Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS Material Allowables Statistical Analysis Report

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1. Introduction

This report contains statistical analysis of the Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS Fabric qualification material property data published in NCAMP Test Report CAM-RP-2019-007 MPDR 03-08-2023. The lamina and laminate material property data have been generated with NCAMP oversight in accordance with NSP 100 NCAMP Standard Operating Procedures; the test panels and test specimens have been inspected by NCAMP Authorized Inspection Representatives (AIR) and the testing has been witnessed by NCAMP Authorized Engineering Representatives (AER). However, the data may not fulfill all the needs of any specific company's program; specific properties, environments, laminate architecture, and loading situations may require additional testing.

B-Basis values, A-estimates, and B-estimates were calculated using a variety of techniques that are detailed in Section 2. The qualification material was procured to NCAMP Material Specification NMS 401 Base Rev B 02-02-2023. NCAMP Material Specification NMS 401/3 Revision A 03-08-2023 was created at later date as a supplement material specification for Tenax®-E HTA40 3K 5HS weave fabric fiber. The qualification test panels were consolidated in accordance with NCAMP Process Specification NPS 84013 Rev B 02-01-2023 with Baseline “M” Consolidate Cycle. The NCAMP Test Plan NTP 4013Q1 Rev E 12-06-17 was used for this qualification program.

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

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

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

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

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

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

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 401/3. NMS 401/3 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 401/3.* NMS 401/3 is a free, publicly available, non-proprietary aerospace industry material specification.

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1.1 Symbols and Abbreviations

Test Method	**Abbreviation**
Warp Compression	WC
Warp Tension	WT
Fill Compression	FC
Fill Tension	FT
In-Plane Shear	IPS
Short Beam Strength	SBS
Unnotched Tension	UNT
Unnotched Compression	UNC
Short Beam Strength	SBS
Laminate Short Beam Strength	SBS1
Filled Hole Tension	FHT
Filled Hole Compression	FHC
Open Hole Tension	OHT
Open Hole Compression	OHC
Single Shear Bearing	SSB
Interlaminar Tension	ILT
Curved Beam Strength	CBS
Compression After Impact	CAI

Table 1-1: Test Method Abbreviations

Test Property	Symbol
Warp Compression Strength	F_1^{cu}
Warp Compression Modulus	E_1^{c}
Warp Tension Strength	F_1^{tu}
Warp Tension Modulus	E_1^{t}
Warp Tension Poisson's Ratio	ν_{12}^{t}
Fill Compression Strength	F_2^{cu}
Fill Compression Modulus	E_2^{c}
Fill Tension Strength	F_2^{tu}
Fill Tension Modulus	E_2^{t}
In-Plane Shear Strength at 4% strain	$F_{12}^{s4\%strain}$
In-Plane Shear Strength at 0.2% offset	$F_{12}^{s0.2\%}$
In-Plane Shear Modulus	G_{12}^{s}

Table 1-2: Test Property Symbols

Environmental Condition	Abbreviation	Temperature
Cold Temperature Dry	CTD	−65˚±5˚F
Room Temperature Dry	RTD	70˚±10˚F
Elevated Temperature Dry	ETD	180˚±5˚F
Elevated Temperature Wet	ETW	180˚±5˚F

Table 1-3: Environmental Conditions Abbreviations

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

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

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

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2019-007 MPDR 03-08-2023.

1.2 Pooling Across Environments

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

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

1.3 Basis Value Computational Process

The general form to compute engineering basis values is: $\text{basis value} = \bar{X} - kS$ where k is a factor based on the sample size and the distribution of the sample data. There are many different methods to determine the value of *k* in this equation, depending on the sample size and the distribution of the data. In addition, the computational formula used for the standard deviation, S, may vary depending on the distribution of the data. The details of those different computations and when each should be used are in section 2.

1.4 Modified Coefficient of Variation (CV) Method

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

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

The material allowables in this report are calculated using both the as-measured CV and modified CV, so users have the choice of using either one. When the measured CV is greater than 8%, the modified CV method does not change the basis value. NCAMP recommended values make use of the modified CV method when it is appropriate for the data.

When the data fails the Anderson-Darling K-sample test for batch to batch variability or when the data fails the normality test, the modified CV method is not appropriate and no modified CV basis value will be provided. When the ANOVA method is used, it may produce excessively conservative basis values. When appropriate, a single batch or two batch estimate may be provided in addition to the ANOVA estimate.

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

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

2. Background

Statistical computations are performed with CMH17 STATS. Pooling across environments will be used whenever it is permissible according to CMH-17-1G guidelines. If pooling is not permissible, the results of a single point analysis provided by CMH17 STATS is included instead. If the data does not meet CMH-17-1G requirements for a single point analysis, estimates are created by a variety of methods depending on which is most appropriate for the dataset available. Specific procedures used are presented in the individual sections where the data is presented.

2.1 CMH17 STATS Statistical Formulas and Computations

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

2.1.1 Basic Descriptive Statistics

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

Mean: $$\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n}$$ **Equation 1**

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

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

2.1.3 Basis Value Computations

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

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

2.1.3.1 K-factor computations

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

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

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

Where

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

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

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

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

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

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

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

2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

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

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

2.1.4.1 Transformation of data based on Modified CV

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

To accomplish this requires a transformation in two steps:

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

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

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

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

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

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

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

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

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

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

2.1.5 Determination of Outliers

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

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

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

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

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

2.1.6 The k-Sample Anderson Darling Test for Batch Equivalency

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

The k-sample Anderson-Darling test statistic is:

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

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:

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

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.

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

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:

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

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

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

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

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

The Anderson Darling test statistic (AD) is:

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

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

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

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

2.1.8 Levene's Test for Equality of Coefficient of Variation

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

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

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

2.1.9 Distribution Tests

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

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

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

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

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

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

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

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

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

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

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

2.1.9.3.1 Estimating Weibull Parameters

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

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

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

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

2.1.9.3.2 Goodness-of-fit test for the Weibull distribution

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

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

The Anderson-Darling test statistic is

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

and the observed significance level is

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

where

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

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

2.1.9.3.3 Basis value calculations for the Weibull distribution

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

$$B = \hat{q}e^{\left(-V/\hat{\beta}\sqrt{n}\right)}$$ **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 $\left(0 < a < b < \infty\right)$ is given by the area under the normal distribution between ln(a) and ln(b).

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

2.1.9.4.1 Goodness-of-fit test for the Lognormal distribution

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

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

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

The Anderson-Darling statistic is then computed using Equation 30 above and the observed significance level (OSL) is computed using Equation 31 above. This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if in fact the data are a sample from a lognormal distribution. If OSL ≤ 0.05, one may conclude (at a five percent risk of being in error) that the population is not lognormally distributed. Otherwise, the hypothesis that the population is lognormally distributed is not rejected. For further information on these procedures, see reference 6.

2.1.9.4.2 Basis value calculations for the Lognormal distribution

If the data set is assumed to be from a population with a lognormal distribution, basis values are calculated using the equation above in section 2.1.3. However, the calculations are performed using the logarithms of the data rather than the original observations. The computed basis values are then transformed back to the original units by applying the inverse of the log transformation.

2.1.10 Non-parametric Basis Values

Non-parametric techniques do not assume any particularly underlying distribution for the population the sample comes from. It does require that the batches be similar enough to be grouped together, so the ADK test must have a positive result. While it can be used instead of assuming the normal, lognormal or Weibull distribution, it typically results in lower basis values. One of following two methods should be used, depending on the sample size.

2.1.10.1 Non-parametric Basis Values for large samples

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

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

For B-basis values:

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

For A-Basis values:

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

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

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

2.1.10.2 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

The A-basis value is:

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

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

The Hanson-Koopmans method can be used to calculate A-basis values for n less than 299. Find the value k_A corresponding to the sample size n in Table 2-3. For an A-basis value that meets all the requirements of CMH-17-1G, there must be at least five batches represented in the data and at least 55 data points. For a B-basis value, there must be at least three batches represented in the data and at least 18 data points.

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

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

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

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

2.1.11 Analysis of Variance (ANOVA) Basis Values

ANOVA is used to compute basis values when the batch to batch variability of the data does not pass the ADK test. Since ANOVA makes the assumption that the different batches have equal variances, the data is checked to make sure the assumption is valid. Levene's test for equality of variance is used (see section 2.1.8). If the dataset fails Levene's test, the basis values computed are likely to be conservative. Thus this method can still be used but the values produced will be listed as estimates.

2.1.11.1 Calculation of basis values using ANOVA

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

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

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

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

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

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

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

Next, the mean sums of squares are computed:

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

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

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

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

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

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

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

Denote the ratio of mean squares by

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

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

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

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

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

2.2 Single Batch and Two Batch Estimates using Modified CV

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

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

3. Summary of Results

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

3.1 NCAMP Recommended B-basis Values

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

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

If the data appear questionable (e.g. when the CTD-RTD-ETW trend of the basis values is not consistent with the CTD-RTD-ETW trend of the average values), then the B-basis values will not be recommended.

NCAMP Recommended B-basis Values for
Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS Fabric prepreg

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	WT	WC	FT	FC	SBS*	IPS* 0.2% Offset	IPS* 4% Strain
CTD (-65° F)	B-basis	116.7	98.27	114.3	98.15	12.53	6.331	10.57
	Mean	130.7	108.3	128.5	112.1	14.19	7.158	11.95
	CV	6.000	6.041	6.000	5.162	6.000	6.000	6.000
RTD (70° F)	B-basis	116.4	86.09	117.0	NA:A	11.83**	5.048	NA:A
	Mean	130.6	96.01	131.2	95.13	13.03	5.700	9.336
	CV	6.382	6.519	6.589	8.497	6.000	6.000	6.000
ETD (180° F)	B-basis		74.71		78.29	9.685		
	Mean		84.72		88.74	10.89		
	CV		6.000		6.044	6.000		
ETW (180° F)	B-basis	119.1	72.74	118.6	NA:A	9.021	4.150	NA:A
	Mean	133.1	82.61	132.6	77.54	10.23	4.680	7.078
	CV	6.065	6.307	6.000	8.738	6.000	6.000	6.000

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA implies that tests were run but data did not meet NCAMP 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 Single Point CMH Stats 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
Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS Fabric prepreg

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 Initial Peak	SSB Proc C 2% Offset	SSB Proc C Ultimate	SBS1*
25/50/25	CTD (-65˚ F)	B-basis	44.20		49.83		81.24					
		Mean	49.37		55.59		90.76					
		CV	6.000		6.267		6.000					
	RTD (70˚ F)	B-basis	42.56	39.92	46.35	60.93†	78.21	60.72		95.45	111.7	10.93
		Mean	47.76	44.32	52.11	68.80	87.91	68.77		107.6	124.2	12.10
		CV	6.000	6.000	6.000	6.000	6.000	6.000		6.000	6.000	6.000
	ETW (180˚ F)	B-basis	46.09	33.41	48.52	NA	78.69	NA:A		NA:A	92.28	8.020
		Mean	51.22	37.76	54.20	56.15	84.08	53.38		96.31	105.0	9.183
		CV	6.000	6.000	6.000	6.141	3.411	7.871		7.208	6.203	6.000
10/80/10	CTD (-65˚ F)	B-basis	40.11		43.18		51.34					
		Mean	44.82		47.66		58.14					
		CV	6.000		6.000		6.000					
	RTD (70˚ F)	B-basis	36.96	33.15	38.57	44.78**	48.41	47.21		92.46	110.80	
		Mean	41.65	36.80	43.05	49.71	54.73	49.76		103.8	123.40	
		CV	6.000	6.000	6.000	6.000	6.000	6.000		6.000	6.00	
	ETW (180˚ F)	B-basis	30.87	26.99	31.94	36.30	45.02	NA:A		79.08	95.52	
		Mean	35.08	30.58	36.35	41.15	50.91	38.54		90.39	108.07	
		CV	6.000	6.000	6.000	2.727	6.000	6.191		6.985	6.000	
40/20/40	CTD (-65˚ F)	B-basis	47.64		50.40		101.5					
		Mean	53.43		57.18		113.4					
		CV	6.000		6.000		6.000					
	RTD (70˚ F)	B-basis	46.52	38.13	NA:A	73.83	102.9	77.38	NA:I	84.05	95.58	
		Mean	52.31	42.47	55.05	82.39	114.9	86.19	95.02	94.11	108.2	
		CV	6.000	6.000	5.890	6.359	6.000	6.000	6.000	6.000	6.000	
	ETW (180˚ F)	B-basis	51.87	33.41	51.86	56.73	101.4	57.92	NA:I	70.70	84.74	
		Mean	57.57	37.69	58.55	65.25	113.3	66.51	81.50	80.76	95.96	
		CV	6.000	6.000	6.000	6.511	6.000	7.289	6.633	6.817	6.000	

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the given B-basis value.
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 are available for that property and condition.
* Dataset is as-measured rather than normalized
** Indicates the Single Point CMH Stats B-basis value is greater than 90% of the mean value.
† FHC > UNC; when data for FHC>UNC, FHC data is for informational purposes only and it may not substantial enough to be used for design. The UNC basis value is recommended

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

3.2 Lamina and Laminate Summary Tables

Prepreg Material: Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS
Material Specification: NMS 401/3
Process Specification: NPS 84013 Baseline Consolidate Cycle C

Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS
Lamina Properties Summary

Fabric: HTA40 3K 5HS **Resin:** PEEK - Evonik Vestakeep 2000

DMA Tg(dry): 267.64 °F **DSC Melting Temperature (Peak):** 646.67 °F **Tg METHOD:** DMA (ASTM D7028)
DMA Tg(wet): 252.55 °F **Tg METHOD:** DSC (ASTM D3418)

Date of fiber manufacture: Feb 2015 to Oct 2019 **Date of testing:** Jan 2018 to Jul 2022
Date of resin manufacture: Jun 2015 to April 2020 **Date of data submittal:** July 2022
Date of semipreg manufacture: Feb 2016 to Oct 2020 **Date of analysis:** July 2022 to Nov 2022
Date of composite manufacture: Sep 2017 to July 2021

