Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Uni-Directional Slit Tape (0.25 inch) Material Allowables Statistical Analysis Report

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1. Introduction

This report contains statistical analysis of the Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slit Tape (0.25 inch) material property data published in NCAMP Test Report CAM-RP-2023-002 Rev N/C. The lamina and laminate material property data have been generated with NCAMP oversight through NCAMP Special Project Number NPN 052101 and also meet the requirements outlined in NCAMP Standard Operating Procedure NSP 100. The test panels, test specimens, and test setups have been inspected by NCAMP Authorized Inspection Representatives (AIR) and the testing has been witnessed by NCAMP Authorized Engineering Representative (AER).

B-Basis values, A-estimates, and B-estimates were calculated using a variety of techniques that are detailed in section two. The qualification material was utilizing NCAMP Material Specification NMS 397/3 Rev – dated January 24, 2024, NMS 397/3 lists the information for procurement. The qualification test panels were cured in accordance with NCAMP Process Specification NPS 83961AFP “C” cure cycle Rev - dated January 25, 2023. The NCAMP Test Plan NTP 3963Q1 Rev B was used for this qualification program.

The panels were fabricated at Advanced Technologies Lab for Aerospace Systems (ATLAS), National Institute for Aviation Research, Wichita State University, 1845 N. Fairmount, Wichita, KS 67260-0093. 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).

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 397/3. NMS 397/3 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 397/3. NMS 397/3* is a free, publicly available, non-proprietary aerospace industry material specification.

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

1.1 Symbols and Abbreviations

Test Property	Abbreviation
Longitudinal Compression	LC
Longitudinal Tension	LT
Transverse Compression	TC
Transverse Tension	TT
In-Plane Shear	IPS
In-Plane Shear V-Notched	VNS
Short Beam Strength	SBS
Laminate Short Beam Strength	SBS1
Unnotched Tension	UNT
Unnotched Compression	UNC
Filled Hole Tension	FHT
Filled Hole Compression	FHC
Open Hole Tension	OHT
Open Hole Compression	OHC
Single Shear Bearing	SSB
Interlaminar Tension	ILT
Curved Beam Strength	CBS
Compression After Impact	CAI

Table 1-1: Test Property Abbreviations

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

Table 1-2: Test Property Symbols

Environmental Condition	Abbreviation	Temperature
Cold Temperature Ambient	CTA	–65° F
Room Temperature Ambient	RTA	70° F
Elevated Temperature Ambient	ETA1	180° F
Elevated Temperature Ambient	ETA2	250° F
Elevated Temperature Wet	ETW1	180° F
Elevated Temperature Wet	ETW2	250° F

Table 1-3: Environmental Conditions Abbreviations

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

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

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

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2023-002 Rev A.

1.2 Pooling Across Environments

When pooling across environments was allowable, the pooled co-efficient of variation was used. CMH17 STATS (CMH17 Approved **S**tatistical Analysis Program) was used to determine if pooling was allowable and to compute the pooled coefficient of variation for those tests. In these cases, the modified coefficient of variation based on the pooled data was used to compute the basis values.

When pooling across environments was not advisable because the data was not eligible for pooling and engineering judgment indicated there was no justification for overriding the result, then B-Basis values were computed for each environmental condition separately, which are also provided by CMH17 STATS.

1.3 Basis Value Computational Process

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

1.4 Modified Coefficient of Variation (CV) Method

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

The modified Coefficient of Variation (CV) used in this report is in accordance with section 8.4.4 of CMH-17-1H. 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: $$\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n}$$ **Equation 1**

Std. Dev.: $$S = \sqrt{\tfrac{1}{n-1} \sum_{i=1}^{n} \left(X_i - \bar{X} \right)^2}$$ **Equation 2**

% Co. Variation: $$\frac{S}{\bar{X}} \times 100$$ **Equation 3**

Where n refers to the number of specimens in the sample and X_i refers to the individual specimen measurements.

2.1.2 Statistics for Pooled Data

Prior to computing statistics for the pooled dataset, the data is normalized to a mean of one by dividing each value by the mean of all the data for that condition. This transformation does not affect the coefficients of variation for the individual conditions.

2.1.2.1 Pooled Standard Deviation

The formula to compute a pooled standard deviation is given below:

Pooled Std. Dev.: $$S_p = \sqrt{\frac{\sum_{i=1}^{k}(n_i - 1)S_i^2}{\sum_{i=1}^{k}(n_i - 1)}}$$ **Equation 4**

Where *k* refers to the number of batches, S_i indicates the standard deviation of i^{th} sample, and n_i refers to the number of specimens in the i^{th} sample.

2.1.2.2 Pooled Coefficient of Variation

Since the mean for the normalized data is 1.0 for each condition, the pooled normalized data also has a mean of one. The coefficient of variation for the pooled normalized data is the pooled standard deviation divided by the pooled mean, as in equation 3. Since the mean for the pooled normalized data is one, the pooled coefficient of variation is equal to the pooled standard deviation of the normalized data.

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

2.1.3 Basis Value Computations

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

Basis Values: $$\begin{aligned} A-basis &= \overline{X} - K_a S \\ B-basis &= \overline{X} - K_b S \end{aligned}$$ **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:

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

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

Where

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

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

$f = N - r$

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

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

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

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

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

2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

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

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

2.1.4.1 Transformation of data based on Modified CV

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

To accomplish this requires a transformation in two steps:

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

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

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

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

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

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

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

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

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

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

2.1.5 Determination of Outliers

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

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

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

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

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

2.1.6 The k-Sample Anderson Darling Test for Batch Equivalency

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

The k-sample Anderson-Darling test statistic is:

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

Where

n_i = the number of test specimens in each batch

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

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

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

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

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

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

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

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

With

$$a = (4g-6)(k-1) + (10-6g)S$$

$$b = (2g-4)k^2 + 8Tk + (2g-14T-4)S - 8T + 4g - 6$$

$$c = (6T+2g-2)k^2 + (4T-4g+6)k + (2T-6)S + 4T$$

$$d = (2T+6)k^2 - 4Tk$$

$$S = \sum_{i=1}^{k} \frac{1}{n_i}$$

$$T = \sum_{i=1}^{n-1} \frac{1}{i}$$

$$g = \sum_{i=1}^{n-2} \sum_{j=i+1}^{n-1} \frac{1}{(n-i)j}$$

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

2.1.7 The Anderson Darling Test for Normality

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

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

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

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

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

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

The Anderson Darling test statistic (AD) is:

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

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

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

This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if, in fact, the data are a sample from a normal population. If OSL > 0.05, the data is considered sufficiently close to a normal distribution.

2.1.8 Levene's Test for Equality of Coefficient of Variation

Levene's test performs an Analysis of Variance on the absolute deviations from their sample medians. The absolute value of the deviation from the median is computed for each data value. $w_{ij} = \left|y_{ij} - \tilde{y}_i\right|$ An F-test is then performed on the transformed data values as follows:

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

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

2.1.9 Distribution Tests

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

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

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

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

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

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

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

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

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

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

The exact computation of k_A values is $1/\sqrt{n}$ times the 0.95th quantile of the noncentral t-distribution with noncentrality parameter $2.326\sqrt{n}$ and n − 1 degrees of freedom (Reference 11). Since this is not a calculation that Excel can handle easily, the following approximation to the k_A values is used:

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

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

2.1.9.3 Two-parameter Weibull Distribution

A probability distribution for which the probability that a randomly selected observation from this population lies between *a* and *b* $(0 < a < b < \infty)$ is given by

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

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

In order to compute a check of the fit of a data set to the Weibull distribution and compute basis values assuming Weibull, it is first necessary to obtain estimates of the population shape and scale parameters (Section 2.1.9.3.1). Calculations specific to the goodness-of-fit test for the Weibull distribution are provided in section 2.1.9.3.2.

2.1.9.3.1 Estimating Weibull Parameters

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

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

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

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

2.1.9.3.2 Goodness-of-fit test for the Weibull distribution

The two-parameter Weibull distribution is considered by comparing the cumulative Weibull distribution function that best fits the data with the cumulative distribution function of the data. Using the shape and scale parameter estimates from section 2.1.9.3.1, let

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

The Anderson-Darling test statistic is

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

and the observed significance level is

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

where

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

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

2.1.9.3.3 Basis value calculations for the Weibull distribution

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

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

where

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

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

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

V is the value in Table 2-1 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:

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

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

The Anderson-Darling statistic is then computed using 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:

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

For A-Basis values:

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

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

The B-basis value is the r_Bth lowest observation in the data set, while the A-basis value is the r_Ath lowest observation in the data set. For example, in a sample of size n = 30, the lowest (r = 1) observation is the B-basis value. Further information on this procedure may be found in reference 7.

2.1.10.2 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

Equation 50

The A-basis value is:

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

Equation 51

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

The Hanson-Koopmans method can be used to calculate A-basis values for n less than 299. Find the value k_A corresponding to the sample size n in Table 2-3. For an A-basis value that meets all the requirements of CMH-17-1H, 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 $\left(n_i, \overline{x}_i, s_i^2\right)$ while statistics that were computed with the entire dataset do not have a subscript. Individual data values are represented with a double subscript, the first number indicated the batch and the second distinguishing between the individual data values within the batch. *k* stands for the number of batches in the analysis. With these statistics, the Sum of Squares Between batches (SSB) and the Total Sum of Squares (SST) are computed:

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

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

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

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

Next, the mean sums of squares are computed:

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

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

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

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

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

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

Two k-factors are computed using the methodology of section 8.3.5 of CMH-17-1Husing a sample size of n (denoted k_0) and a sample size of k (denoted k_1). Whether this value is an A- or B-basis value depends only on whether k_0 and k_1 are computed for A or B-basis values.

Denote the ratio of mean squares by

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

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

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

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

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

2.2 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.

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

2.3 0º Lamina Strength Derivation

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

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

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

$$BF = \frac{E_1\left[V_0E_2 + (1-V_0)E_1\right] - (\nu_{12}E_2)^2}{\left[V_0E_1 + (1-V_0)E_2\right]\left[V_0E_2 + (1-V_0)E_1\right] - (\nu_{12}E_2)^2} \quad \textbf{Equation 62}$$

V_0=fraction of 0º plies in the cross-ply laminate (½ for UNT0 and 1/3 for UNC0)
E_1 = Average across of batches of modulus for LC and LT as appropriate
E_2 = Average across of batches of modulus for TC and TT as appropriate
ν_{12} = major Poisson's ratio of 0º plies from an average of all batches

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

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

2.3.1 0º Lamina Strength Derivation (Alternate Formula)

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

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

$$F^{cu}_{0^\circ} = F^{cu}_{0^\circ/90^\circ}\frac{E^c_1}{E^c_{0^\circ/90^\circ}}, \quad F^{tu}_{0^\circ} = F^{tu}_{0^\circ/90^\circ}\frac{E^t_1}{E^t_{0^\circ/90^\circ}} \quad \textbf{Equation 63}$$

with

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

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

E^c_1, E^t_1 are the modulus values for LC and LT respectively

$E^c_{0^\circ/90^\circ}$, $E^t_{0^\circ/90^\circ}$ are the modulus values for UNC0 and UNT0 respectively

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

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 tables Table 3-1 and Table 3-2 of recommended values.

1. Recommended values are NEVER estimates. Only B-basis values that meet all requirements of CMH-17-1H 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
Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slip Tape (0.25 inch)

All B-basis values in this table meet the standards for publication in CMH-17-1G Handbook

Values are for normalized data unless otherwise noted

Lamina Strength Tests

Environment	Statistic	LC from UNC0**	LT	TC*	TT*	UNC0 [0/90]	IPS*		VNS*			SBS*
							0.2% Offset	5% Strain	0.2% Offset	5% Strain	Ultimate	
CTA (-65º F)	B-basis	190.3	458.3	44.17	6.685	72.10	9.720	14.78	10.02	17.31	26.37	19.32
	Mean	300.0	518.2	49.11	8.094	113.7	10.76	16.42	11.77	19.21	29.32	22.01
	CV	8.659	6.000	6.351	8.813	8.659	6.000	6.000	8.287	6.000	6.000	6.199
RTA (70º F)	B-basis	240.2	451.2	33.09	5.877	90.21	7.077	11.79	8.097	13.45	21.57	14.84
	Mean	280.7	527.7	38.01	9.399	105.4	8.119	13.43	9.185	15.35	24.53	16.83
	CV	7.319	7.348	6.000	18.98	7.319	6.000	6.000	6.000	6.000	6.000	6.000
ETA1 (180º F)	B-basis	NA: I		NA: I		NA: I						NA: I
	Mean	259.2		29.13		96.45						12.88
	CV	2.768		2.149		2.768						1.488
ETA2 (250º F)	B-basis	NA: I		NA: I		NA: I						NA: I
	Mean	250.4		22.92		92.70						10.44
	CV	8.427		3.764		8.427						2.556
ETW1 (180º F)	B-basis	NA: I	NA: I	NA: I	NA: I	NA: I	NA: I	NA: I	NA: I	NA: I	NA: I	NA: I
	Mean	256.5	504.5	23.87	6.684	94.93	5.678	8.473	6.490	10.08	16.72	11.39
	CV	4.803	8.447	0.8927	4.279	4.803	1.071	1.304	1.644	1.885	1.597	3.113
ETW2 (250º F)	B-basis	160.8	426.6	13.55	NA: A	58.10	NA: A	NA: A	3.617	5.656	NA: A	6.752
	Mean	200.8	489.2	15.45	3.921	72.55	3.261	5.253	4.113	6.420	11.39	7.865
	CV	10.02	6.568	6.232	6.691	10.02	5.898	5.350	6.108	6.026	4.758	7.164

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

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

NCAMP Recommended B-basis Values for
Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slip Tape (0.25 inch)
All B-basis values in this table meet the standards for publication in CMH-17-1G Handbook
Values are for normalized data unless otherwise noted

Laminate Strength Tests

Lay-up	ENV	Statistic	OHT	OHC	FHT	FHC	UNT	UNC	SSB Proc. C 2% Offset	SSB Proc. C Ultimate	SBS1*
25/50/25	CTA (-65° F)	B-basis	73.58		77.30		132.6				
		Mean	83.15		87.50		149.7				
		CV	6.000		6.000		6.010				
	RTA (70° F)	B-basis	82.25	43.75	83.14	66.28	144.0	100.4	96.24	135.0	11.49
		Mean	91.82	49.63	93.35	74.94	161.2	111.2	109.2	153.1	13.03
		CV	6.000	6.000	6.000	6.000	6.087	6.218	6.000	6.000	6.000
	ETW2 (250° F)	B-basis	102.6	31.46	96.05	44.53	139.7	56.08	NA:A	96.68	NA:A
		Mean	116.4	35.74	106.3	50.52	158.5	66.92	93.67	112.0	4.059
		CV	6.000	6.058	6.000	6.000	6.000	7.574	9.208	6.914	7.913
10/80/10	CTA (-65° F)	B-basis	52.89		58.65		77.40				
		Mean	58.92		64.96		85.87				
		CV	6.000		6.000		6.000				
	RTA (70° F)	B-basis	52.38	39.59	56.28	57.93	75.56	67.77	100.7	133.3	
		Mean	58.42	43.60	62.59	63.58	84.03	74.78	114.2	147.6	
		CV	6.000	6.082	6.000	6.000	6.000	6.000	6.000	6.000	
	ETW2 (250° F)	B-basis	46.85	22.99	43.24	31.09	59.45	38.11	NA:A	95.19	
		Mean	52.89	26.99	49.55	36.75	67.92	45.09	93.16	109.4	
		CV	6.000	6.000	6.000	6.135	6.000	7.006	6.953	6.045	
50/40/10	CTA (-65° F)	B-basis	119.6		115.7		241.4**				
		Mean	138.3		134.9		264.5				
		CV	6.000		6.132		4.581				
	RTA (70° F)	B-basis	134.2	64.57	128.9	88.33	250.5	148.2	99.68	130.3	
		Mean	152.8	71.33	148.1	97.69	284.1	168.1	113.1	147.8	
		CV	6.000	6.000	6.322	6.000	6.000	6.000	6.000	6.000	
	ETW2 (250° F)	B-basis	205.0	42.33	157.4	53.60	223.4**	NA:A	NA:A	NA:A	
		Mean	223.7	49.09	176.4	62.96	237.2	103.1	87.34	105.9	
		CV	6.000	6.193	7.800	6.823	2.944	8.777	10.15	7.913	

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

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

3.2 Lamina and Laminate Summary Tables

Material: Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slip Tape (0.25 inch)			**Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slit Tape (0.25 inch) Lamina Properties Summary**
Material Specification: NMS 397/3			
Process Specification: NPS 83961			
Fiber: T1100G-24000-71E	**Resin:** 3960		
Tg(dry): 373.37° F	**Tg(wet):** 306.95° F	**Tg METHOD:** ASTM D7028	

	Lot #1 (A)	Lot #2 (B)	Lot #3 (C)		
Fiber Lot	A1120K2	A1120K2	A1120J1		
Date of fiber manufacture	10/31/2020	10/31/2020	9/30/2020	**Date of testing**	8/23/2022 to 6/1/2023
Resin Lot	Multiple	Multiple	Multiple	**Date of data submittal**	6/26/2023
Date of resin manufacture	Multiple	Multiple	Multiple		
Prepreg Lot	A5210392	A5210797	A3201290		
Date of prepreg manufacture	3/11/2021	7/30/2021	12/8/2020	**Date of analysis**	7/5/2023 to 7/10/2023
Date of composite manufacture	6/3/2022 - 11/29/2022				

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY

Data reported: As-measured followed by normalized values in parentheses, normalizing tply: 0.0070 in

Values shown in shaded boxes do not meet CMH-17-1G requirements and are estimates only

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

Properties	CTA (–65° F)			RTA (70° F)			ETW1 (180° F)			ETW2 (250° F)		
	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean
F_1^{tu}	475.2	456.7	518.2	463.5	454.3	528.7	401.6	393.5	505.0	441.8	424.8	483.2
[ksi]	(467.0)	(458.3)	(518.2)	(476.0)	(451.2)	(527.7)	(386.1)	NA	(504.5)	(440.2)	(426.6)	(489.2)
E_1^t			24.58			24.73			25.58			25.31
[Msi]			(24.51)			(24.67)			(25.54)			(25.59)
ν_{12}^t			0.3217			0.3344			0.3365			0.3715
F_2^{tu} [ksi]	6.685	NA	8.094	5.877	NA	9.399	5.818	5.073	6.684	2.677	NA	3.921
E_2^t [Msi]			1.476			1.330			1.111			0.6996
F_1^{cu} [ksi]	190.3	NA	299.3	242.4	238.6	280.8	226.0	195.7	257.8	160.1	NA	200.8
from UNC0*	(190.3)	NA	(300.0)	(244.6)	(240.2)	(280.7)	(219.2)	(194.7)	(256.5)	(160.8)	NA	(200.8)
E_1^c			21.72			21.71			21.87			21.64
[Msi]			(21.63)			(21.62)			(21.46)			(21.52)
ν_{12}^c			0.3383			0.3492			0.3943			0.4157
F_2^{cu} [ksi]	44.55	44.17	49.11	36.22	33.09	38.01	23.23	18.12	23.87	14.09	13.55	15.45
E_2^c [Msi]			1.495			1.386			1.198			0.9105
UNC0 [0/90] Strength	72.06	NA	113.4	91.02	89.56	105.4	83.50	72.29	95.24	57.81	NA	72.52
[ksi]	(72.10)	NA	(113.7)	(91.89)	(90.21)	(105.4)	(81.12)	(72.05)	(94.93)	(58.10)	NA	(72.55)
UNC0 [0/90] Modulus			8.000			8.028			8.231			8.231
[Msi]			(8.023)			(8.033)			(8.202)			(8.231)
(IPS) $F_{12}^{s0.2\%}$ [ksi]	9.634	9.720	10.76	7.629	7.077	8.119	5.494	4.309	5.678	2.349	NA	3.261
(IPS) $F_{12}^{s5\%\ strain}$[ksi]	14.30	14.78	16.42	12.31	11.79	13.43	8.138	6.431	8.473	3.311	NA	5.253
(IPS) G_{12}^s [Msi]			0.8492			0.7338			0.5418			0.3310
(VNS) $F_{12}^{s0.2\%}$ [ksi]	10.02	NA	11.77	8.929	8.097	9.185	6.166	4.926	6.490	3.771	3.617	4.113
(VNS) $F_{12}^{s5\%strain}$ [ksi]	17.99	17.31	19.21	14.90	13.45	15.35	9.507	7.653	10.08	4.984	5.656	6.420
(VNS) F_{12}^{su} [ksi]	28.01	26.37	29.32	22.84	21.57	24.53	15.91	12.69	16.72	7.648	NA	11.39
(VNS) G_{12}^s [Msi]			0.8960			0.7615			0.5709			0.4036
SBS [ksi]	17.40	19.32	22.01	14.78	14.84	16.83	10.32	8.645	11.39	6.882	6.752	7.865

Derived from cross-ply using back-out factor.

In-Plane Shear (IPS) data was calculated per ASTM D3518.

In-Plane Shear V-Notched (VNS) data was calculated per ASTM D5379.

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

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY Cont.						
Properties	ETA1 (180° F)			ETA2 (250° F)		
	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean
F_1^{cu} [ksi]	239.7	197.6	260.4	187.0	NA	252.3
from UNC0*	(237.5)	(196.8)	(259.2)	(186.5)	NA	(250.4)
E_1^c			22.15			21.90
[Msi]			(21.78)			(21.51)
ν_{12}^c			0.3646			0.3730
F_2^{cu} [ksi]	27.23	22.11	29.13	20.31	17.40	22.92
E_2^c [Msi]			1.279			1.201
UNC0 [0/90] Strength	89.03	73.40	96.70	69.10	NA	93.24
[ksi]	(88.36)	(73.20)	(96.45)	(69.04)	NA	(92.70)
UNC0 [0/90] Modulus			7.924			8.024
[Msi]			(7.903)			(7.979)
SBS [ksi]	12.30	9.779	12.88	9.632	7.924	10.44

**** Derived from cross-ply using back-out factor***

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

Material: Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slip Tape (0.25 inch)
Material Specification: NMS 397/3
Process Specification: NPS 83961
Fiber: T1100G-24000-71E **Resin:** 3960

Tg(dry): 373.37° F **Tg(wet):** 306.95° F **Tg METHOD:** ASTM D7028

Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slit Tape (0.25 inch) Laminate Properties Summary

	Lot #1 (A)	Lot #2 (B)	Lot #3 (C)
Fiber Lot	A1120K2	A1120K2	A1120J1
Date of fiber manufacture	10/31/2020	10/31/2020	9/30/2020
Resin Lot	Multiple	Multiple	Multiple
Date of resin manufacture	Multiple	Multiple	Multiple
Prepreg Lot	A5210392	A5210797	A3201290
Date of prepreg manufacture	3/11/2021	7/30/2021	12/8/2020
Date of composite manufacture	6/3/2022 - 11/29/2022		

Date of testing 8/23/2022 to 6/1/2023
Date of data submittal 6/26/23
Date of analysis 7/5/2023 to 7/10/2023

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY
Data reported as normalized used a normalizing t_{ply} of 0.0070 in
Values shown in shaded boxes do not meet CMH-17-1G requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test	Property	Layup:		Quasi Isotropic 25/50/25			"Soft" 10/80/10			"Hard" 50/40/10		
		Test Condition	Unit	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean
OHT (normalized)	**Strength**	CTA (–65° F)	ksi	79.68	73.58	83.15	56.90	52.89	58.92	131.3	119.6	138.3
		RTA (70° F)	ksi	85.77	82.25	91.82	56.40	52.38	58.42	145.8	134.2	152.8
		ETW1 (180° F)	ksi	81.42	74.89	98.66	---	---	---	---	---	---
		ETW2 (250° F)	ksi	112.7	102.6	116.4	48.75	46.85	52.89	216.7	205.0	223.7
OHC (normalized)	**Strength**	RTA (70° F)	ksi	47.32	43.75	49.63	33.77	39.59	43.60	67.19	64.57	71.33
		ETW1 (180° F)	ksi	37.68	31.89	42.02	---	---	---	---	---	---
		ETW2 (250° F)	ksi	33.51	31.46	35.74	24.88	22.99	26.99	44.95	42.33	49.09
UNT (normalized)	**Strength**	CTA (–65° F)	ksi	138.1	132.6	149.7	75.66	77.40	85.87	241.4	NA	264.5
	Modulus		Msi	---	---	9.265	---	---	5.909	---	---	14.52
	Strength	RTA (70° F)	ksi	149.6	144.0	161.2	82.00	75.56	84.03	264.1	250.5	284.1
	Modulus		Msi	---	---	9.122	---	---	5.669	---	---	14.34
	Strength	ETW1 (180° F)	ksi	159.0	127.2	167.6	---	---	---	---	---	---
	Modulus		Msi	---	---	9.007	---	---	---	---	---	---
	Strength	ETW2 (250° F)	ksi	125.6	139.7	158.5	63.57	59.45	67.92	223.4	NA	237.2
	Modulus		Msi	---	---	8.626	---	---	4.464	---	---	14.09
UNC (normalized)	**Strength**	RTA (70° F)	ksi	102.9	100.4	111.2	70.26	67.77	74.78	155.7	148.2	168.1
	Modulus		Msi	---	---	8.088	---	---	5.046	---	---	12.53
	Strength	ETW1 (180° F)	ksi	85.14	82.26	94.69	---	---	---	---	---	---
	Modulus		Msi	---	---	7.839	---	---	---	---	---	---
	Strength	ETW2 (250° F)	ksi	58.59	56.08	66.92	39.96	38.11	45.09	56.45	NA	103.1
	Modulus		Msi	---	---	7.810	---	---	4.365	---	---	12.64
FHT (normalized)	**Strength**	CTA (–65° F)	ksi	82.32	77.30	87.50	62.93	58.65	64.96	104.1	115.7	134.9
		RTA (70° F)	ksi	88.16	83.14	93.35	60.56	56.28	62.59	134.5	128.9	148.1
		ETW1 (180° F)	ksi	95.93	90.14	101.9	---	---	---	---	---	---
		ETW2 (250° F)	ksi	101.1	96.05	106.3	47.53	43.24	49.55	159.4	157.4	176.4
FHC (normalized)	**Strength**	RTA (70° F)	ksi	69.98	66.28	74.94	51.66	57.93	63.58	93.07	88.33	97.69
		ETW1 (180° F)	ksi	62.67	50.33	66.31	---	---	---	---	---	---
		ETW2 (250° F)	ksi	46.63	44.53	50.52	33.69	31.09	36.75	45.13	53.60	62.96
SBS1 (as-measured)	**Strength**	RTA (70° F)	ksi	12.50	11.49	13.03	---	---	---	---	---	---
		ETW1 (180° F)	ksi	6.792	6.472	8.527	---	---	---	---	---	---
		ETW2 (250° F)	ksi	2.135	NA	4.059	---	---	---	---	---	---
Single Shear Bearing Proc. C (normalized)	**2% Offset Strength**	RTA (70° F)	ksi	103.1	96.24	109.2	108.1	100.7	114.2	106.2	99.68	113.1
		ETW1 (180° F)	ksi	98.82	84.69	111.6	---	---	---	---	---	---
		ETW2 (250° F)	ksi	35.90	NA	93.67	53.61	NA	93.16	29.85	NA	87.34
Single Shear Bearing Proc. C (normalized)	**Ultimate Strength**	RTA (70° F)	ksi	143.1	135.0	153.1	140.5	133.3	147.6	139.9	130.3	147.8
		ETW1 (180° F)	ksi	121.4	98.81	130.2	---	---	---	---	---	---
		ETW2 (250° F)	ksi	73.44	96.68	112.0	81.27	95.19	109.4	51.76	NA	105.9
Single Shear Bearing Proc. C (normalized)	**Chord Modulus**	RTA (70° F)	Msi	---	---	1.878	---	---	1.318	---	---	1.768
		ETW1 (180° F)	Msi	---	---	2.060	---	---	---	---	---	---
		ETW2 (250° F)	Msi	---	---	1.721	---	---	1.260	---	---	1.682
CBS* (as-measured)	**Strength**	CTA (–65° F)	lb	---	---	640.3	---	---	---	---	---	---
		RTA (70° F)	lb	---	---	482.2	---	---	---	---	---	---
		ETW2 (250° F)	lb	---	---	111.4	---	---	---	---	---	---
ILT* (as-measured)	**Strength**	CTA (–65° F)	ksi	---	---	21.89	---	---	---	---	---	---
		RTA (70° F)	ksi	---	---	16.37	---	---	---	---	---	---
		ETW2 (250° F)	ksi	---	---	3.423	---	---	---	---	---	---
CAI (normalized)	**Strength**	RTA (70° F)	ksi	---	---	49.52	---	---	---	---	---	---

*** The actual layup for ILT is [0]22, (100/0/0).**

Table 3-5: Summary of Test Results for Laminate Data

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

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

4.1 Longitudinal Tension (LT)

The LT data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. LT tests were performed at four different environmental conditions. The ETW1 condition lacked sufficient specimens to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

Pooling was appropriate for the normalized CTA and RTA conditions. The pooled as-measured CTA and RTA datasets failed the normality test.

