 | 2.849 | 2.740 | 2.281 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 83.29 | 86.54 | 85.98 | 89.00 |
| Max | 93.04 | 95.12 | 96.86 | 95.61 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 19 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 82.64 | 87.02 | 85.88 | 87.38 |
| A-Estimate | 79.55 | 83.93 | 82.79 | 84.29 |
| Method | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 77.86 | 82.25 | 81.11 | 82.63 |
| A-Estimate | 71.62 | 76.01 | 74.87 | 76.39 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-61: Normalized Statistics, B-Basis Values and Estimates for OHT1 Strength Data

| As Measured Open Hole Tension 1 (OHT1) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 82.87 | 87.24 | 85.58 | 87.38 |
| Stdev | 3.672 | 2.938 | 2.547 | 2.095 |
| CV | 4.431 | 3.367 | 2.976 | 2.398 |
| Mod CV | 6.215 | 6.000 | 6.000 | 6.000 |
| Min | 77.61 | 81.06 | 81.79 | 84.08 |
| Max | 88.84 | 91.11 | 91.44 | 91.38 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 19 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 77.88 | 82.25 | 80.59 | 82.42 |
| A-Estimate | 74.59 | 78.96 | 77.30 | 79.12 |
| Method | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 72.71 | NA | 75.44 | 77.16 |
| A-Estimate | 65.51 | | 68.27 | 69.92 |
| Method | Normal | | Normal | Normal |

Table 4-62: As Measured Statistics, B-Basis Values and Estimates for OHT1 Strength Data

## 4.28 Open-Hole Tension 2 (OHT2)

The OHT2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, and ETW1.

For the normalized dataset, the RTA condition failed the ADK test for batch equivalency, therefore pooling was not possible. The single point normal method was used to compute values for CTA and ETW1, and ANOVA was used to compute estimates for RTA. Applying the modified CV, there were no diagnostic test failures so all conditions were pooled.

For the as measured dataset, the CTA and RTA conditions failed the ADK test for batch equivalency, therefore pooling was not possible. ANOVA was used to compute estimates for CTA and RTA, and the single point normal method was used for ETW1. Applying the modified CV, there were no diagnostic test failures so all conditions were pooled.

There was one statistical outlier. The highest normalized value in batch five of the RTA condition was an outlier for the batch but not for the condition. It was an outlier in the normalized dataset and 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 4-63. The normalized data and B-basis values are shown graphically in Figure 4-31.

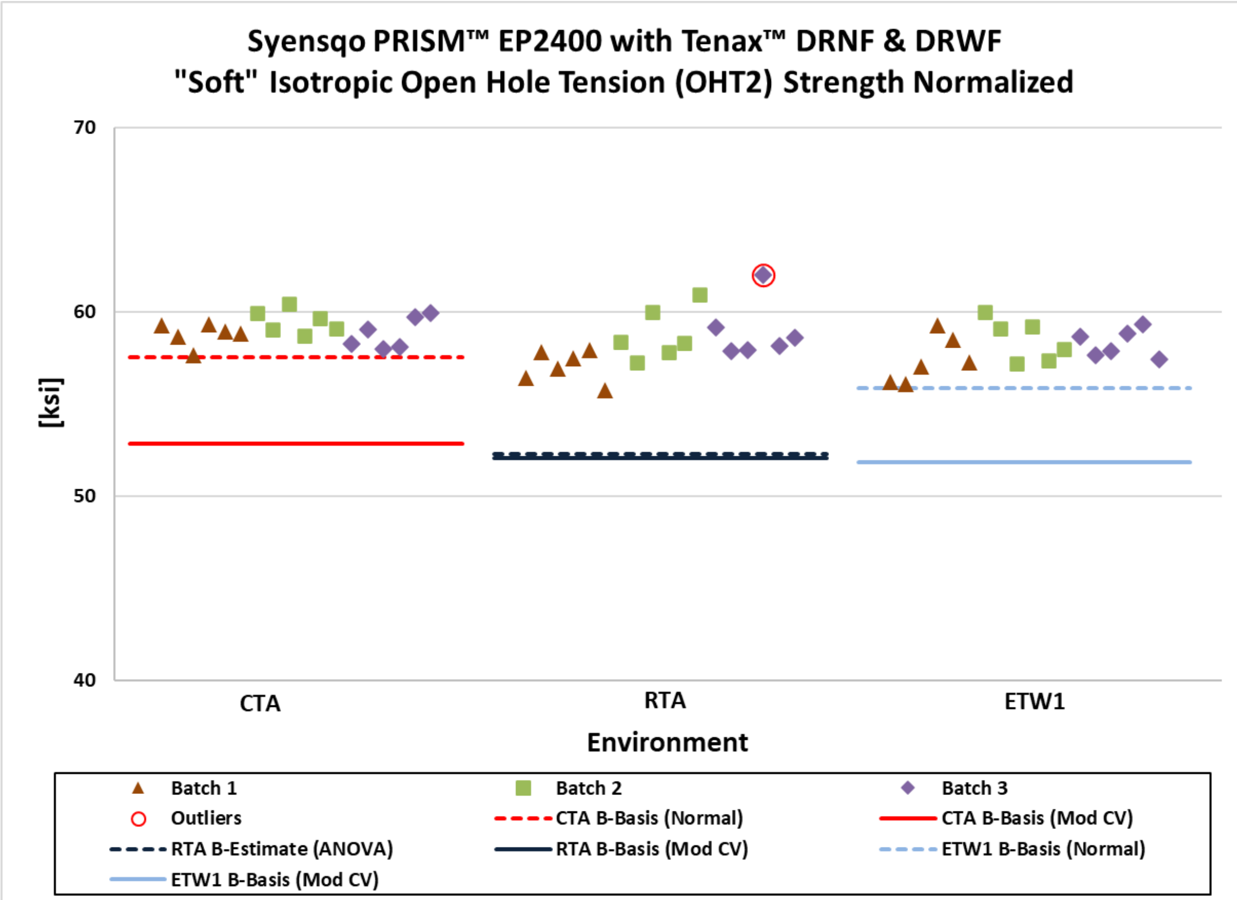


Figure 4-31: Batch Plot for OHT2 Normalized Strength

| Open Hole Tension 2 (OHT2) Strength Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 59.01 | 58.25 | 58.03 | 56.39 | 55.93 | 55.60 |
| Stdev | 0.7466 | 1.516 | 1.113 | 1.130 | 1.818 | 1.534 |
| CV | 1.265 | 2.602 | 1.919 | 2.003 | 3.250 | 2.758 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 57.61 | 55.75 | 56.05 | 54.72 | 53.10 | 52.46 |
| Max | 60.42 | 61.99 | 59.98 | 58.86 | 60.01 | 58.14 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-basis Value | 57.54 | | 55.83 | | | 52.58 |
| B-Estimate | | 52.27 | | 50.73 | 45.51 | |
| A-Estimate | 56.49 | 48.01 | 54.27 | 46.70 | 38.08 | 50.43 |
| Method | Normal | ANOVA | Normal | ANOVA | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | | | |
| B-basis Value | 52.80 | 52.04 | 51.82 | 50.45 | 49.98 | 49.66 |
| A-Estimate | 48.66 | 47.90 | 47.68 | 46.48 | 46.02 | 45.69 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |

Table 4-63: Statistics, B-Basis Values and Estimates for OHT2 Strength Data

## 4.29 Open-Hole Tension 3 (OHT3)

The OHT3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, and ETW1.

For both, the normalized and as measured dataset, using the original CV the three conditions failed the ADK test for batch equivalency, therefore the ANOVA method was used and since they consist of 3 batches, only estimates could be computed. Applying the modified CV, for both datasets the CTA condition failed the ADK test, therefore basis values were not computed for CTA, while the remaining conditions were pooled.

There were no statistical outliers.

Statistics, basis values and estimates are given for the OHT3 strength data in Table 4-64. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-32.

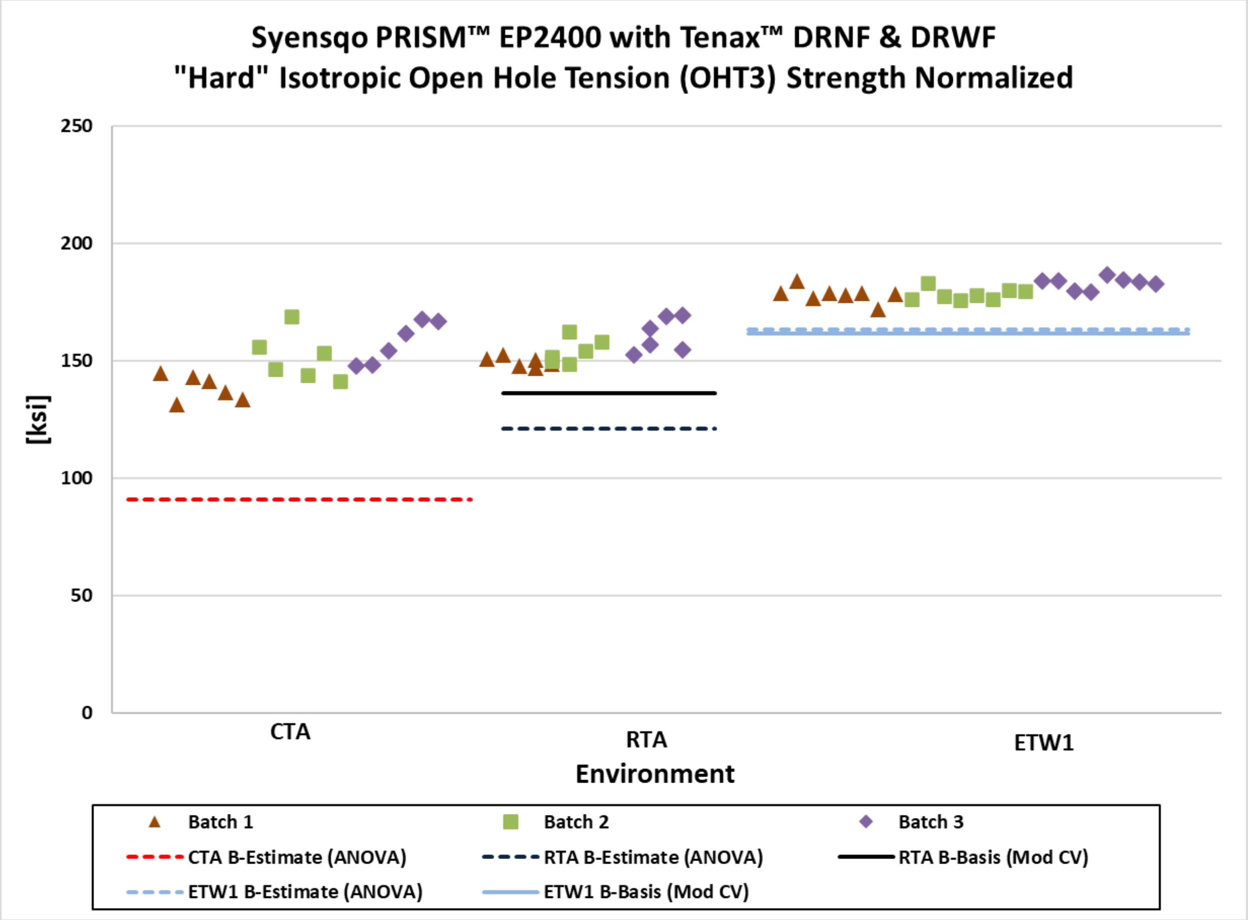


**Figure 4-32: Batch Plot for OHT3 Normalized Strength**

| Open Hole Tension 3 (OHT3) Strength Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| Property | Normalized | | | As Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 149.3 | 154.9 | 179.9 | 146.7 | 151.6 | 177.2 |
| Stdev | 11.46 | 6.926 | 3.519 | 12.49 | 8.110 | 4.673 |
| CV | 7.678 | 4.470 | 1.956 | 8.510 | 5.349 | 2.638 |
| Mod CV | 7.839 | 6.235 | 6.000 | 8.510 | 6.674 | 6.000 |
| Min | 131.2 | 146.8 | 172.1 | 127.8 | 141.9 | 168.1 |
| Max | 168.9 | 169.2 | 186.8 | 167.3 | 168.7 | 185.2 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 24 | 18 | 18 | 24 |
| Estimates | | | | | | |
| B-Estimate | 90.76 | 121.2 | 163.3 | 78.40 | 104.5 | 148.8 |
| A-Estimate | 49.01 | 97.19 | 151.4 | 29.66 | 70.94 | 128.5 |
| Method | ANOVA | ANOVA | ANOVA | ANOVA | ANOVA | ANOVA |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | NA | 136.4 | 161.8 | NA | 132.9 | 158.9 |
| A-Estimate | | 123.8 | 149.2 | | 120.3 | 146.1 |
| Method | | Pooled | Pooled | | Pooled | Pooled |

Table 4-64: Statistics, B-Basis Values and Estimates for OHT3 Strength Data

## 4.30 Open-Hole Tension 4 (OHT4)

The OHT4 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

Both conditions tested consist of one batch with six specimens, therefore, only estimates are provided.

For both the normalized dataset and the as measured dataset, the single point normal method was used to compute estimates using the original cv and the normal method for modified CV was used to compute estimates using the modified CV.

There was one statistical outlier. The lowest normalized value of the ETW1 condition was an outlier for the batch and for the condition. It was an outlier in the normalized dataset but not in the as measured dataset.

Statistics and estimates are given for the OHT4 strength data in Table 4-65. The normalized data and B-estimates are shown graphically in Figure 4-33.