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY
Data reported: As-measured followed by normalized values in parentheses, normalizing tply: 0.01226 in
Values shown in shaded boxes do not meet CMH17-1G requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test Condition	CTD (–65° F)			RTD (70° F)			ETD (180° F)			ETW (180° F)		
Test Property	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean
F_1^{tu}	111.5	116.4	130.6	118.6	117.2	131.5				115.1	119.5	133.6
(ksi)	(110.1)	(116.7)	(130.7)	(118.3)	(116.4)	(130.6)				(113.0)	(119.1)	(133.1)
E_1^t			8.654			8.626						8.591
(Msi)			(8.664)			(8.562)						(8.556)
ν_{12}^t			0.04857			0.03836						0.03756
F_2^{tu}	115.0	116.1	130.4	118.2	117.4	131.7				126.9	119.5	133.6
(ksi)	(108.6)	(114.3)	(128.5)	(111.7)	(117.0)	(131.2)				(126.1)	(118.6)	(132.6)
E_2^t			8.692			8.468						8.405
(Msi)			(8.562)			(8.435)						(8.342)
F_1^{cu}	100.4	99.24	109.5	84.73	87.02	97.16	80.01	74.98	85.21	71.04	73.41	83.50
(ksi)	(101.1)	(98.27)	(108.3)	(88.91)	(86.09)	(96.01)	(77.55)	(74.71)	(84.72)	(68.12)	(72.74)	(82.61)
E_1^c			7.971			8.075			8.104			8.264
(Msi)			(7.907)			(8.023)			(8.100)			(8.229)
F_2^{cu}	102.6	101.8	113.7	70.95	83.93	96.02	74.38	76.95	89.10	54.24	NA	77.42
(ksi)	(101.1)	(98.15)	(112.1)	(64.47)	NA	(95.13)	(81.67)	(78.29)	(88.74)	(52.66)	NA	(77.54)
E_2^c			8.007			8.126			8.161			8.253
(Msi)			(7.906)			(8.070)			(8.132)			(8.240)
$F_{12}^{s0.2\%}$ (ksi)	6.687	6.331	7.158	5.237	5.048	5.700				4.180	4.150	4.680
$F_{12}^{s4\%\ strain}$ (ksi)	11.13	10.57	11.95	8.408	NA	9.336				6.477	NA	7.078
G_{12}^s (Msi)			0.6735			0.5950						0.4861
SBS (ksi)	13.20	12.53	14.19	12.35	11.83	13.03	10.40	9.685	10.89	8.853	9.021	10.23

Table 3-3: Summary of basis values for Lamina Data

Prepreg Material: Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS
Material Specification: NMS 401/3
Process Specification: NPS 84013 Baseline Consolidate Cycle C

Tenax®-E TPWF PEEK-HTA40 E13 3K 5HS
Laminate Properties Summary

Fabric: HTA40 3K 5HS **Resin:** PEEK - Evonik Vestakeep 2000

DMA Tg(dry): 267.64 ˚F **DSC Melting Temperature (Peak):** 646.67 ˚F **Tg METHOD:** DMA (ASTM D7028)
DMA Tg(wet): 252.55 ˚F **Tg METHOD:** DSC (ASTM D3418)

Date of fiber manufacture:	Feb 2015 to Oct 2019	**Date of testing:**	Jan 2018 to Jul 2022
Date of resin manufacture:	Jun 2015 to April 2020	**Date of data submittal:**	Jul 2022
Date of semipreg manufacture:	Feb 2016 to Oct 2020	**Date of analysis:**	Jul 2022 to Nov 2022
Date of composite manufacture:	Sep 2017 to July 2021		

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY
Data reported as normalized used a normalizing t_{ply} of 0.01226 in
Values shown in shaded boxes do not meet CMH17-1G requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test	Property	Layup		(1) Quasi Isotropic 25/50/25			(2) "Soft" 10/80/10			(3) "Hard" 40/20/40		
		Test Condition	Unit	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean
OHT (normalized)	**Strength**	CTD (−65˚ F)	ksi	47.71	44.20	49.37	43.04	40.11	44.82	50.21	47.64	53.43
		RTD (70˚ F)	ksi	46.10	42.56	47.76	39.88	36.96	41.65	49.09	46.52	52.31
		ETW (180˚ F)	ksi	46.78	46.09	51.22	33.33	31.07	35.08	54.40	51.87	57.57
OHC (normalized)	**Strength**	RTD (70˚ F)	ksi	41.99	39.92	44.32	34.69	33.15	36.80	40.40	38.13	42.47
		ETW (180˚ F)	ksi	33.55	33.41	37.76	26.47	26.99	30.58	35.65	33.41	37.69
UNT (normalized)	**Strength**	CTD (−65˚ F)	ksi	78.10	81.24	90.76	55.42	51.34	58.14	106.8	101.5	113.4
	Modulus		Msi	---	---	6.228	---	---	4.156	---	---	7.765
	Strength	RTD (70˚ F)	ksi	75.31	78.21	87.91	52.02	48.41	54.73	108.4	102.9	114.9
	Modulus		Msi	---	---	6.139	---	---	4.033	---	---	7.753
	Strength	ETW (180˚ F)	ksi	78.69	NA	84.08	48.20	45.02	50.91	106.8	101.4	113.3
	Modulus		Msi	---	---	5.975	---	---	3.812	---	---	7.665
UNC (normalized)	**Strength**	RTD (70˚ F)	ksi	59.83	60.72	68.77	47.21	NA	49.76	79.37	77.38	86.19
	Modulus		Msi	---	---	5.743	---	---	3.834	---	---	7.055
	Strength	ETW (180˚ F)	ksi	36.81	NA	53.38	27.76	NA	38.54	59.86	57.92	66.51
	Modulus		Msi	---	---	5.703	---	---	3.703	---	---	7.238
SBS1 (as-measured)	**Strength**	RTD (70˚ F)	ksi	10.77	10.93	12.10	---	---	---	---	---	---
		ETW (180˚ F)	ksi	8.724	8.020	9.183	---	---	---	---	---	---
FHT (normalized)	**Strength**	CTD (−65˚ F)	ksi	44.45	49.83	55.59	45.18	43.18	47.66	51.95	50.40	57.18
		RTD (70˚ F)	ksi	50.17	46.35	52.11	40.58	38.57	43.05	41.28	NA	55.05
		ETW (180˚ F)	ksi	52.27	48.52	54.20	32.75	31.94	36.35	50.66	51.86	58.55
FHC (normalized)	**Strength**	RTD (70˚ F)	ksi	61.97†	60.93†	68.80†	45.22	44.78	49.71	73.99	73.83	82.39
		ETW (180˚ F)	ksi	39.79†	NA	56.15†	36.28†	36.30	41.15†	51.74	56.73	65.25
SSB Proc C (normalized)	**Initial Peak Strength**	RTD (70˚ F)	ksi	---	---	---	---	---	---	90.87	81.02	95.02
		ETW (180˚ F)	ksi	---	---	---	---	---	---	64.43	70.51	81.50
	2% Offset Strength	RTD (70˚ F)	ksi	102.5	95.45	107.6	99.60	92.46	103.8	89.82	84.05	94.11
		ETW (180˚ F)	ksi	66.69	NA	96.31	71.76	79.08	90.39	65.21	70.70	80.76
	Ultimate Strength	RTD (70˚ F)	ksi	119.4	111.7	124.2	116.8	110.8	123.4	104.0	95.58	108.2
		ETW (180˚ F)	ksi	95.87	92.28	105.0	101.5	95.52	108.1	91.77	84.74	95.96
CAI (normalized)	**Strength**	RTD (70˚ F)	ksi	43.48	38.25	45.69	---	---	---	---	---	---
ILT* (as-measured)	**Strength**	CTD (−65˚ F)	ksi	9.841	NA	19.10	---	---	---	---	---	---
		RTD (70˚ F)	ksi	3.812	NA	13.86	---	---	---	---	---	---
		ETW (180˚ F)	ksi	8.882	8.719	10.64	---	---	---	---	---	---
CBS* (as-measured)	**Strength**	CTD (−65˚ F)	lb	426.2	572.1	685.3	---	---	---	---	---	---
		RTD (70˚ F)	lb	338.2	NA	493.4	---	---	---	---	---	---
		ETW (180˚ F)	lb	317.8	310.9	378.0	---	---	---	---	---	---

* The NCAMP layup for ILT/CBS is [0]7s. Informational only, please refer to NPS 84013 Section 4.5 for processing information.

† FHC > UNC; when data for FHC>UNC, FHC data is for informational purposes only and it may not substantial enough to be used for design. The UNC basis value is recommended

Table 3-4: Summary of basis values for Laminate Data

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

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

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

When a dataset fails the Anderson-Darling k-sample (ADK) test for batch-to-batch variation, an ANOVA analysis is required. In order for B-basis values to be computed using the ANOVA method, data from five batches are required. Since this qualification dataset has only three batches, the basis values computed using ANOVA are considered estimates only. However, the basis values resulting from the ANOVA method using only three batches may be overly conservative. The ADK test is performed again after a transformation of the data according to the assumptions of the modified CV method (see section 2.1.4 for details). If the dataset still passes the ADK test at this point, modified CV basis values are provided. If the dataset does not pass the ADK test after the transformation, estimates may be computed using the modified CV method per the guidelines of CMH-17-1G section 8.3.10.

4.1 Warp Tension (WT)

The WT data are normalized, so both normalized and as-measured statistics are provided. Only the RTD datasets pass ADK test. All conditions passed the normality test. The normal single approach was used to compute basis values for RTD normalized and as-measured and ANOVA method was used for the other environments. After the mod-CV transformation, all environments are poolable for both normalized and as-measured datasets.

There were three statistical outliers. The lowest value in batch of the RTD condition was an outlier for batch two but not for the RTD condition, it was an outlier for both the normalized and as-measured datasets. The largest value in batch four of the RTD condition was an outlier for batch 4 in the as-measured dataset only, it was not an outlier for the RTD condition or for the normalized dataset. The lowest value in batch three of the ETW1 condition was an outlier for batch three only in the normalized dataset, it was not an outlier for the ETW1 condition or for the as-measured dataset. All outliers were retained for analysis.

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

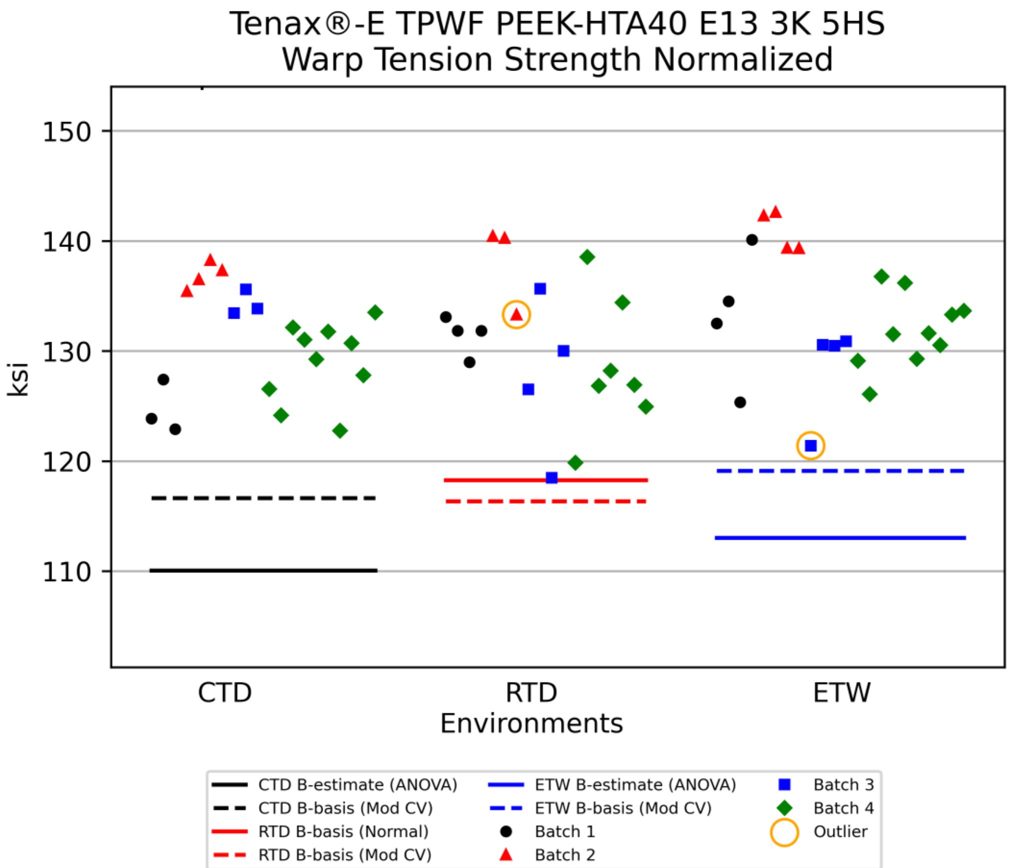

Figure 4-1: Batch plot for WT normalized strength

Warp Tension Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	130.7	130.6	133.1	130.6	131.5	133.6
Stdev	4.928	6.219	5.495	4.645	6.556	5.496
CV	3.770	4.763	4.129	3.557	4.984	4.114
Mod CV	6.000	6.382	6.065	6.000	6.492	6.057
Min	122.8	118.5	121.4	121.6	121.4	123.0
Max	138.3	140.4	142.6	136.8	146.7	142.0
No. Batches	4	4	4	4	4	4
No. Spec.	20	18	22	20	18	22
Basis Values and Estimates						
B-Basis		118.3			118.6	
B-Estimate	110.1		113.0	111.5		115.1
A-Estimate	95.77	109.6	99.08	98.26	109.4	102.2
Method	ANOVA	Normal	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Value and Estimates						
B-Basis	116.7	116.4	119.1	116.4	117.2	119.5
A-Estimate	107.2	106.9	109.6	106.8	107.7	110.0
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

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

Warp Tension Modulus Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	8.664	8.562	8.556	8.654	8.626	8.591
Stdev	0.1505	0.09499	0.1144	0.1091	0.1638	0.1366
CV	1.738	1.109	1.337	1.261	1.899	1.590
Mod CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	8.303	8.404	8.396	8.421	8.339	8.410
Max	8.916	8.748	8.776	8.859	8.944	8.828
No. Batches	4	4	4	4	4	4
No. Spec.	20	18	22	20	18	22

Table 4-2: Statistics from WT Modulus Data

4.2 Fill Tension (FT)

The FT data is normalized, so both normalized and as-measured statistics are provided. For normalized datasets, only ETW passed the ADK test and normality test so normality method was used for ETW, while CTD and RTD failed the ADK test, so ANOVA method was used. . For the as-measured datasets the CTD condition failed the ADK test, while the RTD and ETW passed the ADK test but failed Levene's test for pooling, so single approach was applied to both environments. The normal method was used for computing B-basis for RTD and ETW and ANOVA method for CTD. For modified CV approach, all datasets, both normalized and as-measured, passed the ADK test and passed Levene's test for pooling, so pooling approach was applied for the modified CV basis values.

There were two statistical outliers. In CTD environment for as-measured and normalized datasets a lower batch outlier for batch four was observed. It was not an outlier for the CTD condition. In the RTD normalized dataset, a lower batch outlier in batch four was found. It was not an outlier for the RTD condition or for the as-measured dataset. Both outliers were retained for analysis.