The ETW1 normalized dataset had a CV higher than 8%, so modified CV basis values could not be provided for that dataset.

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

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

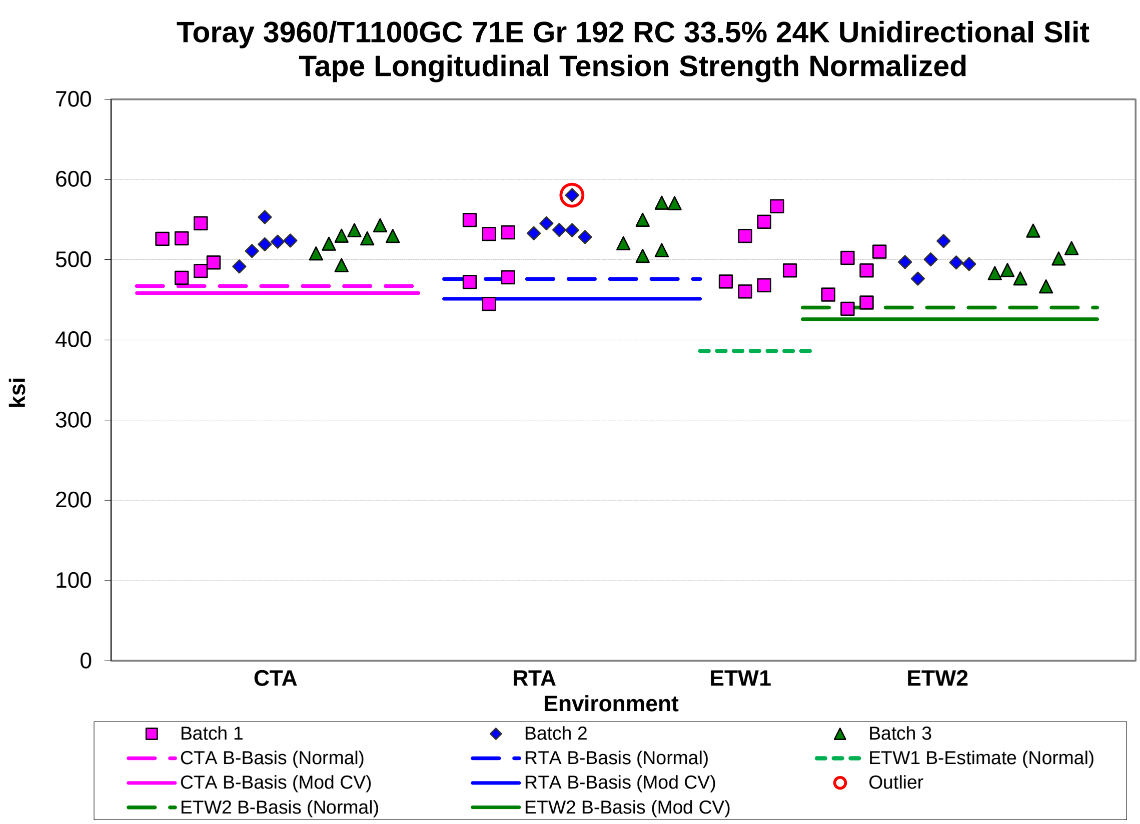

Figure 4-1 Batch plot for LT strength normalized

Longitudinal Tension Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	518.2	527.7	504.5	489.2	518.2	528.7	505.0	483.2
Stdev	20.64	35.34	42.61	25.12	22.34	33.01	37.22	21.28
CV	3.982	6.696	8.447	5.135	4.312	6.243	7.371	4.403
Mod CV	6.000	7.348	8.447	6.568	6.156	7.122	8.000	6.201
Min	477.4	444.8	460.4	438.7	476.5	449.6	467.3	446.5
Max	553.0	580.4	566.5	536.4	562.6	576.7	559.6	537.0
No. Batches	3	3	2	3	3	3	2	3
No. Spec.	20	18	7	19	20	18	7	19
Basis Value and Estimates								
B-basis Value	467.0	476.0		440.2	475.2	463.5		441.8
B-Estimate			386.1				401.6	
A-Estimate	431.8	440.9	302.9	405.5	444.5	417.3	328.9	412.3
Method	pooled	pooled	Normal	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	458.3	451.2	NA	426.6	456.7	454.3		424.8
B-Estimate							393.5	
A-Estimate	415.8	397.0		382.2	413.1	401.8	317.2	383.4
Method	Normal	Normal		Normal	Normal	Normal	Normal	Normal

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

Longitudinal Tension Modulus Statistics								
	Normalized				As-measured			
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	24.51	24.67	25.54	25.59	24.58	24.73	25.58	25.31
Stdev	0.3255	0.2639	0.5438	0.5087	0.5556	0.4450	0.3515	0.4436
CV	1.328	1.069	2.129	1.988	2.260	1.800	1.374	1.753
Mod CV	6.000	6.000	8.000	6.000	6.000	6.000	8.000	6.000
Min	23.68	24.21	24.86	24.97	23.46	23.83	25.08	24.69
Max	25.07	25.17	26.23	27.28	25.28	25.29	26.07	26.17
No. Batches	3	3	2	3	3	3	2	3
No. Spec.	18	18	7	18	18	18	7	18

Table 4-2: Statistics for LT Modulus data

4.2 Transverse Tension (TT)

The TT data is not normalized for unidirectional tape, only as-measured values are provided. Data is available for two properties, strength and modulus. TT tests were performed at four different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

The ETW2 dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. It did not pass the ADK test after the modified CV transformation, so modified CV basis values are not provided for that dataset.

The CTA and RTA datasets had a CV higher than 8%, so modified CV basis values could not be provided.

There were two outliers, both in the CTA condition. The lowest value in batch one was an outlier for the CTA condition but not for the batch one. The largest value in batch two was an outlier for batch two but not for the CTA condition. Both outliers were retained for this analysis.

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

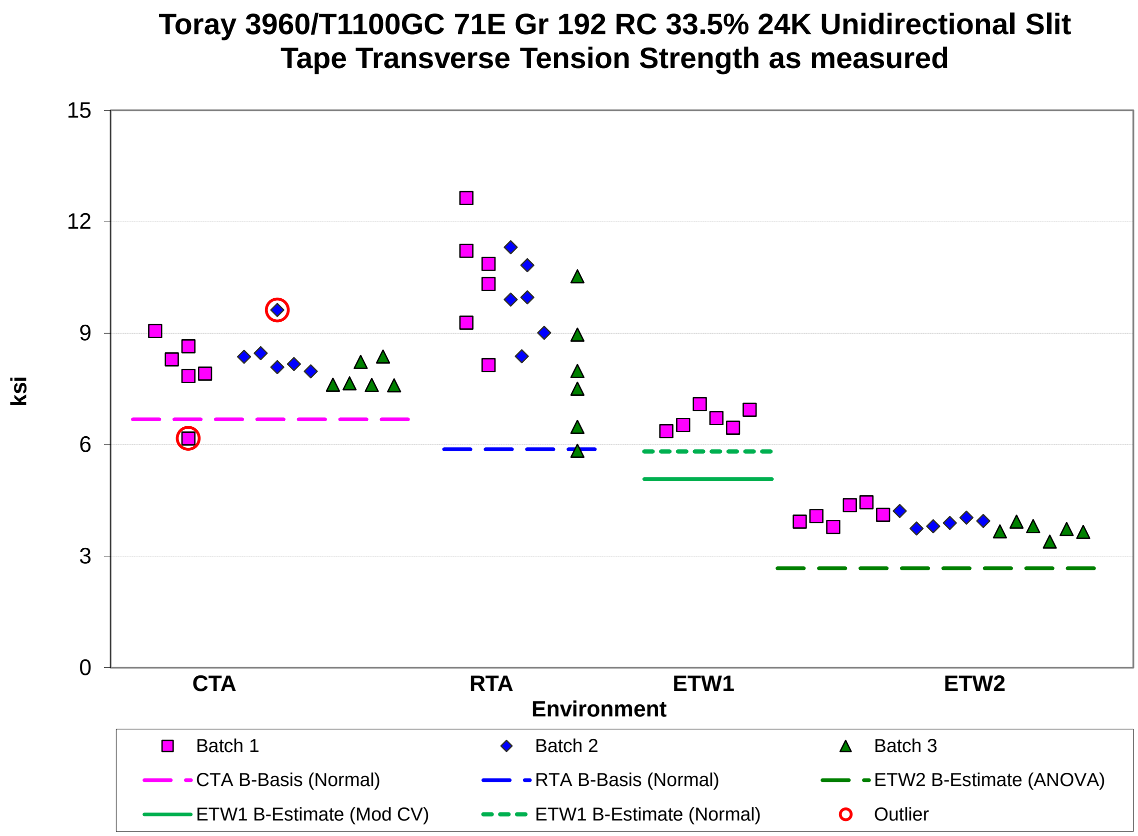

Figure 4-2: Batch Plot for TT Strength as-measured

Transverse Tension Strength Basis Values and Statistics				
As-measured				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	8.094	9.399	6.684	3.921
Stdev	0.7133	1.784	0.2860	0.2624
CV	8.813	18.98	4.279	6.691
Mod CV	8.813	18.98	8.000	7.346
Min	6.168	5.838	6.365	3.396
Max	9.622	12.64	7.090	4.451
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-basis Value	6.685	5.877		
B-estimate			5.818	2.677
A-estimate	5.687	3.381	5.202	1.790
Method	Normal	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	NA	NA		NA
B-estimate			5.073	
A-estimate			3.971	
Method			Normal	

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

Transverse Tension Modulus Statistics				
As-measured				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	1.476	1.330	1.111	0.6996
Stdev	0.07723	0.01902	0.03621	0.04292
CV	5.232	1.431	3.261	6.136
Mod CV	6.616	6.000	8.000	7.068
Min	1.284	1.292	1.076	0.6489
Max	1.623	1.357	1.146	0.7847
No. Batches	3	3	1	3
No. Spec.	18	18	6	18

Table 4-4: Statistics from TT Modulus data as-measured

4.3 Longitudinal Compression (LC)

The LC data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. LC tests were performed at six different environmental conditions. The ETA1, ETA2 and ETW1 conditions only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for those conditions. Strength values are not available directly from the LC test specimens. The strength values for 0º properties are computed via the formulas specified in section 2.3 from the UNC0 specimen values.

The RTA and ETW2 datasets, both normalized and as-measured, did not have an adequate fit to the normal distribution. The Weibull distribution was used to compute the basis values. After the transformation of data to fit the assumptions of the modified CV method, those datasets all passed the normality test so modified CV basis values are provided.

The CTA dataset both normalized and as-measured, failed all three distribution tests, requiring the non-parametric approach to compute design values.

The CTA, ETA2, and ETW2 datasets, both normalized and as-measured, had a CV higher than 8%, so modified CV basis values could not be provided for those datasets.

There were three outliers. The lowest value in batch three of the CTA condition was an outlier for both batch three and CTA condition. The lowest value in batch one of the ETW2 condition was an outlier for the batch one but not for the ETW2 condition. The lowest value in batch three of the ETW2 condition was an outlier for the ETW2 condition but not for the batch three. All three outliers were outliers for both the normalized and as-measured datasets. All three outliers were retained for this analysis.

Statistics, basis values and estimates are given for normalized strength data in Table 4-5, the as-measured strength data in Table 4-6, for the normalized modulus data in Table 4-7, and for the as-measured modulus data in Table 4-8. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-3.

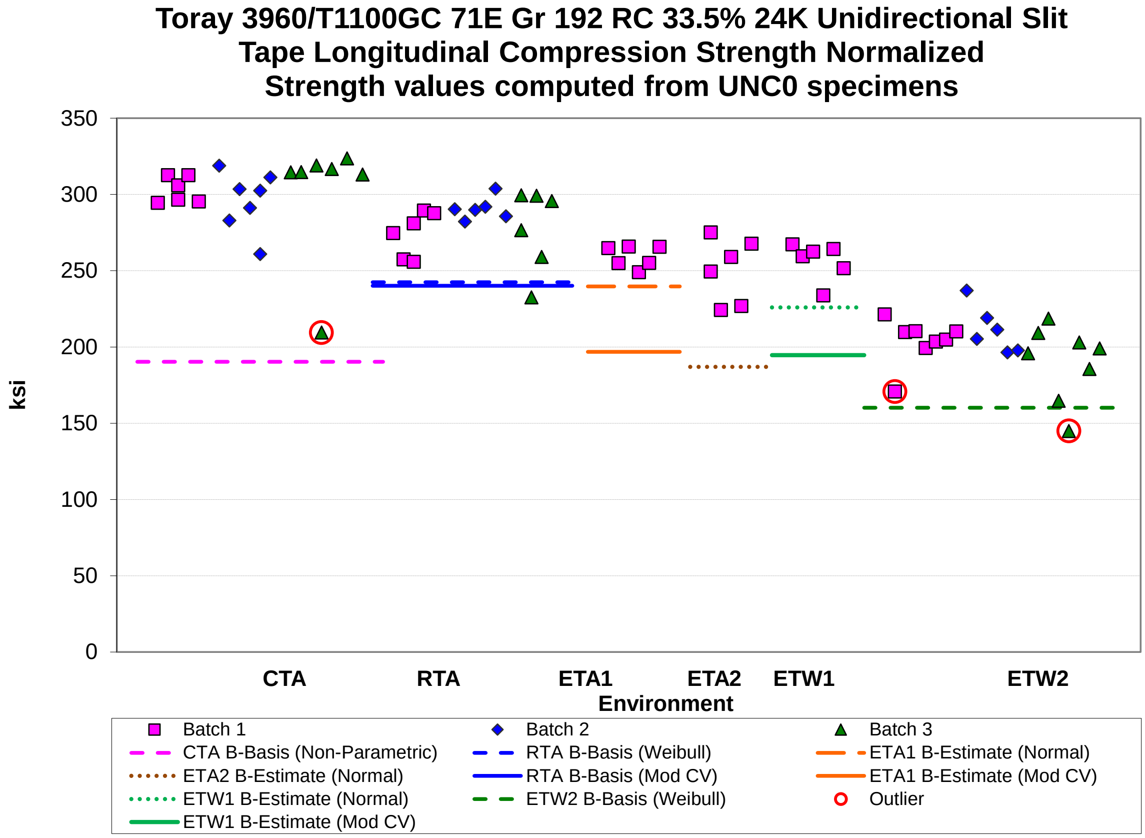

Figure 4-3 Batch plot for LC Strength normalized derived from UNC0

Longitudinal Compression Strength Basis Values and Statistics normalized						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	300.0	280.7	259.2	250.4	256.5	200.8
Stdev	25.98	18.63	7.18	21.10	12.32	20.12
CV	8.659	6.637	2.768	8.427	4.803	10.02
Mod CV	8.659	7.319	8.000	8.427	8.000	10.02
Min	209.4	232.6	249.0	224.3	233.8	144.9
Max	323.6	303.8	265.9	275.2	267.3	237.1
No. Batches	3	3	1	1	1	3
No. Spec.	20	18	6	6	6	22
Basis Value and Estimates						
B-basis Value	190.3	244.6				160.8
B-Estimate			237.5	186.5	219.2	
A-Estimate	115.5	208.7	222.1	141.1	192.7	124.7
Method	Non-Parm.	Weibull	Normal	Normal	Normal	Weibull
Modified CV Basis Value Estimates						
B-basis Value	NA	240.2		NA		NA
B-Estimate			196.8		194.7	
A-Estimate		211.5	154.0		152.4	
Method		Normal	Normal		Normal	

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

Longitudinal Compression Strength Basis Values and Statistics as-measured						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	299.3	280.8	260.4	252.3	257.8	200.8
Stdev	25.67	20.29	6.820	21.57	10.50	20.65
CV	8.575	7.227	2.619	8.547	4.071	10.28
Mod CV	8.575	7.613	8.000	8.547	8.000	10.28
Min	209.5	230.8	252.9	223.0	239.2	143.2
Max	320.2	302.8	270.8	274.7	270.1	238.5
No. Batches	3	3	1	1	1	3
No. Spec.	20	18	6	6	6	22
Basis Value and Estimates						
B-basis Value	190.3	242.4				160.1
B-Estimate			239.7	187.0	226.0	
A-Estimate	117.3	204.6	225.0	140.6	203.4	123.5
Method	Non-Parm.	Weibull	Normal	Normal	Normal	Weibull
Modified CV Basis Value Estimates						
B-basis Value	NA	238.6		NA		NA
B-Estimate			197.6		195.7	
A-Estimate		208.7	154.7		153.2	
Method		Normal	Normal		Normal	

Table 4-6: Statistics and Basis Values for LC Strength derived from UNC0 as-measured

Longitudinal Compression Modulus Statistics normalized						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	21.63	21.62	21.78	21.51	21.46	21.52
Stdev	0.5696	0.6001	0.3998	0.6097	0.7350	0.4989
CV	2.634	2.776	1.835	2.834	3.424	2.318
Mod CV	6.000	6.000	8.000	8.000	8.000	6.000
Min	20.30	20.41	20.86	20.42	20.58	20.73
Max	23.10	22.83	22.28	22.30	22.32	22.72
No. Batches	3	3	2	2	1	3
No. Spec.	36	36	12	12	6	18

Table 4-7: Statistics from LC Modulus normalized data

Longitudinal Compression Modulus Statistics as measured						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	21.72	21.71	22.15	21.90	21.87	21.64
Stdev	0.4564	0.5426	0.4403	0.6296	0.6770	0.5986
CV	2.101	2.499	1.987	2.874	3.096	2.766
Mod CV	6.000	6.000	8.000	8.000	8.000	6.000
Min	20.74	20.87	21.31	20.86	21.03	20.65
Max	22.72	23.28	22.86	22.75	22.63	23.04
No. Batches	3	3	2	2	1	3
No. Spec.	36	36	12	12	6	18

Table 4-8: Statistics from LC Modulus as-measured data

4.4 Transverse Compression (TC)

The TC data is not normalized for unidirectional tape, only as-measured values are provided. Data is available for two properties, strength and modulus. TC tests were performed at six different environmental conditions. The ETA1, ETA2, and ETW1 conditions only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for those conditions.

Pooling was appropriate for the CTA and RTA conditions for the modified CV basis values only. Prior to the modified CV transformation of data, they failed Levene's test and could not be pooled.

There were no statistical outliers.

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

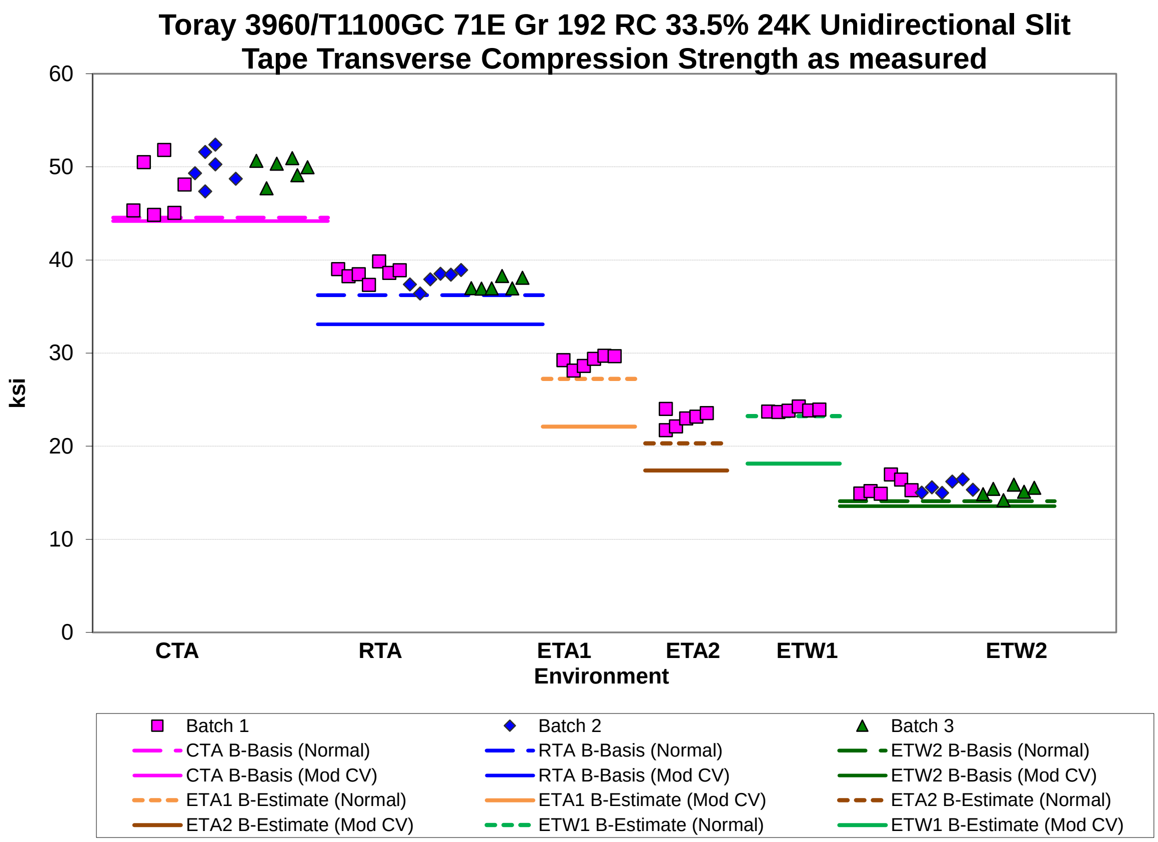

Figure 4-4: Batch Plot for TC strength as-measured

Transverse Compression Strength Basis Values and Statistics						
As-measured						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	49.11	38.01	29.13	22.92	23.87	15.45
Stdev	2.309	0.9188	0.6261	0.8626	0.2131	0.6898
CV	4.702	2.417	2.149	3.764	0.8927	4.464
Mod CV	6.351	6.000	8.000	8.000	8.000	6.232
Min	44.84	36.40	28.13	21.71	23.67	14.21
Max	52.39	39.85	29.72	24.00	24.27	16.95
No. Batches	3	3	1	1	1	3
No. Spec.	18	19	6	6	6	18
Basis Values and Estimates						
B-basis Value	44.55	36.22				14.09
B-estimate			27.23	20.31	23.23	
A-estimate	41.32	34.95	25.89	18.45	22.77	13.13
Method	Normal	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-basis Value	44.17	33.09				13.55
B-estimate			22.11	17.40	18.12	
A-estimate	40.81	29.73	17.31	13.62	14.18	12.21
Method	pooled	pooled	Normal	Normal	Normal	Normal

Table 4-9: Statistics and Basis Values for TC Strength data

Transverse Compression Modulus Statistics as-measured						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	1.495	1.386	1.279	1.201	1.198	0.9105
Stdev	0.02958	0.02736	0.03340	0.03444	0.01689	0.04346
CV	1.979	1.975	2.612	2.867	1.410	4.773
Mod CV	6.000	6.000	8.000	8.000	8.000	6.386
Min	1.447	1.314	1.227	1.160	1.176	0.8394
Max	1.552	1.429	1.316	1.237	1.218	0.9823
No. Batches	3	3	1	1	1	3
No. Spec.	18	19	6	6	6	18

Table 4-10: Statistics from TC Modulus data

4.5 Short-Beam Strength (SBS)

The SBS data is not normalized, only as-measured values are provided. Data is available for only one property, strength. SBS tests were performed at six different environmental conditions. The ETA1, ETA2, and ETW1 conditions only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for those conditions.

The CTA and RTA datasets failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Both datasets passed the ADK test after the modified CV transformation, so modified CV basis values are provided but pooling was not appropriate due to a failure of Levene's test.

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

Statistics and basis values are given for SBS data in Table 4-11. The as-measured data, B-basis values and B-estimates are shown graphically in Figure 4-5.