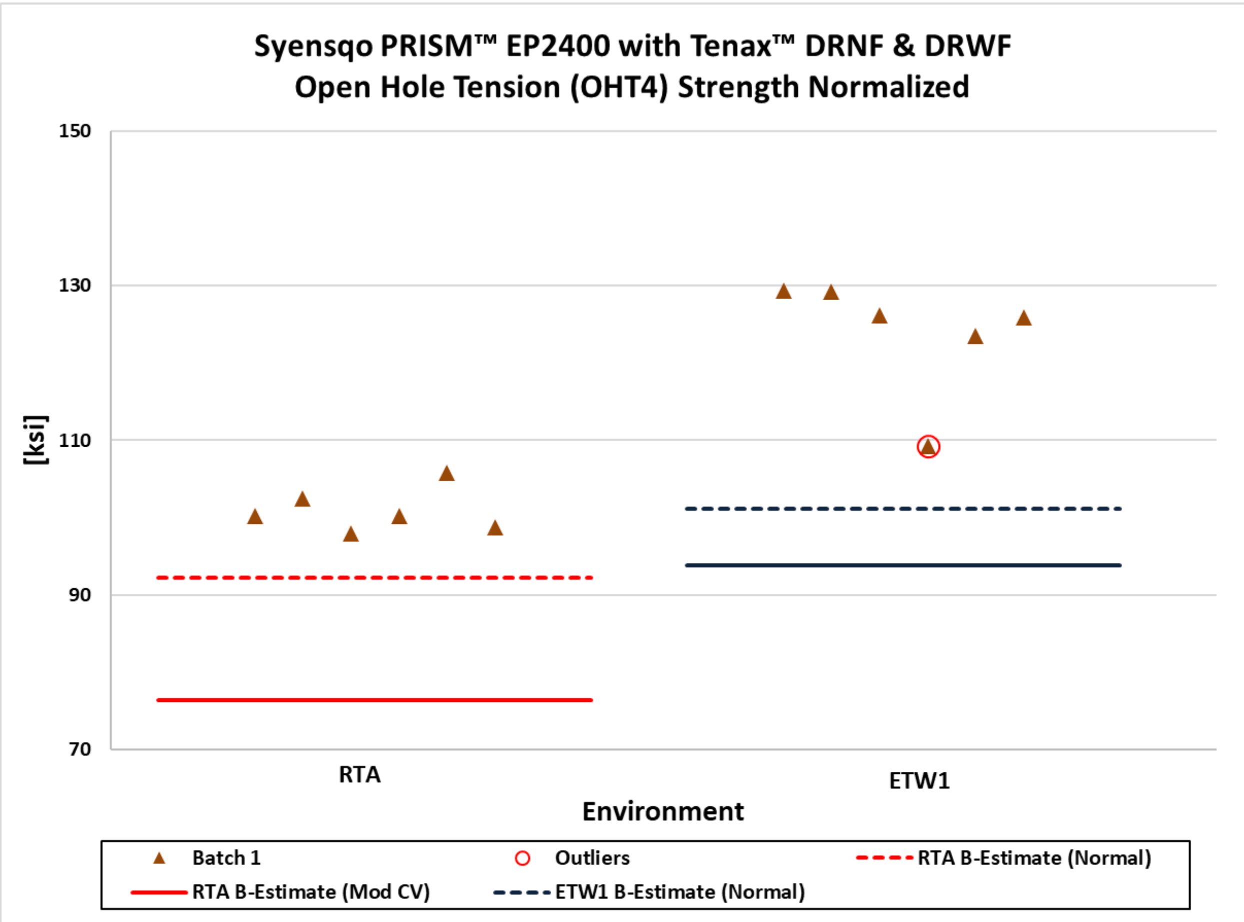


**Figure 4-33: Batch Plot for OHT4 Normalized Strength**

| Open Hole Tension 4 (OHT4) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 100.9 | 123.9 | 92.71 | 114.9 |
| Stdev | 2.871 | 7.518 | 3.337 | 8.497 |
| CV | 2.845 | 6.068 | 3.599 | 7.398 |
| Mod CV | 8.000 | 8.000 | 8.000 | 8.000 |
| Min | 98.00 | 109.2 | 88.96 | 98.89 |
| Max | 105.9 | 129.4 | 97.28 | 121.6 |
| No. Batches | 1 | 1 | 1 | 1 |
| No. Spec. | 6 | 6 | 6 | 6 |
| Estimates | | | | |
| B-Estimate | 92.22 | 101.1 | 82.61 | 89.13 |
| A-Estimate | 86.04 | 84.93 | 75.42 | 70.83 |
| Method | Normal | Normal | Normal | Normal |
| Modified CV Estimates | | | | |
| B-Estimate | 76.46 | 93.87 | 82.61 | 89.13 |
| A-Estimate | 59.08 | 72.52 | 75.42 | 70.83 |
| Method | Normal | Normal | Normal | Normal |

Table 4-65: Statistics and Estimates for OHT4 Strength Data

## 4.31 Filled-Hole Tension 1 (FHT1)

The FHT1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW1.

For the normalized dataset, the ETA condition failed the ADK test for batch equivalency. There were no other test failures. ANOVA was used to compute estimates for ETA and the remaining conditions were pooled. Applying the modified CV, there were no diagnostic test failure so all conditions were pooled.

For the as measured dataset, the CTA and ETA conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for CTA and ETA and the remaining conditions were pooled. Applying the modified CV, there were no diagnostic test failures so all conditions were pooled.

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

Statistics, basis values and estimates are given for the FHT1 strength data in Table 4-66 and Table 4-67. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-34.

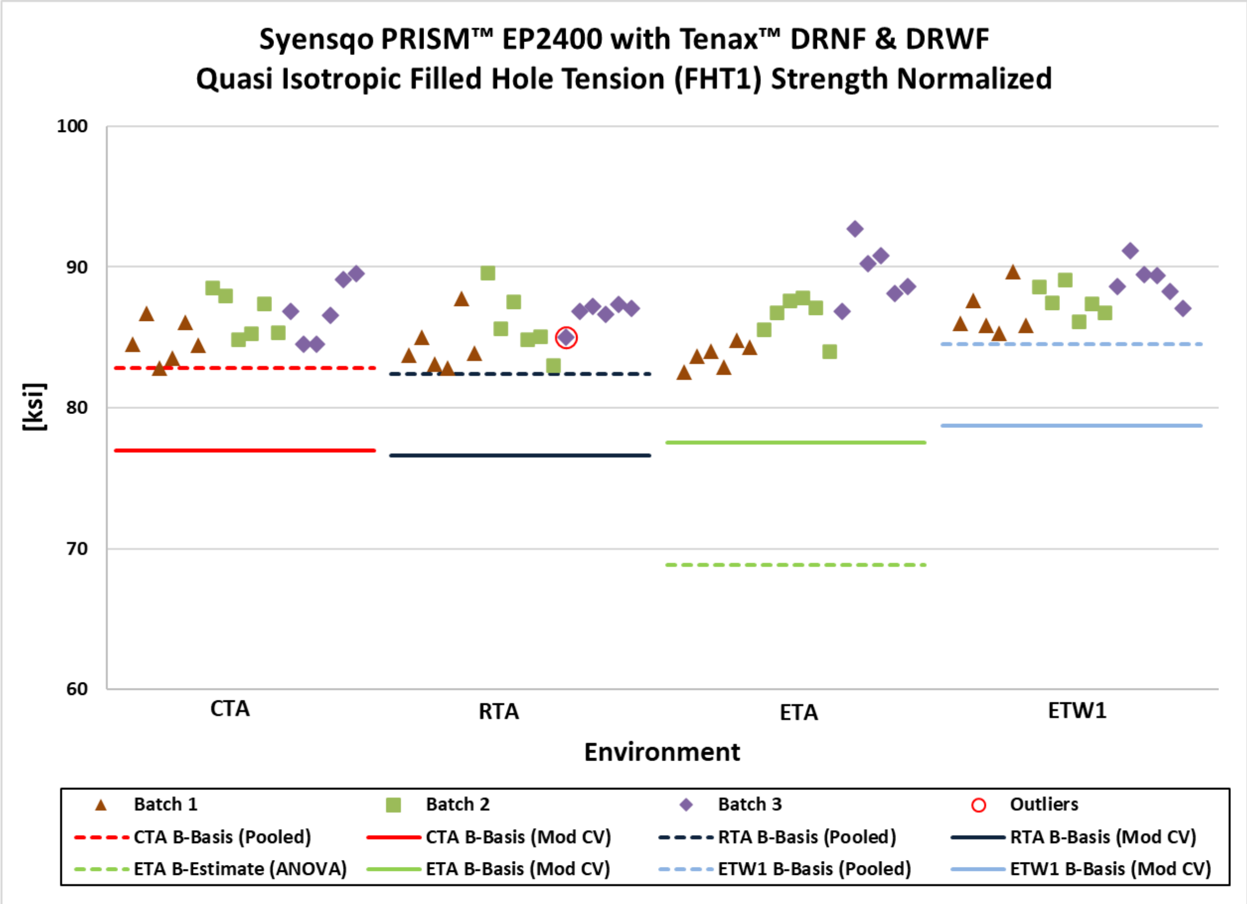


**Figure 4-34: Batch Plot for FHT1 Normalized Strength**

| Normalized Filled Hole Tension 1 (FHT1) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 86.04 | 85.68 | 86.59 | 87.77 |
| Stdev | 1.938 | 1.925 | 2.872 | 1.626 |
| CV | 2.253 | 2.246 | 3.316 | 1.853 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 82.82 | 82.79 | 82.51 | 85.26 |
| Max | 89.53 | 89.57 | 92.72 | 91.16 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 82.79 | 82.43 | | 84.52 |
| B-Estimate | | | 68.81 | |
| A-Estimate | 80.62 | 80.26 | 56.12 | 82.35 |
| Method | Pooled | Pooled | ANOVA | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 76.98 | 76.62 | 77.53 | 78.71 |
| A-Estimate | 71.01 | 70.65 | 71.55 | 72.74 |
| Method | Pooled | Pooled | Pooled | Pooled |

**Table 4-66: Normalized Statistics, B-Basis Values and Estimates for FHT1 Strength Data**

| As Measured Filled Hole Tension 1 (FHT1) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | CTA | RTA | ETA | ETW1 |
| Mean | 80.95 | 80.55 | 81.61 | 82.98 |
| Stdev | 1.929 | 2.285 | 3.429 | 2.208 |
| CV | 2.383 | 2.836 | 4.201 | 2.661 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 77.92 | 77.02 | 77.02 | 79.72 |
| Max | 83.97 | 85.21 | 89.57 | 88.28 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | | 76.46 | | 78.89 |
| B-Estimate | 71.00 | | 60.65 | |
| A-Estimate | 63.90 | 73.67 | 45.69 | 76.11 |
| Method | ANOVA | Pooled | ANOVA | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 72.38 | 71.97 | 73.04 | 74.41 |
| A-Estimate | 66.73 | 66.32 | 67.39 | 68.76 |
| Method | Pooled | Pooled | Pooled | Pooled |

**Table 4-67: As Measured Statistics, B-Basis Values and Estimates for FHT1 Strength Data**

## 4.32 Filled-Hole Tension 2 (FHT2)

The FHT2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, and ETW1.

For the normalized dataset, all 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 so all conditions were pooled.

For the as measured dataset, there were no diagnostic test failures so all conditions were pooled with the as measured CV and with the modified CV.

There was one statistical outlier. The lowest normalized value in batch one of the ETW1 conditions was an outlier for the batch but not for the condition. It was an outlier in the normalized dataset and in the as measured dataset. It was retained for analysis.

Statistics, basis values and estimates are given for the FHT2 strength data in Table 4-68. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-35.

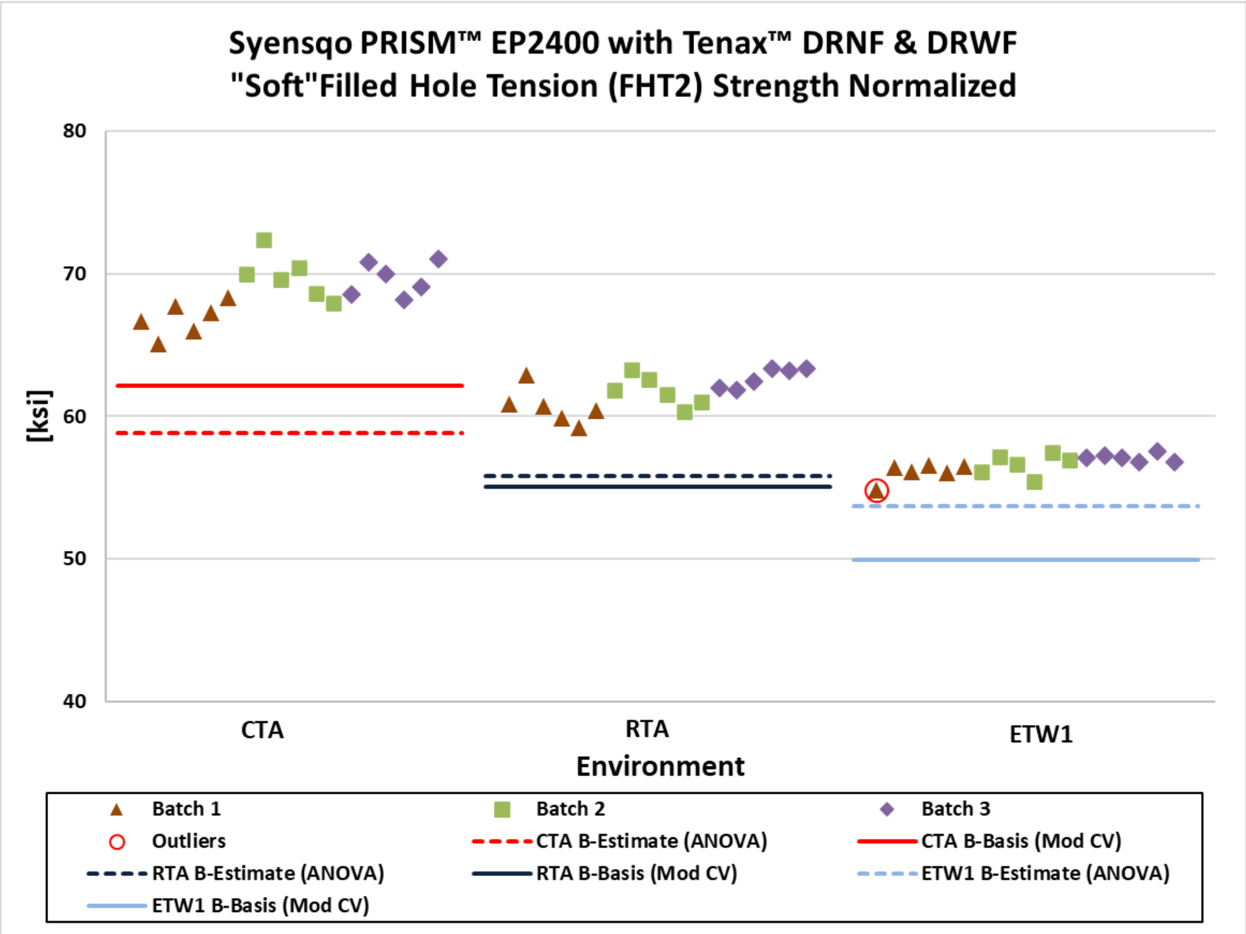


**Figure 4-35: Batch plot for FHT2 Normalized Strength**

| Filled-Hole Tension 2 (FHT2) Strength Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 68.77 | 61.70 | 56.60 | 65.53 | 59.09 | 54.13 |
| Stdev | 1.867 | 1.289 | 0.7041 | 1.326 | 0.8098 | 0.8979 |
| CV | 2.716 | 2.090 | 1.244 | 2.024 | 1.371 | 1.659 |
| Mod CV | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 65.07 | 59.18 | 54.83 | 63.12 | 57.64 | 52.93 |
| Max | 72.38 | 63.38 | 57.51 | 68.91 | 60.79 | 55.35 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-Basis Value | | | | 63.70 | 57.26 | 52.29 |
| B-Estimate | 58.85 | 55.80 | 53.69 | | | |
| A-Estimate | 51.78 | 51.59 | 51.62 | 62.47 | 56.03 | 51.07 |
| Method | ANOVA | ANOVA | ANOVA | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | 62.12 | 55.06 | 49.95 | 59.18 | 52.74 | 47.78 |
| A-Estimate | 57.69 | 50.62 | 45.52 | 54.94 | 48.51 | 43.54 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |

Table 4-68: Statistics, B-Basis Values and Estimates for FHT2 Strength Data

## 4.33 Filled-Hole Tension 3 (FHT3)

The FHT3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTA, RTA, and ETW1.

For the normalized dataset, there were no diagnostic test failures so all conditions were pooled with the as measured CV and with the modified CV.

For the as measured dataset, the RTA condition failed the ADK test for batch equivalency, therefore pooling was not possible. ANOVA was used to compute estimates for RTA and the single point normal method was used for the remaining conditions. Applying the modified CV, there were no diagnostic test failures so all conditions were pooled.

There were no statistical outliers.

Statistics, basis values and estimates are given for the FHT3 strength data in Table 4-69. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-36.