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

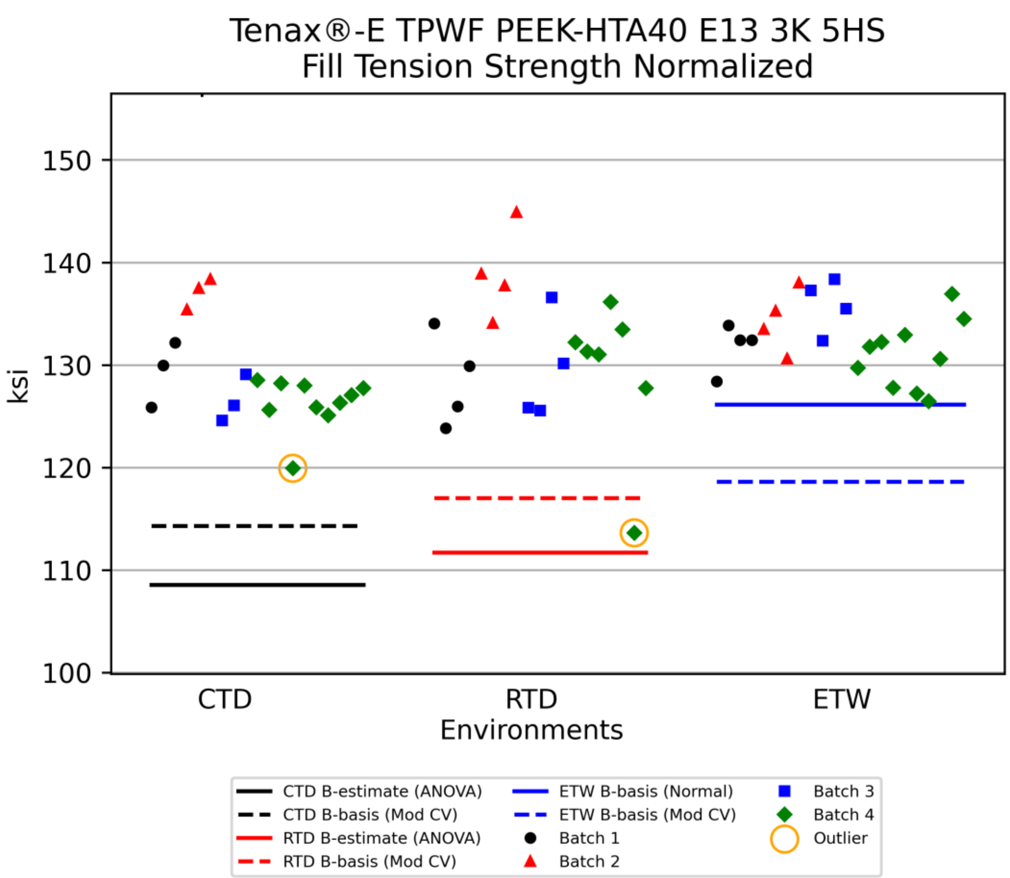

Figure 4-2: Batch Plot for FT normalized strength

Fill Tension Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	128.5	131.2	132.6	130.4	131.7	133.6
Stdev	4.580	6.794	3.447	3.909	6.956	3.594
CV	3.564	5.178	2.598	2.997	5.280	2.690
Mod CV	6.000	6.589	6.000	6.000	6.640	6.000
Min	119.9	113.6	126.5	122.6	114.0	127.4
Max	138.4	144.9	138.4	138.0	144.1	140.8
No. Batches	4	4	4	4	4	4
No. Spec.	19	19	22	19	19	22
Basis Values and Estimates						
B-Basis			126.1		118.2	126.9
B-Estimate	108.6	111.7		115.0		
A-Estimate	94.75	98.11	121.5	104.3	108.6	122.0
Method	ANOVA	ANOVA	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	114.3	117.0	118.6	116.1	117.4	119.5
A-Estimate	104.8	107.5	109.1	106.5	107.8	109.9
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

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

Fill Tension Modulus Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	8.562	8.435	8.342	8.692	8.468	8.405
Stdev	0.2074	0.2018	0.2950	0.1999	0.1517	0.2723
CV	2.422	2.393	3.536	2.300	1.792	3.240
Mod CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	8.204	8.138	7.410	8.187	8.251	7.391
Max	9.011	8.788	8.759	9.012	8.772	8.755
No. Batches	4	4	4	4	4	4
No. Spec.	19	19	22	19	19	22

Table 4-4: Statistics from FT Modulus Data

4.3 Warp Compression (WC)

The WC data is normalized, so both normalized and as-measured statistics are provided. For normalized and as-measured datasets, only ETW didn't pass the ADK test , so ANOVA method was used for the ETW condition. For normalized datasets, the CTD, RTD and ETD conditions met the requirements for pooling but as-measured datasets failed normality test and single point approach was required. The as-measured , RTD dataset failed the normality test and the For modified CV, all four conditions could be pooled for both normalized and as-measured datasets.

There were four statistical outliers. The CTD condition had two outliers in the as-measured dataset. The lowest values in batch one and batch two were outliers for their respective batches but not for the CTD condition and not for the normalized datasets. The lowest value in batch three of the RTD condition was an outlier for both the normalized and as-measured datasets. It was an outlier for the RTD condition but not for batch three. The lowest value in batch one of the ETW condition was an outlier for both the normalized and as-measured dataset and for both batch one and for the ETW condition. All outliers were retained for computations.

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

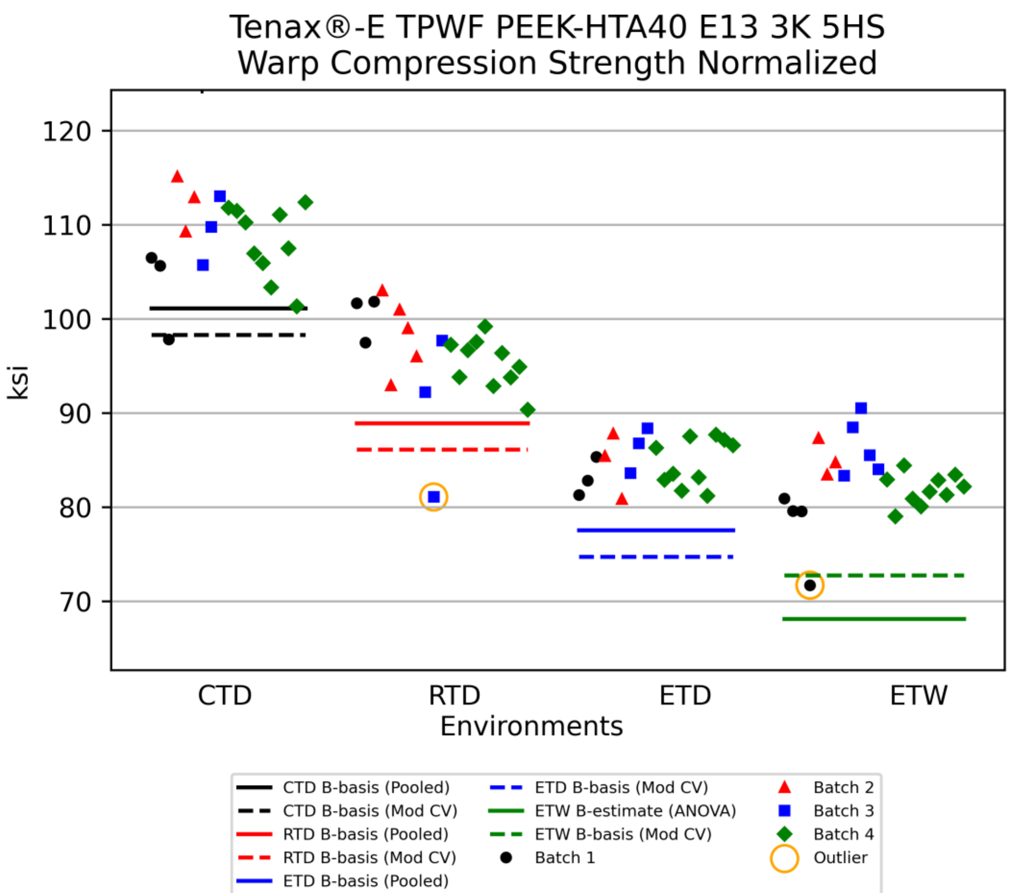

Figure 4-3: Batch plot for WC normalized strength

Warp Compression Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	CTD (−65° F)	RTD (70° F)	ETD (180° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETD (180° F)	ETW (180° F)
Mean	108.3	96.01	84.72	82.61	109.5	97.16	85.21	83.50
Stdev	4.419	4.836	2.543	3.811	4.669	5.539	2.670	3.442
CV	4.081	5.037	3.002	4.614	4.265	5.701	3.133	4.123
Mod CV	6.041	6.519	6.000	6.307	6.132	6.851	6.000	6.061
Min	97.79	81.06	80.83	71.69	97.75	79.61	80.83	73.65
Max	115.1	103.0	88.37	90.51	114.8	108.0	89.00	91.22
No. Batches	4	4	4	4	4	4	4	4
No. Spec.	19	21	19	22	19	21	19	22
Basis Values and Estimates								
B-Basis	101.1	88.91	77.55		100.4	84.73	80.01	
B-Estimate				68.12				71.04
A-Estimate	96.33	84.11	72.76	58.04	93.92	72.53	76.32	62.36
Method	Pooled	Pooled	Pooled	ANOVA	Normal	Weibull	Normal	ANOVA
Modified CV Basis Values and Estimates								
B-Basis	98.27	86.09	74.71	72.74	99.24	87.02	74.98	73.41
A-Estimate	91.66	79.47	68.09	66.10	92.48	80.25	68.22	66.62
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

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

Warp Compression Modulus Statistics								
	Normalized				As-measured			
Env	CTD (−65° F)	RTD (70° F)	ETD (180° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETD (180° F)	ETW (180° F)
Mean	7.907	8.023	8.100	8.229	7.971	8.075	8.104	8.264
Stdev	0.4142	0.1652	0.2826	0.2094	0.5067	0.2676	0.3406	0.2630
CV	5.238	2.059	3.489	2.544	6.357	3.314	4.203	3.183
Mod CV	6.619	6.000	6.000	6.000	7.179	6.000	6.102	6.000
Min	7.148	7.582	7.297	7.698	7.106	7.434	7.399	7.584
Max	8.376	8.276	8.569	8.708	8.536	8.501	8.571	8.672
No. Batches	4	4	4	4	4	4	4	4
No. Spec.	22	23	24	36	22	23	24	36

Table 4-6: Statistics from WC Modulus Data

4.4 Fill Compression (FC)

The FC data is normalized, so both normalized and as-measured statistics are provided. The as-measured ETD dataset and both the normalized and as-measured RTD and ETW datasets failed the ADK test so the ANOVA method was used for those datasets. The normal distribution had an adequate fit for the normalized and as-measured CTD and the normalized ETD datasets. The CTD, RTD and ETD datasets met all requirements for pooling after the modified CV transformation of data was applied. No statistical outliers were detected.

Statistics, basis values and estimates are given for the FC strength data in Table 4-7 and for the FC modulus data in Table 4-8. The normalized data, B-estimates and B-basis values are shown graphically in Fig. 4-4.

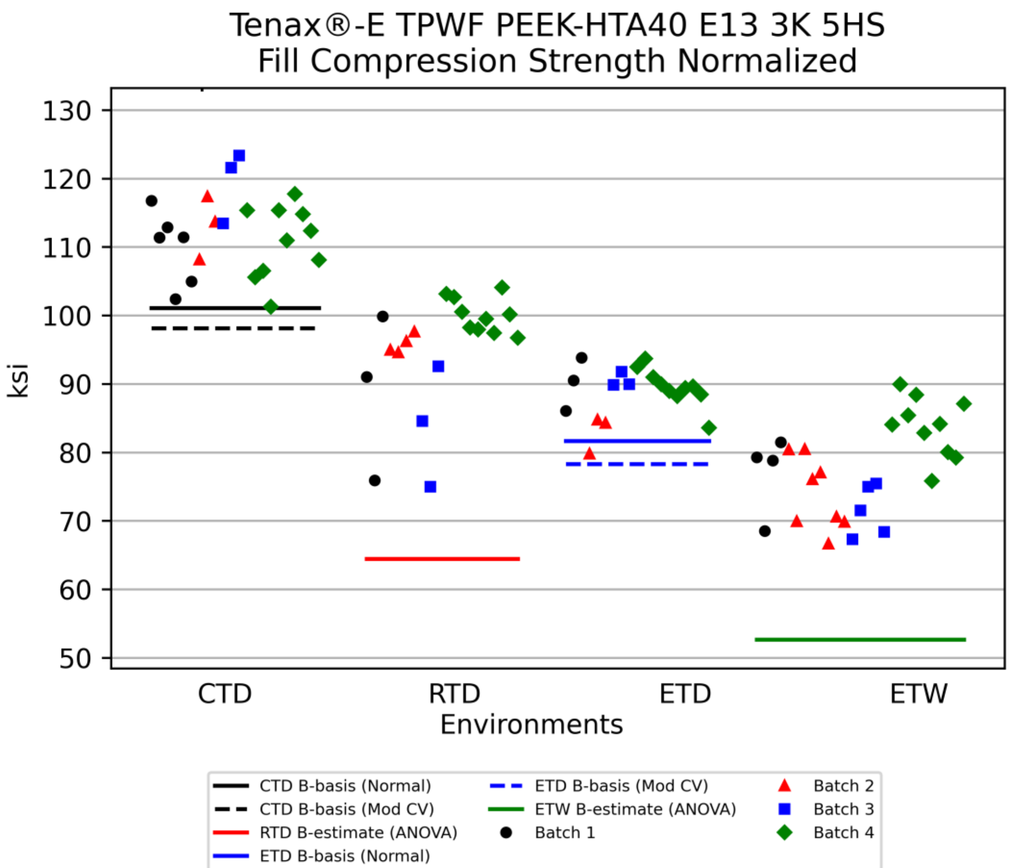

Figure 4-4: Batch Plot for FC normalized strength

Fill Compression Strength Basis Values and Statistics								
	Normalized				As-measured			
Env	CTD (−65˚ F)	RTD (70˚ F)	ETD (180˚ F)	ETW (180˚ F)	CTD (−65˚ F)	RTD (70˚ F)	ETD (180˚ F)	ETW (180˚ F)
Mean	112.1	95.13	88.74	77.54	113.7	96.02	89.10	77.42
Stdev	5.785	8.084	3.628	6.775	5.911	7.377	3.813	6.693
CV	5.162	8.497	4.088	8.738	5.196	7.683	4.279	8.646
Mod CV	6.581	8.497	6.044	8.738	6.598	7.841	6.139	8.646
Min	101.3	74.97	79.80	66.64	103.0	76.74	79.33	66.06
Max	123.4	104.1	93.85	89.96	125.7	104.0	93.79	90.68
No. Batches	4	4	4	4	4	4	4	4
No. Spec.	22	20	19	27	22	20	19	27
Basis Values and Estimates								
B-Basis	101.1		81.67		102.6			
B-Estimate		64.47		52.66		70.95	74.38	54.24
A-Estimate	93.36	43.16	76.65	35.33	94.64	53.48	64.15	38.06
Method	Normal	ANOVA	Normal	ANOVA	Normal	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis	98.15	NA	78.29	NA	101.8	83.93	76.95	NA
A-Estimate	88.21		70.88		93.62	75.80	68.84	
Method	Normal		Normal		Pooled	Pooled	Pooled	

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

Fill Compression Modulus Statistics								
	Normalized				As-measured			
Env	CTD (−65˚ F)	RTD (70˚ F)	ETD (180˚ F)	ETW (180˚ F)	CTD (−65˚ F)	RTD (70˚ F)	ETD (180˚ F)	ETW (180˚ F)
Mean	7.906	8.070	8.132	8.240	8.007	8.126	8.161	8.253
Stdev	0.3785	0.2925	0.2449	0.3088	0.4141	0.3470	0.2801	0.3372
CV	4.788	3.625	3.012	3.748	5.171	4.270	3.433	4.086
Mod CV	6.394	6.000	6.000	6.000	6.586	6.135	6.000	6.043
Min	7.148	7.379	7.633	7.450	7.100	7.316	7.679	7.350
Max	8.351	8.593	8.568	9.080	8.496	8.688	8.744	9.162
No. Batches	4	4	4	4	4	4	4	4
No. Spec.	22	23	24	34	22	23	24	34

Table 4-8: Statistics from FC Modulus Data

4.5 In-Plane Shear (IPS)

In-Plane Shear data is not normalized. Data was reported on three properties: 0.2% Offset Strength, Strength at 4% Strain, and Modulus.