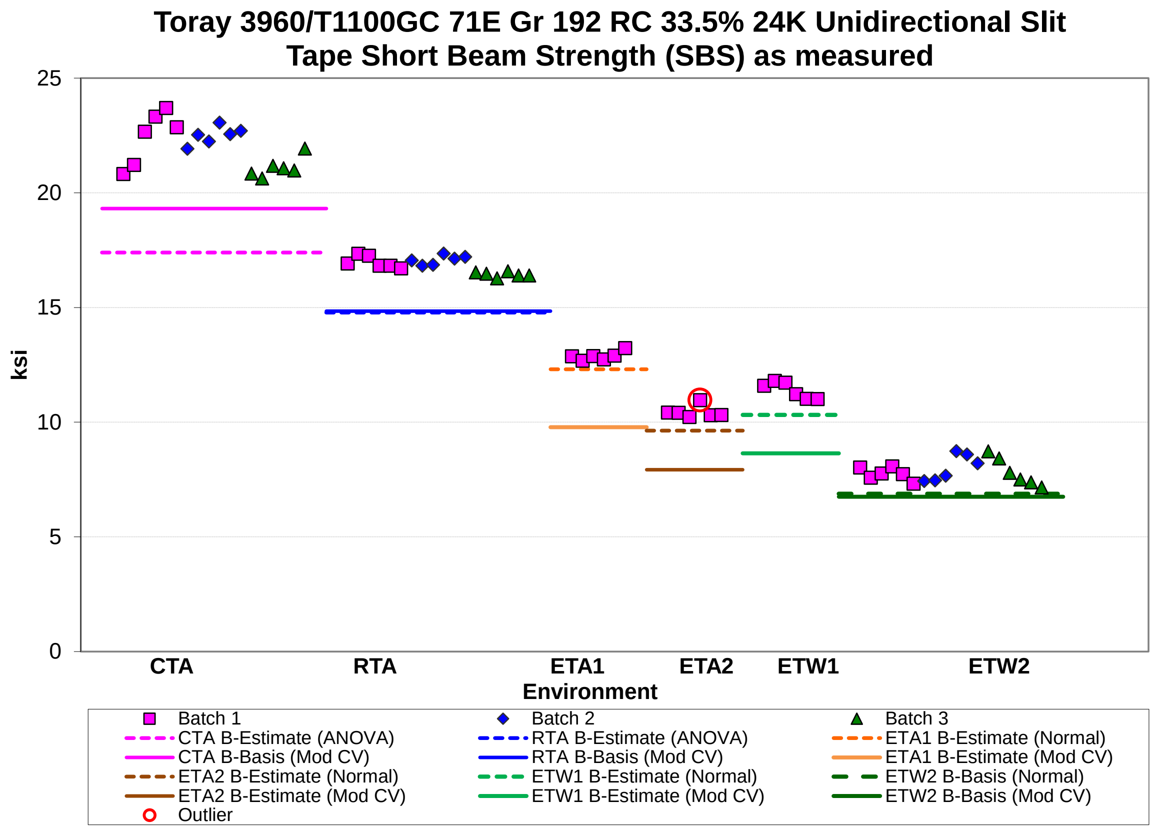

Figure 4-5: Batch plot for SBS as-measured

Short Beam Strength (SBS) Basis Values and Statistics As-measured						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	22.01	16.83	12.88	10.44	11.39	7.865
Stdev	0.9683	0.3421	0.1917	0.2668	0.3546	0.4977
CV	4.398	2.033	1.488	2.556	3.113	6.329
Mod CV	6.199	6.000	8.000	8.000	8.000	7.164
Min	20.63	16.28	12.68	10.22	11.01	7.156
Max	23.70	17.35	13.23	10.96	11.80	8.738
No. Batches	3	3	1	1	1	3
No. Spec.	18	18	6	6	6	18
Basis Values and Estimates						
B-basis Value						6.882
B-estimate	17.40	14.78	12.30	9.632	10.32	
A-estimate	14.10	13.32	11.89	9.057	9.552	6.186
Method	ANOVA	ANOVA	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-basis Value	19.32	14.84				6.752
B-estimate			9.779	7.924	8.645	
A-estimate	17.41	13.43	7.654	6.203	6.767	5.965
Method	Normal	Normal	Normal	Normal	Normal	Normal

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

4.6 In-Plane Shear (IPS)

The IPS data is not normalized, only as-measured values are provided. Data is provided on three properties, 0.2% offset strength, strength at 5% strain and modulus. IPS tests were performed at four different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for those conditions.

The CTA, RTA and ETW2 datasets for both 0.2% offset strength and strength at 5% strain failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. The CTA and RTA datasets for both 0.2% offset strength and strength at 5% strain passed the ADK test after the modified CV transformation, so modified CV basis values are provided for those dataset. Pooling was appropriate for the CTA and RTA datasets for both 0.2% offset strength and strength at 5% strain. The ETW2 datasets did not pass the ADK test after the modified CV transformation, so modified CV basis values are not provided for that condition.

There were two statistical outliers. The lowest value in batch one of the ETW2 dataset for 0.2% offset strength was an outlier for batch one but not for the ETW2 condition. The lowest value in batch three of the ETW2 dataset for strength at 5% strain was an outlier for batch three but not for the ETW2 condition. Both outliers were retained for this analysis.

Statistics, estimates and basis values are given for the 0.2% offset strength data in Table 4-12, the strength at 5% strain data in Table 4-13 and modulus data in Table 4-14. The as-measured data, B-estimates and B-basis values are shown graphically for the 0.2% offset strength in Figure 4-6 and for strength at 5% strain in Figure 4-7.

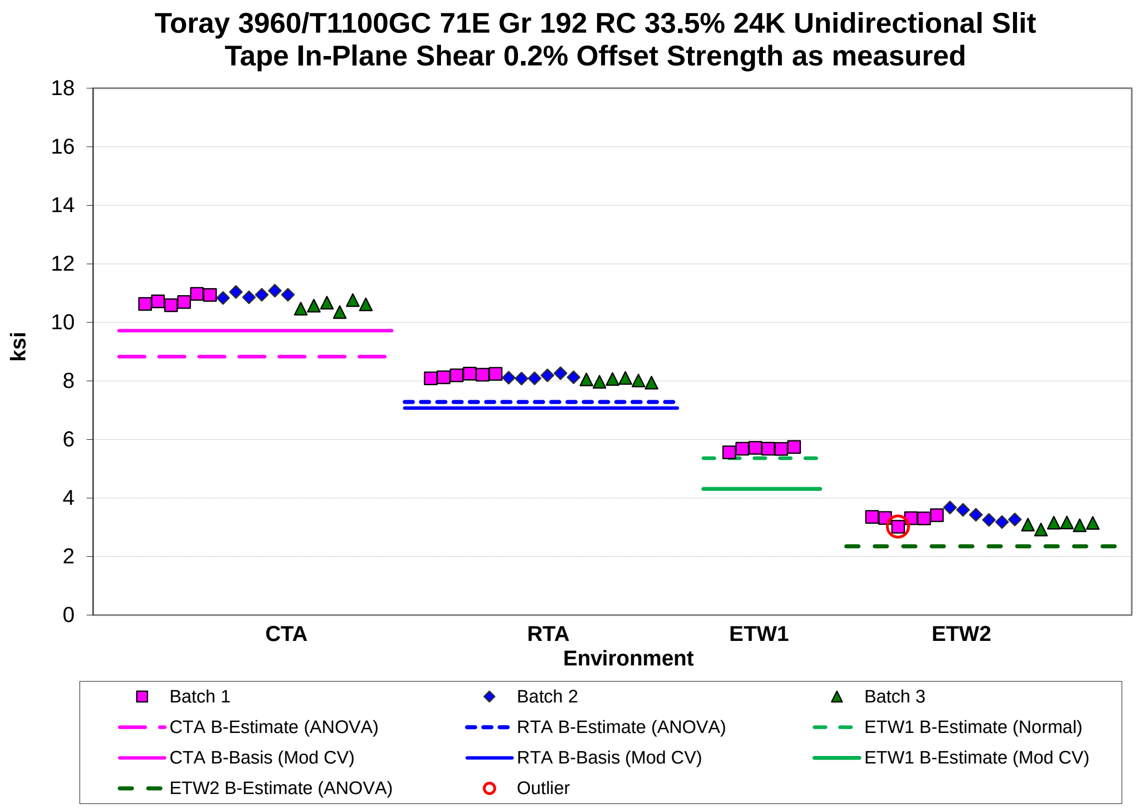

Figure 4-6: Batch plot for IPS for 0.2% Offset Strength as-measured

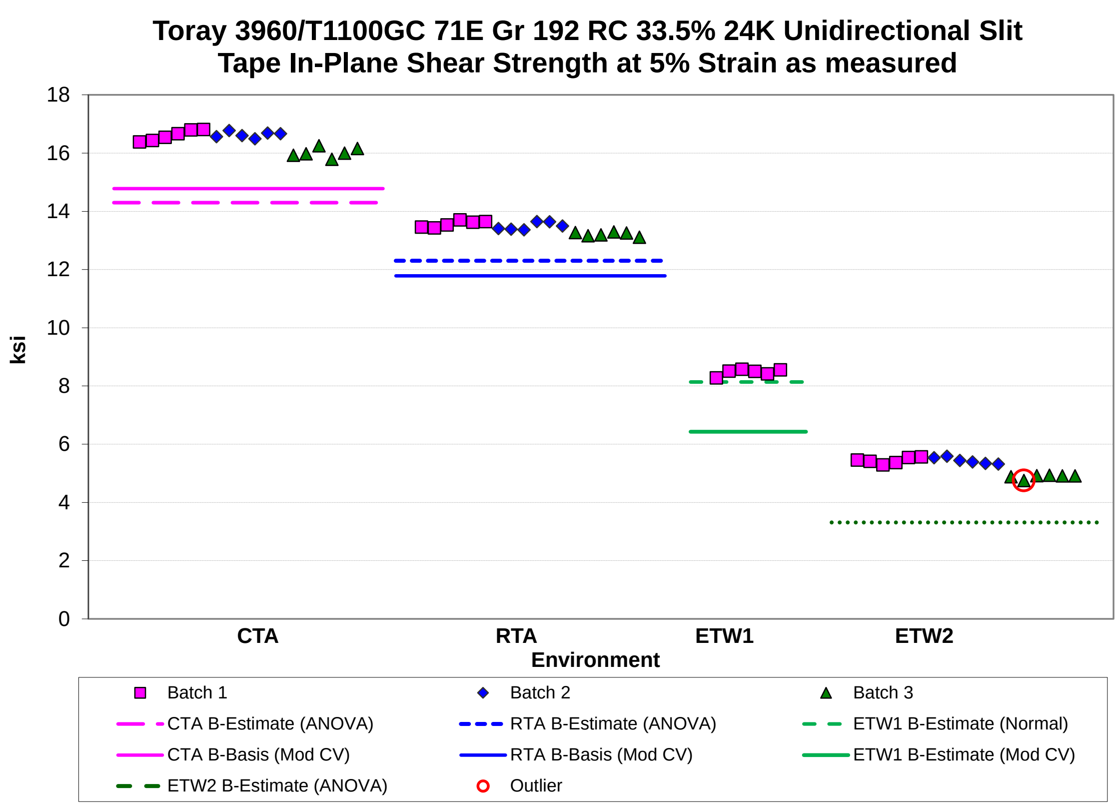

Figure 4-7: Batch plot for IPS Strength at 5% Strain as-measured

In-Plane Shear Strength Basis Values and Statistics As-measured 0.2% Offset Strength				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	10.76	8.119	5.678	3.261
Stdev	0.2046	0.09326	0.06080	0.1923
CV	1.901	1.149	1.071	5.898
Mod CV	6.000	6.000	8.000	6.949
Min	10.35	7.943	5.564	2.924
Max	11.09	8.267	5.741	3.678
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-estimate	9.634	7.629	5.494	2.349
A-estimate	8.829	7.279	5.363	1.700
Method	ANOVA	ANOVA	Normal	ANOVA
Modified Basis Values and Estimates				
B-basis Value	9.720	7.077		NA
B-estimate			4.309	
A-estimate	9.011	6.368	3.373	
Method	pooled	pooled	Normal	

Table 4-12: Statistics and Basis Values for IPS 0.2% Offset Strength data

In-Plane Shear Strength Basis Values and Statistics As-measured Strength at 5% Strain				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	16.42	13.43	8.473	5.253
Stdev	0.3266	0.1843	0.1105	0.2810
CV	1.989	1.373	1.304	5.350
Mod CV	6.000	6.000	8.000	6.675
Min	15.79	13.11	8.276	4.755
Max	16.81	13.70	8.574	5.584
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-estimate	14.30	12.31	8.138	3.311
A-estimate	12.79	11.51	7.900	1.925
Method	ANOVA	ANOVA	Normal	ANOVA
Modified Basis Values and Estimates				
B-basis Value	14.78	11.79		NA
B-estimate			6.431	
A-estimate	13.66	10.67	5.034	
Method	pooled	pooled	Normal	

Table 4-13: Statistics and Basis Values for IPS Strength at 5% Strain data

In Plane Shear Modulus Statistics As-measured				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	0.8492	0.7338	0.5418	0.3310
Stdev	0.02115	0.01170	0.006182	0.02387
CV	2.490	1.594	1.141	7.212
Mod CV	6.000	6.000	8.000	7.606
Min	0.8094	0.7146	0.5324	0.2936
Max	0.8793	0.7537	0.5514	0.3784
No. Batches	3	3	1	3
No. Spec.	18	18	6	18

Table 4-14: Statistics from IPS Modulus data

4.7 In-Plane Shear V-Notched (VNS)

The VNS data is not normalized, only as-measured values are provided. Data is provided on four properties, 0.2% offset strength, strength at 5% strain, ultimate strength and modulus. VNS tests were performed at four different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for those conditions.

The CTA dataset for strength at 5% strain, the RTA dataset for ultimate strength and the ETW2 datasets for strength at 5% strain and ultimate strength failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. The CTA and ETW2 datasets for strength at 5% strain, the RTA dataset for ultimate strength passed the ADK test after the modified CV transformation, so modified CV basis values are provided for those dataset. Pooling was appropriate for the CTA and RTA datasets for strength at 5% strain and ultimate strength. The ETW2 dataset for ultimate strength did not pass the ADK test after the modified CV transformation, so modified CV basis values are not provided for that condition.

The CTA dataset for 0.2% offset strength did not pass the normality test, but the Weibull distribution had an adequate fit, so design values were computed using the Weibull distribution. The CTA dataset for 0.2% offset strength had a CV greater than 8%, so no modified CV basis values could be provided for that condition. .

There were no statistical outliers.

Statistics, basis values and estimates are given for 0.2% offset strength in Table 4-15, the strength at 5% strain in Table 4-16, ultimate strength data in Table 4-17, and for the modulus data in Table 4-18. The as-measured data, the B-basis values and B-estimates are shown graphically for 0.2% offset strength in Figure 4-8, strength at 5% strain in Figure 4-9, and for ultimate strength in Figure 4-10.

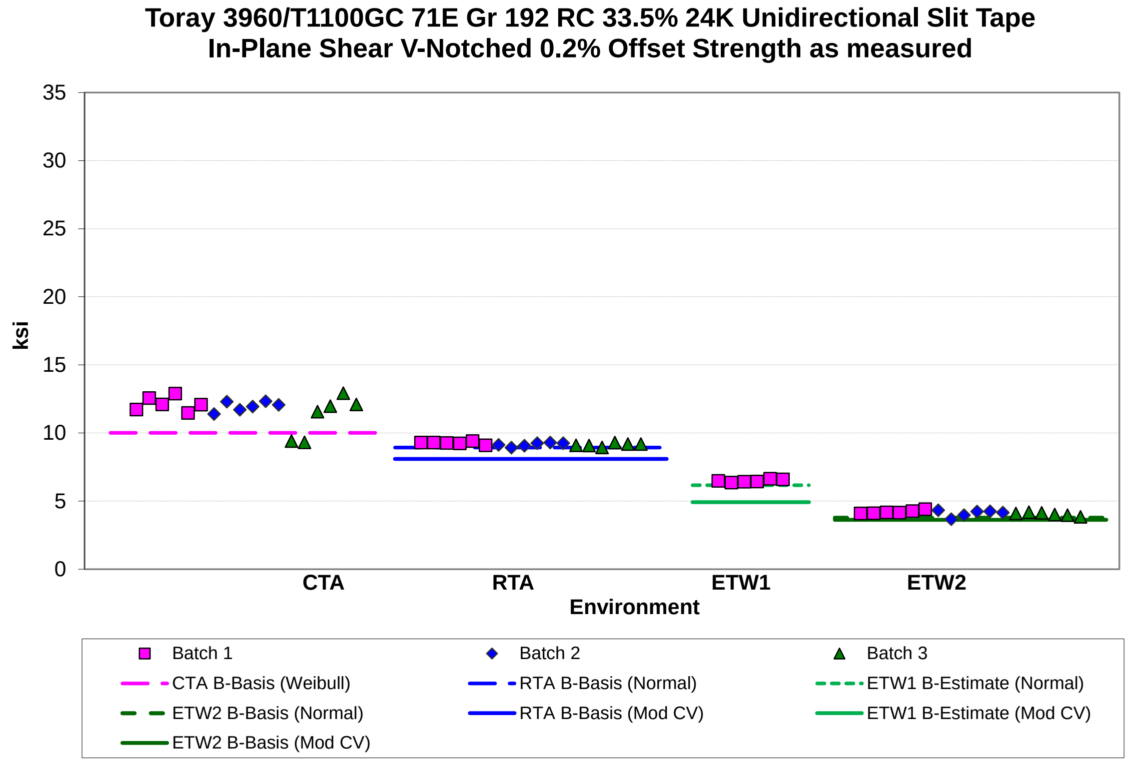

Figure 4-8: Batch Plot for VNS 0.2% Offset Strength as-measured

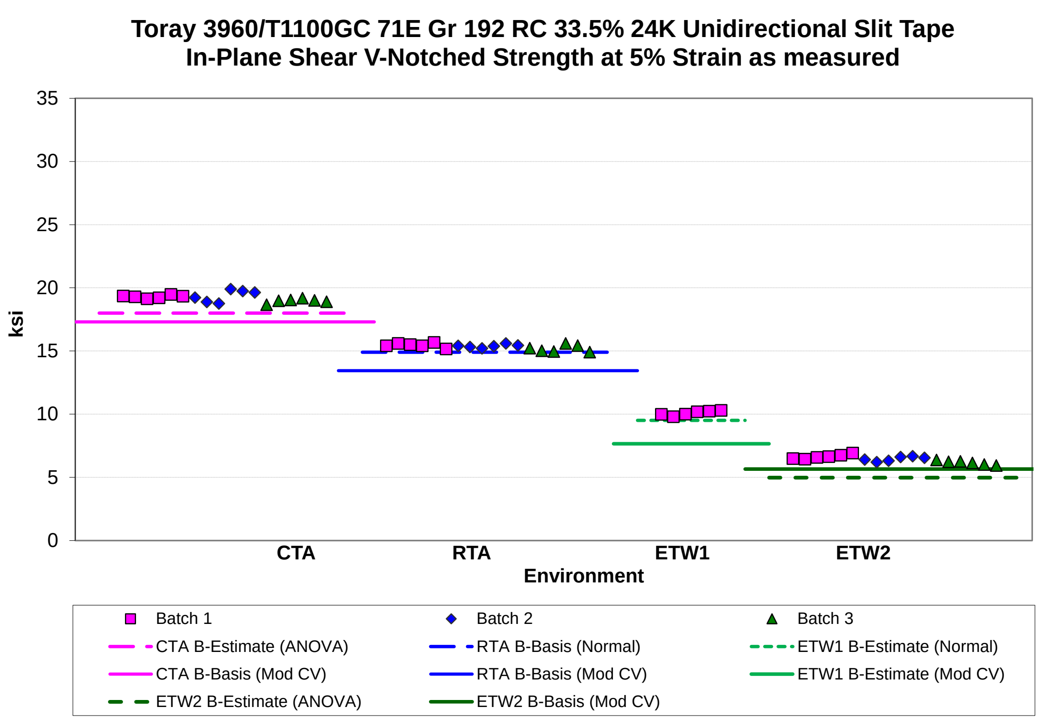

Figure 4-9: Batch Plot for VNS Strength at 5% Strain as-measured

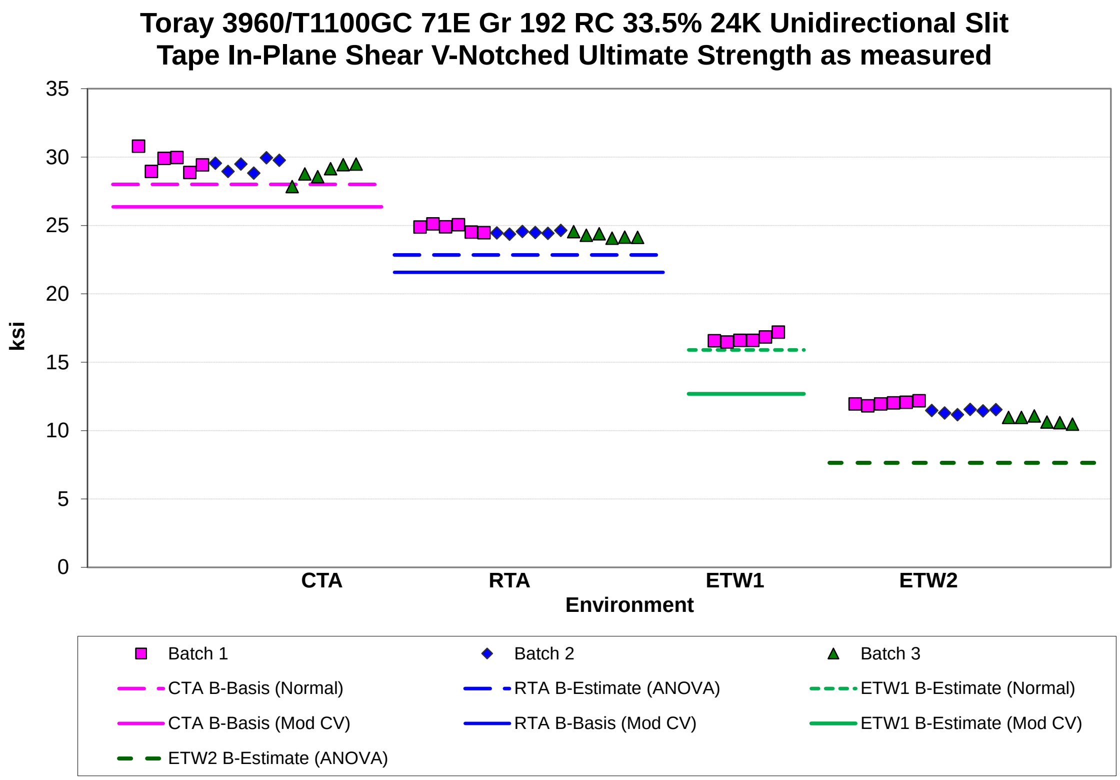

Figure 4-10: Batch Plot for VNS Ultimate Strength as-measured

In Plane Shear V-Notched Basis Values and Statistics As-measured 0.2% Offset Strength				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	11.77	9.185	6.490	4.113
Stdev	0.9755	0.1300	0.1067	0.1734
CV	8.287	1.415	1.644	4.216
Mod CV	8.287	6.000	8.000	6.108
Min	9.316	8.929	6.358	3.678
Max	12.93	9.408	6.641	4.402
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-basis Value	10.02	8.929		3.771
B-estimate			6.166	
A-estimate	8.316	8.747	5.937	3.528
Method	Weibull	Normal	Normal	Normal
Modified CV Basis Values and Estimates				
B-basis Value	NA	8.097		3.617
B-estimate			4.926	
A-estimate		7.328	3.856	3.267
Method		Normal	Normal	Normal

Table 4-15: Statistics and Basis Values for VNS 0.2% Offset Strength data

In Plane Shear V-Notched Basis Values and Statistics As-measured Strength at 5% Strain				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	19.21	15.35	10.08	6.420
Stdev	0.3338	0.2266	0.1901	0.2602
CV	1.738	1.477	1.885	4.052
Mod CV	6.000	6.000	8.000	6.026
Min	18.66	14.90	9.795	5.942
Max	19.90	15.68	10.30	6.924
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-basis Value		14.90		
B-estimate	17.99		9.507	4.984
A-estimate	17.13	14.58	9.098	3.960
Method	ANOVA	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	17.31	13.45		5.656
B-estimate			7.653	
A-estimate	16.01	12.15	5.990	5.116
Method	pooled	pooled	Normal	Normal

Table 4-16: Statistics and Basis Values for VNS Strength at 5% Strain data

In Plane Shear V-Notched Basis Values and Statistics As-measured Ultimate Strength				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	29.32	24.53	16.72	11.39
Stdev	0.6630	0.2990	0.2670	0.5422
CV	2.261	1.219	1.597	4.758
Modified CV	6.000	6.000	8.000	6.379
Min	27.85	24.08	16.48	10.47
Max	30.80	25.12	17.20	12.19
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-basis Value	28.01			
B-estimate		22.84	15.91	7.648
A-estimate	27.09	21.64	15.33	4.974
Method	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	26.37	21.57		NA
B-estimate			12.69	
A-estimate	24.36	19.56	9.931	
Method	pooled	pooled	Normal	

Table 4-17: Statistics and Basis Values for VNS Ultimate Strength data

In Plane Shear V-Notched Modulus Statistics As-measured				
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	0.8960	0.7615	0.5709	0.4036
Stdev	0.09885	0.01533	0.01188	0.01701
CV	11.03	2.013	2.081	4.214
Mod CV	11.03	6.000	8.000	6.107
Min	0.8096	0.7386	0.5559	0.3761
Max	1.230	0.7938	0.5860	0.4372
No. Batches	3	3	1	3
No. Spec.	18	18	6	18

Table 4-18: Statistics from VNS Modulus data

4.8 "25/50/25" Unnotched Tension 1 (UNT1)

The UNT1 data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. UNT1 tests were performed at four different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

The ETW2 datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Both of the ETW2 datasets passed the ADK test after the modified CV transformation, so modified CV basis values are provided for those datasets.

Pooling was appropriate for the CTA and RTA conditions for both the normalized and as-measured datasets.

There were no statistical outliers.

Statistics, basis values and estimates are given for UNT1 strength data in 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 4-11.