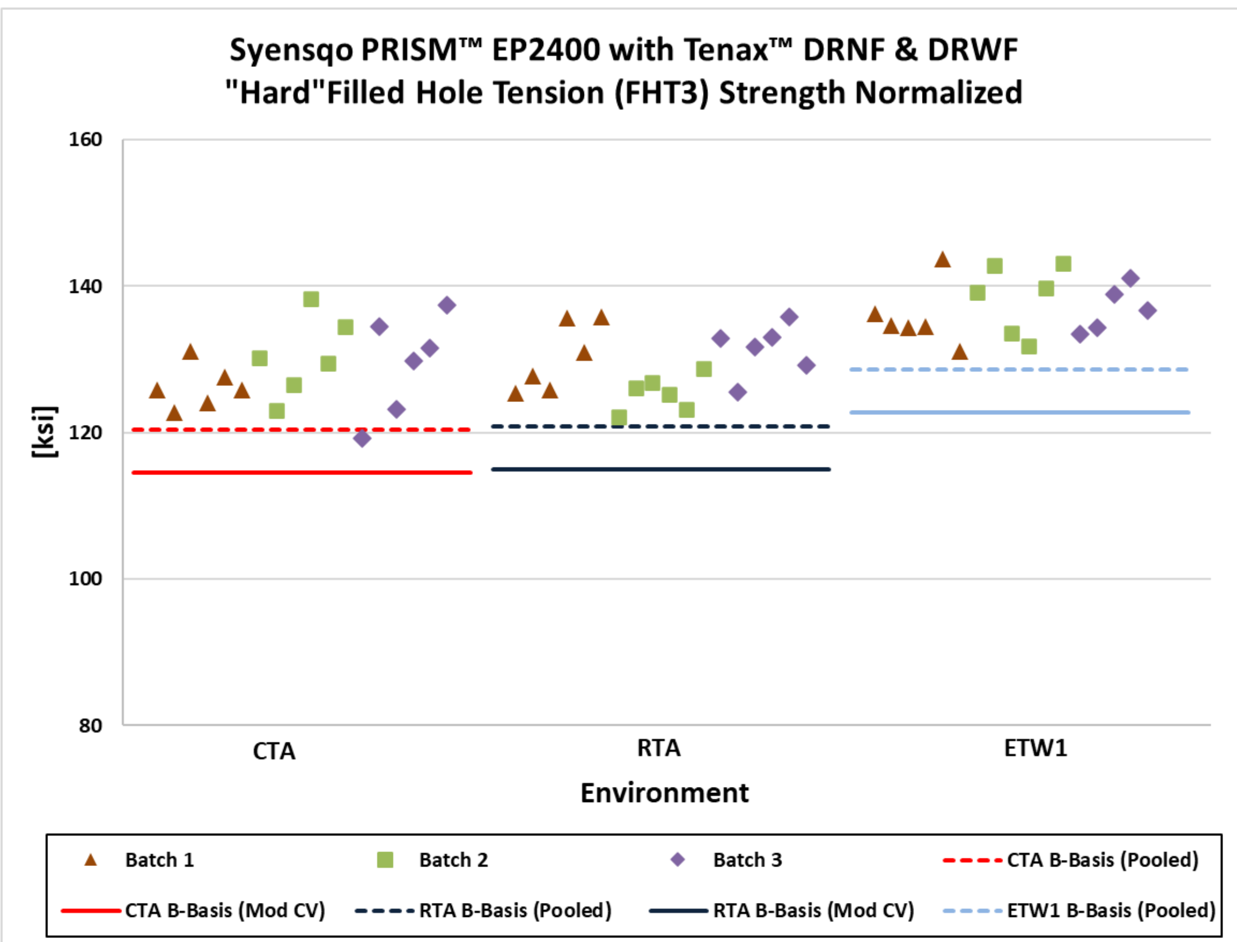


**Figure 4-36: Batch plot for FHT3 Normalized Strength**

| Filled-Hole Tension 3 (FHT3) Strength Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 128.6 | 129.0 | 136.7 | 127.6 | 127.7 | 135.7 |
| Stdev | 5.336 | 4.367 | 4.084 | 4.900 | 4.293 | 4.099 |
| CV | 4.150 | 3.386 | 2.987 | 3.839 | 3.362 | 3.020 |
| Mod CV | 6.075 | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 |
| Min | 119.2 | 122.1 | 131.1 | 121.2 | 121.4 | 128.2 |
| Max | 138.3 | 135.8 | 143.8 | 139.3 | 135.2 | 143.5 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-Basis Value | 120.4 | 120.8 | 128.6 | 118.0 | | 127.6 |
| B-Estimate | | | | | 106.9 | |
| A-Estimate | 114.9 | 115.3 | 123.1 | 111.1 | 92.01 | 121.9 |
| Method | Pooled | Pooled | Pooled | Normal | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | 114.6 | 115.0 | 122.7 | 113.8 | 113.8 | 121.9 |
| A-Estimate | 105.2 | 105.6 | 113.4 | 104.5 | 104.6 | 112.6 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |

**Table 4-69: Statistics, B-Basis Values and Estimates for FHT3 Strength Data**

## 4.34 Open-Hole Compression 1 (OHC1)

The OHC1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA, ETW1 and ETW2.

The ETW2 condition consists of one batch with six specimens, therefore only estimates could be computed for ETW2.

For both the normalized dataset and the as measured dataset, the ETW1 condition failed the ADK test for batch equivalency. The RTA and ETA conditions were pooled, ANOVA was used to compute estimates for ETW1 and the single point normal method was used for ETW2. Applying the modified CV, the normal method for modified CV was used for ETW2 and the remaining conditions were pooled.

There were no statistical outliers.

Statistics, basis values and estimates are given for the OHC1 strength data in Table 4-70 and Table 4-71. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-37.

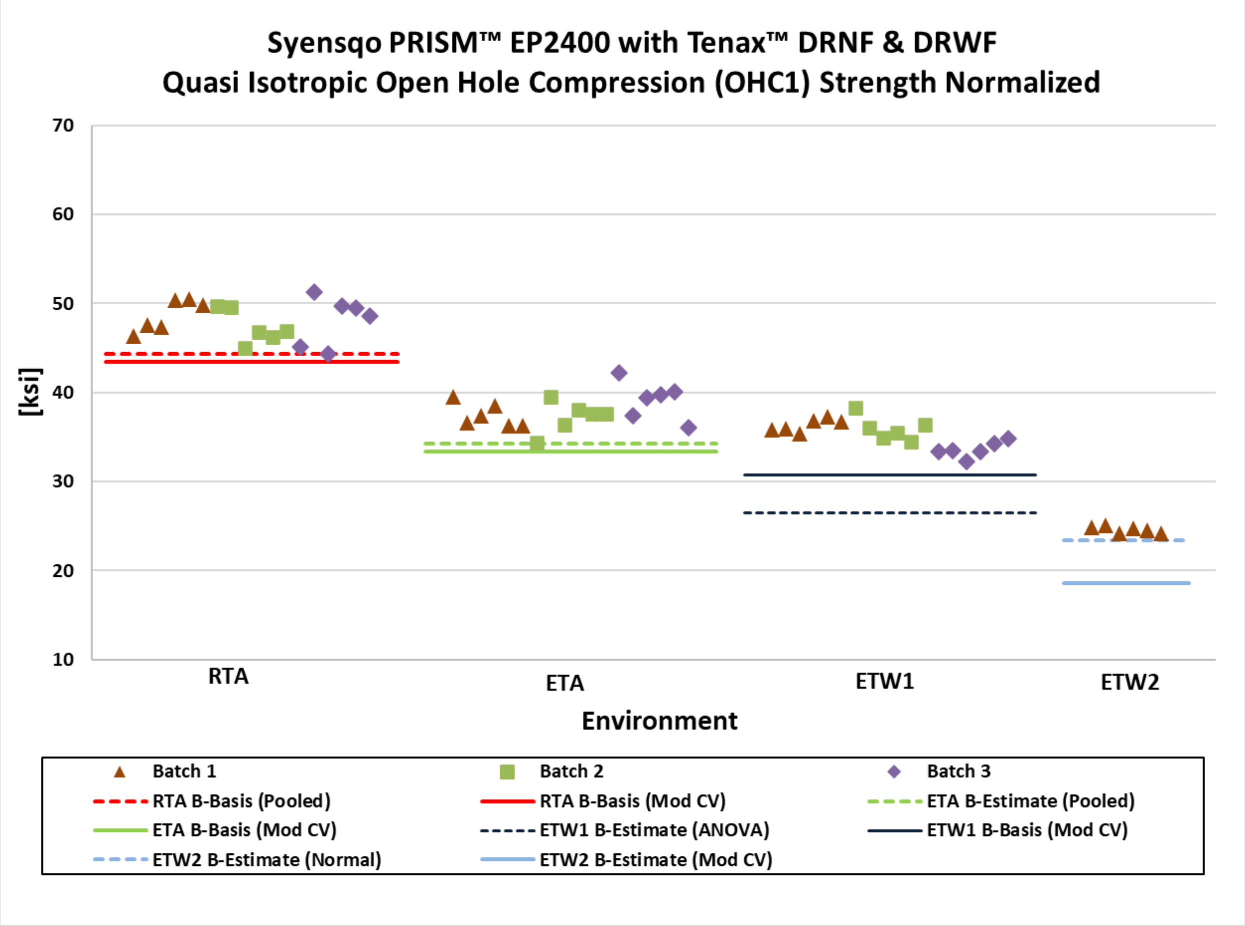


**Figure 4-37: Batch Plot for OHC1 Normalized Strength**

| Normalized Open Hole Compression 1 (OHC1) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 48.04 | 37.97 | 35.30 | 24.60 |
| Stdev | 2.125 | 1.891 | 1.566 | 0.3955 |
| CV | 4.424 | 4.982 | 4.436 | 1.608 |
| Mod CV | 6.212 | 6.491 | 6.218 | 8.000 |
| Min | 44.33 | 34.33 | 32.29 | 24.14 |
| Max | 51.33 | 42.26 | 38.34 | 25.12 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 6 |
| Basis Values and Estimates | | | | |
| B-basis Value | 44.37 | 34.30 | | |
| B-Estimate | | | 26.50 | 23.40 |
| A-Estimate | 41.88 | 31.81 | 20.22 | 22.55 |
| Method | Pooled | Pooled | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-basis Value | 43.49 | 33.42 | 30.75 | |
| B-Estimate | | | | 18.64 |
| A-Estimate | 40.46 | 30.38 | 27.72 | 14.40 |
| Method | Pooled | Pooled | Pooled | Normal |

Table 4-70: Normalized Statistics, B-Basis Values and Estimates for OHC1 Strength Data

| As Measured Open Hole Compression 1 (OHC1) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Env | RTA | ETA | ETW1 | ETW2 |
| Mean | 44.71 | 35.27 | 32.90 | 22.77 |
| Stdev | 1.735 | 1.864 | 1.279 | 0.5887 |
| CV | 3.881 | 5.285 | 3.886 | 2.585 |
| Mod CV | 6.000 | 6.643 | 6.000 | 8.000 |
| Min | 41.94 | 31.85 | 30.42 | 22.12 |
| Max | 48.37 | 39.72 | 35.69 | 23.63 |
| No. Batches | 3 | 3 | 3 | 1 |
| No. Spec. | 18 | 18 | 18 | 6 |
| Basis Values and Estimates | | | | |
| B-basis Value | 41.43 | 31.99 | | |
| B-Estimate | | | 26.34 | 20.99 |
| A-Estimate | 39.20 | 29.76 | 21.67 | 19.72 |
| Method | Pooled | Pooled | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-basis Value | 40.55 | 31.11 | 28.74 | |
| B-Estimate | | | | 17.26 |
| A-Estimate | 37.77 | 28.33 | 25.96 | 13.33 |
| Method | Pooled | Pooled | Pooled | Normal |

**Table 4-71: As Measured Statistics, B-Basis Values and Estimates for OHC1 Strength Data**

## 4.35 Open-Hole Compression 2 (OHC2)

The OHC2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

For both the normalized dataset and the as measured dataset, the ETW1 condition failed the ADK test for batch equivalency. The single point normal method was used to compute values and estimates for RTA, and ANOVA was used to compute estimates for ETW1. Applying the modified CV, there were no diagnostic test failures so both conditions were pooled.

There was one statistical outlier. The lowest as measured value in batch one of the ETW1 condition was an outlier for the batch but not for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHC2 strength data in Table 4-72. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-38.

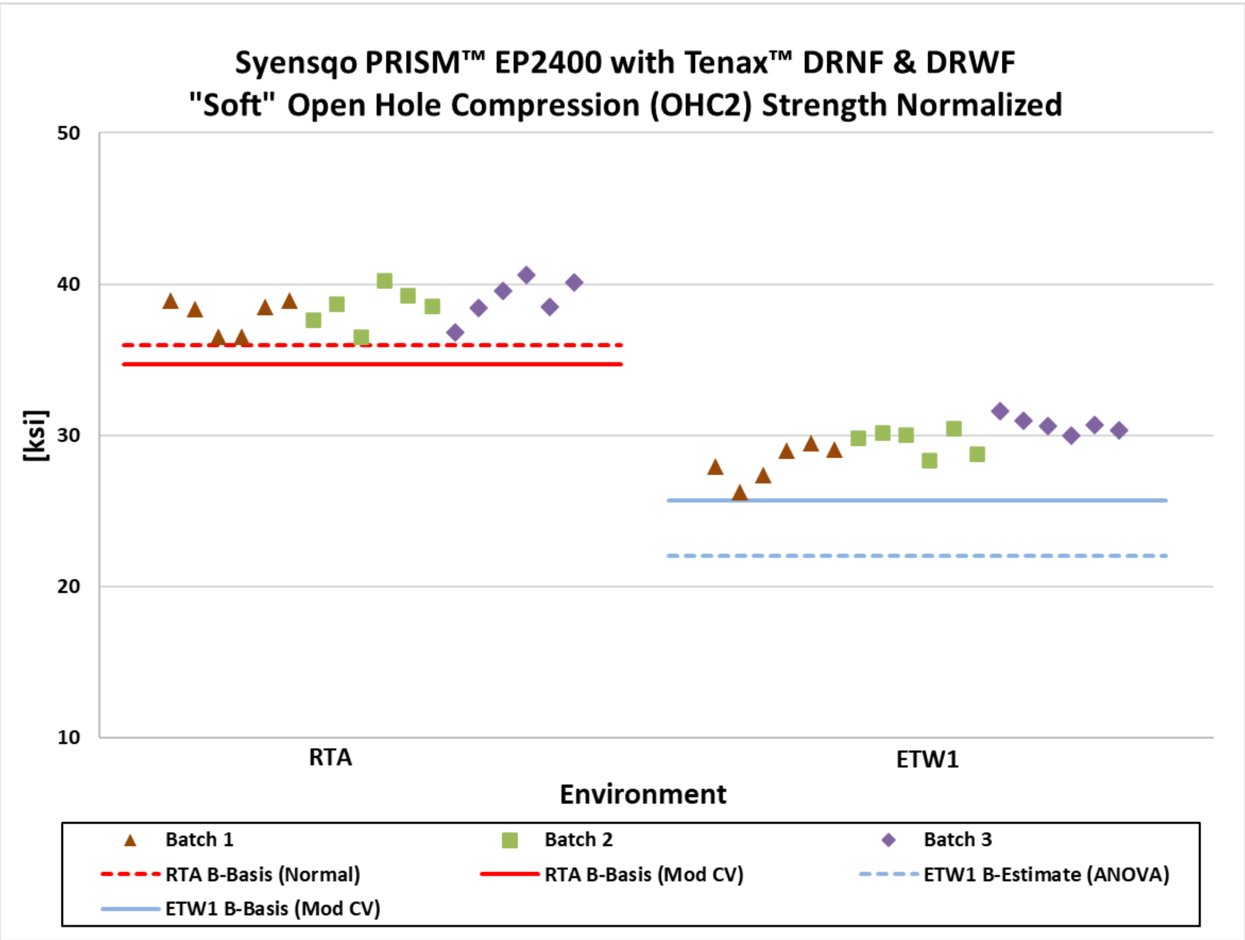


**Figure 4-38: Batch Plot for OHC2 Normalized Strength**

| Open Hole Compression 2 (OHC2) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 38.48 | 29.49 | 36.72 | 27.96 |
| Stdev | 1.275 | 1.358 | 1.388 | 0.8734 |
| CV | 3.314 | 4.605 | 3.779 | 3.124 |
| Mod CV | 6.000 | 6.302 | 6.000 | 6.000 |
| Min | 36.50 | 26.27 | 34.17 | 25.86 |
| Max | 40.62 | 31.59 | 38.66 | 29.47 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-basis Value | 35.96 | | 33.98 | |
| B-Estimate | | 22.00 | | 23.71 |
| A-Estimate | 34.18 | 16.65 | 32.04 | 20.68 |
| Method | Normal | ANOVA | Normal | ANOVA |
| Modified CV Basis Values and Estimates | | | | |
| B-basis Value | 34.66 | 25.68 | 33.15 | 24.39 |
| A-Estimate | 32.06 | 23.08 | 30.73 | 21.96 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-72: Statistics, B-Basis Values and Estimates for OHC2 Strength Data

## 4.36 Open-Hole Compression 3 (OHC3)

The OHC3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

For the normalized dataset, there were no diagnostic test failures so both conditions were pooled using the as measured CV and the modified CV.