Datasets for all three conditions for both strength properties failed the Anderson-Darling k-sample (ADK) test, so only estimates computed using the ANOVA approach could be provided. After the transformation of data for the modified CV approach, all the 0.2% Offset strength datasets and the CTD dataset for the strength at 4% strain passed the ADK test, so modified CV values are provided for those datasets.
The 0.2% Offset strength datasets all failed the ADK test, therefore ANOVA method was used to compute B estimates.

There were two statistical outliers. The largest value in batch three of the CTD condition for 0.2% Offset Strength was an outlier for batch three but not for the CTD condition. The only value in batch one of the ETW condition for strength at 4% strain was an outlier for the ETW condition. Both outliers were retained for computation.

Statistics, basis values and estimates are given for the IPS strength properties in Table 4-9 and for the IPS modulus in Table 4-10. The as-measured data, B-basis values and B-estimates are shown graphically in Figure 4-5 and Figure 4-6.

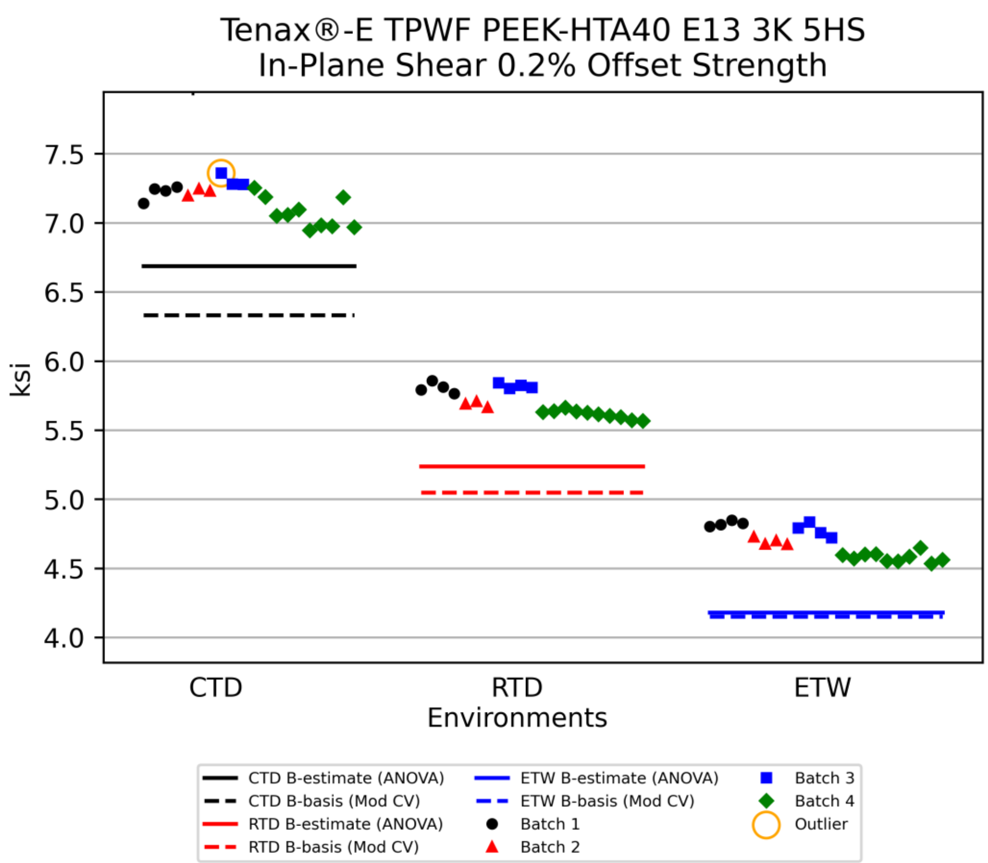

Figure 4-5: Batch plot for IPS 0.2% offset strength as-measured

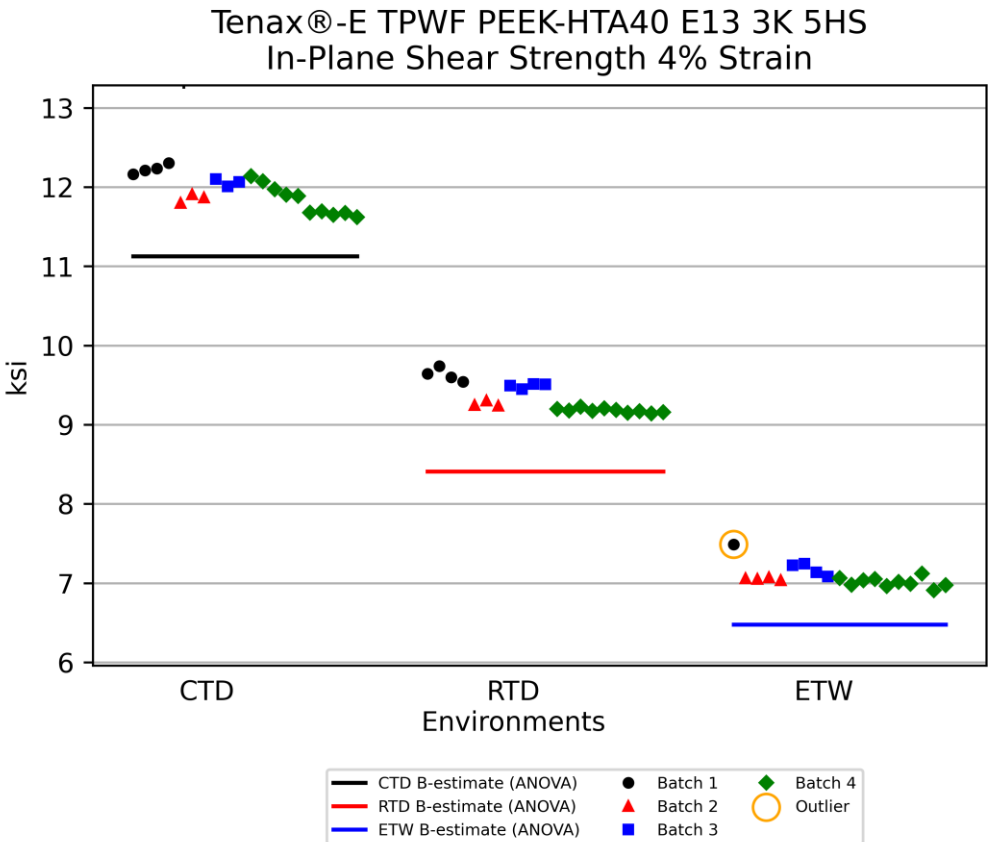

Figure 4-6: Batch plot for IPS 4% strain strength as-measured

In Plane Shear Strength Basis Values and Statistics As-measured						
	0.2% Offset Strength			Strength at 4% Strain		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	7.158	5.700	4.680	11.95	9.336	7.078
Stdev	0.1235	0.0979	0.1070	0.2132	0.1926	0.1296
CV	1.725	1.718	2.286	1.785	2.063	1.831
Mod CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	6.946	5.565	4.534	11.62	9.140	6.910
Max	7.359	5.857	4.848	12.30	9.739	7.488
No. Batches	4	4	4	4	4	4
No. Spec.	20	21	22	20	21	19
Basis Values and Estimates						
B-Estimate	6.687	5.237	4.180	11.13	8.408	6.477
A-Estimate	6.360	4.917	3.834	10.56	7.766	6.060
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-Basis	6.331	5.048	4.150	10.57	NA	NA
A-Estimate	5.743	4.584	3.772	9.584		
Method	Normal	Normal	Normal	Normal		

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

IPS Modulus Statistics As-measured			
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	0.6735	0.5950	0.4861
Stdev	0.01104	0.009766	0.02306
CV	1.638	1.641	4.744
Mod CV	6.000	6.000	6.372
Min	0.6585	0.5801	0.4482
Max	0.6951	0.6125	0.5250
No. Batches	4	4	4
No. Spec.	20	21	22

Table 4-10: Statistics for IPS Modulus Data

4.6 "25/50/25" Unnotched Tension 1 (UNT1)

The UNT1 data is normalized, so both normalized and as-measured statistics are provided. The normalized and as-measured CTD dataset and the normalized RTD dataset failed ADK test, so ANOVA method was used for these. The Weibull distribution had the best fit for the normalized ETW dataset while the as-measured ETW dataset failed tests for the normal, lognormal and Weibull distributions, thereby the non-parametric approach to compute basis values was used.

For as-measured datasets after the modified CV transformation of data, all requirements for pooling were met. For normalized datasets, only the CTD and RTD conditions met the requirements for pooling. No modified CV basis values could be provided for the normalized ETW dataset due to lack of normality.

There were two statistical outliers. The lowest value in batch 3 of the normalized CTD dataset was an outlier for batch 3 but not for the CTD condition and not for the as-measured dataset. The lowest value in batch 3 of the ETW condition was an outlier for both the normalized and as-measuared datasets. It was an outlier only for batch 3 in the as-measured dataset but it was an outlier for both batch 3 and the ETW condition for the normalized dataset. Both outliers were retained for computation purposes.

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

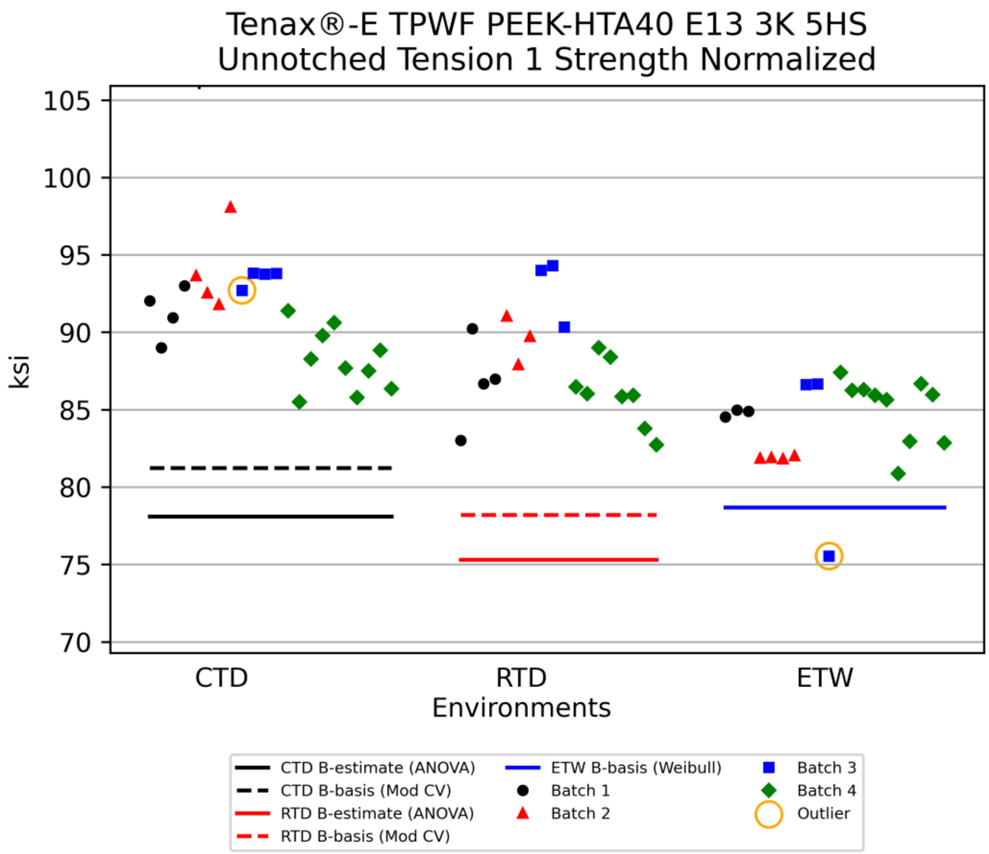

Figure 4-7: Batch Plot for UNT1 normalized strength

Unnotched Tension (UNT1) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	90.76	87.91	84.08	90.79	87.86	83.85
Stdev	3.164	3.322	2.868	2.611	3.311	3.335
CV	3.486	3.779	3.411	2.875	3.769	3.978
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	85.49	82.73	75.54	86.44	82.03	75.48
Max	98.07	94.29	87.39	97.48	94.15	87.58
No. Batches	4	4	4	4	4	4
No. Spec.	22	18	20	22	18	20
Basis Values and Estimates						
B-Basis			78.69		81.32	73.26
B-Estimate	78.10	75.31		81.84		
A-Estimate	68.30	66.56	72.81	75.60	76.69	61.59
Method	ANOVA	ANOVA	Weibull	ANOVA	Normal	Non-parametric
Modified CV Basis Values and Estimates						
B-Basis	81.24	78.21	NA	81.71	78.60	74.68
A-Estimate	74.64	71.25		75.53	72.46	68.52
Method	Pooled	Pooled		Pooled	Pooled	Pooled

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

Unnotched Tension (UNT1) Modulus Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	6.228	6.139	5.975	6.231	6.136	5.957
Stdev	0.09120	0.05053	0.1935	0.07648	0.05979	0.1995
CV	1.464	0.8232	3.239	1.227	0.9745	3.350
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	6.031	6.049	5.227	6.057	6.053	5.253
Max	6.418	6.262	6.208	6.391	6.294	6.200
No. Batches	4	4	4	4	4	4
No. Spec.	22	18	20	22	18	20

Table 4-12: Statistics from UNT1 Modulus Data

4.7 “10/80/10” Unnotched Tension 2 (UNT2)

The UNT2 data is normalized, so both normalized and as-measured statistics are provided. For normalized original CV all environments passed ADK test and tests for pooling, so pooling approach was used for these 3 environments. For normalized and modified CV data, all three environments passed ADK test and normality test, but failed to meet requirements for pooling, so normal distribution method was used for computing B basis values for these.

For as-measured dataset, CTD and RTD environments failed ADK test while ETW passed it. So, ANOVA method was used for computing B estimates for CTD and RTD while normal single approach was used for computing B basis value for ETW. For as-measured modified CV, CTD and RTD environments passed pooling test so pooling approach was used for these two, while normal distribution method was used for ETW.