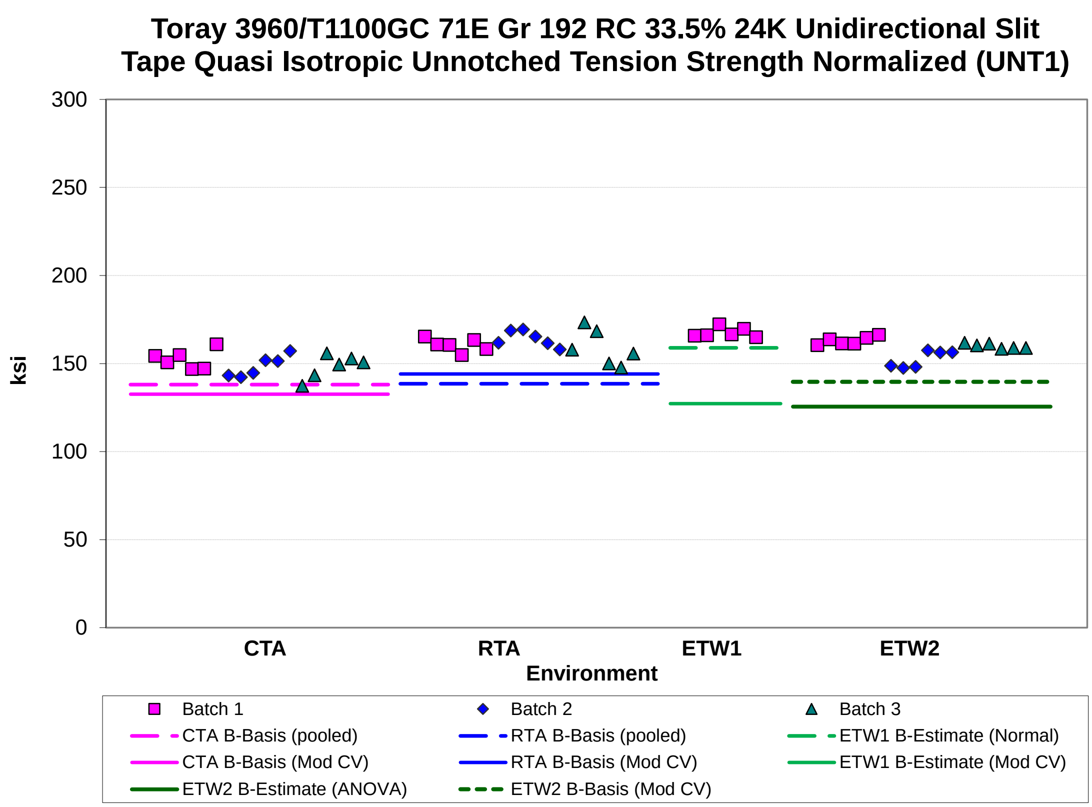

Figure 4-11: Batch Plot for UNT1 strength normalized

Unnotched Tension (UNT1) Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	149.7	161.2	167.6	158.5	149.5	160.9	168.0	158.4
Stdev	6.018	6.729	2.841	5.447	6.095	6.751	2.830	5.102
CV	4.019	4.175	1.695	3.438	4.076	4.196	1.684	3.221
Modified CV	6.010	6.087	8.000	6.000	6.038	6.098	8.000	6.000
Min	137.4	147.8	165.0	147.5	136.1	147.4	165.6	148.5
Max	161.0	173.4	172.3	166.3	161.4	171.6	172.5	166.3
No. Batches	3	3	1	3	3	3	1	3
No. Spec.	18	18	6	18	18	18	6	18
Basis Values and Estimates								
B-basis Value	138.1	149.6			137.8	149.2		
B-estimate			159.0	125.6			159.4	127.1
A-estimate	130.2	141.6	152.9	102.1	129.8	141.2	153.3	104.7
Method	pooled	pooled	Normal	ANOVA	pooled	pooled	Normal	ANOVA
Modified CV Basis Values and Estimates								
B-basis Value	132.6	144.0		139.7	132.4	143.7		139.6
B-estimate			127.2				127.5	
A-estimate	120.9	132.4	99.56	126.4	120.7	132.0	99.82	126.4
Method	pooled	pooled	Normal	Normal	pooled	pooled	Normal	Normal

Table 4-19: Statistics and Basis Values for UNT1 Strength data

Unnotched Tension (UNT1) Modulus Statistics								
	Normalized				As-measured			
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	9.265	9.122	9.007	8.626	9.253	9.106	9.031	8.625
Stdev	0.1136	0.1228	0.04639	0.1553	0.1226	0.1463	0.04643	0.1776
CV	1.226	1.347	0.5151	1.800	1.325	1.607	0.5141	2.060
Modified CV	6.000	6.000	8.000	6.000	6.000	6.000	8.000	6.000
Min	9.080	8.855	8.918	8.308	9.037	8.819	8.950	8.296
Max	9.469	9.276	9.045	8.965	9.426	9.303	9.078	8.963
No. Batches	3	3	1	3	3	3	1	3
No. Spec.	18	18	6	18	18	18	6	18

Table 4-20: Statistics from UNT1 Modulus data

4.9 “10/80/10” Unnotched Tension 2 (UNT2)

The UNT2 data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. UNT2 tests were performed at three different environmental conditions.

The CTA datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Both of the CTA datasets passed the ADK test after the modified CV transformation, so modified CV basis values are provided for those datasets.

The ETW2 datasets, both normalized and as-measured, failed the normality test, but the Weibull distribution had an adequate fit, so design values were computed using the Weibull distribution. After the modified CV transformation of the data, these datasets passed the normality test so modified CV basis values are provided. Pooling was appropriate for all three conditions for modified CV basis values for both the normalized and as-measured datasets.

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

Statistics, basis values and estimates are given for UNT2 strength data in Table 4-21 and for the modulus data in Table 4-22. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-12.

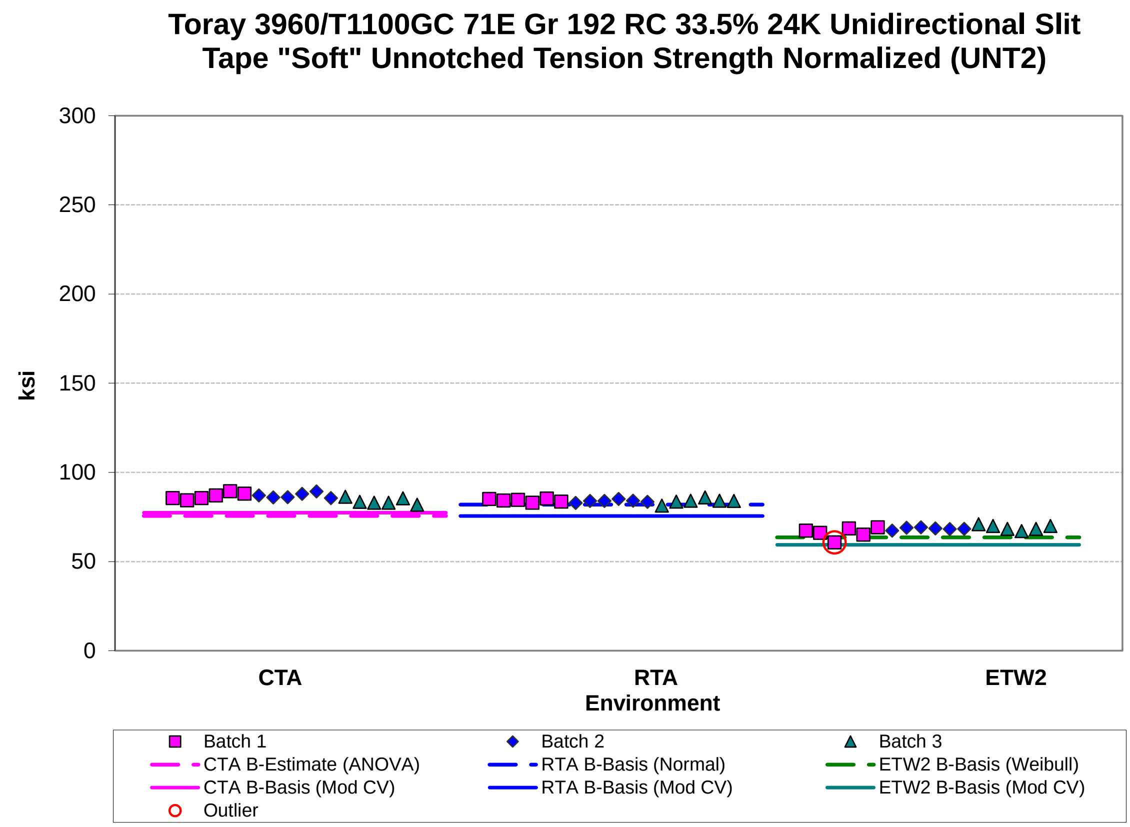

Figure 4-12: Batch Plot for UNT2 strength normalized

Unnotched Tension (UNT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	85.87	84.03	67.92	85.69	83.76	67.84
Stdev	2.153	1.030	2.262	2.451	1.196	2.141
CV	2.508	1.225	3.331	2.860	1.428	3.157
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	81.84	81.41	60.80	81.36	80.60	60.84
Max	89.50	85.95	70.98	89.79	85.41	70.26
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-basis Value		82.00	63.57		81.40	64.12
B-estimate	75.66			72.33		
A-estimate	68.38	80.56	58.88	62.80	79.72	60.03
Method	ANOVA	Normal	Weibull	ANOVA	Normal	Weibull
Modified CV Basis Values and Estimates						
B-basis Value	77.40	75.56	59.45	77.24	75.31	59.39
A-estimate	71.75	69.92	53.81	71.61	69.68	53.75
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-21: Statistics and Basis Values for UNT2 Strength data

Unnotched Tension (UNT2) Modulus Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	5.909	5.669	4.464	5.897	5.651	4.459
Stdev	0.1378	0.08138	0.06625	0.1625	0.08926	0.06361
CV	2.333	1.435	1.484	2.756	1.580	1.426
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	5.650	5.516	4.348	5.588	5.511	4.347
Max	6.235	5.816	4.602	6.255	5.813	4.555
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-22: Statistics from UNT2 Modulus data

4.10 “50/40/10” Unnotched Tension 3 (UNT3)

The UNT3 data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. UNT3 tests were performed at three different environmental conditions.

The as-measured ETW2 dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. This dataset passed the ADK test after the modified CV transformation, so modified CV basis values are provided for that dataset.

The normalized RTA dataset failed the normality test, but the Weibull distribution had an adequate fit, so design values were computed using the Weibull distribution. After the modified CV transformation of the data, this dataset passed the normality test so modified CV basis values are provided.

The normalized CTA dataset failed all three distribution tests, requiring the non-parametric approach to compute design values. After the modified CV transformation of the data, this dataset did not pass the normality test so modified CV basis values are not provided.

After the modified CV transformation of the normalized ETW2 dataset, this dataset did not pass the normality test so modified CV basis values are not provided.

Pooling was appropriate for the as-measured CTA and RTA datasets.

There were two statistical outliers. The largest value in batch two of the CTA condition was an outlier for batch two but not for the CTA condition. The lowest value in batch two of the RTA condition was an outlier for both batch two and the RTA condition. Those outliers were for both the normalized and as-measured datasets. Both outliers were retained for this analysis.

Statistics and basis values are given for UNT3 strength data in Table 4-23 and for the modulus data in Table 4-24. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-13.

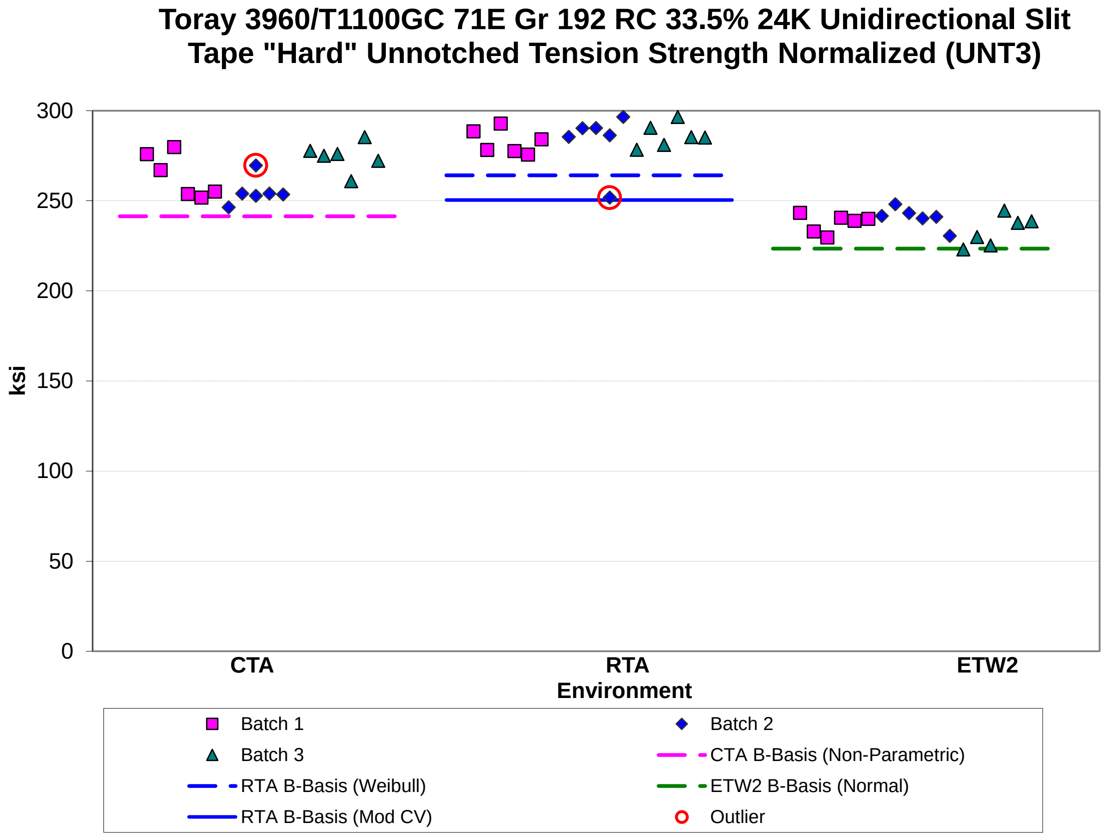

Figure 4-13: Batch Plot for UNT3 strength normalized

Unnotched Tension (UNT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (−65°F)	RTA (70°F)	ETW2 (250°F)	CTA (−65°F)	RTA (70°F)	ETW2 (250°F)
Mean	264.5	284.1	237.2	263.3	282.7	236.4
Stdev	12.11	10.20	6.982	11.09	9.988	7.318
CV	4.581	3.589	2.944	4.211	3.533	3.096
Modified CV	6.290	6.000	6.000	6.106	6.000	6.000
Min	246.4	251.8	223.1	247.4	252.2	221.7
Max	285.3	296.5	248.1	282.0	296.8	248.1
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-basis Value	241.4	264.1	223.4	244.1	263.5	
B-estimate						208.1
A-estimate	197.8	242.8	213.6	231.0	250.4	187.9
Method	Non-Parm.	Weibull	Normal	pooled	pooled	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	NA	250.5	NA	233.2	252.6	208.4
A-estimate		226.7		212.8	232.1	188.6
Method		Normal		pooled	pooled	Normal

Table 4-23: Statistics and Basis Values for UNT3 Strength data

Unnotched Tension (UNT3) Modulus Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	14.52	14.34	14.09	14.46	14.26	14.05
Stdev	0.1544	0.1281	0.2426	0.1825	0.1429	0.2616
CV	1.064	0.8935	1.721	1.262	1.002	1.862
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	14.20	14.09	13.67	14.05	13.99	13.66
Max	14.82	14.57	14.51	14.74	14.45	14.43
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-24: Statistics from UNT3 Modulus data

4.11 "33/0/67" Unnotched Compression 0/90 (UNC0)

The UNC0 data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. UNC0 tests were performed at six different environmental conditions. The ETA1, ETA2 and ETW1 conditions only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for those conditions.

The RTA and ETW2 datasets, both normalized and as-measured, did not have an adequate fit to the normal distribution. The Weibull distribution was used to compute the basis values. After the transformation of data to fit the assumptions of the modified CV method, those datasets all passed the normality test so modified CV basis values are provided.

The CTA dataset, both normalized and as-measured, failed all three distribution tests, requiring the non-parametric approach to compute design values.

The CTA, ETA2 and ETW2 datasets, both normalized and as-measured, had a CV. higher than 8%, so modified CV basis values could not be provided for those datasets.

There were three outliers. The lowest value in batch three of the CTA condition was an outlier for both batch three and the CTA condition. The lowest value in batch one of the ETW2 condition was an outlier for the batch one but not for the ETW2 condition. The lowest value in batch three of the ETW2 condition was an outlier for the ETW2 condition but not for the batch three. All three outliers were outliers for both the normalized and as-measured datasets. All three outliers were retained for this analysis.

Statistics and estimates of basis values are given for the normalized strength data in Table 4-25, the as-measured strength data in Table 4-26, for the normalized modulus data in Table 4-27 and for the as-measured modulus data in Table 4-28. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-14.

Toray 3960/T1100GC 71E Gr 192 RC 33.5% 24K Unidirectional Slit Tape Unnotched Compression 0/90 Strength Normalized (UNC0)

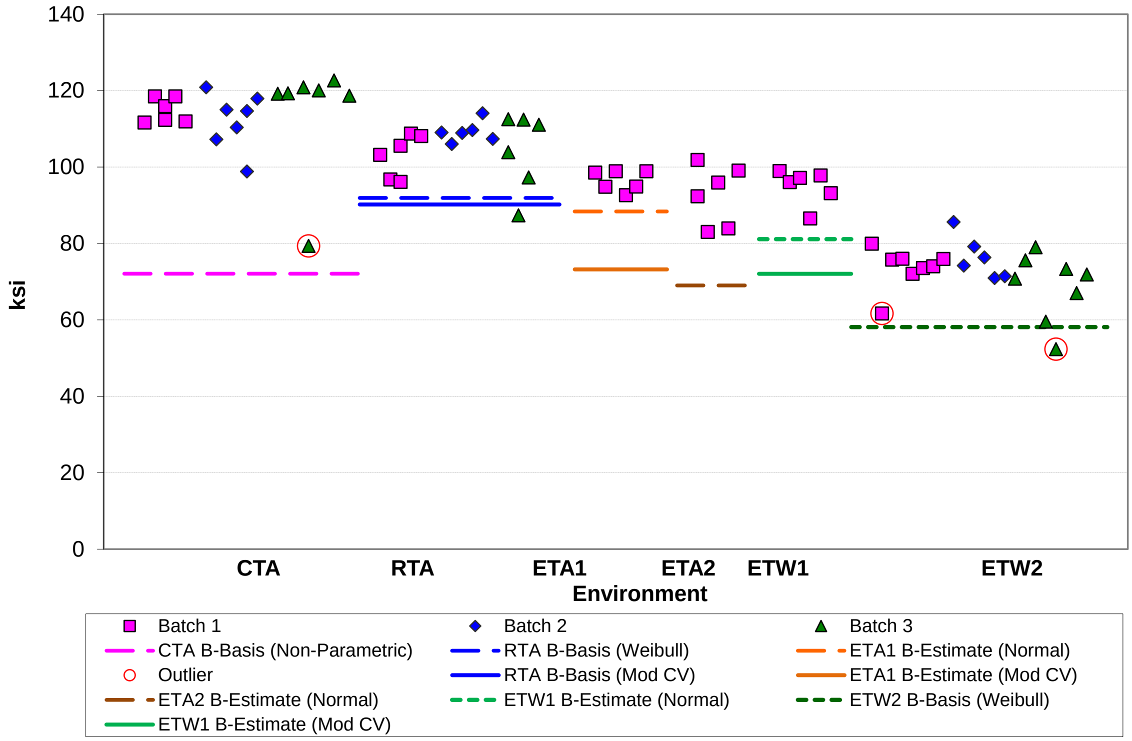

Figure 4-14: Batch Plot for UNC0 strength normalized

Unnotched Compression 0/90 (UNC0) Strength Basis Values and Statistics Normalized						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	113.7	105.4	96.45	92.70	94.93	72.55
Stdev	9.844	6.998	2.670	7.812	4.560	7.267
CV	8.659	6.637	2.768	8.427	4.803	10.02
Modified CV	8.659	7.319	8.000	8.427	8.000	10.02
Min	79.36	87.36	92.65	83.03	86.54	52.35
Max	122.6	114.1	98.92	101.9	98.92	85.64
No. Batches	3	3	1	1	1	3
No. Spec.	20	18	6	6	6	22
Basis Values and Estimates						
B-basis Value	72.10	91.89				58.10
B-estimate			88.36	69.04	81.12	
A-estimate	43.78	78.40	82.61	52.22	71.30	45.05
Method	Non-Parm.	Weibull	Normal	Normal	Normal	Weibull
Modified CV Basis Values and Estimates						
B-basis Value	NA	90.21		NA		NA
B-estimate			73.20		72.05	
A-estimate		79.43	57.30		56.40	
Method		Normal	Normal		Normal	

Table 4-25: Statistics and Basis Values for UNC0 Strength data Normalized

Unnotched Compression 0/90 (UNC0) Strength Basis Values and Statistics As-measured						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	113.4	105.4	96.70	93.24	95.24	72.52
Stdev	9.721	7.617	2.533	7.969	3.878	7.458
CV	8.575	7.227	2.619	8.547	4.071	10.28
Modified CV	8.575	7.613	8.000	8.547	8.000	10.28
Min	79.33	86.63	93.94	82.39	88.35	51.70
Max	121.3	113.7	100.6	101.5	99.77	86.12
No. Batches	3	3	1	1	1	3
No. Spec.	20	18	6	6	6	22
Basis Values and Estimates						
B-basis Value	72.06	91.02				57.81
B-estimate			89.03	69.10	83.50	
A-estimate	44.42	76.80	83.58	51.94	75.15	44.60
Method	Non-Parm.	Weibull	Normal	Normal	Normal	Weibull
Modified CV Basis Values and Estimates						
B-basis Value	NA	89.56		NA		NA
B-estimate			73.40		72.29	
A-estimate		78.35	57.45		56.58	
Method		Normal	Normal		Normal	

Table 4-26: Statistics and Basis Values for UNC0 Strength data As-measured

Unnotched Compression 0/90 (UNC0) Modulus Statistics Normalized						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	8.023	8.033	7.903	7.979	8.202	8.231
Stdev	0.3060	0.1682	0.1185	0.1900	0.1044	0.2513
CV	3.813	2.094	1.499	2.381	1.273	3.053
Mod CV	6.000	6.000	8.000	8.000	8.000	6.000
Min	7.464	7.780	7.704	7.752	8.087	7.778
Max	8.694	8.294	8.054	8.307	8.352	8.559
No. Batches	3	3	1	1	1	3
No. Spec.	19	18	6	6	6	18

Table 4-27: Statistics from UNC0 Modulus data Normalized

Unnotched Compression 0/90 (UNC0) Modulus Statistics As-measured						
Env	CTA (− 65°F)	RTA (70°F)	ETA1 (180°F)	ETA2 (250°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	8.000	8.028	7.924	8.024	8.231	8.231
Stdev	0.3484	0.1863	0.1430	0.1293	0.1310	0.2116
CV	4.355	2.321	1.805	1.612	1.591	2.570
Mod CV	6.178	6.000	8.000	8.000	8.000	6.000
Min	7.462	7.759	7.762	7.855	7.994	7.917
Max	8.976	8.343	8.091	8.243	8.361	8.548
No. Batches	3	3	1	1	1	3
No. Spec.	19	18	6	6	6	18

Table 4-28: Statistics from UNC0 Modulus data As-measured

4.12 “25/50/25” Unnotched Compression 1 (UNC1)

The UNC1 data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. UNC1 tests were performed at three different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

All three conditions met the requirements for pooling for both the normalized and as-measured datasets

There were no statistical outliers.

Statistics, basis values and estimates are given for UNC1 strength data in Table 4-29 and for the modulus data in Table 4-30. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-15.

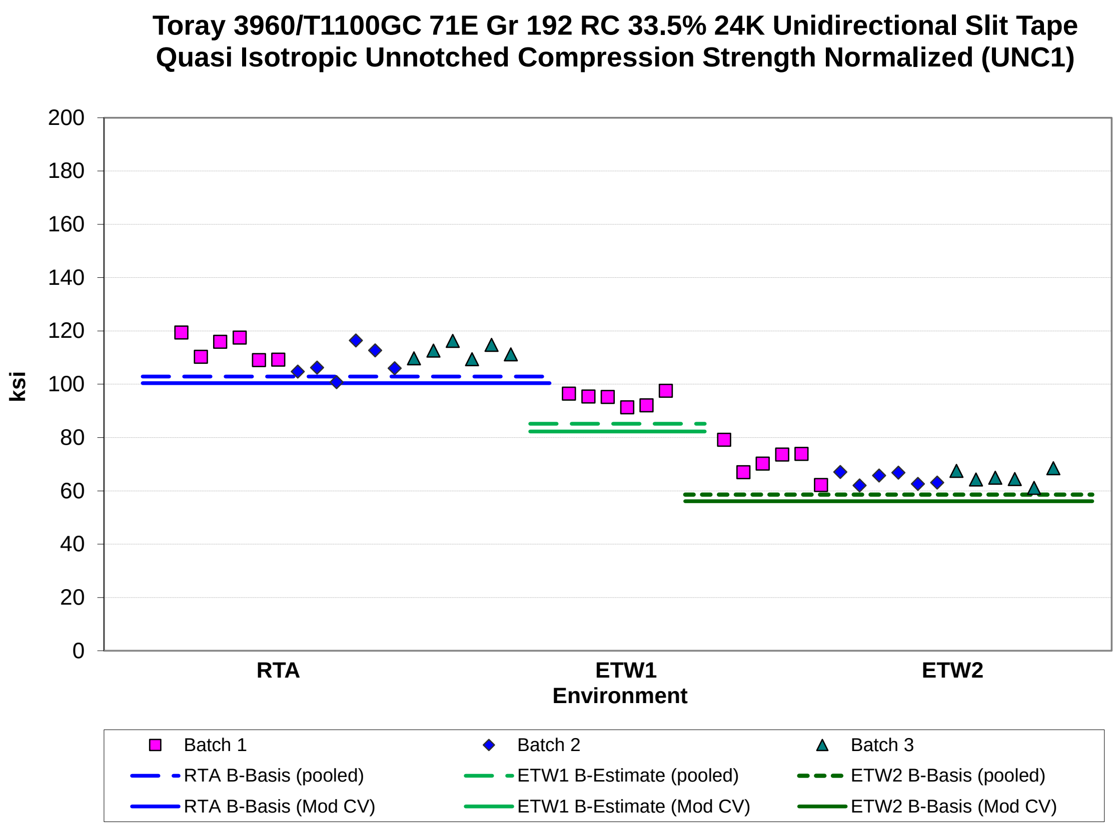

Figure 4-15: Batch plot for UNC1 strength normalized

Unnotched Compression (UNC1) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	111.2	94.69	66.92	111.1	94.98	66.87
Stdev	4.934	2.454	4.784	4.905	2.320	4.944
CV	4.435	2.591	7.149	4.415	2.443	7.393
Modified CV	6.218	8.000	7.574	6.207	8.000	7.696
Min	100.8	91.32	61.16	101.5	91.64	60.69
Max	119.4	97.52	79.19	118.9	97.74	79.35
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and Estimates						
B-basis Value	102.9		58.59	102.7		58.45
B-estimate		85.14			85.33	
A-estimate	97.29	79.70	52.96	97.00	79.83	52.76
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	100.4		56.08	100.2		56.00
B-estimate		82.26			82.51	
A-estimate	93.08	75.17	48.75	92.88	75.40	48.64
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-29: Statistics and Basis Values for UNC1 Strength data

Unnotched Compression (UNC1) Modulus Statistics						
	Normalized			As-measured		
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	8.088	7.839	7.810	8.078	7.864	7.804
Stdev	0.1448	0.08973	0.1664	0.1733	0.09751	0.1776
CV	1.791	1.145	2.130	2.145	1.240	2.276
Modified CV	6.000	8.000	6.000	6.000	8.000	6.000
Min	7.726	7.695	7.413	7.696	7.703	7.446
Max	8.293	7.969	8.048	8.302	7.998	8.074
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18

Table 4-30: Statistics from UNC1 Modulus data

4.13 "10/80/10" Unnotched Compression 2 (UNC2)

The UNC2 data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. UNC2 tests were performed at two different environmental conditions.