For the as measured dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for RTA and the single point normal method was used for ETW1. Applying the modified CV, there were no diagnostic test failures so both conditions were pooled.

There were no statistical outliers.

Statistics, basis values and estimates are given for the OHC3 strength data in Table 4-73. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-39.

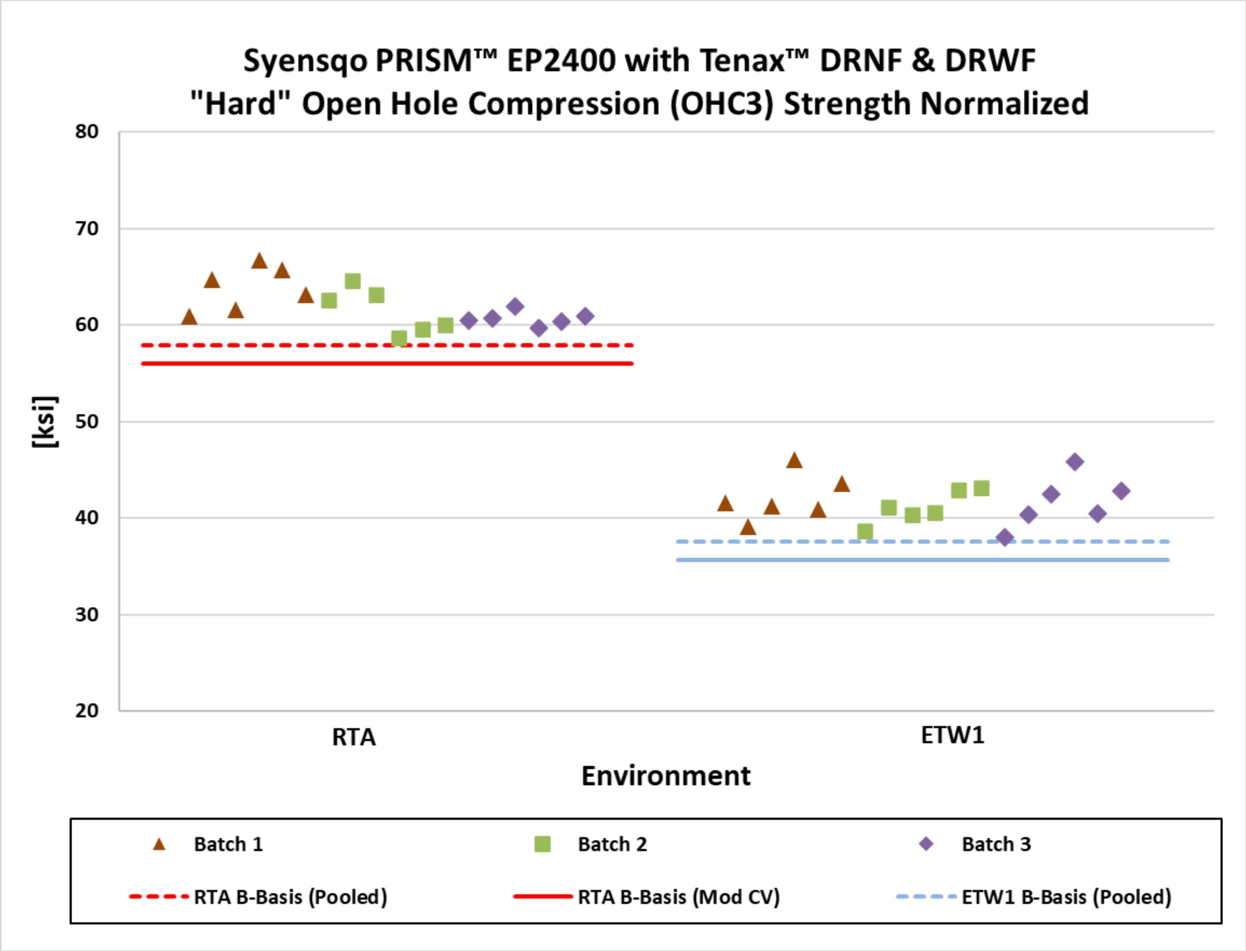


**Figure 4-39: Batch Plot for OHC3 Normalized Strength**

| Open Hole Compression 3 (OHC3) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 61.95 | 41.63 | 60.71 | 40.85 |
| Stdev | 2.275 | 2.190 | 2.635 | 1.986 |
| CV | 3.672 | 5.262 | 4.340 | 4.862 |
| Mod CV | 6.000 | 6.631 | 6.170 | 6.431 |
| Min | 58.66 | 38.03 | 57.05 | 37.38 |
| Max | 66.72 | 46.04 | 66.47 | 44.34 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-basis Value | 57.89 | 37.56 | | 36.93 |
| B-Estimate | | | 47.84 | |
| A-Estimate | 55.12 | 34.79 | 38.66 | 34.15 |
| Method | Pooled | Pooled | ANOVA | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-basis Value | 55.99 | 35.66 | 54.81 | 34.96 |
| A-Estimate | 51.93 | 31.61 | 50.81 | 30.95 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-73: Statistics, B-Basis Values and Estimates for OHC3 Strength Data

## 4.37 Open-Hole Compression 4 (OHC4)

The OHC4 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

Both conditions tested consist of one batch with six specimens, therefore, only estimates are provided.

For both the normalized and as measured datasets, the single point normal method was used to compute estimates for both conditions and applying the modified CV, the normal method for modified CV was used to compute estimates for both conditions.

There were no statistical outliers.

Statistics and estimates are given for the OHT4 strength data in Table 4-74. The normalized data and B-estimates are shown graphically in Figure 4-40.

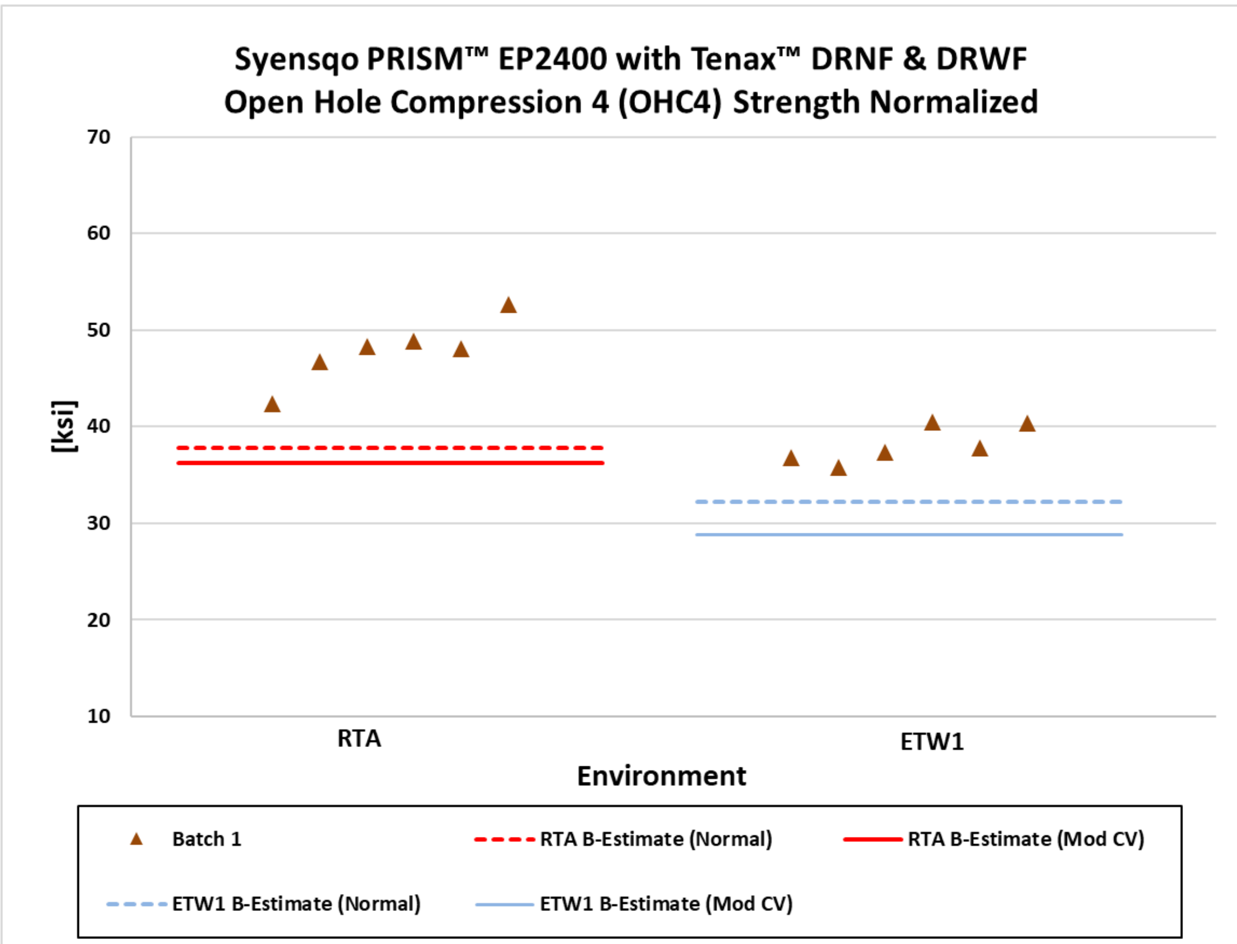


**Figure 4-40: Batch Plot for OHC4 Normalized Strength**

| Open Hole Compression 4 (OHC4) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 47.84 | 38.08 | 43.71 | 34.94 |
| Stdev | 3.304 | 1.918 | 2.758 | 1.208 |
| CV | 6.906 | 5.037 | 6.310 | 3.458 |
| Mod CV | 8.000 | 8.000 | 8.000 | 8.000 |
| Min | 42.43 | 35.78 | 38.93 | 33.44 |
| Max | 52.61 | 40.44 | 47.46 | 36.88 |
| No. Batches | 1 | 1 | 1 | 1 |
| No. Spec. | 6 | 6 | 6 | 6 |
| Estimates | | | | |
| B-Estimate | 37.83 | 32.27 | 35.36 | 31.28 |
| A-Estimate | 30.72 | 28.14 | 29.42 | 28.67 |
| Method | Normal | Normal | Normal | Normal |
| Modified CV Estimates | | | | |
| B-Estimate | 36.25 | 28.85 | 33.12 | 26.47 |
| A-Estimate | 28.01 | 22.29 | 25.59 | 20.45 |
| Method | Normal | Normal | Normal | Normal |

Table 4-74: Statistics and Estimates for OHC4 Strength Data

## 4.38 Filled-Hole Compression 1 (FHC1)

The FHC1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA and ETW1.

The RTA condition consists of three batches and seventeen specimens, therefore pooling was not possible and only estimates are provided for RTA.

For both the normalized and the as measured datasets, the single point normal method was used to compute estimates for RTA and basis values and estimates for ETA and ETW1, using the as measured CV and the modified CV.

There were two statistical outliers. The highest normalized value in batch one of the RTA condition was an outlier for the condition but not for the batch. It was an outlier in the normalized dataset but not in the as measured dataset. The highest normalized values in batch three of the RTA condition was an outlier for the batch but not for the condition. It was an outlier in the normalized dataset but not in the as measured dataset. They were retained for analysis.

Statistics, basis values and estimates are given for the FHC1 strength data in Table 4-75. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-41.