No outliers were detected.

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

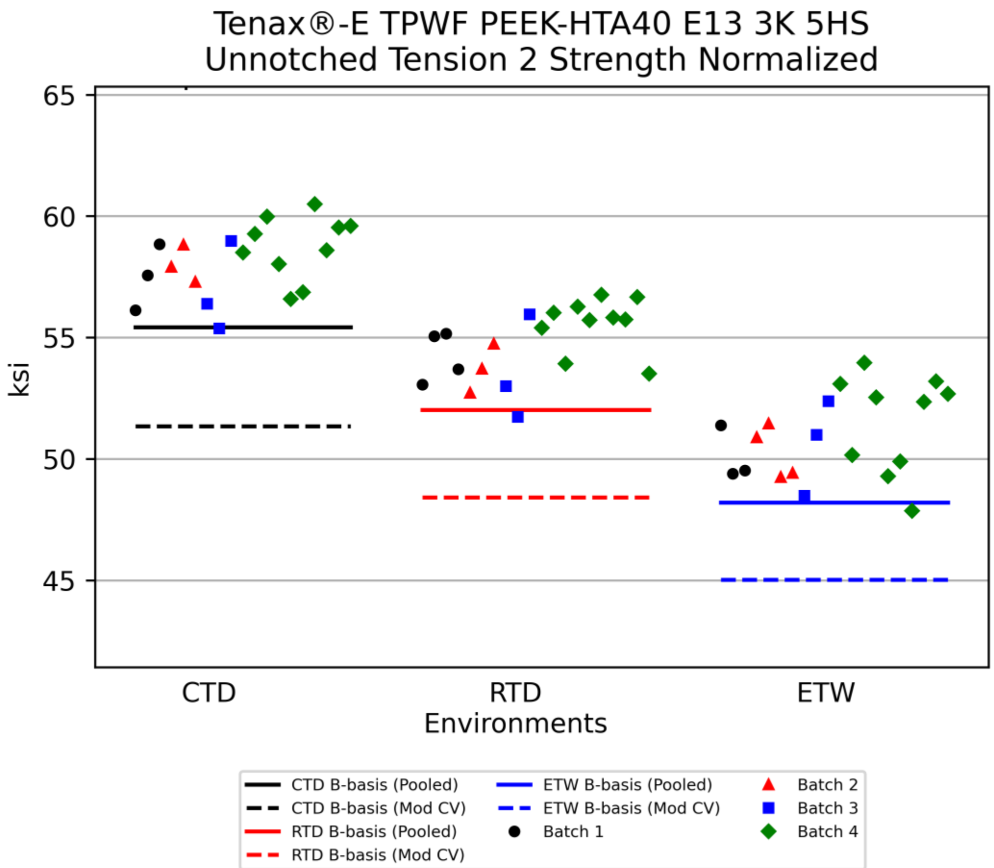

Figure 4-8: Batch Plot for UNT2 normalized strength

Unnotched Tension (UNT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	58.14	54.73	50.91	58.13	54.38	50.64
Stdev	1.417	1.460	1.753	1.832	1.665	1.829
CV	2.437	2.668	3.444	3.152	3.062	3.612
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	55.37	51.72	47.86	54.75	50.96	47.08
Max	60.50	56.76	53.97	61.07	56.60	53.63
No. Batches	4	4	4	4	4	4
No. Spec.	19	20	20	19	20	20
Basis Values and Estimates						
B-Basis	55.42	52.02	48.20			47.12
B-Estimate				51.21	48.55	
A-Estimate	53.60	50.20	46.38	46.40	44.49	44.61
Method	Pooled	Pooled	Pooled	ANOVA	ANOVA	Normal
Modified CV Basis Values and Estimates						
B-Basis	51.34	48.41	45.02	52.06	48.33	44.79
A-Estimate	46.52	43.63	40.84	47.92	44.19	40.63
Method	Normal	Normal	Normal	Pooled	Pooled	Normal

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

Unnotched Tension (UNT2) Modulus Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	4.156	4.033	3.812	4.154	4.007	3.793
Stdev	0.07450	0.06172	0.08813	0.05800	0.06483	0.09964
CV	1.793	1.530	2.312	1.396	1.618	2.627
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	4.061	3.919	3.711	4.081	3.890	3.678
Max	4.319	4.166	4.014	4.273	4.128	4.007
No. Batches	4	4	4	4	4	4
No. Spec.	19	20	19	19	20	19

Table 4-14: Statistics from UNT2 Modulus Data

4.8 "40/20/40" Unnotched Tension 3 (UNT3)

The UNT3 data is normalized, so both normalized and as-measured statistics are provided. All the datasets, both normalized and as-measured, from all three environmental conditions met all requirements for pooling. So, pooling approach was used for these environments.
There were three statistical outliers. The largest value in batch one of the as-measured RTD dataset was an outlier for batch one, but not for the RTD condition and not for the normalized dataset. The lowest value in batch two of the normalized RTD condition was an outlier for batch two but not for the RTD condition and not for the as-measured dataset. The lowest value in batch four of the ETW condition was an outlier for the ETW condition, but not for batch four. It was an outlier for both the normalized and as-measured datsets. All three outliers were retained for computation purposes.

Statistics, basis values and estimates are given for the UNT3 strength data in Table 4-15 and for the UNT3 modulus data in Table 4-16. The normalized data and B-basis values are shown graphically in Figure 4-9.

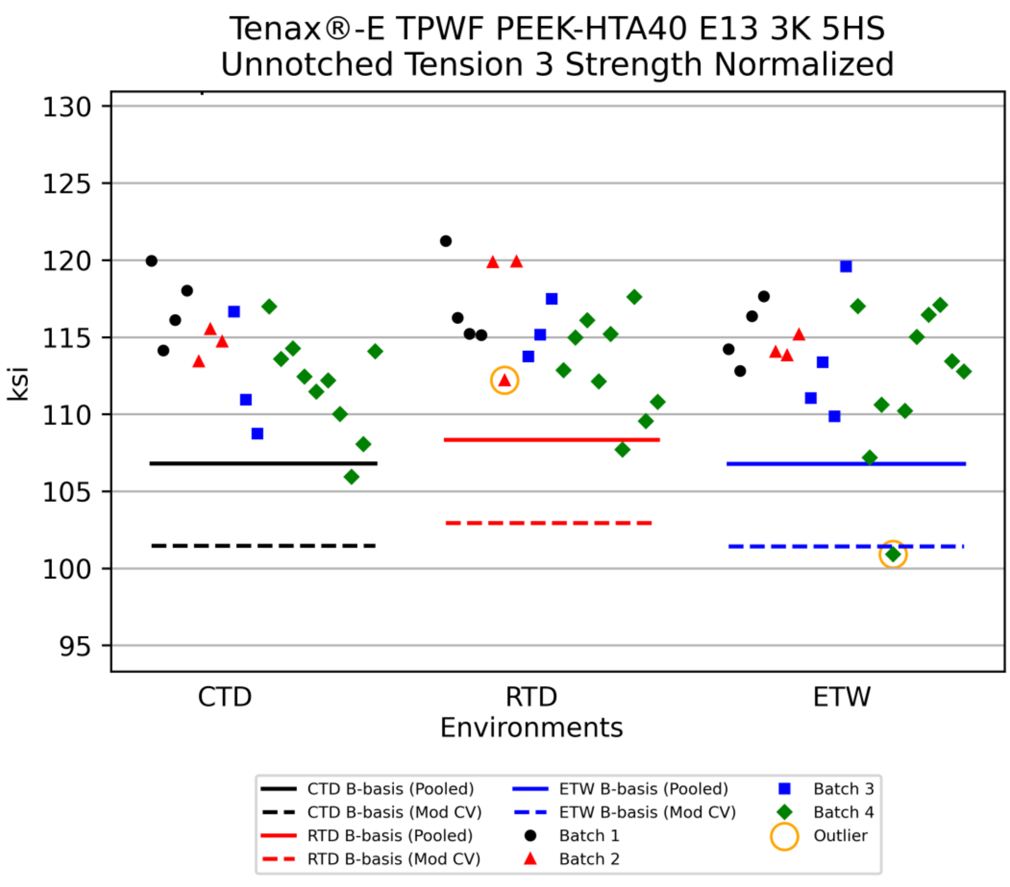

Figure 4-9: Batch Plot for UNT3 normalized strength

Unnotched Tension (UNT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	113.4	114.9	113.3	113.1	114.0	112.9
Stdev	3.500	3.534	4.119	3.499	3.733	4.603
CV	3.088	3.076	3.636	3.094	3.274	4.078
Modified CV	6.000	6.000	6.000	6.000	6.000	6.039
Min	105.9	107.7	100.9	105.8	106.9	99.92
Max	119.9	121.2	119.6	119.2	121.4	120.1
No. Batches	4	4	4	4	4	4
No. Spec.	20	19	21	20	19	21
Basis Values and Estimates						
B-Basis	106.8	108.4	106.8	106.1	107.0	106.0
A-Estimate	102.5	104.0	102.4	101.5	102.4	101.3
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates						
B-Basis	101.5	102.9	101.4	101.2	102.1	101.1
A-Estimate	93.46	94.95	93.41	93.24	94.12	93.07
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

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

Unnotched Tension (UNT3) Modulus Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	7.765	7.753	7.665	7.747	7.694	7.639
Stdev	0.09032	0.06791	0.1636	0.08708	0.1062	0.2301
CV	1.163	0.8758	2.135	1.124	1.380	3.012
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	7.567	7.654	7.409	7.585	7.572	7.404
Max	7.894	7.890	7.988	7.897	7.897	8.132
No. Batches	4	4	4	4	4	4
No. Spec.	20	19	21	20	19	21

Table 4-16: Statistics from UNT3 Modulus Data

4.9 "25/50/25" Unnotched Compression 1 (UNC1)

The UNC1 data is normalized, so both normalized and as-measured statistics are provided. The normalized RTD and both the normalized and as-measured ETW conditions failed the Anderson-Darling k-sample (ADK) test, so the ANOVA method was required to compute basis values. Since this method requires five batches, only B-estimates can be computed for this dataset. Only the normalized RTD dataset passed the ADK test after the modified CV transformation of data, so no modified CV basis values could be provided for the ETW2 datasets. The as-measured RTD passed ADK test. The Weibull distribution provided the best fit to the dataset, so this method was used to compute RTD basis values.

There was one statistical outlier. The lowest value in batch one of the as-measured RTD dataset was an outlier for batch one, but not for the RTD condition or for the normalized dataset. . This outlier was retained for computing purposes.

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

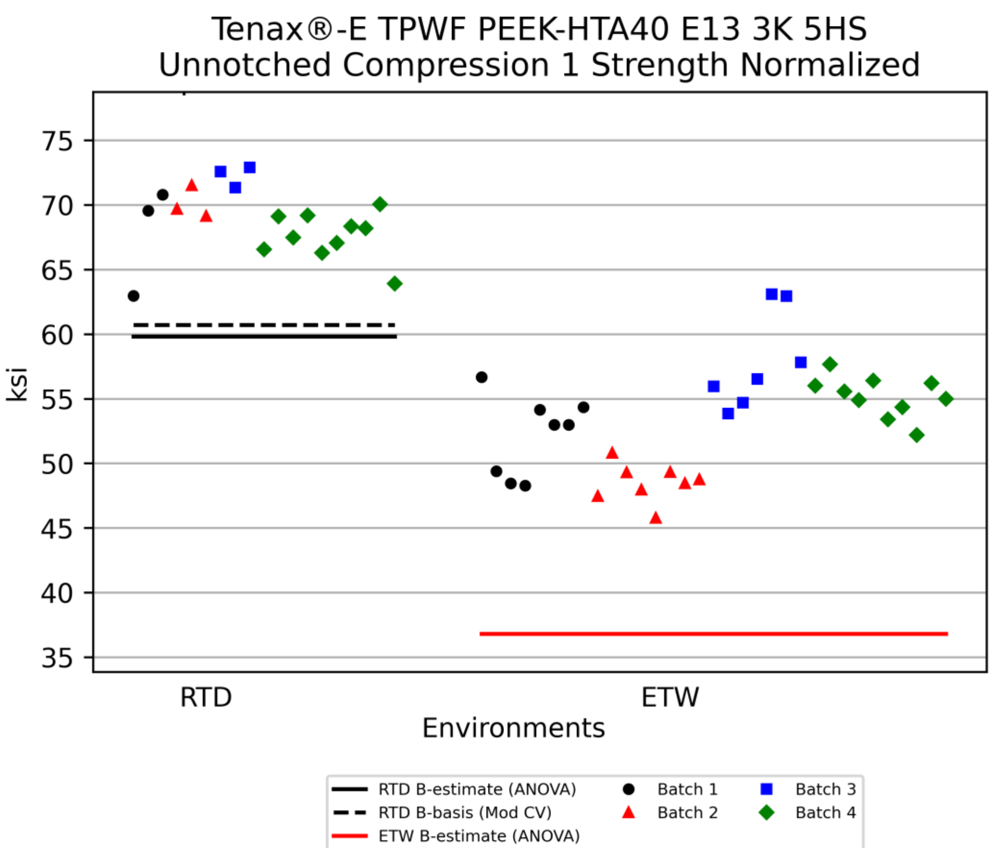

Figure 4-10: Batch plot for UNC1 normalized strength

Unnotched Compression (UNC1) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	68.77	53.38	68.37	52.81
Stdev	2.653	4.202	2.367	4.222
CV	3.858	7.871	3.462	7.995
Modified CV	6.000	7.936	6.000	7.998
Min	62.98	45.78	61.95	45.28
Max	72.91	63.09	71.34	62.07
No. Batches	4	4	4	4
No. Spec.	19	33	19	33
Basis Values and Estimates				
B-Basis			63.66	
B-Estimate	59.83	36.81		36.29
A-Estimate	53.60	25.29	58.59	24.80
Method	ANOVA	ANOVA	Weibull	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	60.72	NA	60.37	NA
A-Estimate	55.02		54.70	
Method	Normal		Normal	

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

Unnotched Compression (UNC1) Modulus Statistics				
	Normalized		As-measured	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	5.743	5.703	5.708	5.642
Stdev	0.1366	0.2440	0.1665	0.2546
CV	2.378	4.279	2.918	4.513
Modified CV	6.000	6.139	6.000	6.257
Min	5.411	5.163	5.334	5.081
Max	5.951	6.285	5.975	6.200
No. Batches	4	4	4	4
No. Spec.	20	33	20	33

Table 4-18: Statistics from UNC1 Modulus Data

4.10 “10/80/10” Unnotched Compression 2 (UNC2)

The UNC2 data is normalized, so both normalized and as-measured statistics are provided. The normalized and as-measured ETW datasets failed the Anderson-Darling k-sample (ADK) test, while RTD datasets, both normalized and as-measured, passed it. Thereby, the ANOVA method was required to compute basis values for ETW while normal method was used for RTD. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the transformation of data for the modified CV approach, only the normalized RTD dataset passed both ADK and normality tests, so modified CV basis values are provided for that dataset only.