The normalized ETW2 datasets, both normalized and as-measured, failed the normality test, but the Weibull distribution had an adequate fit, so design values were computed using the Weibull distribution. After the modified CV transformation of the data, this dataset passed the normality test so modified CV basis values are provided. Pooling the RTA and ETW2 datasets was appropriate for the modified CV basis value computations.

There were no statistical outliers.

Statistics and basis values are given for UNC2 strength data in Table 4-31 and for the modulus data in Table 4-32. The normalized data and the B-basis values are shown graphically in Figure 4-16.

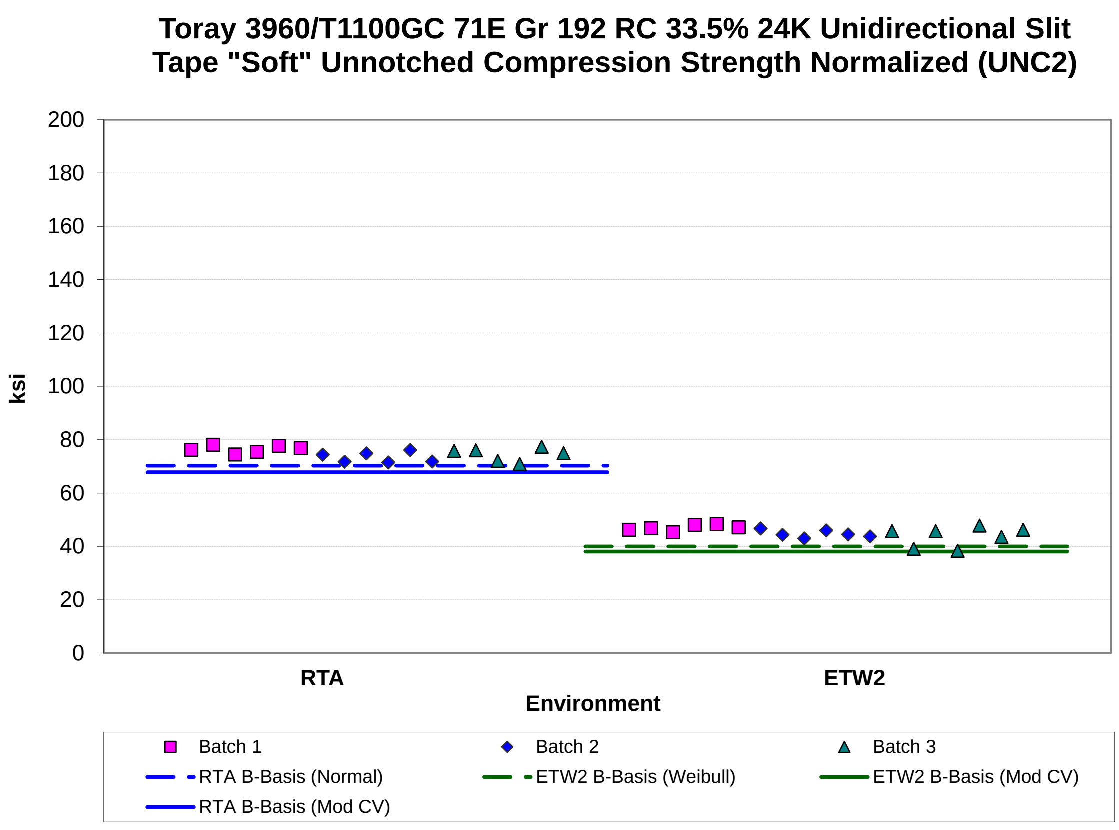

Figure 4-16: Batch plot for UNC2 strength normalized

Unnotched Compression (UNC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	74.78	45.09	74.72	45.10
Stdev	2.291	2.711	2.368	2.791
CV	3.064	6.013	3.169	6.189
Modified CV	6.000	7.006	6.000	7.094
Min	70.86	38.33	70.72	38.22
Max	78.12	48.42	78.56	48.66
No. Batches	3	3	3	3
No. Spec.	18	19	18	19
Basis Values and Estimates				
B-basis Value	70.26	39.96	70.04	39.72
A-estimate	67.05	34.74	66.73	34.30
Method	Normal	Weibull	Normal	Weibull
Modified CV Basis Values and Estimates				
B-basis Value	67.77	38.11	67.67	38.09
A-estimate	63.00	33.33	62.89	33.30
Method	pooled	pooled	pooled	pooled

Table 4-31: Statistics and Basis Values for UNC2 Strength data

Unnotched Compression (UNC2) Modulus Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	5.046	4.365	5.041	4.367
Stdev	0.09109	0.1250	0.08613	0.1292
CV	1.805	2.862	1.709	2.958
Modified CV	6.000	6.000	6.000	6.000
Min	4.866	4.153	4.881	4.131
Max	5.187	4.654	5.182	4.659
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-32: Statistics from UNC2 Modulus data

4.14 “50/40/10” Unnotched Compression 3 (UNC3)

The UNC3 data is normalized, so both normalized and as-measured values are provided. Data is available for two properties, strength and modulus. UNC3 tests were performed at two different environmental conditions.

The ETW2 datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. These datasets did not pass the ADK test after the modified CV transformation, so modified CV basis values are not provided for that dataset.

There were two statistical outliers. The lowest value in batch one of the RTA condition is an outlier for batch one but not for the RTA condition. The largest value in batch three of the ETW2 condition is an outlier for batch three but not for the ETW2 condition. Those outliers were for both the normalized and as-measured datasets. Both outliers were retained for this analysis.

Statistics, basis values and estimates are given for UNC3 strength data in Table 4-33 and for the modulus data in Table 4-34. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-17.

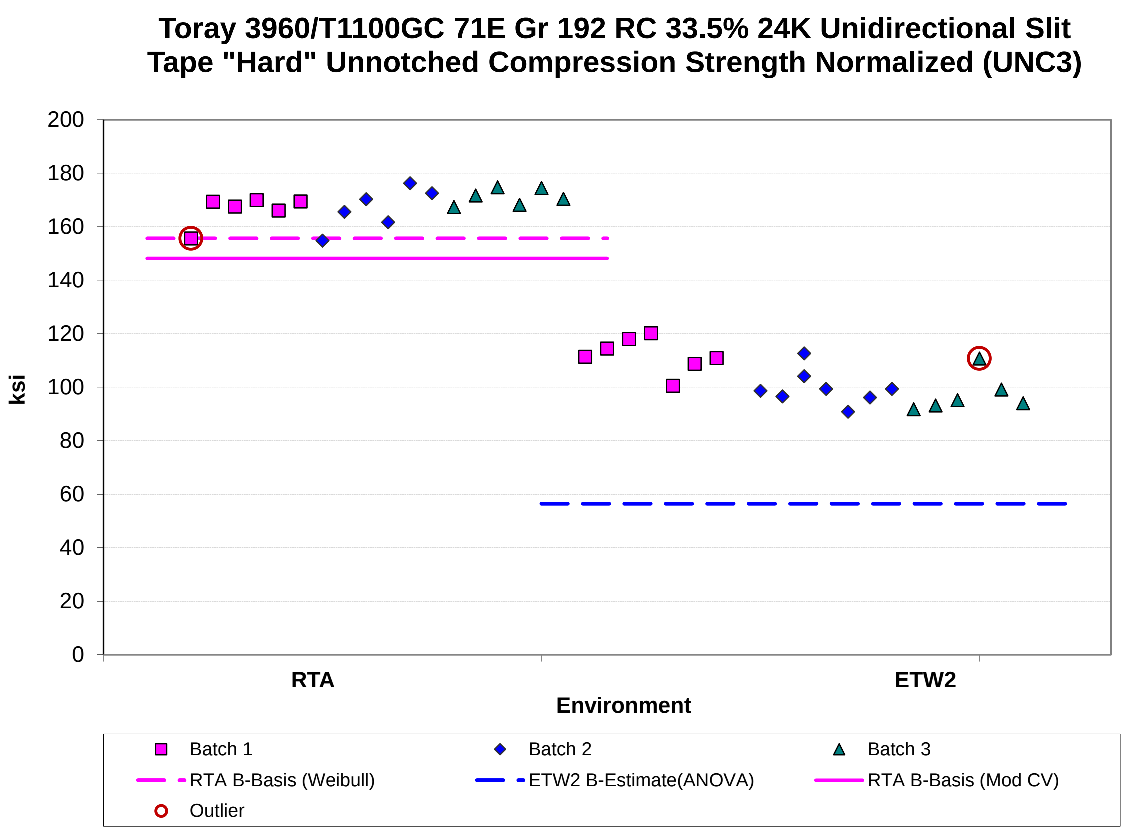

Figure 4-17: Batch plot for UNC3 strength normalized

Unnotched Compression (UNC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	168.1	103.1	167.6	102.8
Stdev	5.873	9.052	6.326	8.788
CV	3.494	8.777	3.774	8.546
Modified CV	6.000	8.777	6.000	8.546
Min	154.7	90.82	154.0	90.97
Max	176.2	120.2	177.6	119.8
No. Batches	3	3	3	3
No. Spec.	18	21	18	21
Basis Values and Estimates				
B-basis Value	155.7		155.1	
B-estimate		56.45		57.99
A-estimate	142.5	23.12	146.3	25.98
Method	Weibull	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	148.2	NA	147.7	NA
A-estimate	134.1		133.7	
Method	Normal		Normal	

Table 4-33: Statistics and Basis Values for UNC3 Strength data

Unnotched Compression (UNC3) Modulus Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	12.53	12.64	12.50	12.61
Stdev	0.1093	0.4571	0.1513	0.4759
CV	0.8722	3.616	1.211	3.773
Modified CV	6.000	6.000	6.000	6.000
Min	12.24	11.95	12.19	11.99
Max	12.73	14.31	12.75	14.38
No. Batches	3	3	3	3
No. Spec.	18	21	18	21

Table 4-34: Statistics from UNC3 Modulus data

4.15 “25/50/25” Laminate Short-Beam Strength (SBS1)

The SBS1 data is not normalized, only as-measured values are provided. Data is available for only one property, strength. SBS1 tests were performed at three different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for those conditions.

The ETW2 dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. This dataset did not pass the ADK test after the modified CV transformation, so modified CV basis values are not provided for that dataset.

There was one outlier. The lowest value in batch two of the RTA condition was an outlier for both batch two and the RTA condition. It was retained for this analysis.

Statistics, estimates and basis values are given for SBS1 strength data in Table 4-35. The as-measured data, B-estimates and the B-basis values are shown graphically in Figure 4-18.

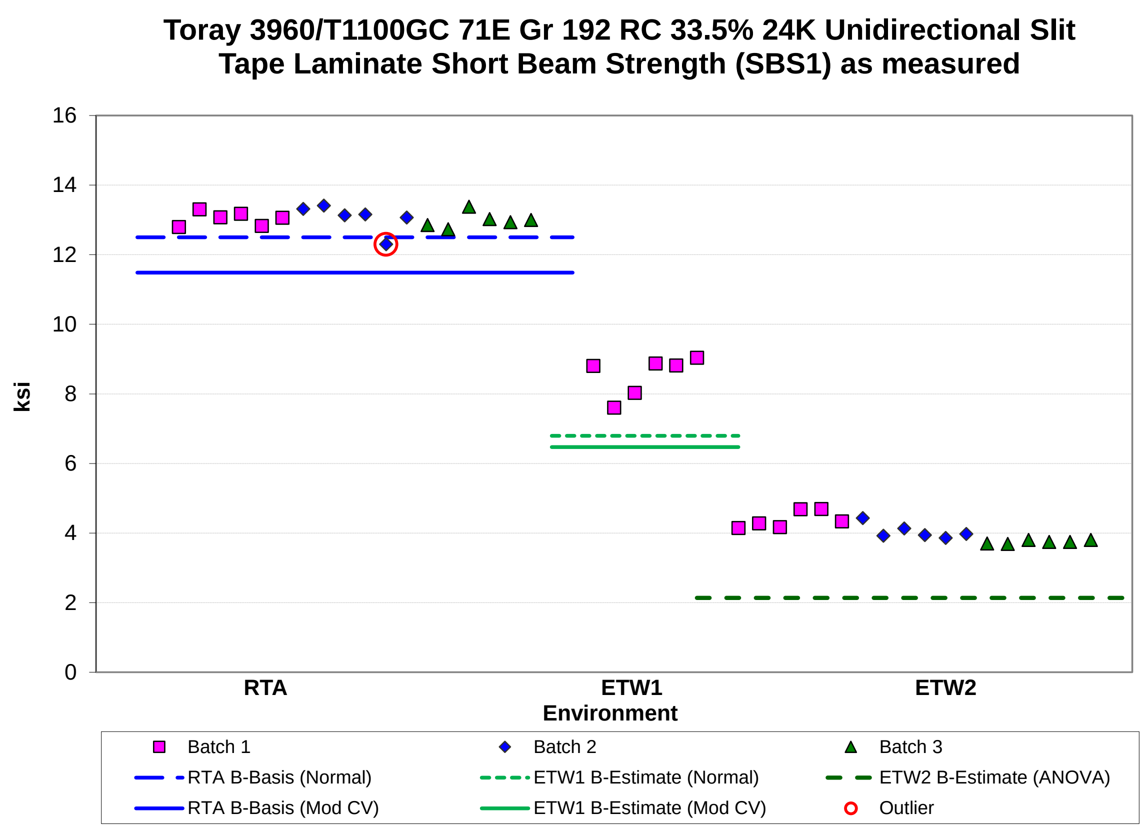

Figure 4-18: Batch plot for SBS1 strength as-measured

Laminate Short Beam Strength (SBS1) Basis Values and Statistics As-measured			
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	13.03	8.527	4.059
Stdev	0.2699	0.5727	0.3212
CV	2.072	6.716	7.913
Modified CV	6.000	8.000	7.957
Min	12.30	7.604	3.687
Max	13.41	9.036	4.690
No. Batches	3	1	3
No. Spec.	18	6	18
Basis Values and Estimates			
B-basis Value	12.50		
B-estimate		6.792	2.135
A-estimate	12.12	5.559	0.7625
Method	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates			
B-basis Value	11.49		NA
B-estimate		6.472	
A-estimate	10.39	5.066	
Method	Normal	Normal	

Table 4-35: Statistics and Basis Values for SBS1 Strength data

4.16 “25/50/25” Open-Hole Tension 1 (OHT1)

The OHT1 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. OHT1 tests were performed at four different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

The CTA and RTA conditions could be pooled for the as-measured datasets but not for the normalized datasets due to a failure of Levene’s test. The CTA and RTA conditions could be pooled for both normalized and as-measured datasets for the modified CV computations.

There were no statistical outliers.

Statistics, basis values and estimates are given for OHT1 strength data in Table 4-36. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-19.

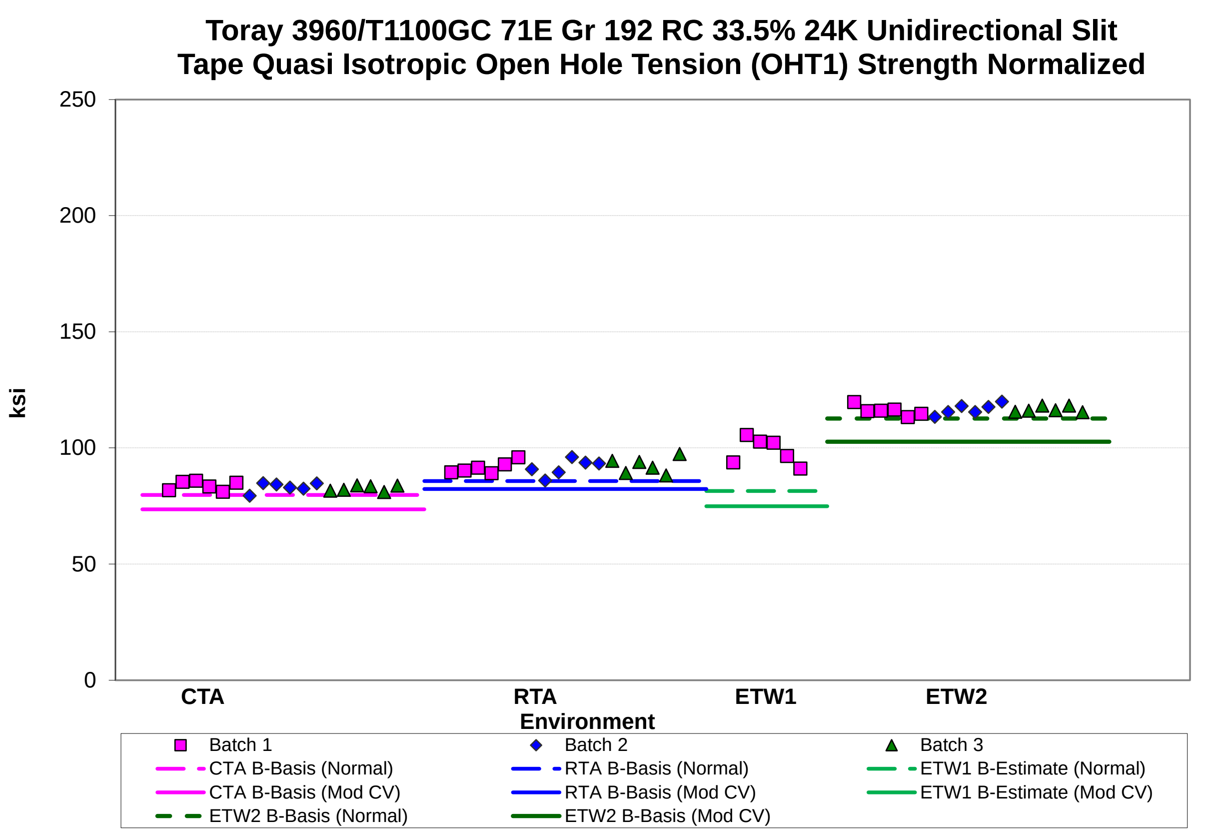

Figure 4-19: Batch Plot for OHT1 strength normalized

Open Hole Tension (OHT1) Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	83.15	91.82	98.66	116.4	83.02	91.68	98.88	116.4
Stdev	1.756	3.068	5.692	1.897	1.867	2.855	5.805	1.840
CV	2.112	3.341	5.769	1.630	2.249	3.114	5.870	1.581
Modified CV	6.000	6.000	8.000	6.000	6.000	6.000	8.000	6.000
Min	79.39	85.99	91.13	113.2	79.70	86.34	91.35	113.8
Max	85.83	97.38	105.6	120.0	86.11	96.66	105.7	119.9
No. Batches	3	3	1	3	3	3	1	3
No. Spec.	18	18	6	18	18	18	6	18
Basis Values and Estimates								
B-basis Value	79.68	85.77		112.7	78.63	87.29		112.7
B-estimate			81.42				81.30	
A-estimate	77.23	81.48	69.17	110.0	75.64	84.30	68.80	110.2
Method	Normal	Normal	Normal	Normal	pooled	pooled	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	73.58	82.25		102.6	73.46	82.12		102.6
B-estimate			74.89				75.05	
A-estimate	67.06	75.74	58.62	92.86	66.96	75.62	58.75	92.84
Method	pooled	pooled	Normal	Normal	pooled	pooled	Normal	Normal

Table 4-36: Statistics and Basis Values for OHT1 Strength data

4.17 “10/80/10” Open-Hole Tension 2 (OHT2)

The OHT2 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. OHT2 tests were performed at three different environmental conditions.

The CTA and RTA conditions could be pooled for the normalized datasets but the ETW2 condition could not be included due to a failure of the normality test for the pooled dataset. All three conditions could be pooled for the normalized modified CV computations. All three conditions met the requirements for pooling for the as-measured datasets.

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

Statistics, basis values and estimates are given for OHT2 strength data in Table 4-37. The normalized data and the B-basis values are shown graphically in Figure 4-20.

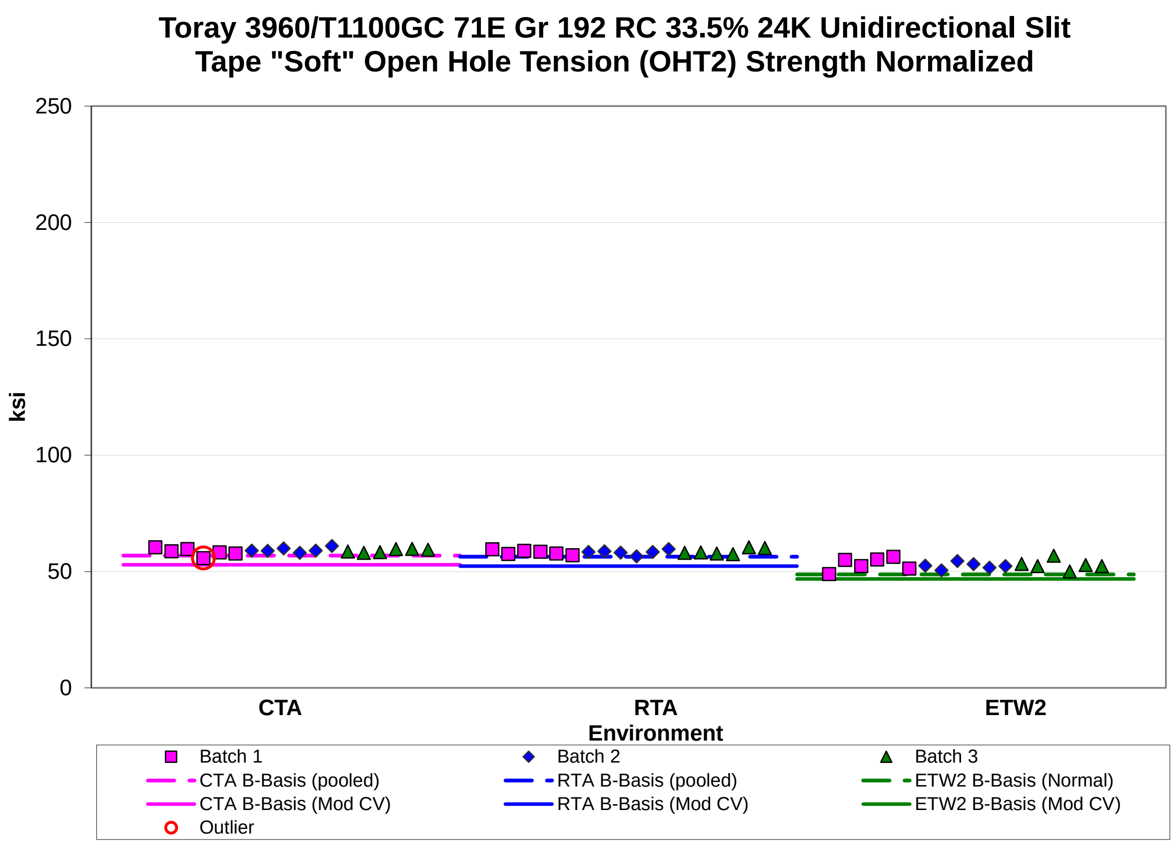

Figure 4-20: Batch Plot for OHT2 strength normalized

Open Hole Tension (OHT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	58.92	58.42	52.89	58.83	58.34	52.80
Stdev	1.161	1.054	2.096	1.177	1.126	2.054
CV	1.970	1.805	3.963	2.000	1.931	3.890
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	55.82	56.52	48.96	56.13	56.51	49.18
Max	60.97	60.46	56.83	60.89	60.55	56.55
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-basis Value	56.90	56.40	48.75	56.15	55.66	50.12
A-estimate	55.53	55.02	45.82	54.36	53.87	48.34
Method	pooled	pooled	Normal	pooled	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	52.89	52.38	46.85	52.80	52.31	46.78
A-estimate	48.86	48.35	42.83	48.78	48.29	42.76
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-37: Statistics and Basis Values for OHT2 Strength data

4.18 “50/40/10” Open-Hole Tension 3 (OHT3)

The OHT3 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. OHT3 tests were performed at three different environmental conditions.

All three conditions met the requirements for pooling for both the normalized and as-measured datasets.

There were no statistical outliers.

Statistics, basis values and estimates are given for OHT3 strength data in Table 4-38. The normalized data and B-basis values are shown graphically in Figure 4-21.