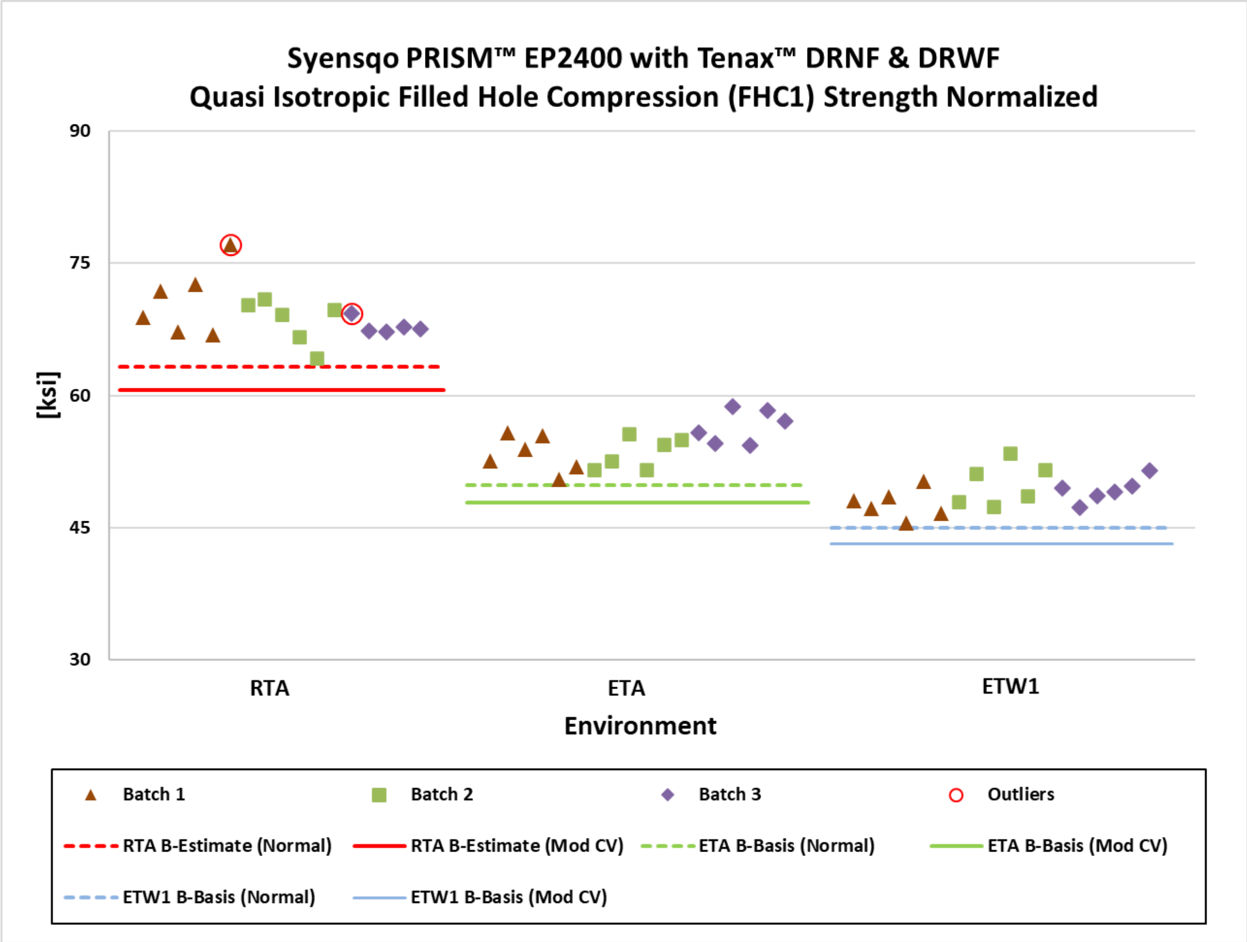


**Figure 4-41: Batch plot for FHC1 Normalized Strength**

| Filled-Hole Compression 1 (FHC1) Strength Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Normalized | | | As-Measured | | |
| Env | RTA | ETA | ETW1 | RTA | ETA | ETW1 |
| Mean | 69.11 | 54.43 | 48.96 | 65.27 | 51.25 | 45.98 |
| Stdev | 2.943 | 2.331 | 2.000 | 3.094 | 2.060 | 1.800 |
| CV | 4.258 | 4.283 | 4.085 | 4.740 | 4.018 | 3.915 |
| Mod CV | 6.129 | 6.142 | 6.042 | 6.370 | 6.009 | 6.000 |
| Min | 64.28 | 50.51 | 45.47 | 59.76 | 47.55 | 42.07 |
| Max | 77.17 | 58.72 | 53.43 | 73.24 | 54.10 | 49.45 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 17 | 18 | 18 | 17 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-Basis Value | | 49.83 | 45.02 | | 47.19 | 42.43 |
| B-Estimate | 63.22 | | | 59.08 | | |
| A-Estimate | 59.05 | 46.56 | 42.22 | 54.70 | 44.31 | 39.91 |
| Method | Normal | Normal | Normal | Normal | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | | 47.83 | 43.12 | | 45.17 | 40.53 |
| B-Estimate | 60.63 | | | 56.95 | | |
| A-Estimate | 54.65 | 43.16 | 38.99 | 51.07 | 40.87 | 36.68 |
| Method | Normal | Normal | Normal | Normal | Normal | Normal |

Table 4-75: Statistics, B-Basis Values and Estimates for FHC1 Strength Data

## 4.39 Filled-Hole Compression 2 (FHC2)

The FHC2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

For the normalized dataset, using the as measured CV and the modified CV, there were no diagnostic test failures, therefore both conditions were pooled.

For the as measured dataset, using the as measured CV and the modified CV, pooling was not possible because in both instances the pooled dataset failed the Levene's test for equality of variances, therefore the single point normal method and the normal method for modified CV were used for both conditions.

There was one statistical outlier. The highest normalized value in batch two of the RTA condition was an outlier for the batch and for the environment. It was an outlier in the normalized dataset and in the as measured dataset. It was retained for this analysis.

Statistics are given for the FHC2 strength data in Table 4-76. The normalized specimen data are shown graphically in Figure 4-42.

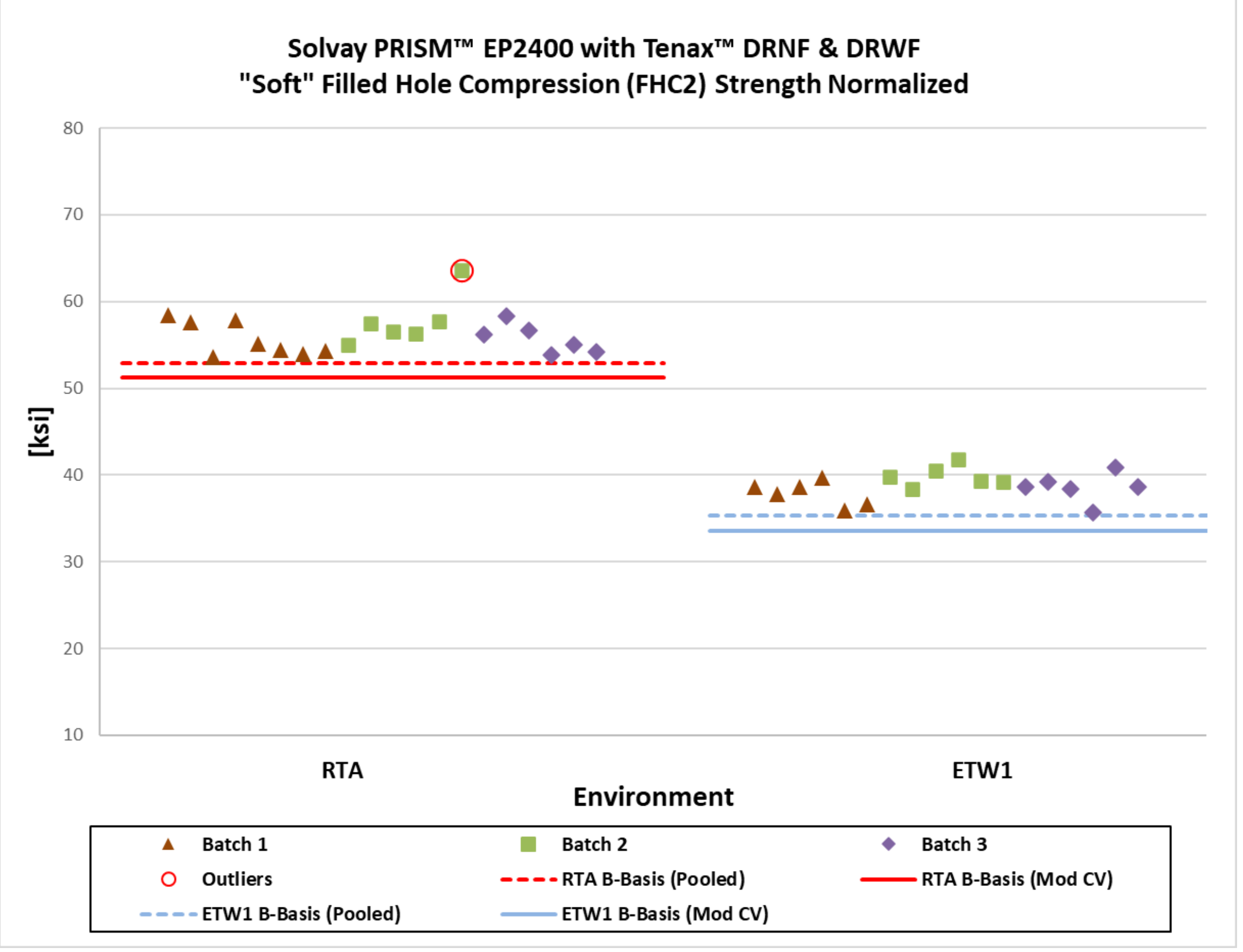


**Figure 4-42: Batch plot for FHC2 Normalized Strength**

| Filled-Hole Compression 2 (FHC2) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Property | Normalized | | As Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 56.38 | 38.74 | 53.70 | 36.93 |
| Stdev | 2.324 | 1.475 | 2.454 | 1.333 |
| CV | 4.121 | 3.807 | 4.570 | 3.610 |
| Mod CV | 6.061 | 6.000 | 6.285 | 6.000 |
| Min | 53.57 | 35.70 | 50.66 | 34.47 |
| Max | 63.65 | 41.81 | 61.13 | 39.48 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 21 | 21 | 21 | 21 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 52.93 | 35.29 | 49.03 | 34.39 |
| A-Estimate | 50.56 | 32.92 | 45.69 | 32.58 |
| Method | Pooled | Pooled | Normal | Normal |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 51.20 | 33.56 | 47.27 | 32.71 |
| A-Estimate | 47.64 | 30.00 | 42.69 | 29.70 |
| Method | Pooled | Pooled | Normal | Normal |

Table 4-76: Statistics, B-Basis Values and Estimates for FHC2 Strength Data

## 4.40 Filled-Hole Compression 3 (FHC3)

The FHC3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

For the normalized dataset, pooling was not possible because the pooled dataset failed the Levene’s test for equality of variances. The single point normal method was used to compute values and estimates for both conditions. Applying the modified CV, pooling was not possible because the pooled dataset failed the normality test, so the normal method for modified CV was used to compute values and estimates for both conditions.

For the as measured dataset, pooling was not possible because the pooled dataset failed the Levene’s test for equality of variances. The single point normal method was used for RTA and the single point Weibull method was used for ETW1. Applying the modified CV, pooling was not possible because the pooled dataset failed the normality test, so the normal method for modified CV was used to compute values and estimates for both conditions.

There were three statistical outliers. The lowest normalized value in batch one of the RTA condition was an outlier for the batch but not for the condition. It was an outlier in the normalized dataset and in the as measured dataset. The lowest as measured value in batch one of the ETW1 condition was an outlier for the batch but not for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. The lowest as measured value in batch three of the ETW1 condition was an outlier for the batch but not for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the FHC3 strength data in Table 4-77. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-43.

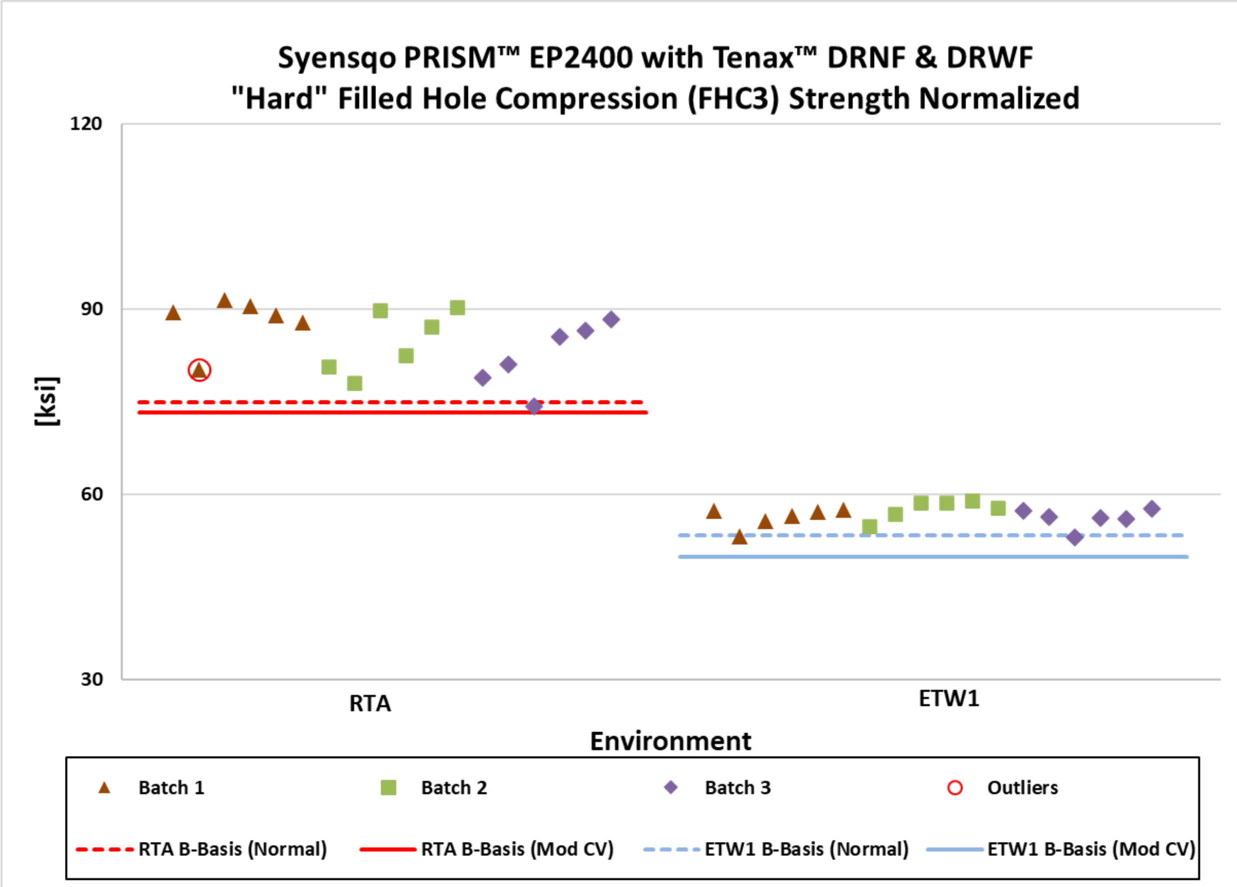


**Figure 4-43: Batch Plot for FHC3 Normalized Strength**

| Filled-Hole Compression 3 (FHC3) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 85.16 | 56.71 | 84.17 | 56.00 |
| Stdev | 5.163 | 1.671 | 5.180 | 1.471 |
| CV | 6.062 | 2.947 | 6.154 | 2.627 |
| Mod CV | 7.031 | 6.000 | 7.077 | 6.000 |
| Min | 74.23 | 53.06 | 74.18 | 52.33 |
| Max | 91.60 | 59.01 | 91.07 | 57.62 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 74.97 | 53.41 | 73.95 | 53.18 |
| A-Estimate | 67.75 | 51.08 | 66.70 | 50.07 |
| Method | Normal | Normal | Normal | Weibull |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 73.34 | 50.00 | 72.41 | 49.36 |
| A-Estimate | 64.98 | 45.24 | 64.09 | 44.67 |
| Method | Normal | Normal | Normal | Normal |

Table 4-77: Statistics, B-Basis Values and Estimates for FHC3 Strength Data

## 4.41 Single-Shear Bearing 1 (SSB1)

The SSB1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA, ETA, and ETW1.

For the properties tested, 2% offset strength and ultimate strength, for both the normalized dataset and the as measured dataset, there were no diagnostic test failures encountered. All conditions were pooled for each of the two properties using the as measured CV and the modified CV.

There was one statistical outlier. The lowest normalized value in batch one of the ETW1 condition for ultimate strength was an outlier for the batch and for the condition. It was an outlier in the normalized dataset but not in the as-measure dataset.

Statistics, basis values and estimates are given for the SSB1 strength data in Table 4-78 and Table 4-79. The normalized data, B-estimates and B-basis values are shown graphically for 2% Offset Strength in Figure 4-44 and for Ultimate Strength in Figure 4-45.