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

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

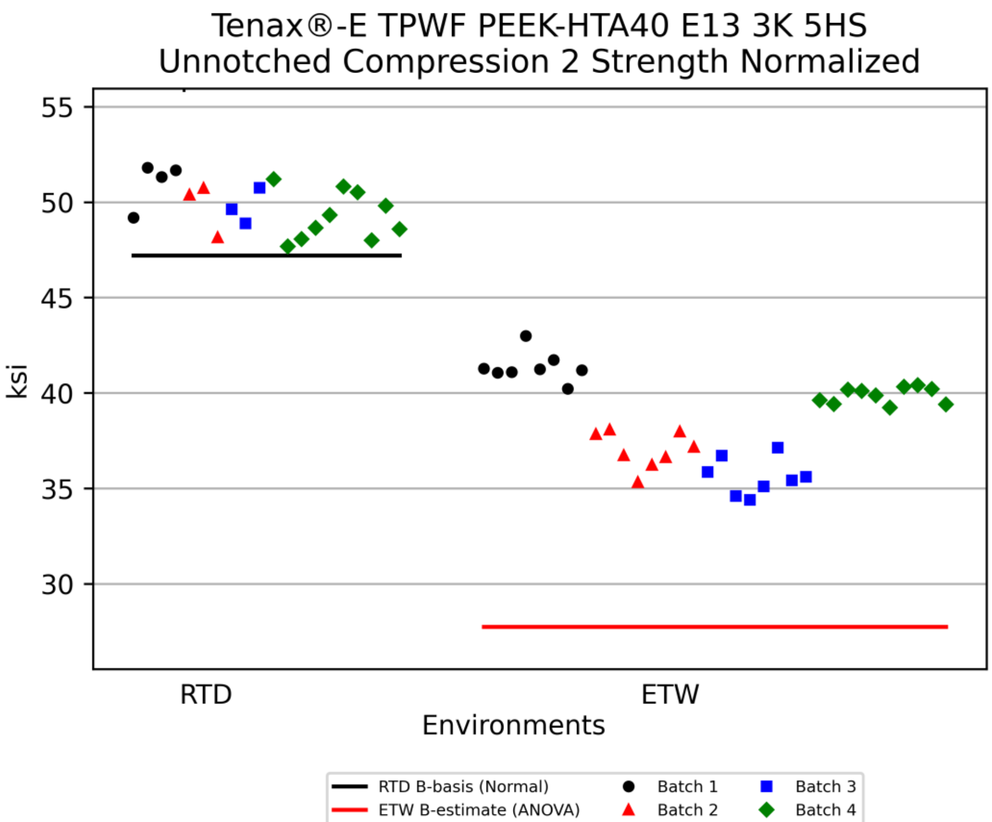

Figure 4-11: Batch plot for UNC2 normalized strength

Unnotched Compression (UNC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	49.76	38.54	50.01	38.92
Stdev	1.321	2.386	1.310	2.283
CV	2.655	6.191	2.619	5.864
Modified CV	6.000	7.095	6.000	6.932
Min	47.68	34.40	47.78	34.94
Max	51.81	42.99	52.47	43.05
No. Batches	4	4	4	4
No. Spec.	20	34	20	34
Basis Values and Estimates				
B-Basis	47.21		47.49	
B-Estimate		27.76		28.84
A-Estimate	45.40	20.29	45.70	21.85
Method	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	NA	NA	44.23	NA
A-Estimate			40.12	
Method			Normal	

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

Unnotched Compression (UNC2) Modulus Statistics				
	Normalized		As-measured	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	3.834	3.703	3.854	3.739
Stdev	0.07167	0.1381	0.06229	0.1337
CV	1.869	3.730	1.616	3.576
Modified CV	6.000	6.000	6.000	6.000
Min	3.661	3.424	3.767	3.463
Max	3.965	4.042	3.989	4.050
No. Batches	4	4	4	4
No. Spec.	20	34	20	34

Table 4-20: Statistics from UNC2 Modulus Data

4.11 "40/20/40" Unnotched Compression 3 (UNC3)

The UNC3 data is normalized, so both normalized and as-measured statistics are provided. Both normalized and as-mesaured datasets satisfied all pooling requirements, thereby pooling approach was used to compute basis values for this dataset.
There was one statistical outlier. The largest value in batch four of the RTD dataset was an outlier for batch four but not for the RTD condition. It was an outlier for both the normalized and as-measured datasets. It was retained for calculation purposes.

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

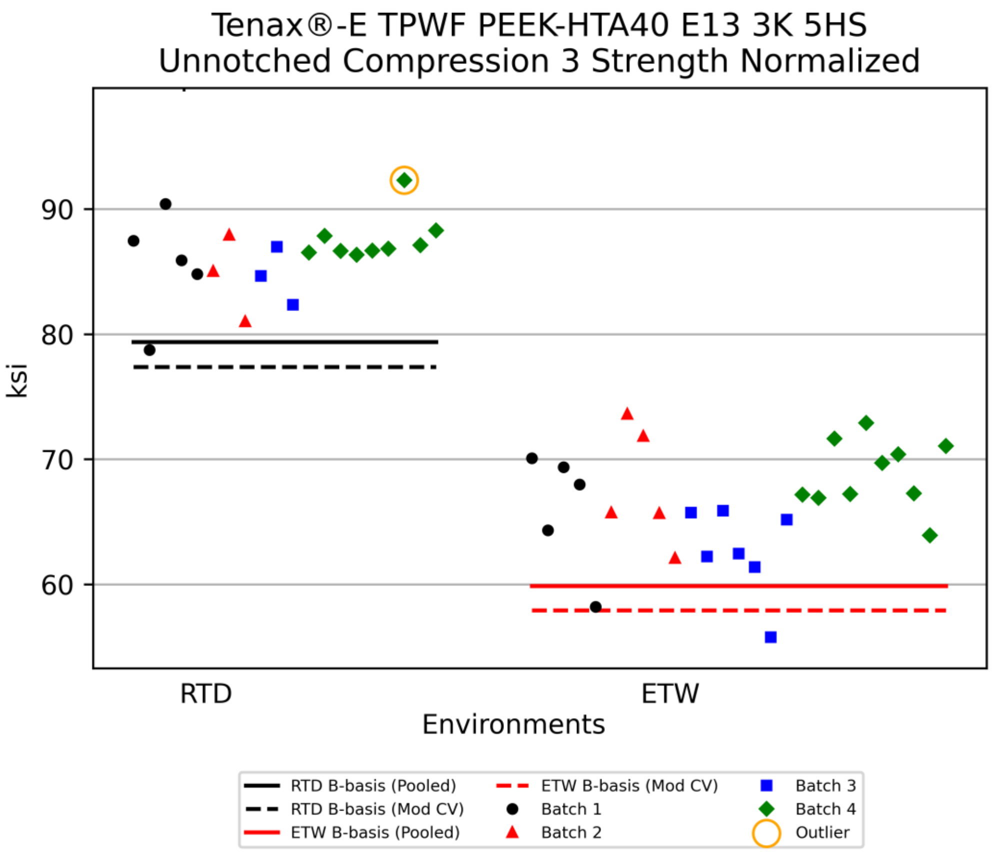

Figure 4-12: Batch plot for UNC3 normalized strength

Unnotched Compression (UNC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)
Mean	86.19	66.51	87.65	67.33
Stdev	3.011	4.375	3.021	4.454
CV	3.494	6.578	3.446	6.616
Modified CV	6.000	7.289	6.000	7.308
Min	78.72	55.77	80.65	56.51
Max	92.29	73.61	93.95	75.68
No. Batches	4	4	4	4
No. Spec.	20	27	20	27
Basis Values and Estimates				
B-Basis	79.37	59.86	80.74	60.59
A-Estimate	74.74	55.19	76.04	55.85
Method	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	77.38	57.92	78.70	58.60
A-Estimate	71.39	51.88	72.62	52.47
Method	Pooled	Pooled	Pooled	Pooled

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

Unnotched Compression (UNC3) Modulus Statistics				
	Normalized		As-measured	
Env	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)
Mean	7.055	7.238	7.154	7.325
Stdev	0.3310	0.2834	0.3342	0.2960
CV	4.721	3.915	4.671	4.041
Modified CV	6.360	6.000	6.336	6.020
Min	6.348	6.753	6.443	6.844
Max	7.665	7.839	7.734	8.009
No. Batches	4	4	4	4
No. Spec.	23	32	23	32

Table 4-22: Statistics from UNC3 Modulus Data

4.12 Lamina Short-Beam Strength (SBS)

The SBS data is not normalized. The CTD condition passed the Anderson-Darling k-sample (ADK) and normality tests, so the normal method was used to compute the basis values for this condition. The RTD, ETD and ETW conditions failed the ADK test, so the ANOVA method was required to compute basis values for these. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the modified CV transformation was applied to the dataset, all conditions passed ADK test, but only RTD, ETD and ETW could be pooled together for modified CV.

There were three statistical outliers. The lowest value in batch four of the RTD condition was an outlier for batch four, but not the RTD condition. The lowest value in batch two of the ETD condition was an outlier for batch two but not the ETD condition. The largest value in batch one of the ETW condition was an outlier for batch one but not for the ETW condition. All outliers were retained for calculation purposes.

Statistics, basis values and estimates are given for the SBS data in Table 4-23. The as-measured data, B-estimates and B-basis values are shown in Figure 4-13.

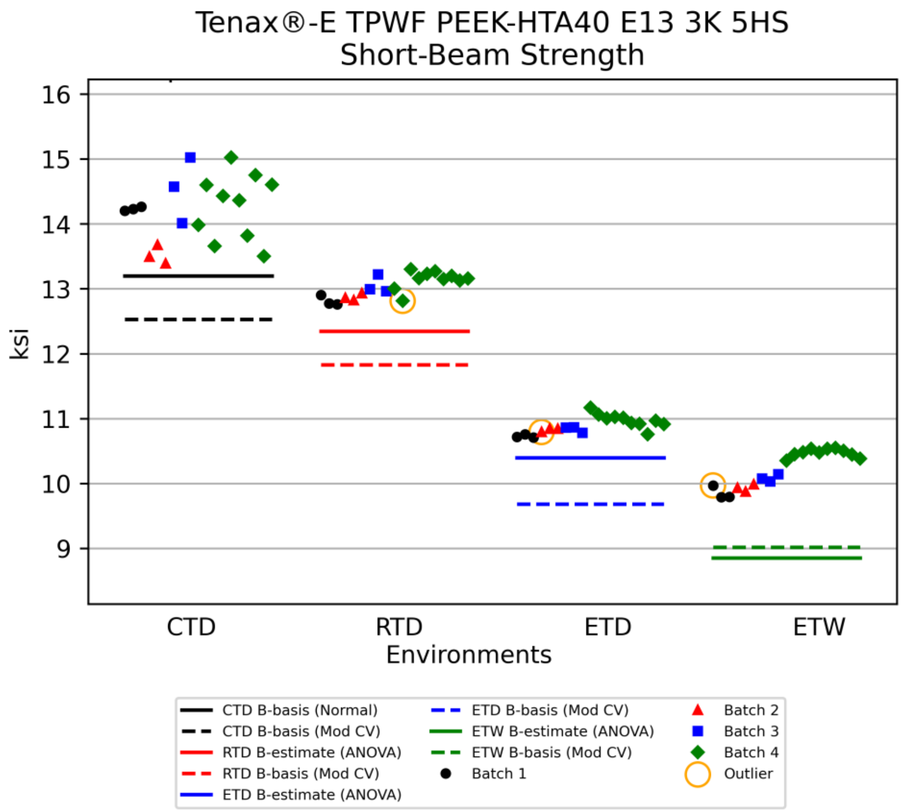

Figure 4-13: Batch plot for SBS as-measured

Short Beam Strength (SBS) Basis Values and Statistics As-measured				
Env	CTD (−65° F)	RTD (70° F)	ETD (180° F)	ETW (180° F)
Mean	14.19	13.03	10.89	10.23
Stdev	0.5075	0.1796	0.1263	0.2804
CV	3.577	1.378	1.159	2.742
Mod CV	6.000	6.000	6.000	6.000
Min	13.39	12.76	10.71	9.791
Max	15.02	13.30	11.17	10.55
No. Batches	4	4	4	4
No. Spec.	19	19	19	19
Basis Values and Estimates				
B-Basis	13.20			
B-Estimate		12.35	10.40	8.853
A-Estimate	12.50	11.87	10.06	7.902
Method	Normal	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	12.53	11.83	9.685	9.021
A-Estimate	11.35	11.02	8.877	8.213
Method	Normal	Pooled	Pooled	Pooled

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

4.13 Laminate Short-Beam Strength (SBS1)

The SBS1 data is not normalized. The RTD environment failed ADK test, so ANOVA method was used to compute basis values for this environment. ETW environment passed ADK test but failed normality and log-normality tests, so Weibull distribution method was used to compute basis values for ETW. For modified CV all statistical tests are passed so pooling method was used.

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

Statistics, basis values and estimates are given for the SBS1 data in Table 4-24. The as-measured data and B-basis values are shown graphically in Figure 4-14.

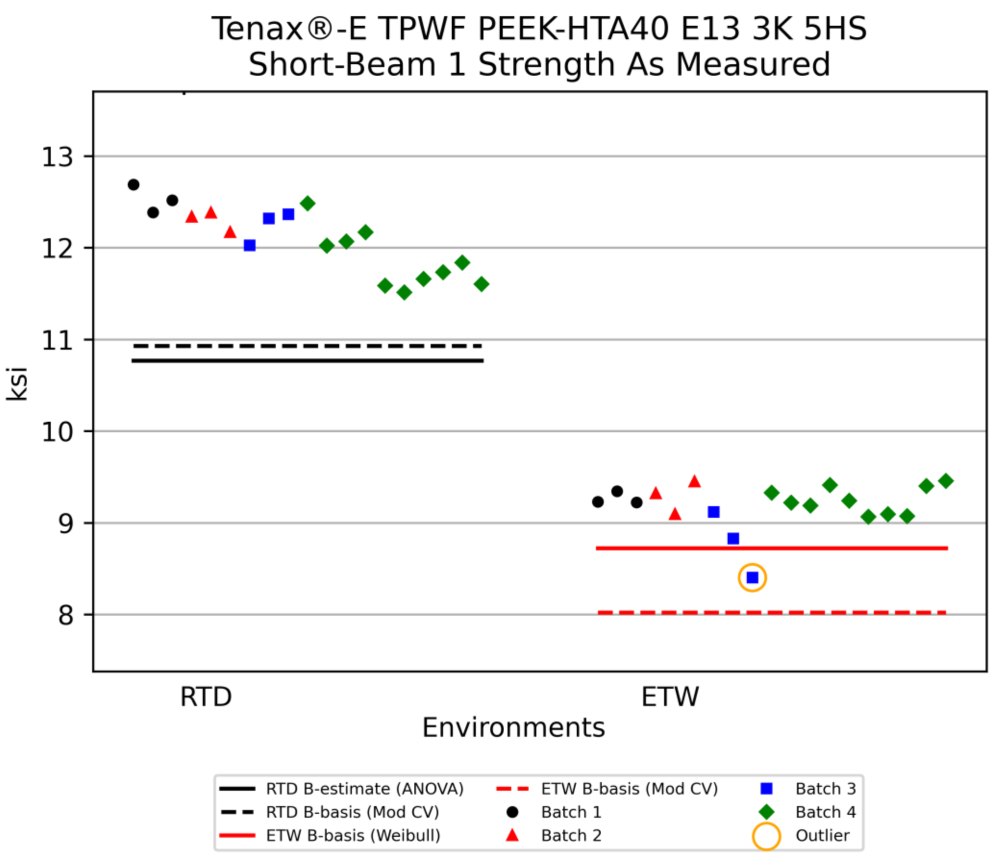

Figure 4-14: Batch plot for SBS1 as-measured

Laminate Short Beam Strength (SBS1) Basis Values and Statistics As-measured		
Env	RTD (70˚ F)	ETW (180˚ F)
Mean	12.10	9.183
Stdev	0.3563	0.2475
CV	2.945	2.695
Modified CV	6.000	6.000
Min	11.51	8.401
Max	12.69	9.457
No. Batches	4	4
No. Spec.	19	19
Basis Values and Estimates		
B-Basis		8.724
B-Estimate	10.77	
A-Estimate	9.853	8.217
Method	ANOVA	Weibull
Modified CV Basis Values and Estimates		
B-Basis	10.93	8.020
A-Estimate	10.14	7.230
Method	Pooled	Pooled

Table 4-24: Statistics and Basis Values for SBS1 Data

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

The OHT1 data is normalized, so both normalized and as-measured statistics are provided.