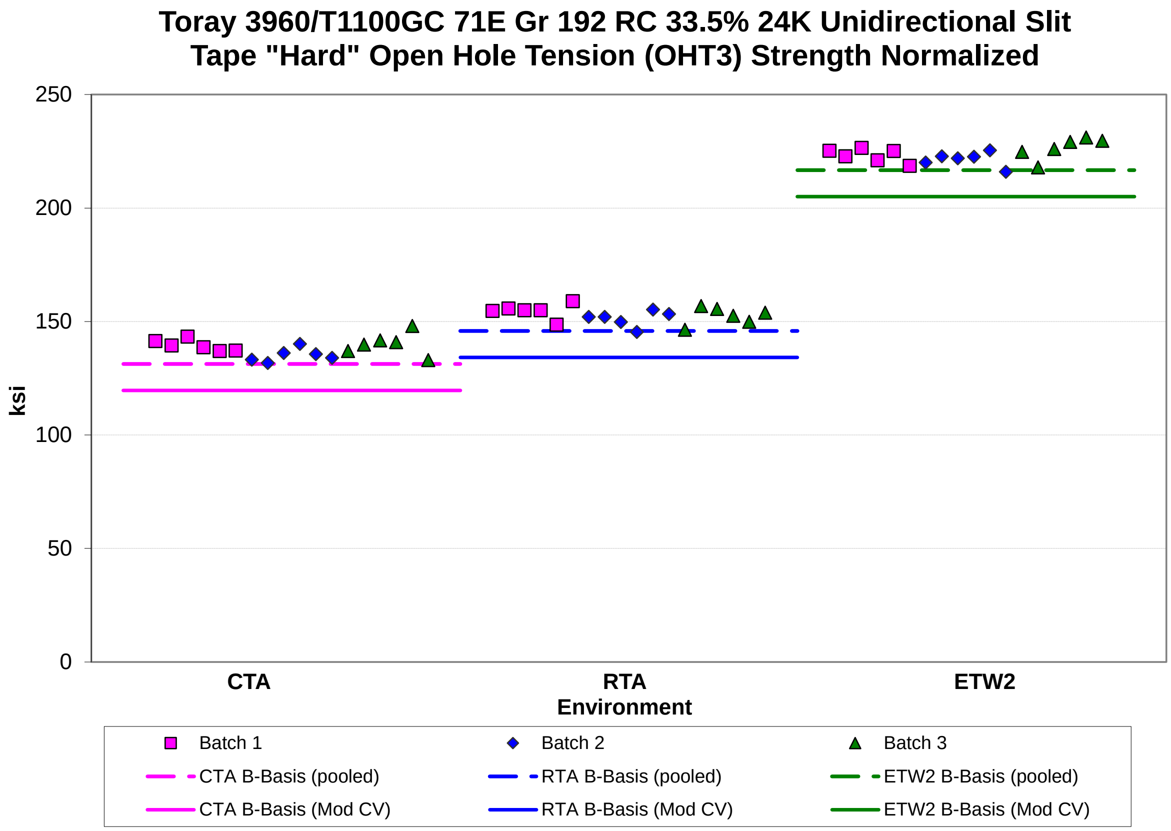

Figure 4-21: Batch Plot for OHT3 strength normalized

Open Hole Tension (OHT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	138.3	152.8	223.7	137.2	151.7	222.1
Stdev	4.107	3.617	4.118	3.813	3.819	3.245
CV	2.971	2.367	1.841	2.779	2.517	1.461
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	131.8	145.4	215.9	130.6	144.4	216.1
Max	148.1	159.0	231.1	145.3	159.4	227.5
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Value Estimates						
B-basis Value	131.3	145.8	216.7	130.8	145.3	215.7
A-estimate	126.6	141.2	212.0	126.5	141.0	211.4
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	119.6	134.2	205.0	118.7	133.2	203.6
A-estimate	107.2	121.7	192.6	106.4	120.8	191.2
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-38: Statistics and Basis Values for OHT3 Strength data

4.19 “25/50/25” Filled-Hole Tension 1 (FHT1)

The FHT1 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. FHT1 tests were performed at four different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

All conditions met the requirements for pooling for both the normalized and as-measured datasets.

There were no statistical outliers.

Statistics, estimates and basis values are given for FHT1 strength data in Table 4-39. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-22.

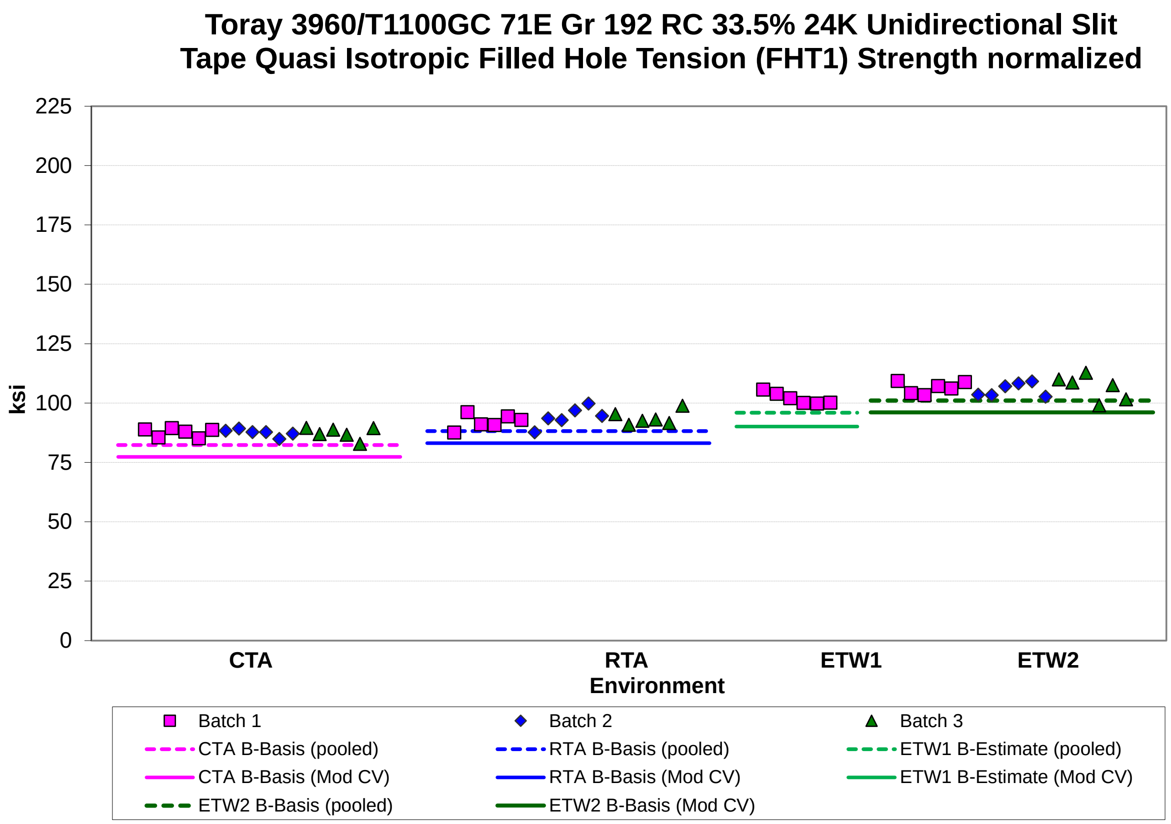

Figure 4-22: Batch plot for FHT1 strength normalized

Filled-Hole Tension (FHT1) Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	87.50	93.35	101.9	106.3	87.53	93.29	102.1	106.2
Stdev	1.885	3.312	2.402	3.508	1.955	3.171	2.507	3.372
CV	2.155	3.548	2.357	3.302	2.233	3.399	2.455	3.175
Modified CV	6.000	6.000	8.000	6.000	6.000	6.000	8.000	6.000
Min	82.79	87.61	99.75	99.08	83.22	87.87	99.89	98.76
Max	89.52	99.75	105.6	112.8	90.30	99.75	106.0	112.1
No. Batches	3	3	1	3	3	3	1	3
No. Spec.	18	18	6	18	18	18	6	18
Basis Values and Estimates								
B-basis Value	82.32	88.16		101.1	82.48	88.24		101.1
B-estimate			95.93				96.31	
A-estimate	78.87	84.72	92.58	97.62	79.12	84.88	93.05	97.78
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates								
B-basis Value	77.30	83.14		96.05	77.33	83.09		95.99
B-estimate			90.14				90.37	
A-estimate	70.51	76.36	83.54	89.26	70.55	76.30	83.77	89.20
Method	pooled	pooled	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-39: Statistics and Basis Values for FHT1 Strength data

4.20 “10/80/10” Filled-Hole Tension 2 (FHT2)

The FHT2 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. FHT2 tests were performed at three different environmental conditions.

All three conditions met the requirements for pooling for both the normalized and as-measured datasets.

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

Statistics and basis values are given for FHT2 strength data in Table 4-40. The normalized data and the B-basis values are shown graphically in Figure 4-23.

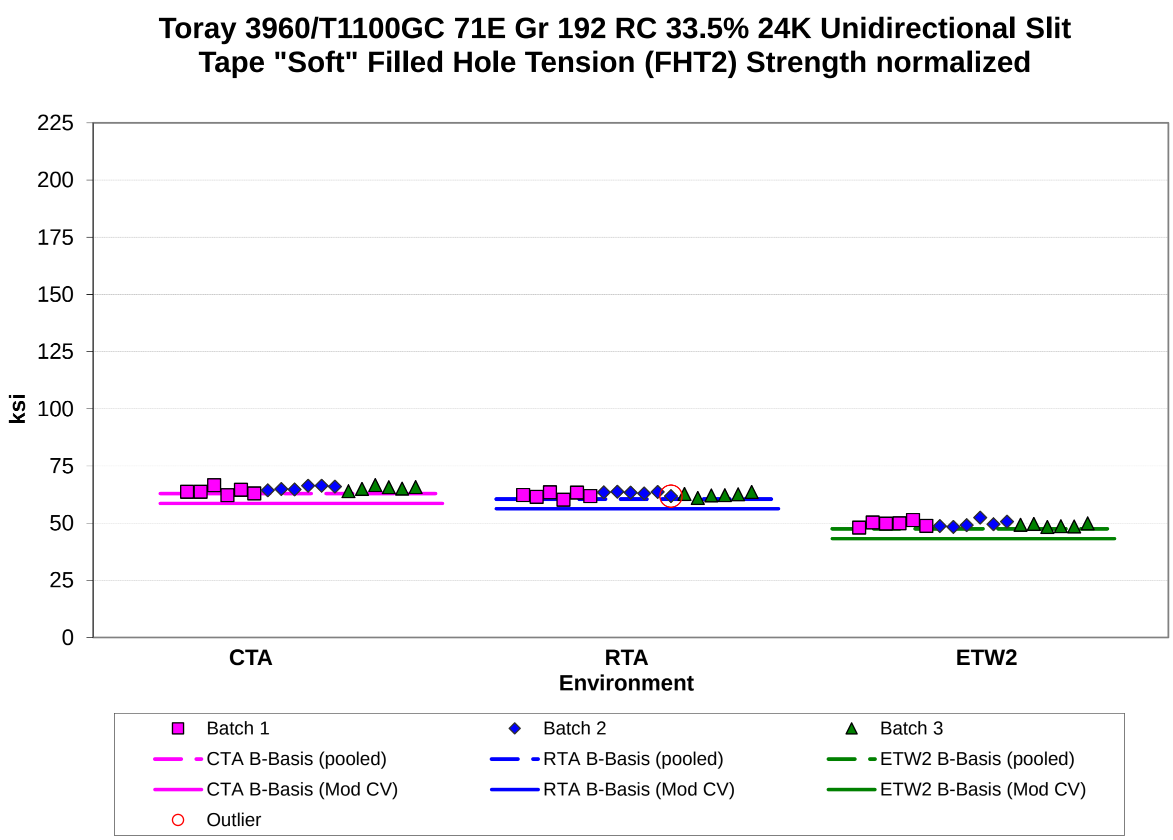

Figure 4-23: Batch plot for FHT2 strength normalized

Filled-Hole Tension (FHT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	64.96	62.59	49.55	64.82	62.44	49.39
Stdev	1.281	1.008	1.129	1.288	1.085	1.217
CV	1.972	1.611	2.279	1.988	1.737	2.463
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	62.25	60.25	48.13	62.36	60.29	47.81
Max	66.74	63.83	52.43	66.67	63.98	52.38
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-basis Value	62.93	60.56	47.53	62.69	60.32	47.27
A-estimate	61.58	59.21	46.17	61.28	58.90	45.85
Method	pooled	pooled	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	58.65	56.28	43.24	58.52	56.14	43.10
A-estimate	54.44	52.07	39.03	54.32	51.94	38.90
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-40: Statistics and Basis Values for FHT2 Strength data

4.21 “50/40/10” Filled-Hole Tension 3 (FHT3)

The FHT3 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. FHT3 tests were performed at three different environmental conditions. .

The normalized ETW2 dataset failed all three distribution tests, requiring the non-parametric approach to compute design values. After the modified CV transformation of the data, this dataset did pass the normality test, so modified CV basis values are provided.

The as-measured RTA and ETW2 datasets met all requirements for pooling.

The CTA datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Both datasets passed the ADK test after the modified CV transformation, so modified CV basis values are provided for that dataset. Pooling was acceptable for computing the modified CV basis values.

There was one statistical outlier. The largest value in batch three of the ETW2 dataset was an outlier for the ETW2 condition, but not for the batch three. It was an outlier in both the normalized and as-measured datasets. It was retained for this analysis.

Statistics, estimates and basis values are given for FHT3 strength data in Table 4-41. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-24.

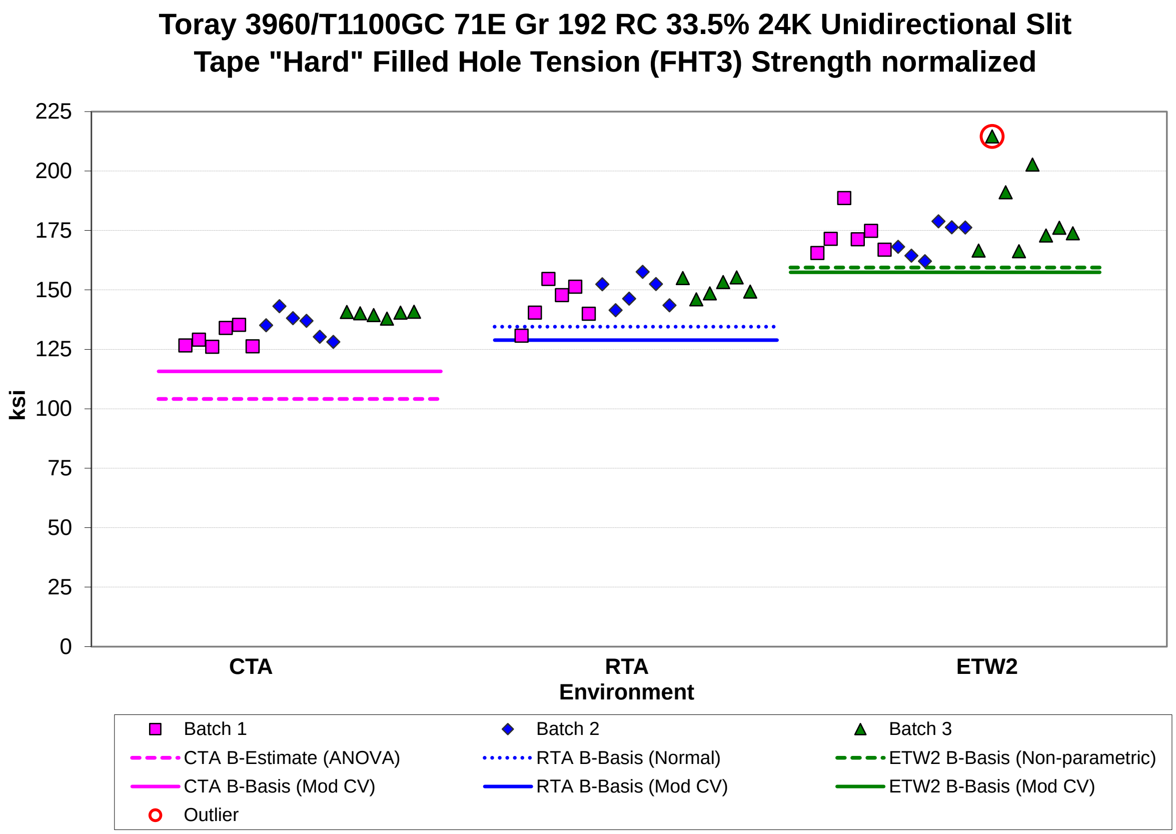

Figure 4-24: Batch plot for FHT3 strength normalized

Filled-Hole Tension (FHT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	134.9	148.1	176.4	134.5	147.4	175.9
Stdev	5.752	6.879	13.41	5.846	7.109	12.98
CV	4.263	4.644	7.600	4.348	4.823	7.380
Modified CV	6.132	6.322	7.800	6.174	6.412	7.690
Min	126.0	130.8	162.1	125.2	129.3	162.8
Max	143.2	157.6	214.5	144.4	158.0	212.3
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	20	18	18	20
Basis Values and Estimates						
B-basis Value		134.5	159.4		128.1	156.8
B-estimate	104.1			103.4		
A-estimate	82.16	124.9	110.5	81.30	115.1	143.7
Method	ANOVA	Normal	Non-Parametric	ANOVA	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	115.7	128.9	157.4	115.4	128.3	157.0
A-estimate	102.9	116.1	144.6	102.7	115.6	144.3
Method	pooled	pooled	pooled	pooled	pooled	pooled

Filled-Hole Tension (FHT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	134.9	148.1	176.4	134.5	147.4	175.9
Stdev	5.752	6.879	13.41	5.846	7.109	12.98
CV	4.263	4.644	7.600	4.348	4.823	7.380
Modified CV	6.132	6.322	7.800	6.174	6.412	7.690
Min	126.0	130.8	162.1	125.2	129.3	162.8
Max	143.2	157.6	214.5	144.4	158.0	212.3
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	20	18	18	20
Basis Values and Estimates						
B-basis Value			159.4			156.8
B-estimate	104.1	134.5		103.4	128.1	
A-estimate	82.16	124.9	110.5	81.30	115.1	143.7
Method	ANOVA	Normal	Non-Parametric	ANOVA	pooled	pooled
Modified CV Basis Values and Estimates						
B-basis Value	115.7	128.9	157.4	115.4	128.3	157.0
A-estimate	102.9	116.1	144.6	102.7	115.6	144.3
Method	pooled	pooled	pooled	pooled	pooled	pooled

Table 4-41: Statistics and Basis Values for FHT3 Strength data

4.22 “25/50/25” Open-Hole Compression 1 (OHC1)

The OHC1 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. OHC1 tests were performed at three different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

The as-measured ETW2 dataset failed the normality test, but the lognormal distribution had an adequate fit to compute design values. After the modified CV transformation of the data, the ETW2 as-measured dataset did pass the normality test, so modified CV basis values are provided.

The normalized ETW2 dataset failed all three distribution tests, requiring the non-parametric approach to compute design values. After the modified CV transformation of the data, the ETW2 normalized dataset did pass the normality test, so modified CV basis values are provided.

There was one statistical outlier. The largest value in the as-measured ETW1 dataset was an outlier. It was not an outlier in the normalized dataset. With only one batch tested in this condition, it can only be assessed as an outlier for batch, not the condition. It was retained for this analysis.

Statistics, estimates and basis values are given for OHC1 strength data in Table 4-42. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-25.

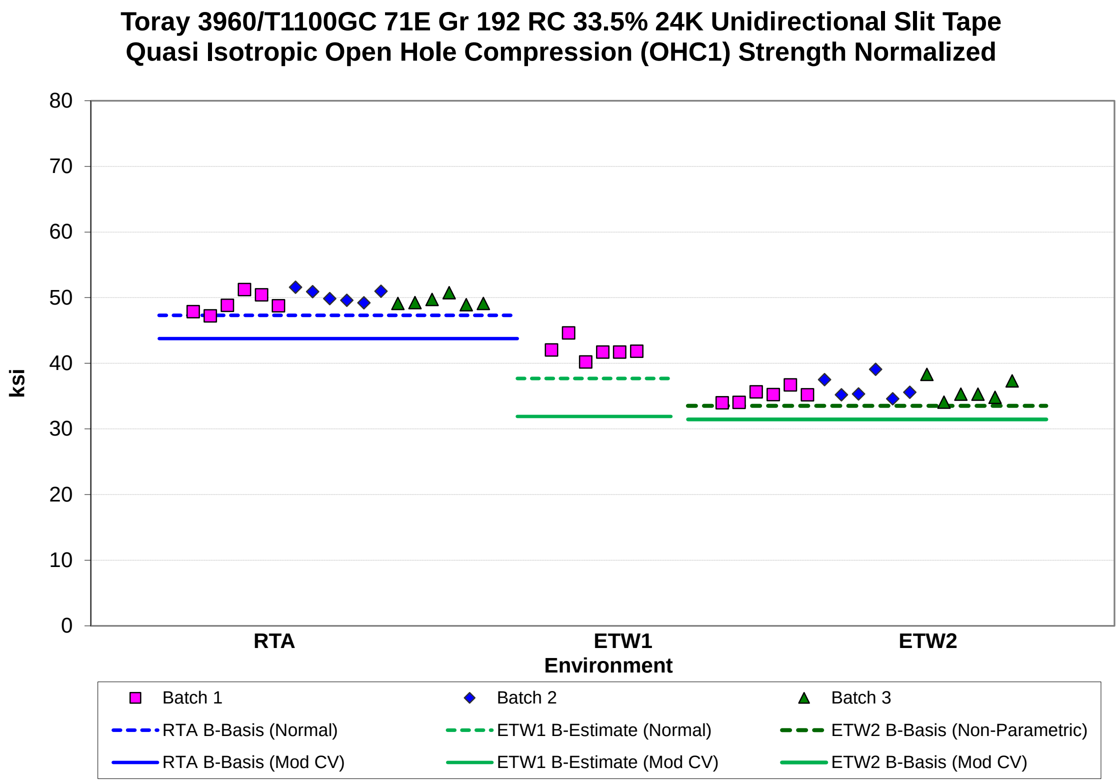

Figure 4-25: Batch plot for OHC1 strength normalized

Open Hole Compression (OHC1) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	49.63	42.02	35.74	49.77	42.48	35.87
Stdev	1.173	1.431	1.471	1.061	1.530	1.448
CV	2.363	3.406	4.116	2.131	3.602	4.036
Modified CV	6.000	8.000	6.058	6.000	8.000	6.018
Min	47.24	40.22	33.97	47.93	40.88	33.86
Max	51.59	44.62	39.09	51.31	45.38	39.36
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and Estimates						
B-basis Value	47.32		33.51	47.67		33.14
B-estimate		37.68			37.85	
A-estimate	45.68	34.60	27.54	46.19	34.55	31.35
Method	Normal	Normal	Non-Parm.	Normal	Normal	Lognormal
Modified CV Basis Values and Estimates						
B-basis Value	43.75		31.46	43.87		31.61
B-estimate		31.89			32.24	
A-estimate	39.60	24.96	28.44	39.70	25.24	28.59
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-42: Statistics and Basis Values for OHC1 Strength data

4.23 “10/80/10” Open-Hole Compression 2 (OHC2)

The OHC2 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. OHC2 tests were performed at two different environmental conditions.

The RTA datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Both datasets passed the ADK test after the modified CV transformation, so modified CV basis values are provided for that dataset. Pooling was acceptable for computing the modified CV basis values.

There were no statistical outliers.

Statistics, estimates and basis values are given for OHC2 strength data in Table 4-43. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-26.

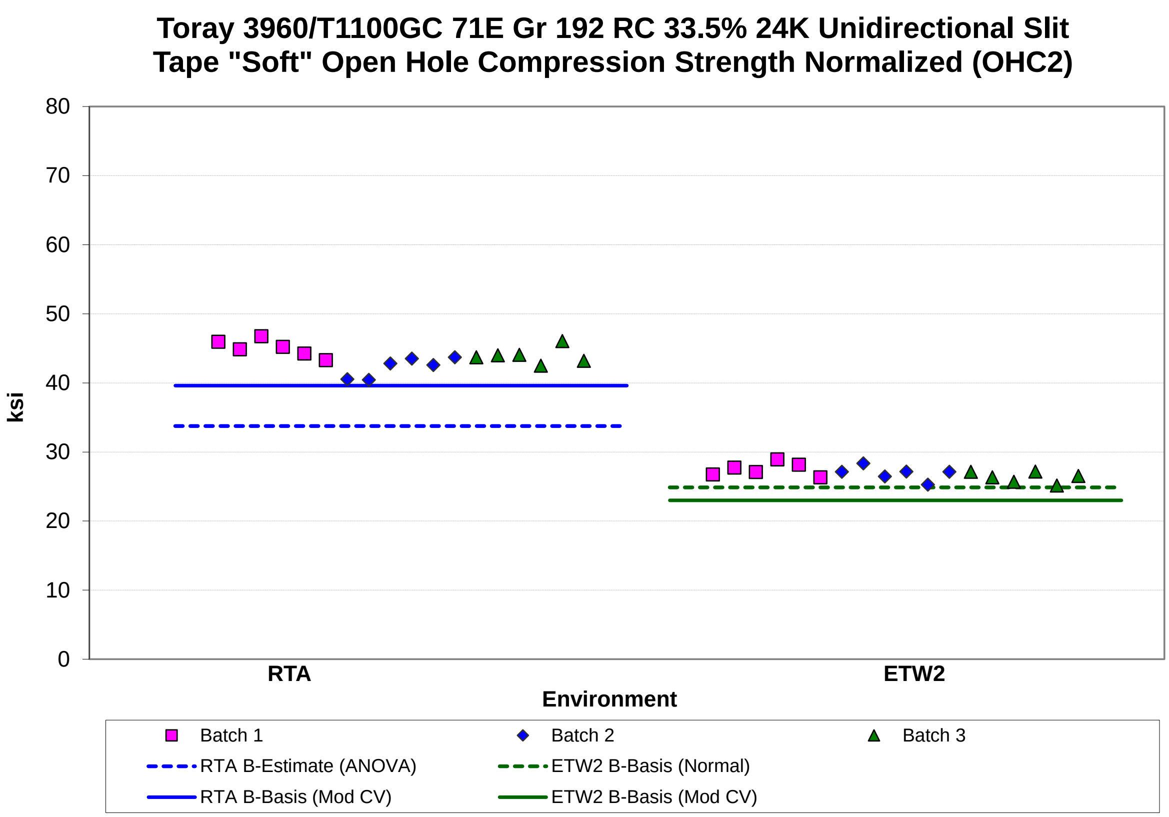

Figure 4-26: Batch plot for OHC2 strength normalized

Open-Hole Compression (OHC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	43.60	26.99	43.50	26.93
Stdev	1.815	1.069	1.846	1.132
CV	4.164	3.962	4.243	4.202
Modified CV	6.082	6.000	6.121	6.101
Min	40.45	25.13	40.39	24.97
Max	46.76	28.94	46.52	29.06
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value		24.88		24.70
B-estimate	33.77		33.14	
A-estimate	26.75	23.38	25.75	23.12
Method	ANOVA	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates				
B-basis Value	39.59	22.99	39.47	22.90
A-estimate	36.87	20.27	36.72	20.16
Method	pooled	pooled	pooled	pooled

Table 4-43: Statistics and Basis Values for OHC2 Strength data

4.24 “50/40/10” Open-Hole Compression 3 (OHC3)

The OHC3 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. OHC3 tests were performed at two different environmental conditions.