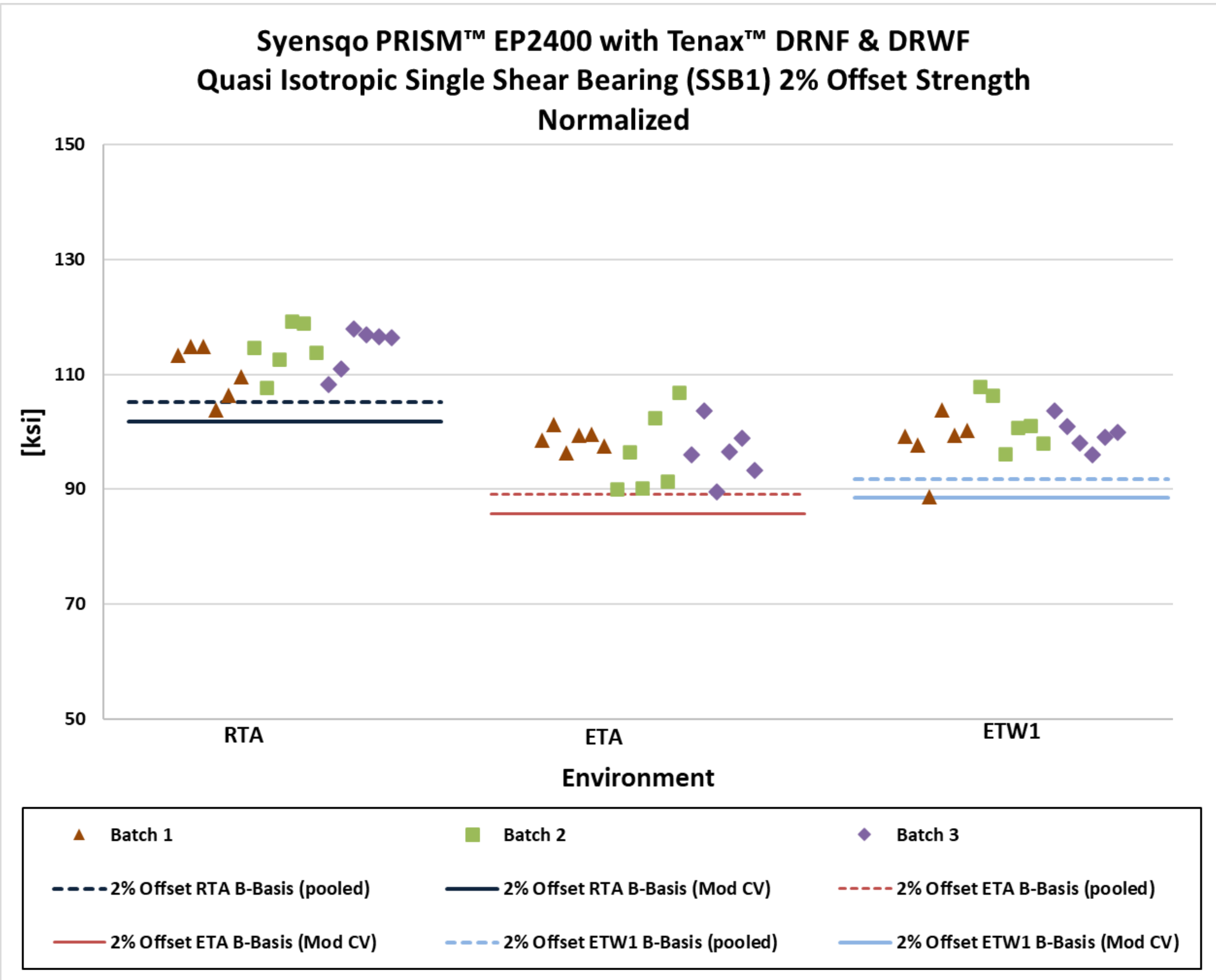


**Figure 4-44: Batch Plot for SSB1 Normalized 2% Offset Strength**

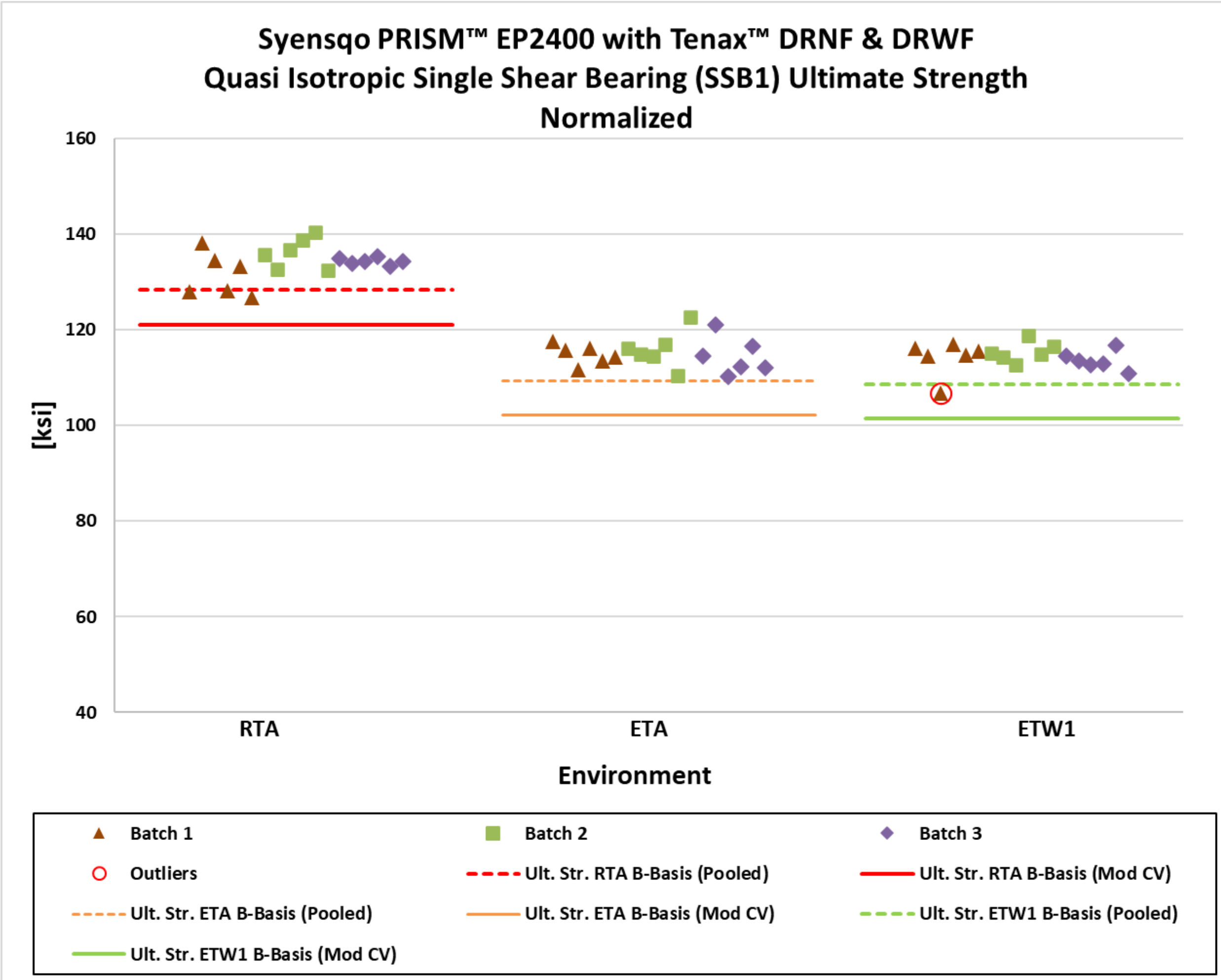


**Figure 4-45: Batch Plot for SSB1 Normalized Ultimate Strength**

| Normalized Single Shear Bearing 1 (SSB1) Strength Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| Property | 2% Offset Strength | | | Ultimate Strength | | |
| Env | RTA | ETA | ETW1 | RTA | ETA | ETW1 |
| Mean | 113.1 | 97.11 | 99.85 | 134.0 | 115.1 | 114.3 |
| Stdev | 4.489 | 4.870 | 4.230 | 3.606 | 3.295 | 2.664 |
| CV | 3.968 | 5.015 | 4.236 | 2.692 | 2.863 | 2.330 |
| Mod CV | 6.000 | 6.508 | 6.118 | 6.000 | 6.000 | 6.000 |
| Min | 103.8 | 89.47 | 88.76 | 126.8 | 110.3 | 106.8 |
| Max | 119.3 | 106.9 | 107.9 | 140.4 | 122.7 | 118.9 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-Basis Value | 105.1 | 89.08 | 91.82 | 128.3 | 109.4 | 108.7 |
| A-Estimate | 99.74 | 83.72 | 86.46 | 124.5 | 105.6 | 104.9 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | 101.8 | 85.76 | 88.50 | 121.1 | 102.2 | 101.4 |
| A-Estimate | 94.21 | 78.18 | 80.92 | 112.5 | 93.56 | 92.83 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |

**Table 4-78: Normalized Statistics, B-Basis Values and Estimates for SSB1 Strength Data**

| As Measured Single Shear Bearing 1 (SSB1) Strength Basis Values and Statistics | | | | | | |
|---|---|---|---|---|---|---|
| Property | 2% Offset Strength | | | Ultimate Strength | | |
| Env | RTA | ETA | ETW1 | RTA | ETA | ETW1 |
| Mean | 107.8 | 92.91 | 94.30 | 127.6 | 110.1 | 108.0 |
| Stdev | 4.360 | 4.585 | 4.006 | 3.538 | 3.076 | 2.523 |
| CV | 4.045 | 4.934 | 4.248 | 2.772 | 2.794 | 2.336 |
| Mod CV | 6.022 | 6.467 | 6.124 | 6.000 | 6.000 | 6.000 |
| Min | 100.7 | 85.92 | 84.71 | 120.5 | 105.8 | 102.0 |
| Max | 114.9 | 101.9 | 99.96 | 133.8 | 117.0 | 112.7 |
| No. Batches | 3 | 3 | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | | | |
| B-Basis Value | 100.1 | 85.25 | 86.64 | 122.2 | 104.7 | 102.5 |
| A-Estimate | 95.02 | 80.15 | 81.53 | 118.6 | 101.0 | 98.91 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | | | |
| B-Basis Value | 96.98 | 82.11 | 83.50 | 115.4 | 97.81 | 95.70 |
| A-Estimate | 89.78 | 74.90 | 76.29 | 107.2 | 89.62 | 87.51 |
| Method | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |

**Table 4-79: As Measured Statistics, B-Basis Values and Estimates for SSB1 Strength Data**

## 4.42 Single-Shear Bearing 2 (SSB2)

The SSB2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

For the 2% offset strength, pooling was not possible for either the normalized nor the as measured datasets because the pooled datasets failed the test for normality. For both the normalized and as measured datasets, the single point normal method was used to compute values and estimates for RTA and the single point non parametric method was used to compute values and estimates for ETW1. Applying the modified CV, both conditions were pooled in both the normalized and as measured datasets.

For ultimate strength, there were no diagnostic test failures for any of the properties in either the normalized nor the as measured datasets, therefore both conditions were pooled.

There were three statistical outliers. The lowest normalized value in batch three of the ETW1 condition for 2% offset strength was an outlier for the batch and for the condition. It was an outlier in the normalized dataset and in the as measured dataset. The highest as measured value in batch one of the RTA condition for ultimate strength was an outlier for the batch but not for the conditions. It was an outlier in the as measured dataset but not in the normalized dataset. The lowest as measured value in batch three of the ETW1 condition for ultimate strength was an outlier for the batch and for the condition. It was an outlier in the as measured dataset but not in the normalized dataset. They were retained for analysis,

Statistics, basis values and estimates are given for the SSB2 strength data in Table 4-80 and Table 4-81. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-46.

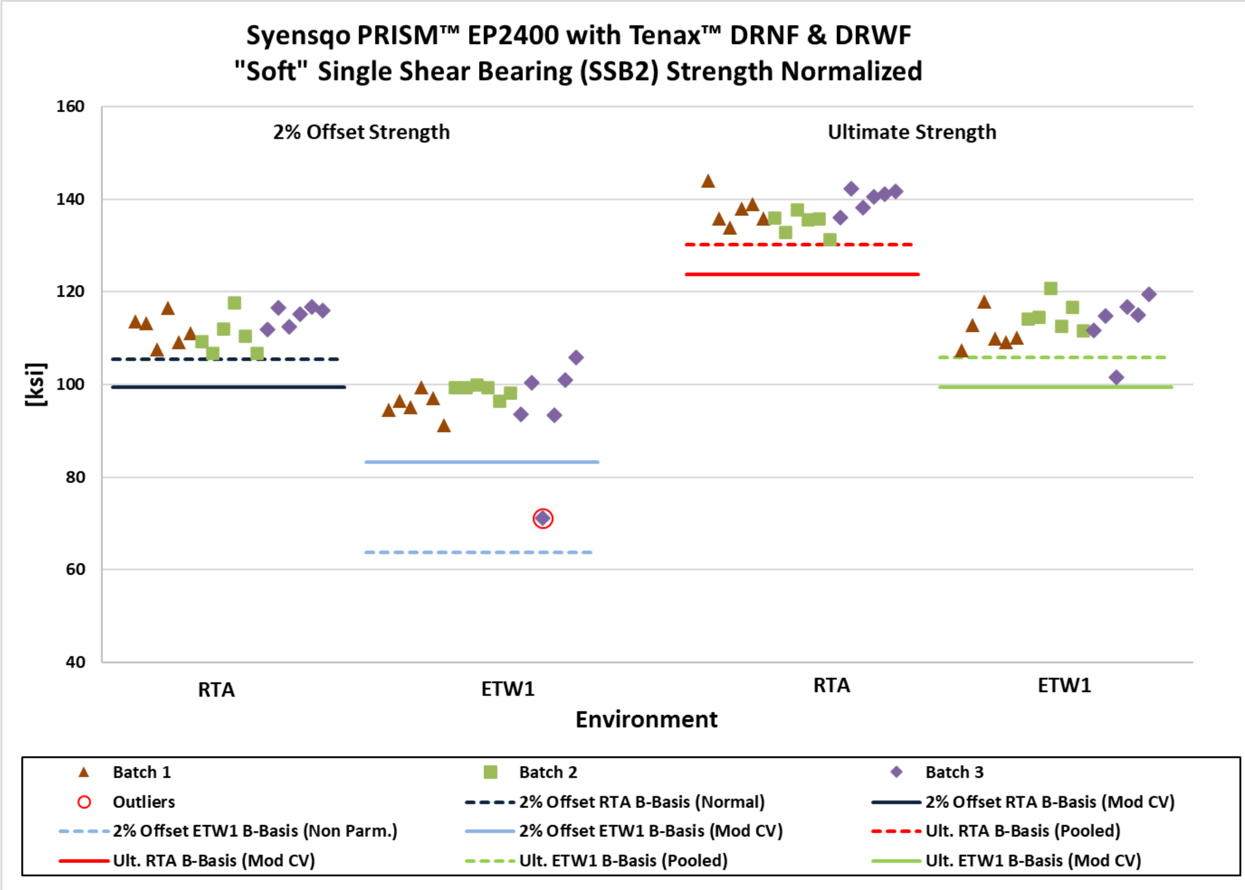


**Figure 4-46: Batch Plot for SSB2 Normalized Strength**

| Normalized Single Shear Bearing 2 (SSB2) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Property | 2% Offset Strength | | Ultimate Strength | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 112.4 | 96.20 | 137.5 | 113.1 |
| Stdev | 3.550 | 7.137 | 3.398 | 4.619 |
| CV | 3.159 | 7.419 | 2.471 | 4.083 |
| Mod CV | 6.000 | 7.709 | 6.000 | 6.041 |
| Min | 106.8 | 71.10 | 131.3 | 101.5 |
| Max | 117.7 | 105.8 | 144.0 | 120.8 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 105.4 | 63.70 | 130.1 | 105.8 |
| A-Estimate | 100.4 | 39.21 | 125.1 | 100.7 |
| Method | Normal | Non-Parm. | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 99.47 | 83.29 | 123.7 | 99.34 |
| A-Estimate | 90.69 | 74.51 | 114.3 | 89.96 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-80: Normalized Statistics, B-Basis Values and Estimates for SSB2 Strength Data

| As Measured Single Shear Bearing 2 (SSB2) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Property | 2% Offset Strength | | Ultimate Strength | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 108.2 | 92.15 | 132.4 | 108.4 |
| Stdev | 3.522 | 6.356 | 3.255 | 3.592 |
| CV | 3.255 | 6.897 | 2.458 | 3.314 |
| Mod CV | 6.000 | 7.449 | 6.000 | 6.041 |
| Min | 101.7 | 69.20 | 126.4 | 98.83 |
| Max | 114.1 | 98.26 | 137.7 | 115.3 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 101.2 | 60.12 | 126.2 | 102.1 |
| A-Estimate | 96.32 | 40.94 | 121.9 | 97.90 |
| Method | Normal | Non-Parm. | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 96.03 | 79.98 | 119.2 | 95.16 |
| A-Estimate | 87.75 | 71.70 | 110.2 | 86.17 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-81: As Measured Statistics, B-Basis Values and Estimates for SSB2 Strength Data

## 4.43 Single-Shear Bearing 3 (SSB3)

The SSB3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTA and ETW1.