The normalized and as-measured ETW datasets filed the ADK test, which means the ANOVA method was required to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. The CTD and RTD datasets, both normalized and as-measured, met all requirements for pooling. Both ETW datasets passed the ADK test after the transformation of data for the modified CV method. All three conditions, both normalized and as-measured, met the requirements for pooling for the modified CV computations.

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

Statistics, basis values and estimates are given for the OHT1 strength data in Table 4-25. The normalized data and B-basis values are shown graphically in Figure 4-15.

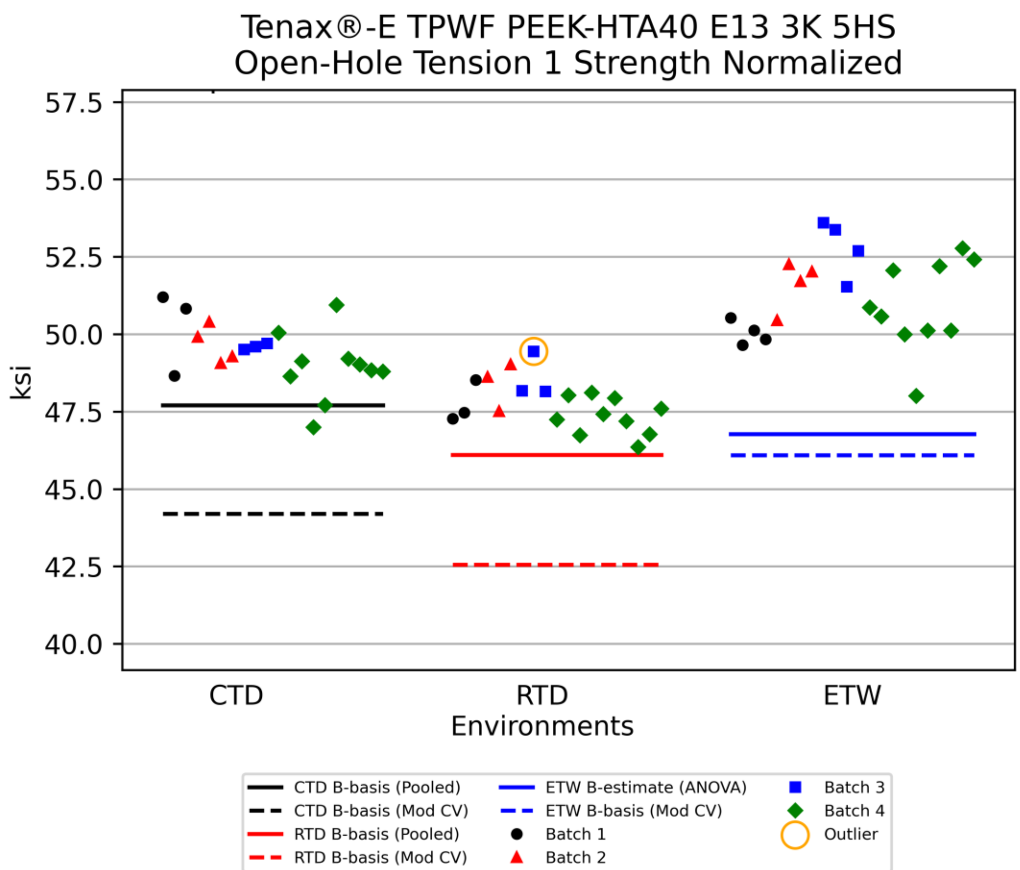

Figure 4-15: Batch Plot for OHT1 normalized strength

Open Hole Tension (OHT1) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	49.37	47.76	51.22	49.50	47.74	51.54
Stdev	1.034	0.7922	1.406	1.021	0.8587	1.433
CV	2.095	1.669	2.744	2.064	1.799	2.781
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	46.99	46.35	48.00	47.65	45.83	49.58
Max	51.20	49.44	53.60	51.75	49.59	53.85
No. Batches	4	4	4	4	4	4
No. Spec.	20	19	22	20	19	22
Basis Values and Estimates						
B-Basis	47.71	46.10		47.80	46.04	
B-Estimate			46.78			46.78
A-Estimate	46.57	44.96	43.68	46.64	44.88	43.45
Method	Pooled	Pooled	ANOVA	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates						
B-Basis	44.20	42.56	46.09	44.30	42.52	46.39
A-Estimate	40.72	39.09	42.60	40.82	39.04	42.89
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-25: Statistics and Basis Values for OHT1 Strength Data

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

The OHT2 data is normalized, so both normalized and as-measured statistics are provided. For the normalized dataset, original CV, all three environments passed the pooling conditions, so pooling approach was used to compute the basis values for these three. For the normalized dataset, modified CV, only CTD and RTD environments passed the pooling conditions, so pooling approach was used to compute the basis values for these two, while normal distribution method was used for ETW.

For the as-measured dataset, original CV, all three environments passed the pooling conditions, so pooling approach was used to compute the basis values for these three. For the as-measured dataset, modified CV, only CTD and RTD environments passed the pooling conditions, so pooling approach was used to compute the basis values for these two, while normal distribution method was used for ETW.

There were two statistical outliers. The largest value in batch two of the as-measured CTD condition was an outlier for batch two but not for the CTD condition and not for the normalized dataset. The largest value in batch two of the ETW condition was an outlier for batch 2 but not for the ETW condition, it was an outlier for both the normalized and as-measured datasets. Both outliers were retained for this analysis.

Statistics, basis values and estimates are given for the OHT2 strength data in Table 4-26. The normalized data and B-basis values are shown graphically in Figure 4-16.

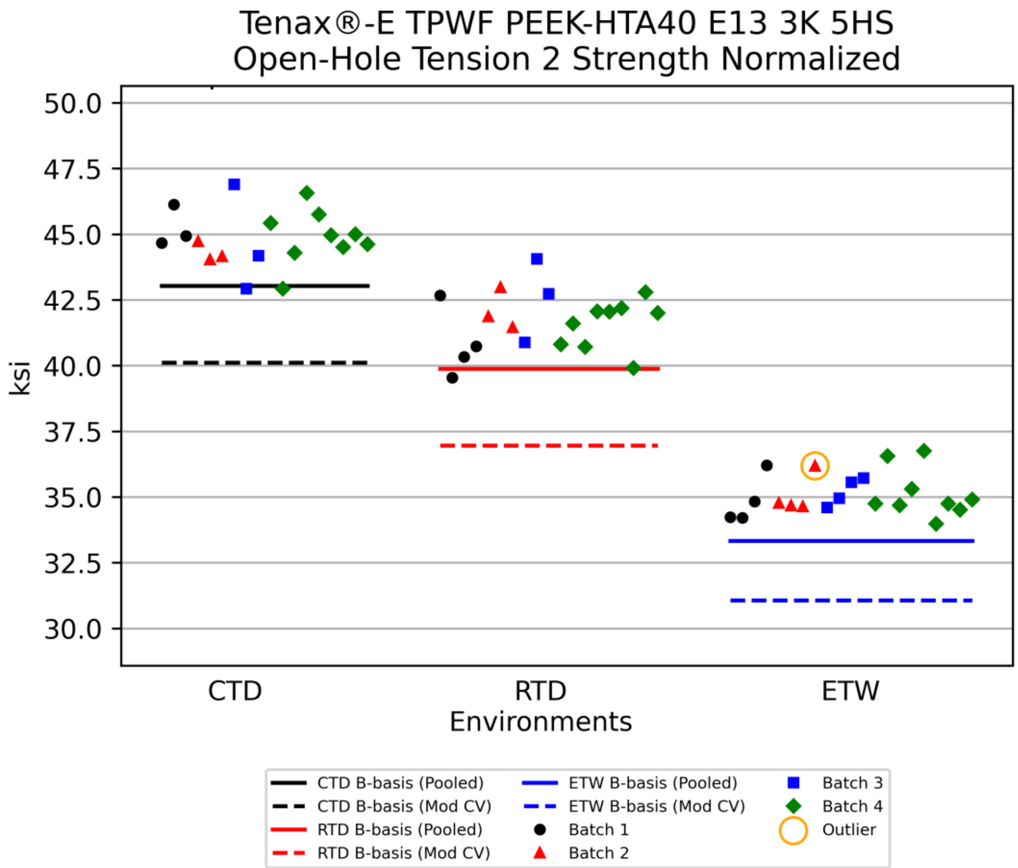

Figure 4-16: Batch Plot for OHT2 normalized strength

Open Hole Tension (OHT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	44.82	41.65	35.08	45.10	41.53	35.11
Stdev	1.070	1.156	0.7863	1.234	1.139	0.9112
CV	2.387	2.775	2.241	2.737	2.742	2.595
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	42.93	39.55	33.98	42.79	39.77	34.03
Max	46.90	44.05	36.76	47.14	43.90	37.52
No. Batches	4	4	4	4	4	4
No. Spec.	18	19	21	18	19	21
Basis Values and Estimates						
B-Basis	43.04	39.88	33.33	43.17	39.61	33.21
A-Estimate	41.86	38.70	32.15	41.89	38.32	31.92
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates						
B-Basis	40.11	36.96	31.07	40.38	36.83	31.10
A-Estimate	36.90	33.76	28.21	37.17	33.62	28.24
Method	Pooled	Pooled	Normal	Pooled	Pooled	Normal

Table 4-26: Statistics and Basis Values for OHT2 Strength Data

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

The OHT3 data is normalized, so both normalized and as-measured statistics are provided. For both the normalized and as-measured datasets (original/modified CV) all three environments met all requirements for pooling the conditions, so pooling approach was used to compute the basis values.

There were three statistical outliers. The lowest value in batch two of the as-measured CTD dataset was an outlier for batch two, but not the CTD condition and not the normalized dataset. The lowest value in batch three of the RTD condition was an outlier for batch three in both the normalized and as-measured datasets, but was not an outlier for the RTD condition. The lowest value in batch four of the ETW condition was an outlier for batch four in both the normalized and as-measured datasets, but was not an outlier for the ETW condition. All three outliers were retained for analysis.

Statistics, basis values and estimates are given for the OHT3 strength data in Table 4-27. The normalized data and B-basis values are shown graphically in Figure 4-17.

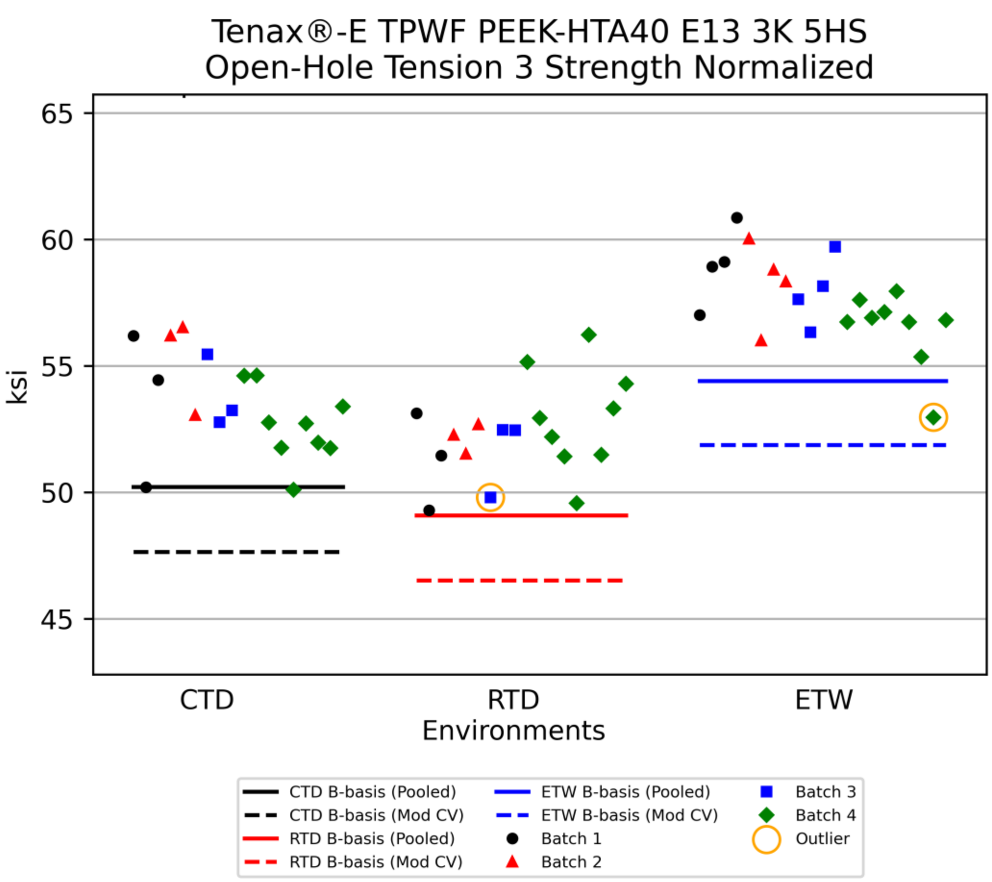

Figure 4-17: Batch Plot for OHT3 normalized strength

Open Hole Tension (OHT3) Strength (ksi) Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	53.43	52.31	57.57	53.65	52.36	57.75
Stdev	1.931	1.803	1.750	2.116	1.783	1.828
CV	3.615	3.446	3.040	3.943	3.404	3.165
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	50.11	49.30	52.96	49.83	49.57	52.91
Max	56.51	56.22	60.86	56.97	56.33	61.27
No. Batches	4	4	4	4	4	4
No. Spec.	18	18	21	18	18	21
Basis Values and Estimates						
B-Basis	50.21	49.09	54.40	50.28	48.99	54.43
A-Estimate	48.06	46.95	52.24	48.04	46.75	52.18
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates						
B-Basis	47.64	46.52	51.87	47.85	46.56	52.03
A-Estimate	43.79	42.67	48.00	43.99	42.70	48.15
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-27: Statistics and Basis Values for OHT3 Strength Data

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

The FHT1 data is normalized, so both normalized and as-measured statistics are provided.