The RTA and ETW2 datasets, both normalized and as-measured, met all requirements for pooling. There were no statistical outliers.

Statistics, estimates and basis values are given for OHC3 strength data in Table 4-44. The normalized data and the B-basis values are shown graphically in Figure 4-27.

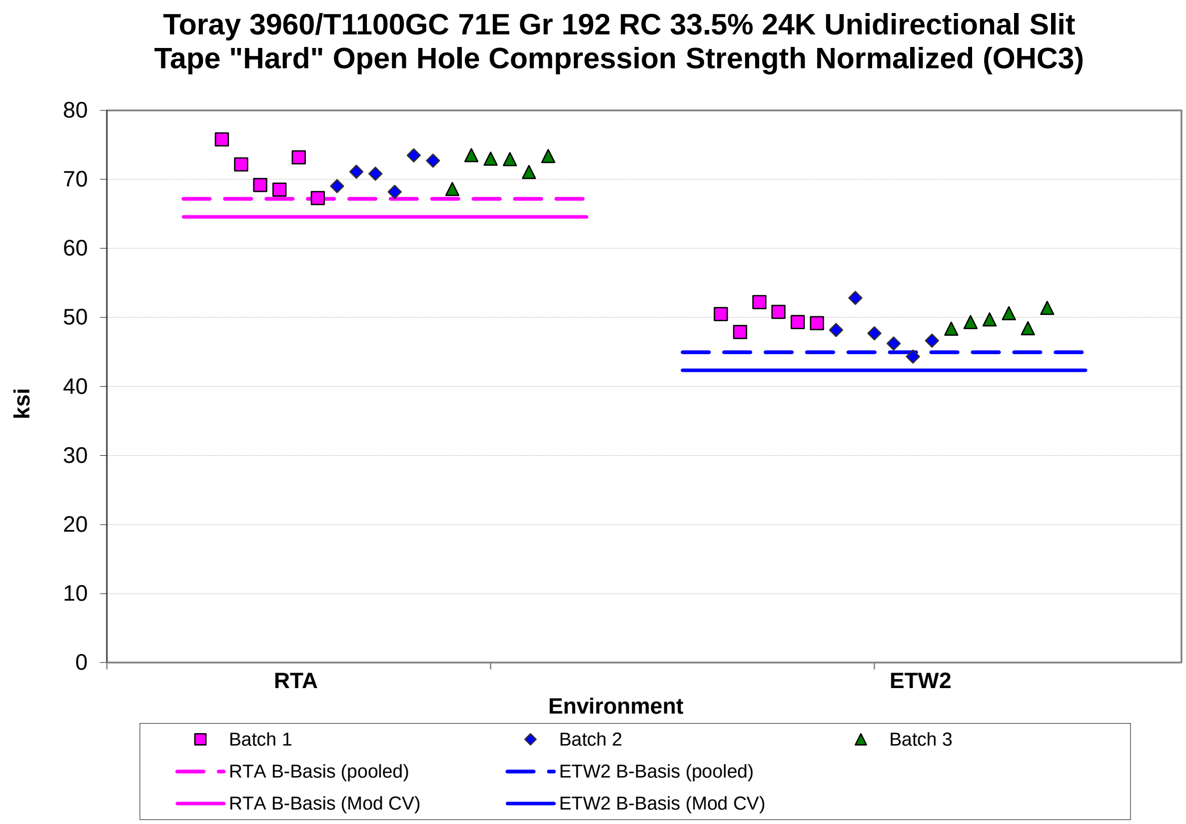

Figure 4-27: Batch plot for OHC3 strength normalized

Open-Hole Compression (OHC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	71.33	49.09	71.04	48.89
Stdev	2.388	2.153	2.351	2.024
CV	3.348	4.386	3.309	4.139
Modified CV	6.000	6.193	6.000	6.069
Min	67.28	44.32	67.08	44.48
Max	75.77	52.83	75.40	52.68
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value	67.19	44.95	67.04	44.90
A-estimate	64.37	42.13	64.33	42.18
Method	pooled	pooled	pooled	pooled
Modified CV Basis Values and Estimates				
B-basis Value	64.57	42.33	64.35	42.20
A-estimate	59.97	37.73	59.80	37.65
Method	pooled	pooled	pooled	pooled

Table 4-44: Statistics and Basis Values for OHC3 Strength data

4.25 “25/50/25” Filled-Hole Compression 1 (FHC1)

The FHC1 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. FHC1 tests were performed at three different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

The as-measured ETW2 dataset failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. This dataset passed the ADK test after the modified CV transformation, so modified CV basis values are provided for that dataset.

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

Statistics, estimates and basis values are given for FHC1 strength data in Table 4-45. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-28.

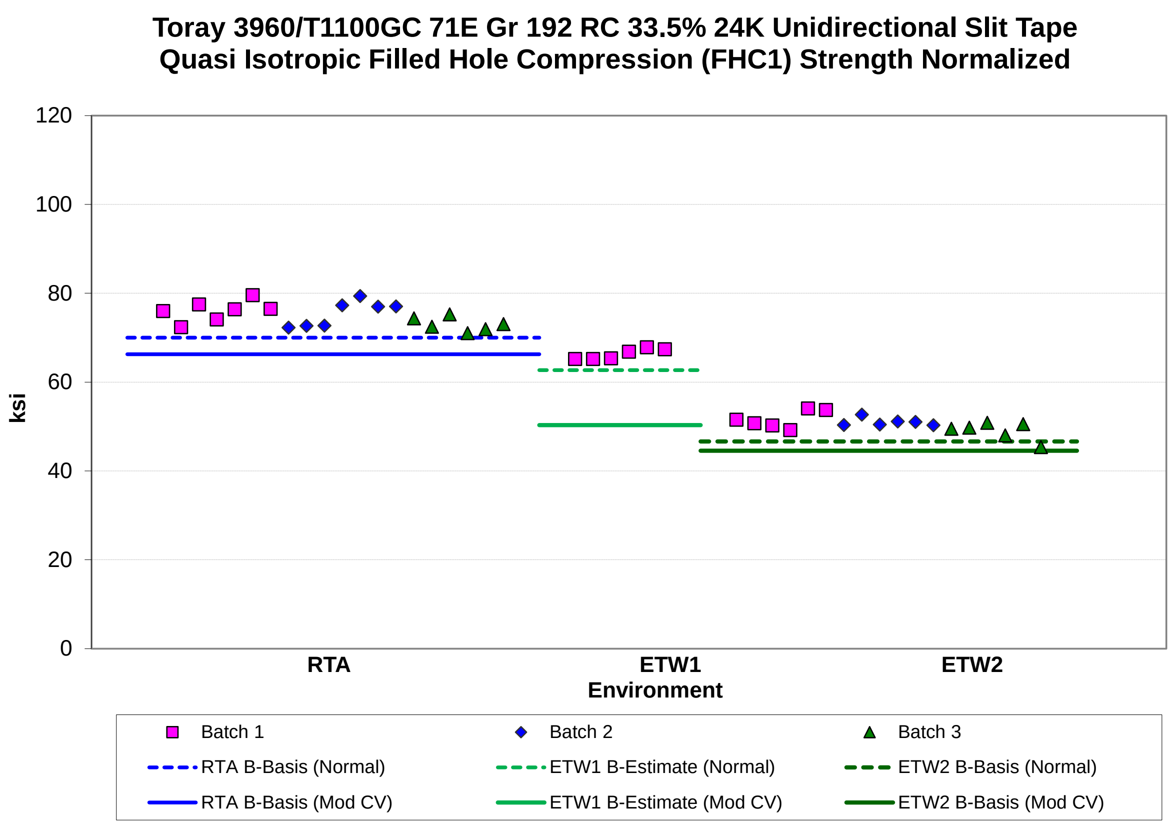

Figure 4-28: Batch plot for FHC1 strength normalized

Filled-Hole Compression (FHC1) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	74.94	66.31	50.52	75.03	66.92	50.65
Stdev	2.578	1.201	1.967	2.789	0.7594	2.118
CV	3.440	1.811	3.893	3.718	1.135	4.180
Modified CV	6.000	8.000	6.000	6.000	8.000	6.090
Min	71.04	65.19	45.36	70.71	66.27	44.94
Max	79.57	67.82	54.05	79.59	68.08	54.15
No. Batches	3	1	3	3	1	3
No. Spec.	20	6	18	20	6	18
Basis Values and Estimates						
B-basis Value	69.98		46.63	69.66		
B-estimate		62.67			64.62	40.93
A-estimate	66.45	60.08	43.88	65.84	62.98	33.99
Method	Normal	Normal	Normal	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	66.28		44.53	66.36		44.56
B-estimate		50.33			50.79	
A-estimate	60.13	39.39	40.30	60.20	39.76	40.26
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-45: Statistics and Basis Values for FHC1 Strength data

4.26 “10/80/10” Filled-Hole Compression 2 (FHC2)

The FHC2 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. FHC2 tests were performed at two different environmental conditions.

The RTA datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Both RTA datasets passed the ADK test after the modified CV transformation, so modified CV basis values are provided for that dataset. Pooling was acceptable for computing the modified CV basis values.

There were two statistical outliers. The lowest value in batch two of the RTA dataset was an outlier for the RTA condition but not for the batch two. It was an outlier in both the normalized and as-measured datasets. The largest value in batch one of the ETW2 condition was an outlier for batch one but not for the ETW2 condition. It was an outlier in both the normalized and as-measured datasets. Both outliers were retained for this analysis.

Statistics, estimates and basis values are given for FHC2 strength data in Table 4-46. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-29.

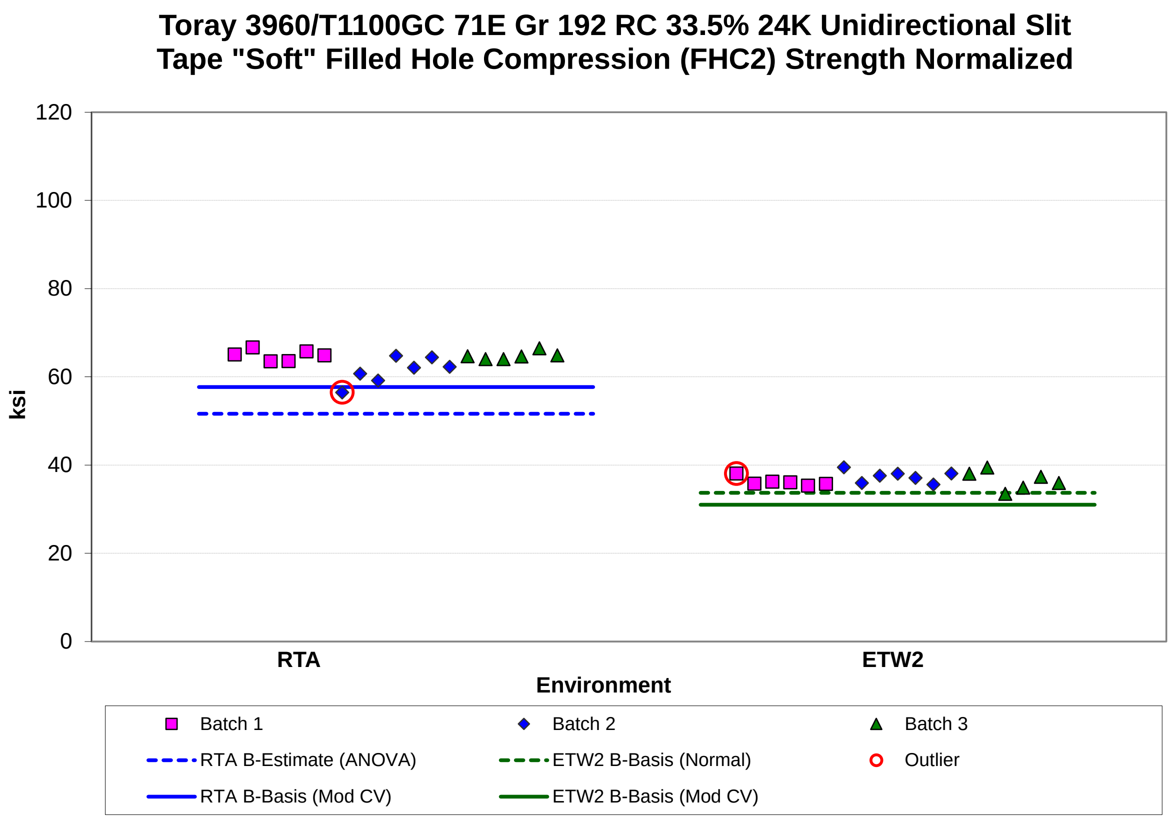

Figure 4-29: Batch plot for FHC2 strength normalized

Filled-Hole Compression (FHC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	63.58	36.75	63.35	36.65
Stdev	2.528	1.569	2.482	1.573
CV	3.975	4.270	3.918	4.292
Modified CV	6.000	6.135	6.000	6.146
Min	56.49	33.48	56.07	33.07
Max	66.66	39.49	66.47	39.55
No. Batches	3	3	3	3
No. Spec.	19	19	19	19
Basis Values and Estimates				
B-basis Value		33.69		33.59
B-estimate	51.66		52.50	
A-estimate	43.15	31.52	44.77	31.41
Method	ANOVA	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates				
B-basis Value	57.93	31.09	57.71	31.02
A-estimate	54.07	27.23	53.86	27.17
Method	pooled	pooled	pooled	pooled

Table 4-46: Statistics and Basis Values for FHC2 Strength data

4.27 "50/40/10" Filled-Hole Compression 3 (FHC3)

The FHC3 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for only one property, strength. FHC3 tests were performed at two different environmental conditions.

The ETW2 datasets, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Both ETW2 datasets passed the ADK test after the modified CV transformation, so modified CV basis values are provided for that dataset. Pooling was acceptable for computing the modified CV basis values.

There was one statistical outlier. The largest value in batch one of the ETW2 condition was an outlier for batch one but not for the ETW2 condition. It was an outlier in both the normalized and as-measured datasets. It was retained for this analysis.

Statistics, estimates and basis values are given for FHC3 strength data in Table 4-47. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-30.

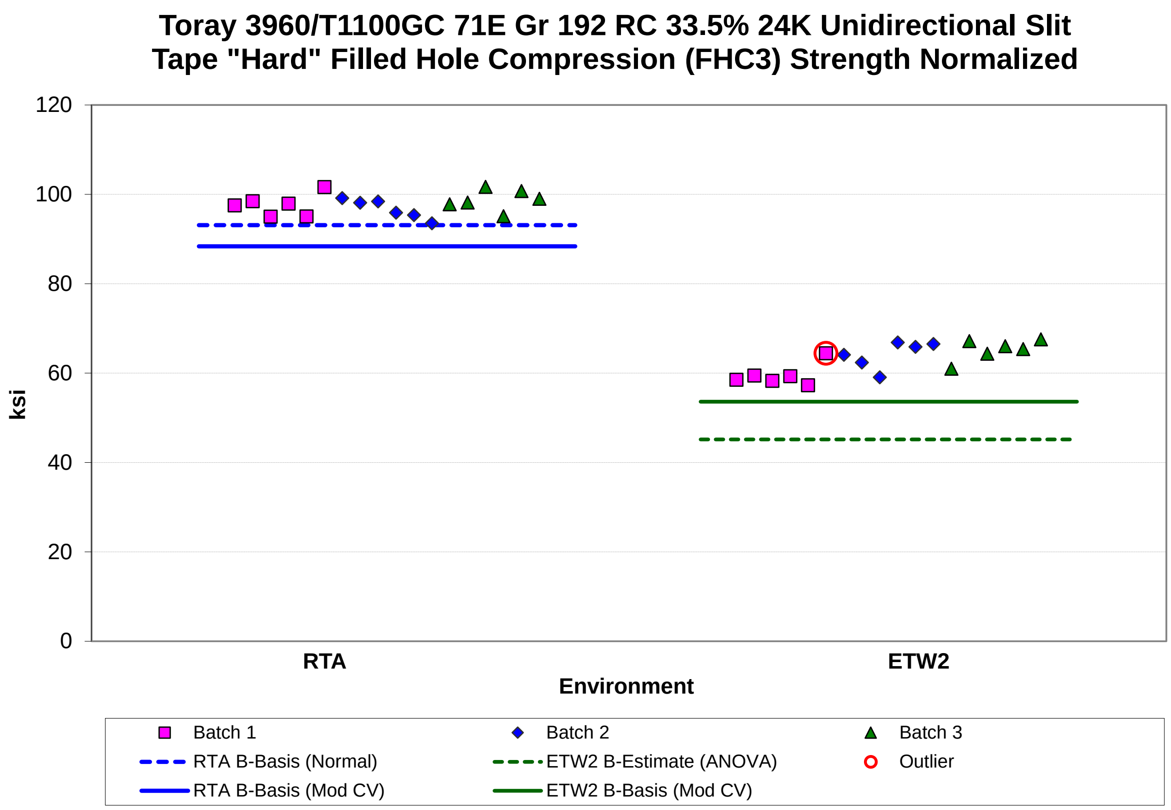

Figure 4-30: Batch plot for FHC3 strength normalized

Filled-Hole Compression (FHC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	97.69	62.96	97.21	62.65
Stdev	2.340	3.555	2.322	3.484
CV	2.395	5.646	2.389	5.561
Modified CV	6.000	6.823	6.000	6.781
Min	93.50	57.25	93.39	56.97
Max	101.6	67.55	101.0	67.11
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-basis Value	93.07		92.62	
B-estimate		45.13		44.83
A-estimate	89.80	32.41	89.37	32.13
Method	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis Value	88.33	53.60	87.91	53.36
A-estimate	81.96	47.23	81.59	47.03
Method	pooled	pooled	pooled	pooled

Table 4-47: Statistics and Basis Values for FHC3 Strength data

4.28 “25/50/25” Single-Shear Bearing 1 (SSB1, Proc. C)

The SSB1 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for three properties, 2% offset strength, ultimate and chord modulus. SSB1 tests were performed at three different environmental conditions. The ETW1 condition only conducted tests with one batch of material which is insufficient to meet CMH-17 guidelines, so only estimates of basis values are provided for that condition.

The ETW2 datasets for both 2% offset strength and ultimate strength, both the normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. Only the normalized ETW2 ultimate strength dataset passed the ADK test after the modified CV transformation, so modified CV basis values are provided for that dataset only.

There was one statistical outlier. The largest value in batch three of the RTA condition for the ultimate strength property was an outlier for batch three only. It was not an outlier for the RTA condition or for the 2% offset strength property. It was an outlier in both the normalized and as-measured datasets. It was retained for this analysis.

Statistics, estimates and basis values are given for the SSB1 2% offset strength data in Table 4-48, for ultimate strength data in Table 4-49, and for the chord modulus data in Table 4-50. The normalized data and the B-basis estimates and values are shown graphically for 2% offset strength in Figure 4-31 and for ultimate strength in Figure 4-32.

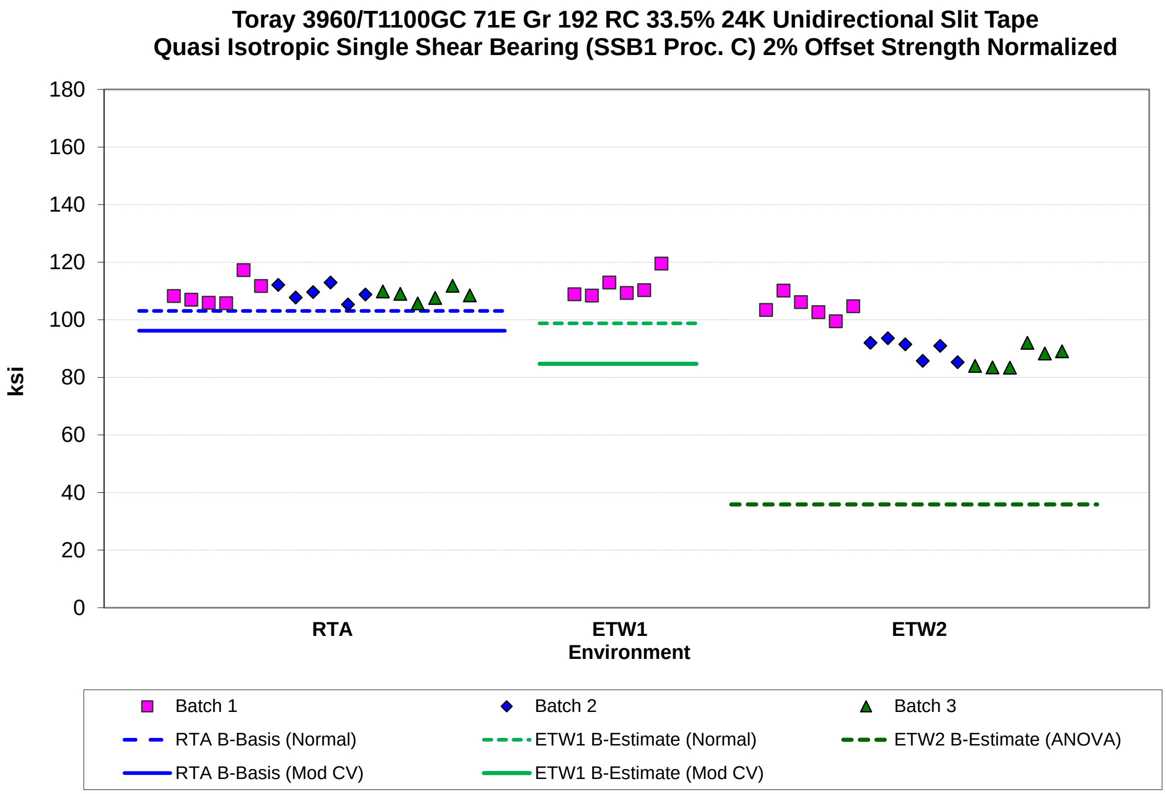

Figure 4-31: Batch plot for SSB1 Proc. C 2% offset strength normalized

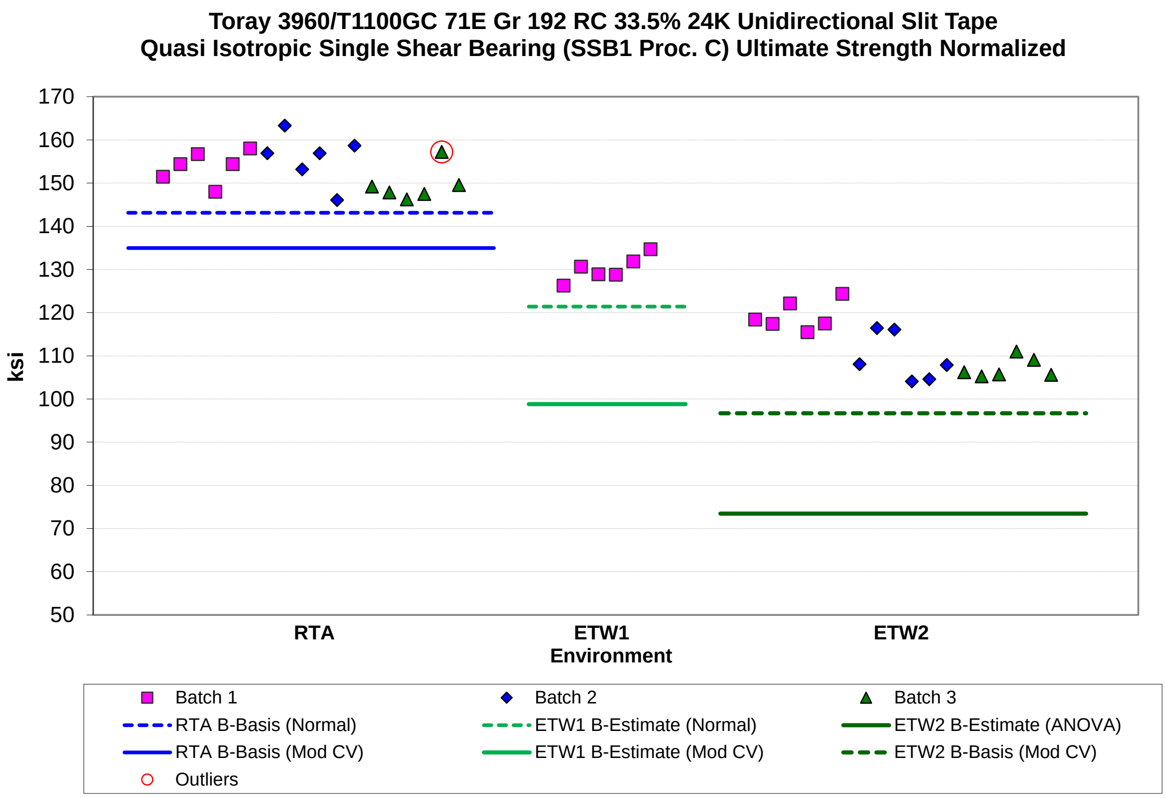

Figure 4-32: Batch plot for SSB1 Proc. C ultimate strength normalized

Single Shear Bearing (SSB1 Proc. C) 2% Offset Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	109.2	111.6	93.67	108.8	111.6	93.31
Stdev	3.094	4.211	8.625	3.249	4.325	8.845
CV	2.834	3.774	9.208	2.986	3.873	9.479
Modified CV	6.000	8.000	9.208	6.000	8.000	9.479
Min	105.3	108.4	83.37	104.3	108.2	82.48
Max	117.3	119.5	110.2	117.4	119.8	109.9
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and Estimates						
B-basis Value	103.1			102.4		
B-estimate		98.82	35.90		98.55	34.01
A-estimate	98.74	89.75	NA	97.85	89.23	NA
Method	Normal	Normal	ANOVA	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	96.24		NA	95.93		NA
B-estimate		84.69			84.74	
A-estimate	87.10	66.29		86.81	66.33	
Method	Normal	Normal		Normal	Normal	

Table 4-48: Statistics for SSB1 Proc. C 2% Offset Strength data

Single Shear Bearing (SSB1 Proc. C) Ultimate Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	153.1	130.2	112.0	152.6	130.3	111.5
Stdev	5.050	2.908	6.524	5.493	2.806	6.838
CV	3.299	2.234	5.827	3.600	2.154	6.131
Modified CV	6.000	8.000	6.914	6.000	8.000	7.066
Min	146.1	126.3	104.1	144.4	126.7	103.9
Max	163.3	134.7	124.4	163.1	135.0	124.7
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and Estimates						
B-basis Value	143.1			141.7		
B-estimate		121.4	73.44		121.8	71.04
A-estimate	136.1	115.1	45.95	134.1	115.7	42.15
Method	Normal	Normal	ANOVA	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates						
B-basis Value	135.0		96.68	134.5		NA
B-estimate		98.81			98.87	
A-estimate	122.1	77.34	85.87	121.7	77.39	
Method	Normal	Normal	Normal	Normal	Normal	

Table 4-49: Statistics and Basis Values for SSB1 Proc. C Ultimate Strength data

Single Shear Bearing (SSB1 Proc. C) Chord Modulus Statistics						
	Normalized			As-measured		
Env	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)	RTA (70°F)	ETW1 (180°F)	ETW2 (250°F)
Mean	1.878	2.060	1.721	1.872	2.061	1.715
Stdev	0.1184	0.1293	0.2349	0.1167	0.1253	0.2378
CV	6.307	6.278	13.65	6.236	6.080	13.87
Modified CV	7.154	8.000	13.65	7.118	8.000	13.87
Min	1.632	1.940	1.429	1.623	1.944	1.415
Max	2.080	2.238	2.173	2.078	2.232	2.175
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18

Table 4-50: Statistics and Basis Values for SSB1 Proc. C Chord Modulus data

4.29 “10/80/10” Single-Shear Bearing 2 (SSB2, Proc. C)

The SSB2 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for three properties, 2% offset strength, ultimate and chord modulus. SSB2 tests were performed at two different environmental conditions.