For the properties tested, 2% offset strength and ultimate strength, for both the normalized dataset and the as measured dataset, there were no diagnostic test failures encountered. All conditions were pooled for each of the two properties using the as measured CV and the modified CV.

There were two statistical outliers. The lowest as measured value in batch two of the RTA condition for 2% offset strength was an outlier for the condition but not for the batch. It was an outlier in the as measured dataset but not in the normalized dataset. The highest value in batch two of the ETW1 condition for ultimate strength was an outlier for the batch and for the condition. It was an outlier in the normalized dataset but not in the as measured dataset. They were retained for analysis.

Statistics, basis values and estimates are given for the SSB3 strength data in Table 4-82 and Table 4-83. The normalized data and B-basis values are shown graphically in Figure 4-47.

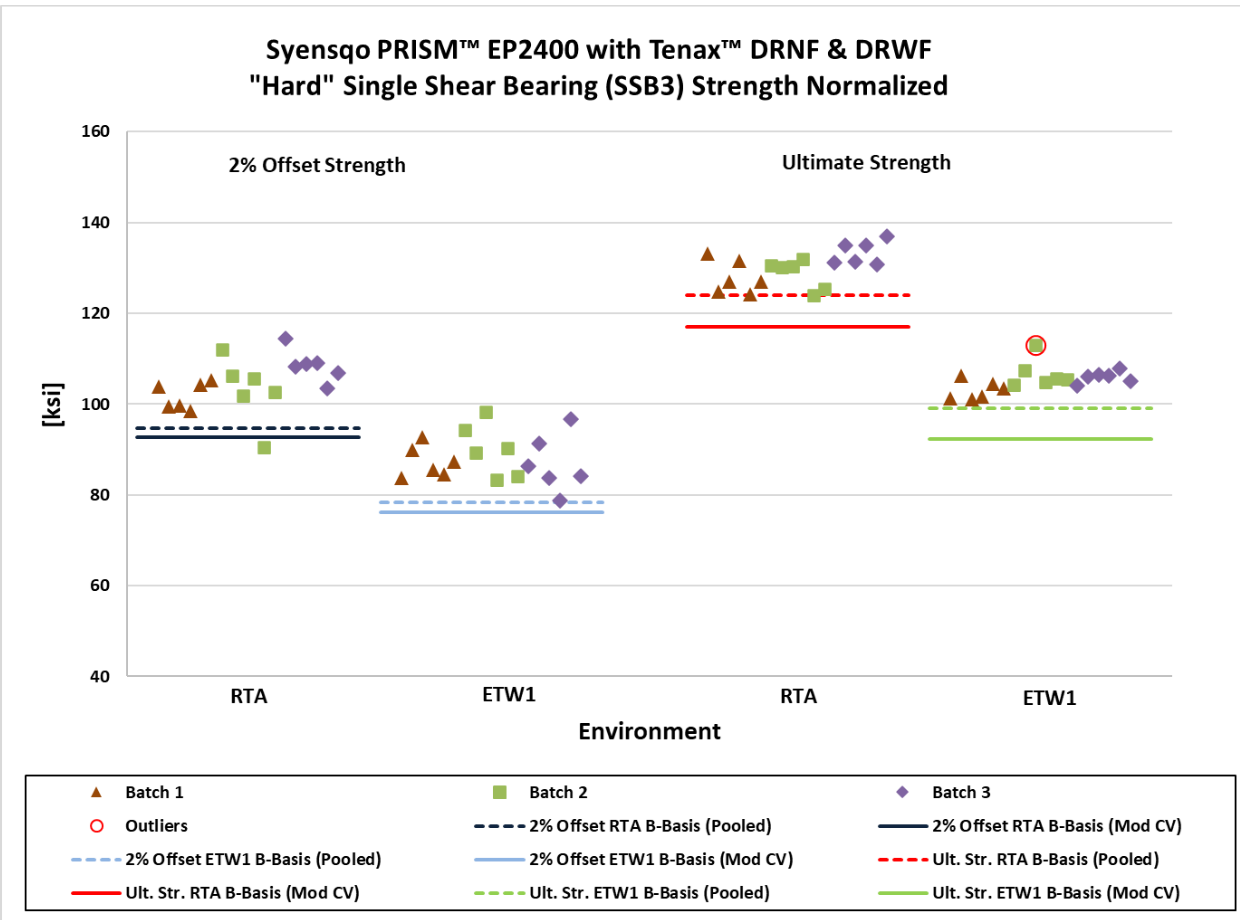


**Figure 4-47: Batch Plot for SSB3 Normalized Strength**

| Normalized Single Shear Bearing 3 (SS32) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Property | 2% Offset Strength | | Ultimate Strength | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 104.5 | 88.02 | 130.0 | 105.2 |
| Stdev | 5.464 | 5.186 | 3.873 | 2.733 |
| CV | 5.229 | 5.892 | 2.979 | 2.597 |
| Mod CV | 6.614 | 6.946 | 6.000 | 6.000 |
| Min | 90.52 | 78.70 | 123.9 | 101.1 |
| Max | 114.4 | 98.2 | 137.0 | 112.9 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 94.79 | 78.31 | 123.9 | 99.14 |
| A-Estimate | 88.19 | 71.71 | 119.7 | 94.99 |
| Method | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 92.61 | 76.13 | 117.1 | 92.32 |
| A-Estimate | 84.52 | 68.05 | 108.3 | 83.53 |
| Method | Pooled | Pooled | Pooled | Pooled |

Table 4-82: Normalized Statistics, B-Basis Values and Estimates for SSB3 Strength Data

| As Measured Single Shear Bearing 3 (SSB3) Strength Basis Values and Statistics | | | | |
|---|---|---|---|---|
| Property | 2% Offset Strength | | Ultimate Strength | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 102.1 | 85.87 | 127.0 | 102.7 |
| Stdev | 5.086 | 5.243 | 3.844 | 2.791 |
| CV | 4.983 | 6.106 | 3.027 | 2.718 |
| Mod CV | 6.492 | 7.053 | 6.000 | 6.000 |
| Min | 87.28 | 77.61 | 119.5 | 97.73 |
| Max | 110.2 | 95.0 | 133.2 | 109.2 |
| No. Batches | 3 | 3 | 3 | 3 |
| No. Spec. | 18 | 18 | 18 | 18 |
| Basis Values and Estimates | | | | |
| B-Basis Value | 92.64 | 76.47 | 120.9 | 96.55 |
| A-Estimate | 86.24 | 70.07 | 116.7 | 92.39 |
| Method | Pooled | Pooled | Pooled | Pooled |
| Modified CV Basis Values and Estimates | | | | |
| B-Basis Value | 90.49 | 74.31 | 114.4 | 90.05 |
| A-Estimate | 82.63 | 66.45 | 105.8 | 81.47 |
| Method | Pooled | Pooled | Pooled | Pooled |

**Table 4-83: As Measured Statistics, B-Basis Values and Estimates for SSB3 Strength Data**

## 4.44 Compression After Impact 1 (CAI1)

The CAI1 data is normalized by cured ply thickness. Basis values are not computed for this property. Testing was done in RTA and ETW1 environmental conditions. Only one batch of material was tested. There was no statistical analysis. Summary statistics are presented in Table 4-84 and the data are displayed graphically in Figure 4-48.

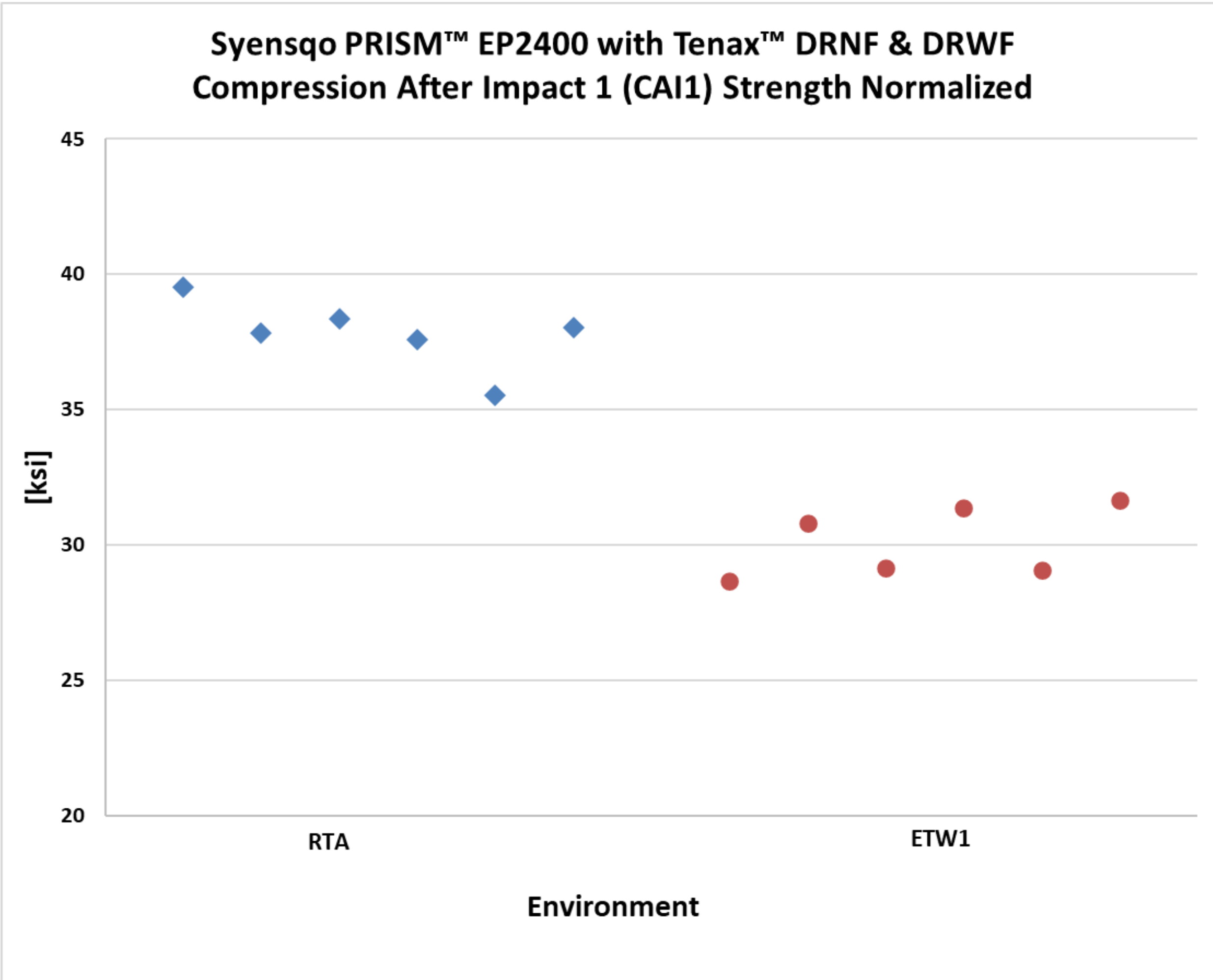


**Figure 4-48: Batch Plot for Compression After Impact Normalized Strength**

| Compression After Impact (CAI1) Strength (ksi) Statistics | | | | |
|---|---|---|---|---|
| | Normalized | | As-Measured | |
| Env | RTA | ETW1 | RTA | ETW1 |
| Mean | 37.81 | 30.12 | 35.63 | 28.36 |
| Stdev | 1.309 | 1.318 | 1.294 | 1.216 |
| CV | 3.462 | 4.377 | 3.632 | 4.286 |
| Min | 35.53 | 28.65 | 33.39 | 26.97 |
| Max | 39.53 | 31.67 | 37.31 | 29.79 |
| No. Batches | 1 | 1 | 1 | 1 |
| No. Spec. | 6 | 6 | 6 | 6 |

Table 4-84: Statistics for CAI1 Strength Data

## 4.45 Interlaminar Tension Strength (ILT) and Curved Beam Strength (CBS)

The ILT data is not normalized. Data is reported on two properties: Interlaminar Tension Strength and Curved Beam Strength. Testing was done in the CTA, RTA and ETW1 environmental conditions. Only one batch of material was tested. There was no statistical analysis. Basis values are not computed for these properties. Summary statistics are presented for Bidiagonal ILT in Table 4-85 and Biaxial ILT in Table 4-86 and the as measured data are displayed graphically for Bidiagonal ILT in Figure 4-49 and for Biaxial ILT in Figure 4-50.