The ETW2 datasets for both 2% offset strength and ultimate strength, both normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. The ultimate strength ETW2 datasets, both normalized and as-measured, passed the ADK test after the modified CV transformation but the 2% offset strength ETW2 datasets did not, so modified CV basis values are provided for only for the ultimate strength datasets.

Both the normalized and as-measured ultimate strength dataset met all requirements for pooling across the environments for the modified CV basis value computations.

There was one statistical outlier. The largest value in batch one of the as-measured RTA condition for the ultimate strength property was an outlier for the RTA condition, but not for the batch one and not for the normalized dataset. It was not an outlier for the 2% offset strength property. It was retained for this analysis.

Statistics, estimates and basis values are given for the SSB2 strength data in Table 4-51 and for the chord modulus data in Table 4-52. The normalized data, B-estimates, and the B-basis values are shown graphically in Figure 4-33.

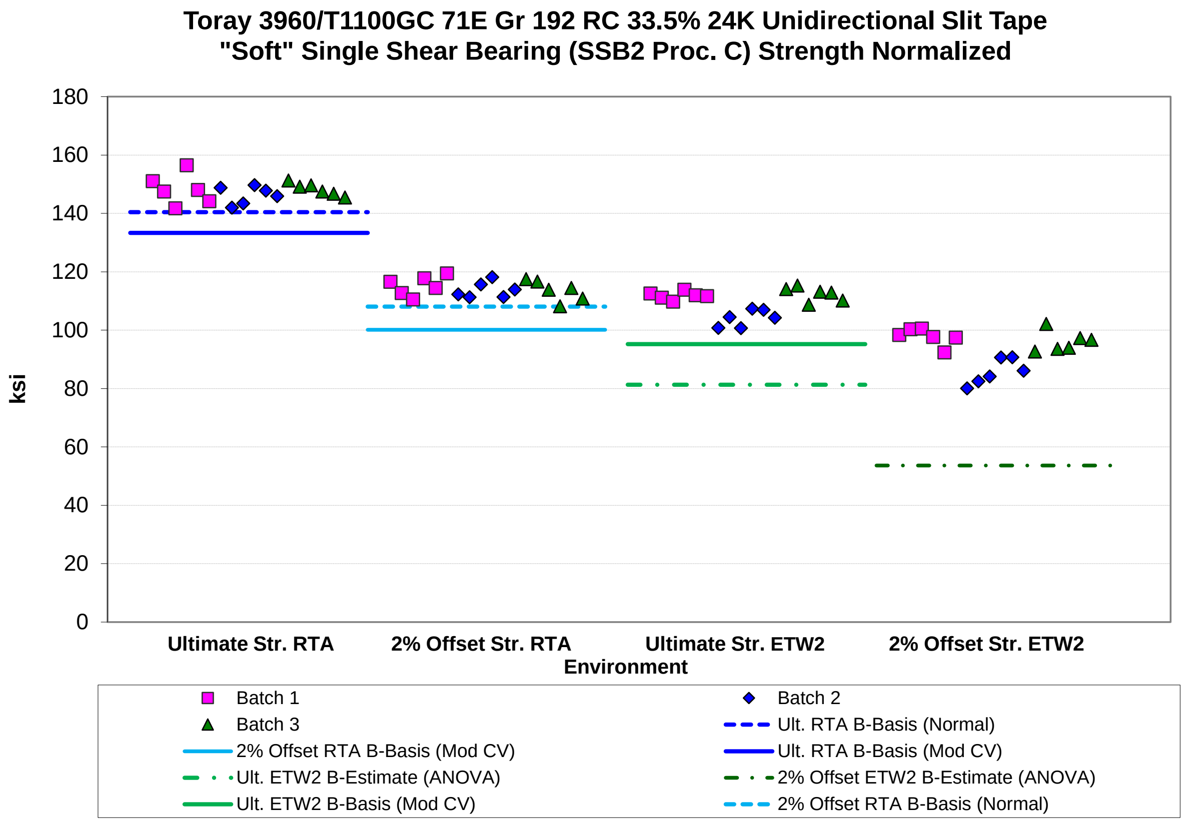

Figure 4-33: Batch plot for SSB2 Proc. C strength normalized

Single Shear Bearing (SSB2 Proc. C) Strength Basis Values and Statistics								
	2% Offset Strength				Ultimate Strength			
	Normalized		As-measured		Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	114.2	93.16	113.6	92.73	147.6	109.4	146.8	108.9
Stdev	3.112	6.477	3.084	6.281	3.602	4.477	3.402	4.167
CV	2.725	6.953	2.715	6.773	2.441	4.091	2.318	3.826
Modified CV	6.000	7.476	6.000	7.387	6.000	6.045	6.000	6.000
Min	108.2	80.04	107.0	80.04	141.7	100.7	141.3	100.7
Max	119.5	102.2	119.1	101.1	156.5	115.3	156.1	114.0
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-basis Value	108.1		107.5		140.5		140.0	
B-estimate		53.61		54.95		81.27		83.37
A-estimate	103.7	25.38	103.2	28.00	135.4	61.18	135.3	65.14
Method	Normal	ANOVA	Normal	ANOVA	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates								
B-basis Value	100.7	NA	100.1	NA	133.3	95.19	132.6	94.79
A-estimate	91.10		90.6		123.7	85.51	123.0	85.19
Method	Normal		Normal		pooled	pooled	pooled	pooled

Table 4-51: Statistics and Basis Values for SSB2 Proc. C Strength data

Single Shear Bearing (SSB2 Proc. C) Chord Modulus Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	1.318	1.260	1.310	1.254
Stdev	0.02780	0.1260	0.02871	0.1227
CV	2.110	10.01	2.191	9.790
Modified CV	6.000	10.01	6.000	9.790
Min	1.252	1.051	1.249	1.050
Max	1.370	1.423	1.366	1.414
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-52: Statistics for SSB2 Proc. C Chord Modulus data

4.30 “50/40/10” Single-Shear Bearing 3 (SSB3, Proc. C)

The SSB3 data is normalized, so statistics for both normalized and as-measured values are provided. Data is available for three properties, 2% offset strength, ultimate and chord modulus. SSB3 tests were performed at two different environmental conditions.

The ETW2 datasets for both 2% offset strength and ultimate strength, both the normalized and as-measured, failed the Anderson Darling k-sample test (ADK test) for batch to batch variability, which means that CMH-17-1H guidelines required using the ANOVA analysis. With fewer than five batches, this is considered an estimate. None of these datasets passed the ADK test after the modified CV transformation, so modified CV basis values are not provided.

There was one statistical outlier. The largest value in batch one of the ETW2 condition for the 2% offset strength property was an outlier for batch one only. It was not an outlier for the ETW2 condition or for the ultimate strength property. It was an outlier in both the normalized and as-measured datasets. It was retained for this analysis.

Statistics, estimates and basis values are given for the SSB3 strength data in Table 4-53 and for the chord modulus data in Table 4-54. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-34.

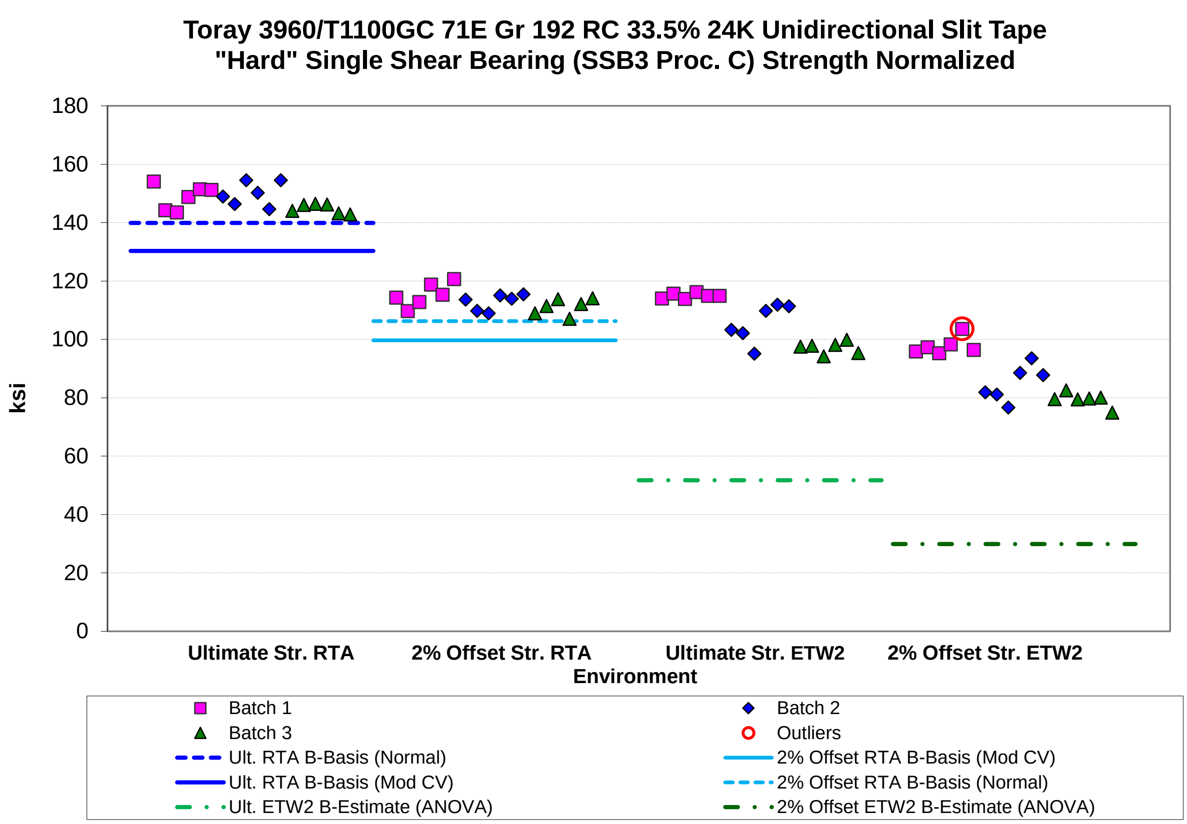

Figure 4-34: Batch plot for SSB3 Proc. C strength normalized

Single Shear Bearing (SSB3 Proc. C) Strength Basis Values and Statistics								
	2% Offset Strength				Ultimate Strength			
	Normalized		As-measured		Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	113.1	87.34	112.3	86.77	147.8	105.9	146.8	105.2
Stdev	3.472	8.862	3.551	8.768	4.019	8.379	4.223	8.376
CV	3.070	10.15	3.162	10.11	2.719	7.913	2.876	7.963
Modified CV	6.000	10.15	6.000	10.11	6.000	7.957	6.000	7.982
Min	107.0	74.92	104.8	73.92	142.8	94.16	140.9	93.30
Max	120.7	103.6	119.7	102.3	154.5	116.2	154.6	115.3
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-basis Value	106.2		105.3		139.9		138.5	
B-estimate		29.85		30.16		51.76		51.21
A-estimate	101.4	NA	100.3	NA	134.3	13.13	132.6	12.68
Method	Normal	ANOVA	Normal	ANOVA	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates								
B-basis Value	99.68	NA	99.00	NA	130.3	NA	129.4	NA
A-estimate	90.21		89.59		117.9		117.1	
Method	Normal		Normal		Normal		Normal	

Table 4-53: Statistics and Basis Values for SSB3 Proc. C Strength data

Single Shear Bearing (SSB3 Proc. C) Chord Modulus Statistics				
	Normalized		As-measured	
Env	RTA (70°F)	ETW2 (250°F)	RTA (70°F)	ETW2 (250°F)
Mean	1.768	1.682	1.756	1.671
Stdev	0.05979	0.1821	0.06520	0.1783
CV	3.382	10.83	3.714	10.67
Modified CV	6.000	10.83	6.000	10.67
Min	1.632	1.451	1.617	1.449
Max	1.860	1.988	1.861	1.972
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-54: Statistics for SSB3 Proc. C Chord Modulus data

4.31 "25/50/25" Compression After Impact 1 (CAI1)

The CAI1 data is normalized. Basis values are not computed for this property. Data from only one batch of material is available. However the summary statistics are presented in Table 4-55 and the data are displayed graphically in Figure 4-35. There were no statistical outliers.

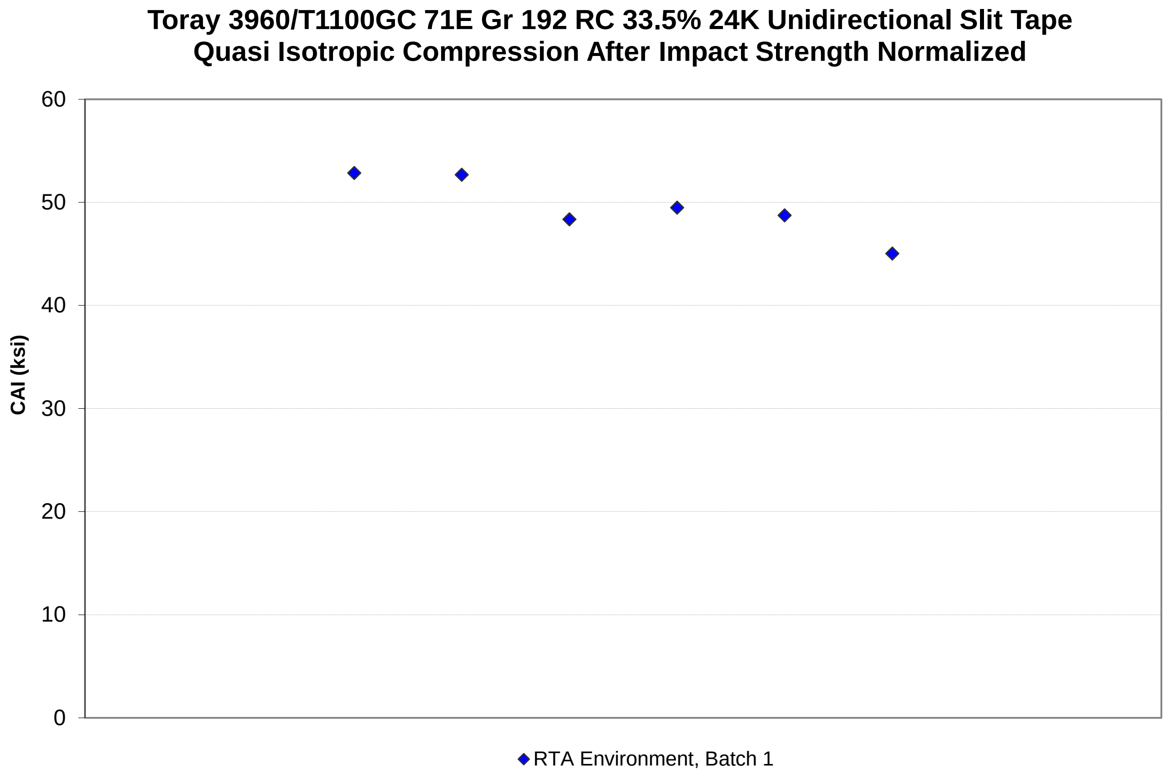

Figure 4-35: Plot for CAI1 strength normalized

Compression After Impact Strength (ksi) Statistics		
	Normalized	As-measured
Env	RTA (70°F)	RTA (70°F)
Mean	49.52	50.24
Stdev	2.937	2.973
CV	5.931	5.917
Modified CV	8.000	8.000
Min	45.03	45.66
Max	52.83	53.55
No. Batches	1	1
No. Spec.	6	6

Table 4-55: Statistics for CAI1 Strength data

4.32 “100/0/0” Interlaminar Tension and Curved Beam Strength (ILT and CBS)

The ILT and CBS data is not normalized. Basis values are not computed for these properties. Data from only one batch of material is available. However the summary statistics are presented in Table 4-56 and the data are displayed graphically in Figure 4-36. There were no statistical outliers.

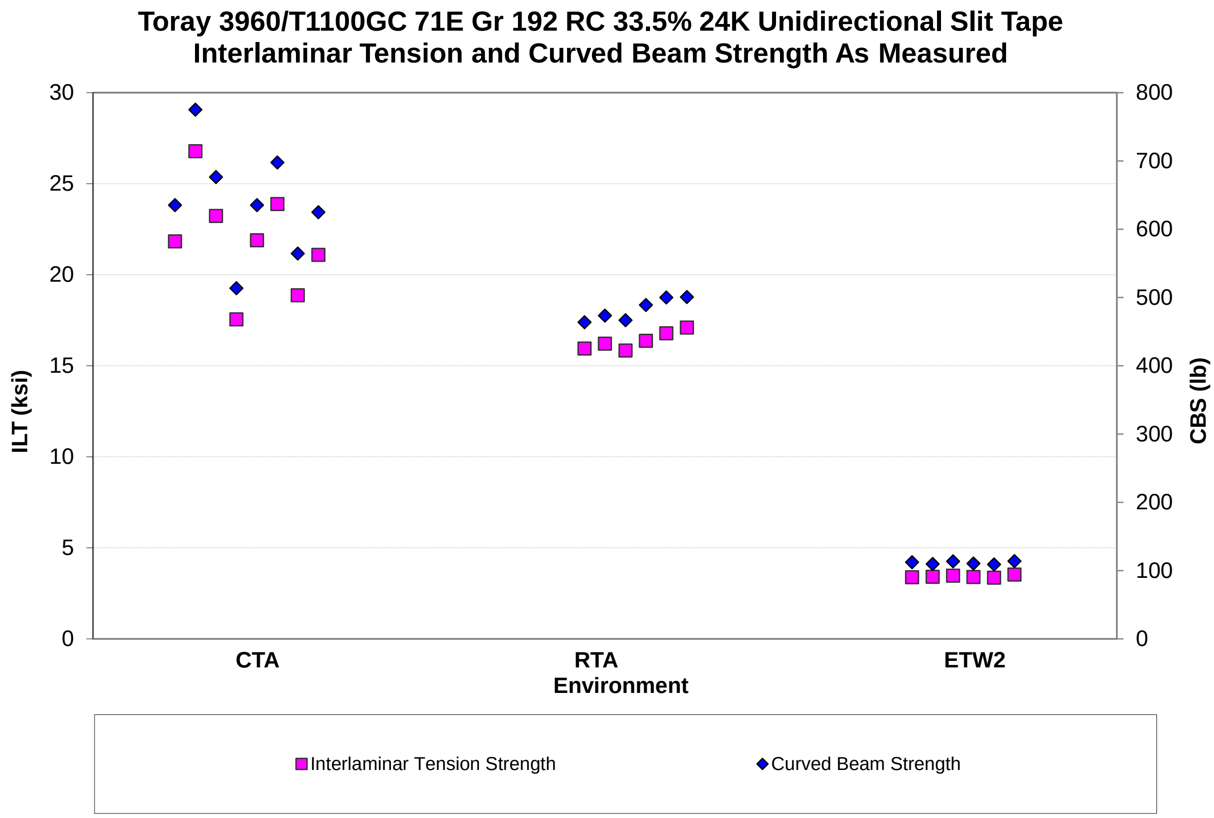

Figure 4-36: Plot for CBS and ILT as-measured

Interlaminar Tension (ILT) and Curved Beam Strength (CBS) Statistics As-Measured						
Property	Interlaminar Strength (ksi)			Curved Beam Strength (lb)		
Env	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)	CTA (− 65°F)	RTA (70°F)	ETW2 (250°F)
Mean	21.89	16.37	3.423	640.3	482.2	111.4
Stdev	2.886	0.4923	0.06192	80.04	16.51	2.03
CV	13.18	3.007	1.809	12.50	3.424	1.819
Mod CV	13.18	8.000	8.000	12.50	8.000	8.000
Min	17.55	15.83	3.361	513.6	463.6	109.1
Max	26.78	17.10	3.525	775.1	500.6	113.9
No. Batches	1	1	1	1	1	1
No. Spec.	8	6	6	8	6	6

Table 4-56: Statistics for ILT and CBS 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-2023-002 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.

Test	Condition	Batch	Specimen Number	Normalized Strength	As-measured Strength	High/ Low	Batch Outlier	Condition Outlier
UNC0	CTA (-65º F)	3	NTP3963Q1-TC-WEB-NIAR-T01-MST2-C-C1-1-UNC0-CTA-2	79.36	79.33	Low	Yes	Yes
LC from UNC0				209.4	209.5			
UNC0	ETW2 (250º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST2-A-C1-1-UNC0-ETW2-2	61.70	61.53	Low	Yes	No
LC from UNC0				170.8	170.4			
UNC0	ETW2 (250º F)	3	NTP3963Q1-TC-WEB-NIAR-T01-MST2-C-C2-1-UNC0-ETW2-2	52.35	51.70	Low	No	Yes
LC from UNC0				144.9	143.2			
TT	CTA (-65º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST1-A-C1-1-TT-CTA-1	NA	6.168	Low	No	Yes
TT	CTA (-65º F)	2	NTP3963Q1-TC-WEB-NIAR-T01-MST1-B-C2-1-TT-CTA-3	NA	9.622	High	Yes	No
LT	RTA (70º F)	2	NTP3963Q1-TC-WEB-NIAR-T01-MST1-B-C1-1-LT-RTA-1	580.4	576.7	High	Yes	No
SBS1	ETA2 (250º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST1-A-C2-1-SBS-ETA2-1	NA	10.96	High	One Batch	
IPS - 0.2% Strength Offset	ETW2 (250º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST3-A-C1-1-IPS-ETW2-3	NA	3.021	Low	Yes	No
IPS - Strength at 5% Strain	ETW2 (250º F)	3	NTP3963Q1-TC-WEB-NIAR-T01-MST3-C-C1-1-IPS-ETW2-2	NA	4.755	Low	Yes	No
UNT2	ETW2 (250º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST7-A-C1-1-UNT2-ETW2-3	60.80	60.84	Low	No	Yes
UNT3	CTA (-65º F)	2	NTP3963Q1-TC-WEB-NIAR-T01-MST8-B-C2-1-UNT3-CTA-3	269.6	270.4	High	Yes	No
UNT3	RTA (70º F)	2	NTP3963Q1-TC-WEB-NIAR-T01-MST8-B-C1-1-UNT3-RTA-2	251.8	252.2	Low	Yes	Yes
UNC3	RTA (70º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST8-A-C1-1-UNC3-RTA-1	155.6	154.8	Low	Yes	No
UNC3	ETW2 (250º F)	3	NTP3963Q1-TC-WEB-NIAR-T01-MST8-C-C2-1-UNC3-ETW2-1R	110.8	109.6	High	Yes	No
OHT2	CTA (-65º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST7-A-C2-1-OHT2-CTA-1	55.82	Not at Outlier	Low	No	Yes
OHC1	ETW1 (180°)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST6-A-C1-1-OHC1-ETW1-2	Not at Outlier	45.38	High	One Batch	
FHT2	RTA (70º F)	2	NTP3963Q1-TC-WEB-NIAR-T01-MST7-B-C2-1-FHT2-RTA-3	61.88	Not at Outlier	Low	Yes	No
FHT3	ETW2 (250º F)	3	NTP3963Q1-TC-WEB-NIAR-T01-MST8-C-C1-1-FHT3-ETW2-2	214.5	212.3	High	No	Yes
FHC1	ETW2 (250º F)	3	NTP3963Q1-TC-WEB-NIAR-T01-MST6-C-C2-1-FHC1-ETW2-3	Not at Outlier	44.94	Low	No	Yes
FHC2	RTA (70º F)	2	NTP3963Q1-TC-WEB-NIAR-T01-MST7-B-C1-1-FHC2-RTA-1	56.49	56.07	Low	No	Yes
FHC2	ETW2 (250º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST7-A-C1-1-FHC2-ETW2-1	38.07	37.95	High	Yes	No
FHC3	ETW2 (250º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST8-A-C2-1-FHC3-ETW2-3	64.41	64.41	High	Yes	No
SBS1	RTA (70º F)	2	NTP3963Q1-TC-WEB-NIAR-T01-MST6-B-C2-1-SBS1-RTA-2	NA	12.30	Low	Yes	Yes
SSB1 - Ultimate Strength	RTA (70º F)	3	NTP3963Q1-TC-WEB-NIAR-T01-MST5-C-C2-1-SSB1-RTA-2	157.2	157.1	High	Yes	No
SSB2 - Ultimate Strength	RTA (70º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST7-A-C2-1-SSB2-RTA-1	Not at Outlier	156.1	High	No	Yes
SSB3 - 2% Offset Strength	ETW2 (250º F)	1	NTP3963Q1-TC-WEB-NIAR-T01-MST8-A-C2-1-SSB3-ETW2-2	103.6	102.3	High	No	Yes

Table 5-1: List of Outliers

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