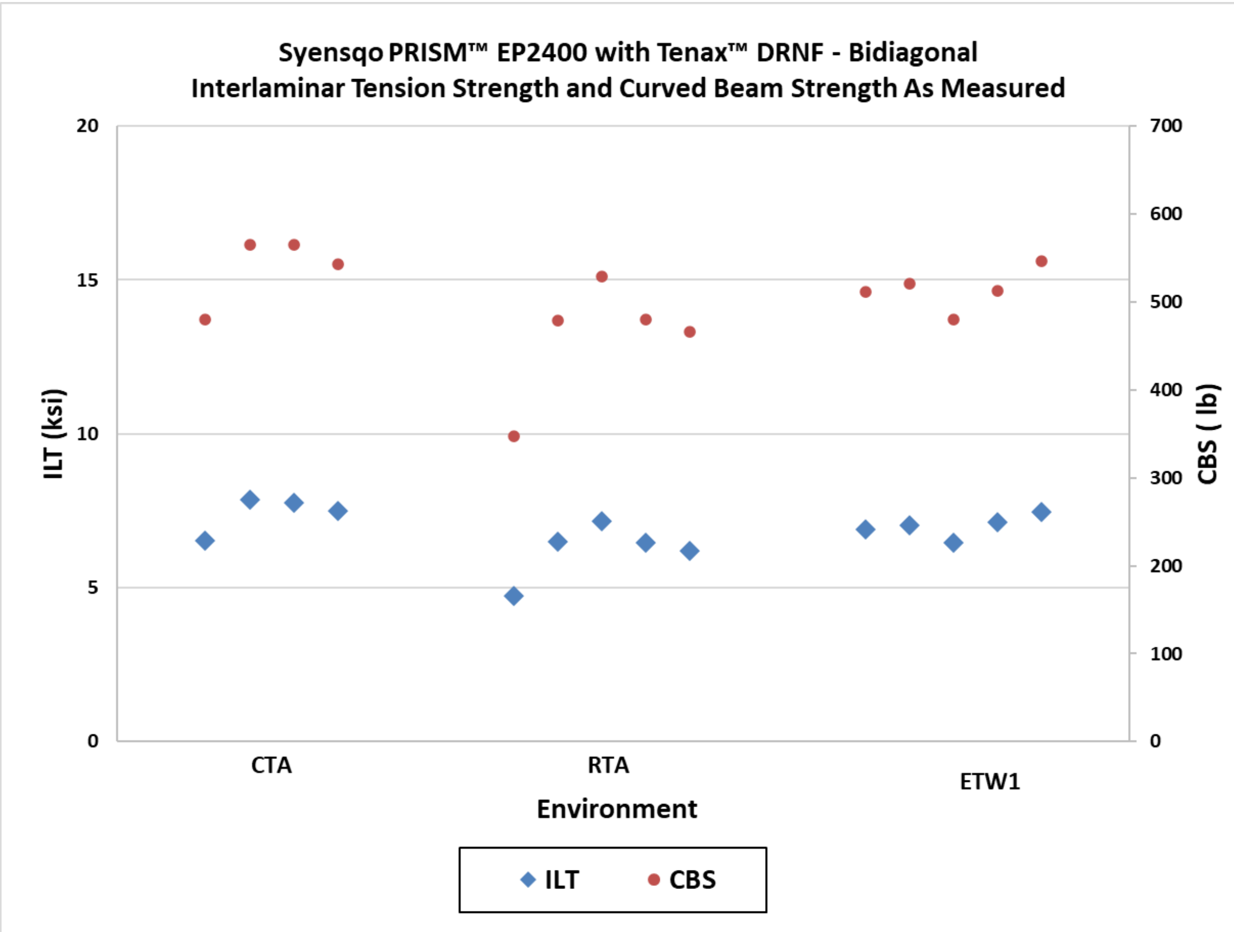


**Figure 4-49: Batch Plot for BD As Measured ILT and CBS**

| Bidiagonal Interlaminar Tension (ILT) Strength Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Interlaminar Tension Strength (ksi) | | | Curved Beam Strength (lb) | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 7.414 | 6.214 | 6.995 | 538.0 | 460.1 | 514.5 |
| Stdev | 0.6060 | 0.9006 | 0.3600 | 40.12 | 67.30 | 23.78 |
| CV | 8.173 | 14.49 | 5.147 | 7.457 | 14.63 | 4.623 |
| Min | 6.533 | 4.740 | 6.461 | 479.9 | 347.6 | 480.3 |
| Max | 7.861 | 7.174 | 7.447 | 564.7 | 528.5 | 546.7 |
| No. Batches | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Spec. | 4 | 5 | 5 | 4 | 5 | 5 |

**Table 4-85: Statistics for BD ILT Strength Data**

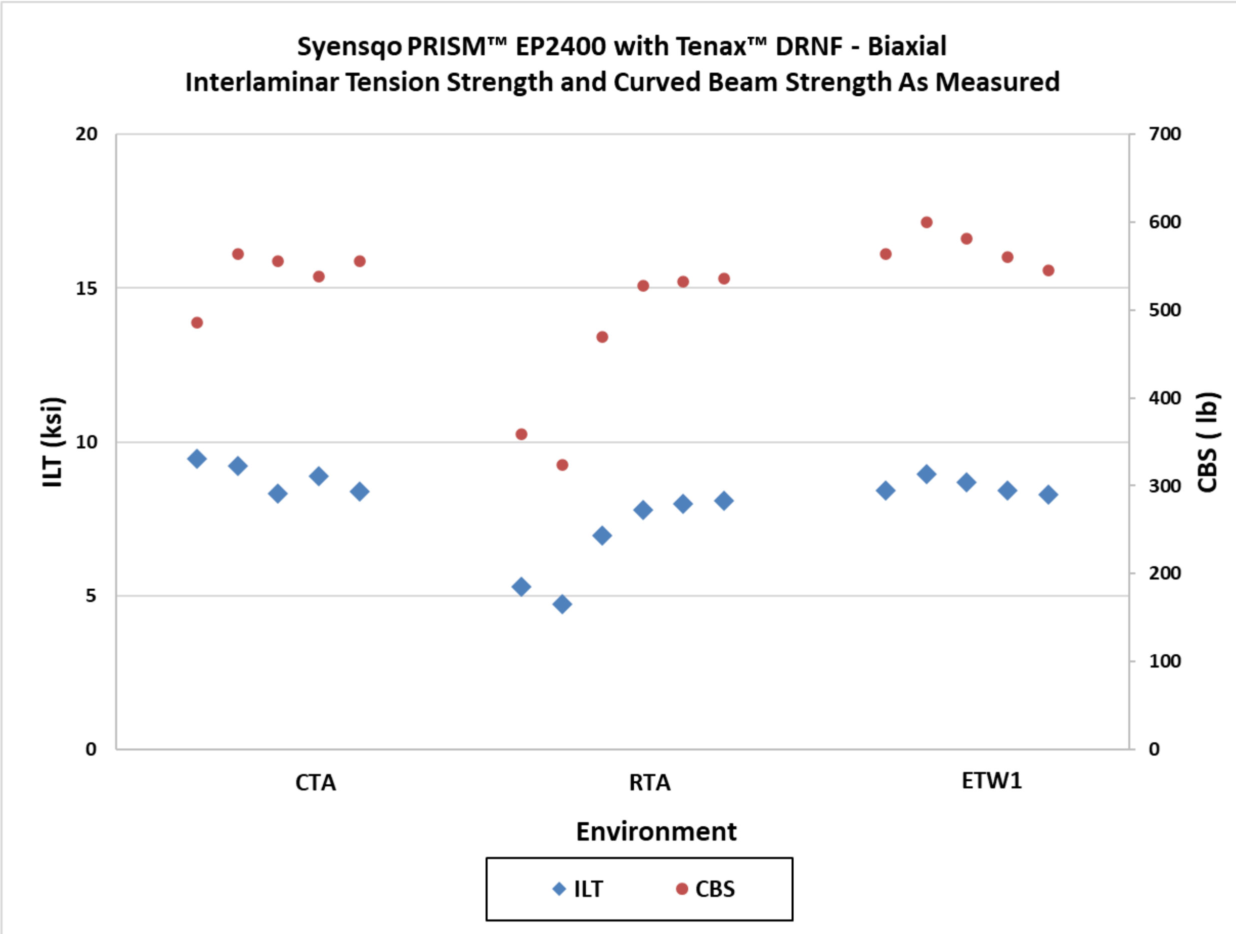


Figure 4-50: Batch Plot for BA As Measured ILT and CBS

| Biaxial Interlaminar Tension (ILT) Strength Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Interlaminar Tension Strength (ksi) | | | Curved Beam Strength (lb) | | |
| Env | CTA | RTA | ETW1 | CTA | RTA | ETW1 |
| Mean | 8.852 | 6.804 | 8.551 | 583.6 | 458.0 | 570.4 |
| Stdev | 0.4907 | 1.464 | 0.2730 | 26.74 | 94.47 | 20.99 |
| CV | 5.543 | 21.52 | 3.193 | 4.581 | 20.62 | 3.681 |
| Min | 8.336 | 4.726 | 8.289 | 545.9 | 323.7 | 545.4 |
| Max | 9.450 | 8.100 | 8.969 | 609.5 | 536.3 | 599.9 |
| No. Batches | 1 | 1 | 1 | 1 | 1 | 1 |
| No. Spec. | 5 | 6 | 5 | 5 | 6 | 5 |

Table 4-86: Statistics for BA ILT Strength Data

# 5. Outliers

Outliers were identified according to the standards documented in section 2.1.5, which are in accordance with the guidelines developed in section 8.3.3 of CMH-17-1H. 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-2024-020 Rev N/C. Outliers for which no causes could be identified are listed in Table 5-1. These outliers were included in the analysis for their respective test properties.

| OUTLIERS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Test | Environmental Condition | Batch | Specimen | As Measured Value | Normalized Value | High/Low | Batch Outlier | Condition Outlier |
| Biaxial 0TEN | RTA | 3 | BA-0TEN-C-C1-1-1A | 169.4 | 183.5 | Low | N | Y |
| Biaxial 90CLC | ETW1 | 2 | BA-90CLC-B-C1-1-4D | 81.65 | Not an Outlier | High | Y | N |
| Biaxial 90TEN | CTA | 1 | BA-90TEN-A-C2-1-2B | 200.3 | 211.0 | Low | Y | N |
| Biaxial 90TEN | CTA | 3 | BA-90TEN-C-C2-1-2B | 183.8 | 193.9 | Low | Y | Y |
| Biaxial SBS | ETW1 | 1 | BA-SBS-A-C1-1-1D | 6.075 | NA | Low | N | Y |
| Bidiagonal 0CLC | ETW1 | 1 | BD-0CLC-A-C1-1-2D | 80.97 | 82.82 | High | Y | N |
| Bidiagonal 0TEN | ETW1 | 1 | BD-0TEN-A-C1-1-3C | Not an Outlier | 212.8 | High | Y | N |
| Bidiagonal IPS 0.2% Offset Strength | ETW1 | 3 | BD-IPS-C-C2-1-1D | 3.610 | NA | Low | N | Y |
| Bidiagonal IPS Strength at 5% Strain | ETW1 | 3 | BD-IPS-C-C2-1-1D | 5.803 | NA | Low | N | Y |
| Bidiagonal SBS | RTA | 1 | BD-SBS-A-C1-1-1A | 10.22 | NA | Low | Y | N |
| Bidiagonal SBS | ETA | 1 | BD-SBS-A-C1-1-1C | 8.136 | NA | High | Y | Y |
| Bidiagonal SBS | ETW2 | 1 | BD-SBS-A-C2-1-3F | 3.929 | NA | High | Y | Y |
| FHC1 | RTA | 1 | M-FHC1-A-C2-1-3A | Not an Outlier | 77.17 | High | N | Y |
| FHC1 | RTA | 3 | M-FHC1-C-C1-1-2A | Not an Outlier | 69.27 | High | Y | N |
| FHC2 | RTA | 2 | M-FHC2-B-C2-1-4A | 61.13 | 63.65 | High | Y | Y |
| FHC3 | RTA | 1 | M-FHC3-A-C1-1-2A | 79.46 | 80.30 | Low | Y | N |
| FHC3 | ETW1 | 1 | M-FHC3-A-C1-1-2D | 52.90 | Not an Outlier | Low | Y | N |
| FHC3 | ETW1 | 3 | M-FHC3-C-C1-1-4D | 52.33 | Not an Outlier | Low | Y | N |
| FHT1 | RTA | 5 | M-FHT1-E-C1-1-1A | Not an Outlier | 85.01 | Low | Y | N |
| FHT2 | ETW1 | 1 | M-FHT2-A-C1-1-1D | 53.11 | 54.83 | Low | Y | N |
| OHC2 | ETW1 | 1 | M-OHC2-A-C1-1-2D | 25.86 | Not an Outlier | Low | Y | N |
| OHT1 | RTA | 1 | M-OHT1-A-C1-1-1A | 82.66 | Not an Outlier | Low | Y | N |
| OHT1 | ETA | 5 | M-OHT1-E-C1-1-1C | 91.44 | Not an Outlier | High | Y | N |
| OHT1 | ETW1 | 1 | M-OHT1-A-C2-1-3D | 91.38 | Not an Outlier | High | Y | N |
| OHT2 | RTA | 5 | M-OHT2-E-C2-1-1A | 60.01 | 61.99 | High | Y | N |
| OHT4 | ETW1 | 1 | M-OHT4-A-C2-1-1D | Not an Outlier | 109.2 | Low | Y | Y |
| SBS1 | RTA | 1 | M-SBS1-A-C2-M-3A | 8.179 | NA | Low | N | Y |
| SBS1 | ETW1 | 2 | M-SBS1-B-C1-M-5D | 5.073 | NA | Low | N | Y |
| SSB1 Utimate Strength | ETW1 | 1 | M-SSB1-A-C1-1-3D | Not an Outlier | 106.8 | Low | Y | Y |
| SSB2 2% Offset Strength | ETW1 | 3 | M-SSB2-C-C1-1-3D | 69.20 | 71.10 | Low | Y | Y |
| SSB2 Ultimate Strength | RTA | 1 | M-SSB2-A-C1-1-1A | 137.7 | Not an Outlier | High | Y | N |
| SSB2 Ultimate Strength | ETW1 | 3 | M-SSB2-C-C1-1-3D | 98.83 | Not an Outlier | Low | Y | Y |
| SSB3 2% Offset Strength | RTA | 2 | M-SSB3-B-C2-1-2A | 87.28 | Not an Outlier | Low | N | Y |
| SSB3 Ultimate Strength | ETW1 | 2 | M-SSB3-B-C1-1-3D | Not an Outlier | 112.9 | High | Y | Y |
| UNC1 | RTA | 2 | M-UNC1-B-C2-1-2A | 69.60 | 75.00 | Low | Y | N |
| UNC1 | RTA | 3 | M-UNC1-C-C2-1-3A | 67.46 | Not an Outlier | Low | Y | N |
| UNT2 | ETW1 | 3 | M-UNT2-C-C1-1-2D | 76.41 | 81.70 | High | Y | Y |
| Unidirectional 0CLC | ETA | 1 | UD-UNC0-A-C1-1-1C | Not an Outlier | 116.4 | High | Y | N |
| Unidirectional IPS 0.2% Offset Strength | RTA | 3 | UD-IPS-C-C1-1-3A | 6.387 | NA | High | N | Y |
| Unidirectional IPS 0Strength at 5% Strain | RTA | 3 | UD-IPS-C-C1-1-2A | 11.37 | NA | High | N | Y |
| Unidirectional UNC0 | ETA | 1 | UD-UNC0-A-C1-1-1C | Not an Outlier | 81.01 | High | Y | N |
| Unidirectional UNT0 | CTA | 1 | UD-UNT0-A-C1-1-3B | 189.2 | 186.0 | Low | N | Y |
| Unidirectional UNT0 | RTA | 2 | UD-UNT0-B-C1-1-3A | 218.8 | Not an Outlier | Low | Y | N |
| Unidirectional UNT0 | ETW1 | 4 | UD-UNT0-D-C2-1-1D | Not an Outlier | 204.9 | High | Y | N |
| NA: Property not normalized | | | | | | | | |

**Table 5-1: List of Outliers**

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