The normalized and as-measured CTD datasets failed the ADK test, which means the ANOVA method was required to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. The RTD and ETW datasets, both normalized and as-measured, met all requirements for pooling. Both CTD datasets passed the ADK test after the transformation of data for the modified CV method. All three conditions, both normalized and as-measured, met the requirements for pooling for the modified CV computations.

There were no statistical outliers.

Statistics, basis values and estimates are given for the FHT1 strength data in Table 4-28. The normalized data and B-basis values are shown graphically in Figure 4-18.

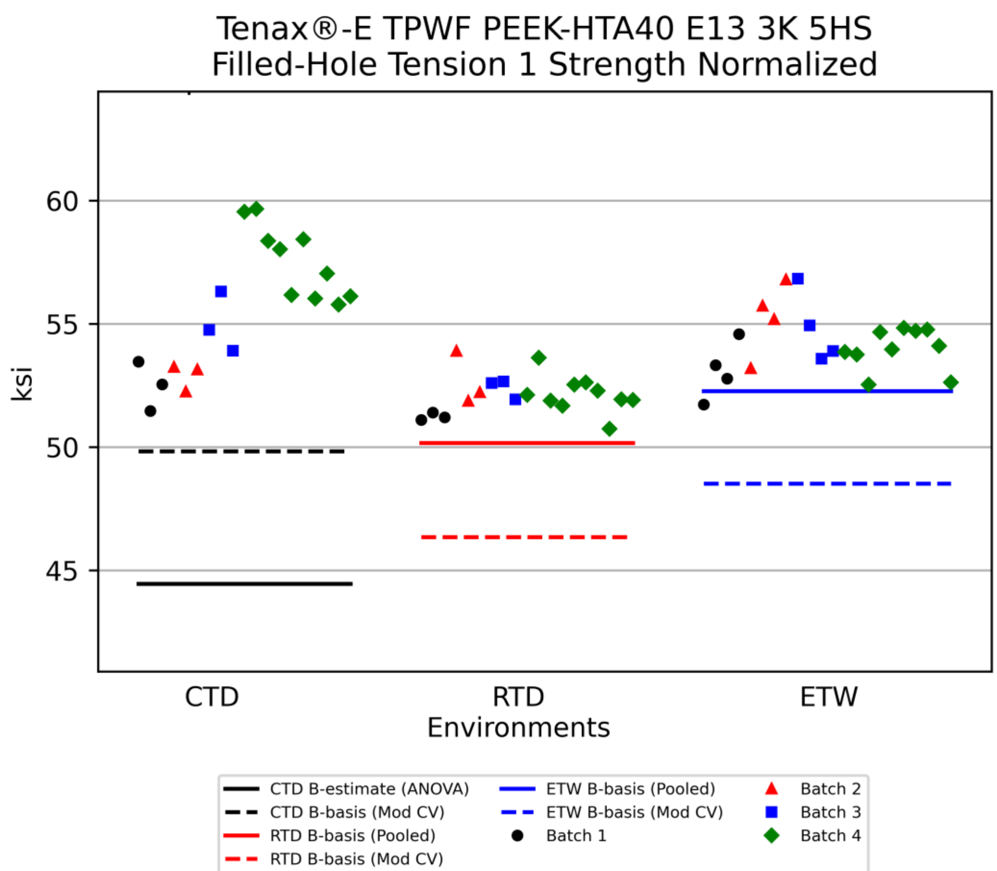

Figure 4-18: Batch plot for FHT1 normalized strength

Filled Hole Tension (FHT1) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	55.59	52.11	54.20	55.68	51.95	54.35
Stdev	2.520	0.7848	1.289	2.753	0.7802	1.277
CV	4.534	1.506	2.378	4.944	1.502	2.350
Modified CV	6.267	6.000	6.000	6.472	6.000	6.000
Min	51.46	50.74	51.73	51.50	50.79	51.56
Max	59.65	53.89	56.83	60.15	53.51	56.71
No. Batches	4	4	4	4	4	4
No. Spec.	19	19	22	19	19	22
Basis Values and Estimates						
B-Basis		50.17	52.27		50.02	52.45
B - estimate	44.45			43.17		
A-Estimate	36.72	48.84	50.95	34.50	48.71	51.13
Method	ANOVA	Pooled	Pooled	ANOVA	Pooled	Pooled
Modified CV Basis Values and Estimates						
B-Basis	49.83	46.35	48.52	49.85	46.12	48.60
A-Estimate	45.98	42.51	44.65	45.96	42.23	44.69
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-28: Statistics and Basis Values for FHT1 Strength Data

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

The FHT2 data is normalized, so both normalized and as-measured statistics are provided. The normalized and as-measured ETW datasets failed the ADK test, which means the ANOVA method was required to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. The CTD and RTD datasets, both normalized and as-measured, met all requirements for pooling. Both ETW datasets passed the ADK test after the transformation of data for the modified CV method. All three conditions, both normalized and as-measured, met the requirements for pooling for the modified CV computations.

There was one statistical outlier. The lowest value in batch one of the normalized RTD data was an outlier for batch 1, but not for the RTD condition and not for the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the FHT2 strength data in Table 4-29. The normalized data and B-basis values are shown graphically in Figure 4-19.

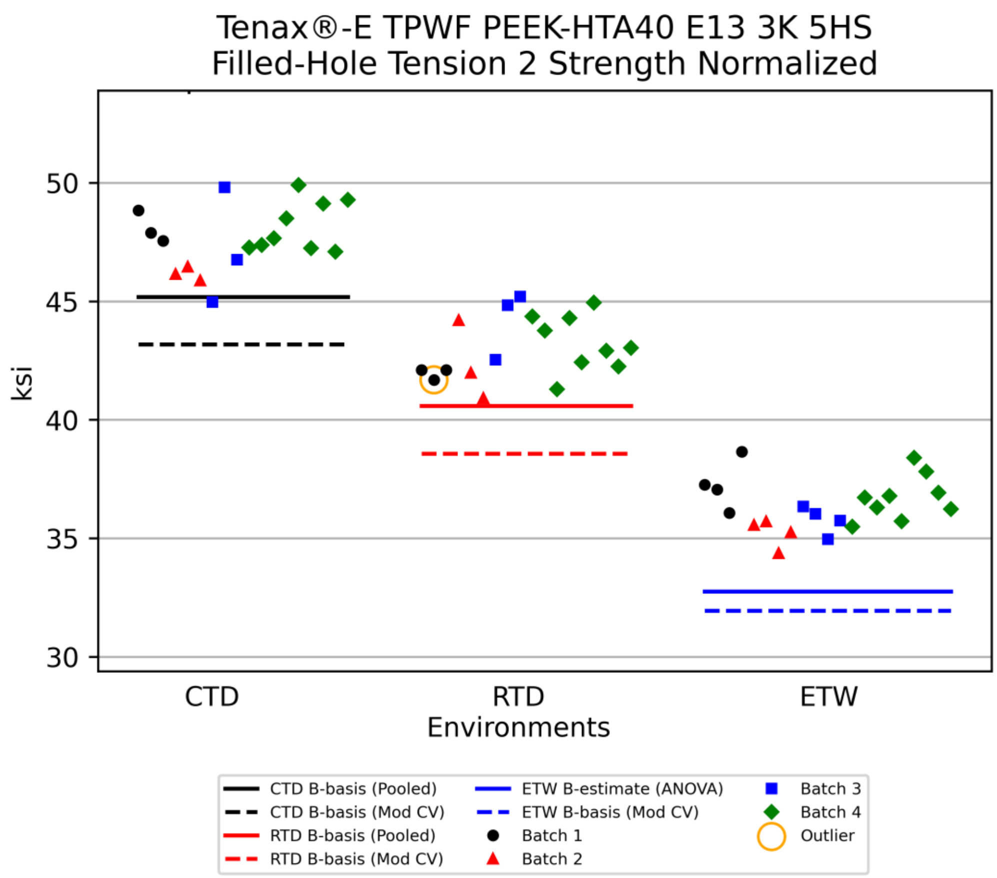

Figure 4-19: Batch plot for FHT2 normalized strength

Filled Hole Tension (FHT2) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	47.66	43.05	36.35	47.74	43.02	36.42
Stdev	1.378	1.335	1.084	1.421	1.280	1.187
CV	2.892	3.101	2.981	2.976	2.974	3.260
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000
Min	44.97	40.92	34.37	45.17	40.62	34.36
Max	49.91	45.20	38.65	50.10	44.95	38.57
No. Batches	4	4	4	4	4	4
No. Spec.	18	18	21	18	18	21
Basis Values and Estimates						
B-Basis	45.18	40.58		45.28	40.56	
B - estimate			32.75			32.02
A-Estimate	43.50	38.89	30.24	43.60	38.88	28.96
Method	Pooled	Pooled	ANOVA	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates						
B-Basis	43.18	38.57	31.94	43.26	38.54	32.01
A-Estimate	40.20	35.59	28.94	40.27	35.55	29.01
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-29: Statistics and Basis Values for FHT2 Strength Data

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

The FHT3 data is normalized, so both normalized and as-measured statistics are provided. The normalized and as-measured RTD and ETW datasets failed the ADK test, which means the ANOVA method was required to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for these datasets. The CTD datasets, both normalized and as-measured, failed all three distributions tests (normal, lognormal and Weibull), which means the non-parametric approach was required to compute the basis values.

After the transformation of data to fit the assumptions of the modified CV approach, the as-measured RTD and both the normalized and as-measured ETW datasets passed the ADK test and the CTD datasets passed the normality test, so modified CV basis values are provided for those datasets. No modified CV basis values could be computed for the normalized RTD dataset. The as-measured datasets met all requirements for pooling for the modified CV basis values computations.

There were two statistical outliers. The largest value in batch one of the as-measured RTD condition was an outlier for batch one, but not for the RTD condition and not for the normalized dataset. The largest value in batch two of the normalized RTD condition was an outlier for batch two, but not for the RTD condition and not for the as-measured dataset. Both outliers were retained for computational purposes.

Statistics, basis values and estimates are given for the FHT3 strength data in Table 4-30. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-20.

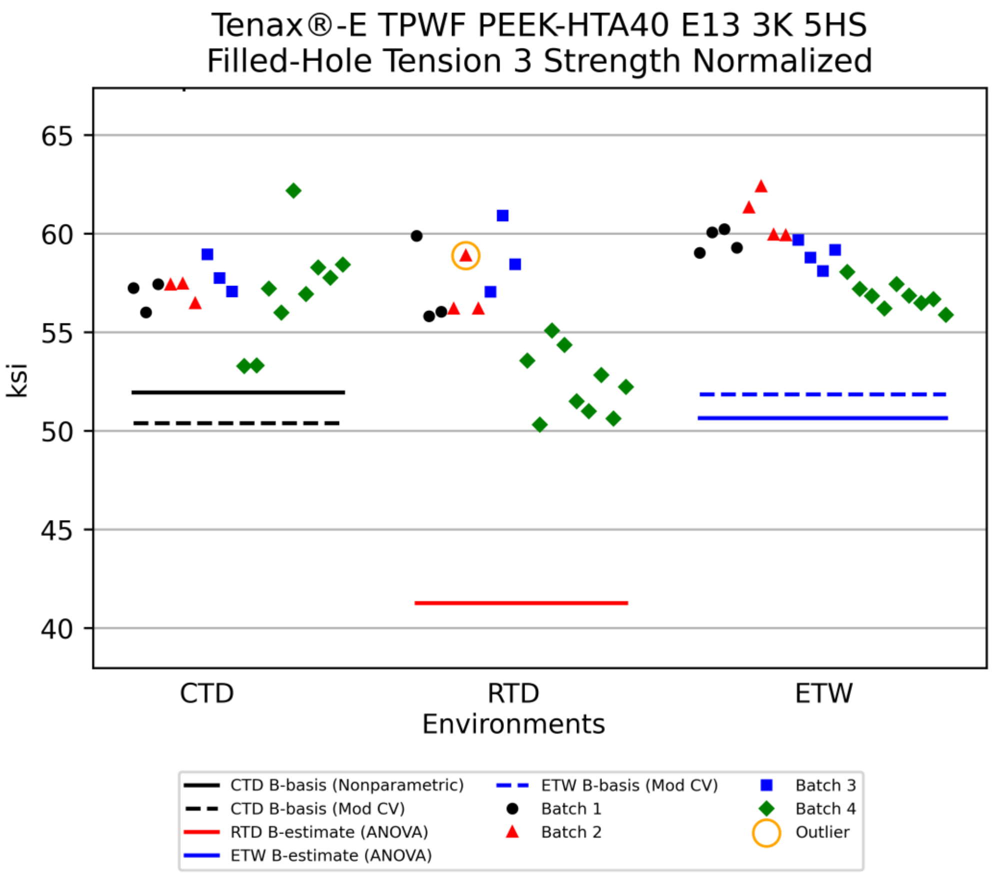

Figure 4-20: Batch plot for FHT3 normalized strength

Filled Hole Tension (FHT3) Strength Basis Values and Statistics						
	Normalized			As-measured		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	57.18	55.05	58.55	57.46	55.01	58.92
Stdev	1.958	3.243	1.782	2.022	3.410	1.470
CV	3.425	5.890	3.043	3.519	6.199	2.495
Modified CV	6.000	6.945	6.000	6.000	7.099	6.000
Min	53.29	50.31	55.89	53.61	50.06	56.68
Max	62.18	60.91	62.40	62.68	61.06	62.02
No. Batches	4	4	4	4	4	4
No. Spec.	18	18	21	18	18	21
Basis Values and Estimates						
B-Basis	51.95			52.28		
B - estimate		41.28	50.66		40.75	52.73
A-Estimate	42.30	31.72	45.19	42.42	30.87	48.43
Method	Non-parametric	ANOVA	ANOVA	Non-parametric	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-Basis	50.40	NA	51.86	51.05	48.60	52.61
A-Estimate	45.61		47.09	46.79	44.34	48.33
Method	Normal		Normal	Pooled	Pooled	Pooled

Table 4-30: Statistics and Basis Values for FHT3 Strength Data

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

The OHC1 data is normalized, so both normalized and as-measured statistics are provided.. The ETW datasets, both normalized and as-measured, failed the ADK test, which means the ANOVA method was required to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. The normal distribution could be used for the RTD datasets, both normalized and as measured. After the transformation of data for the modified CV approach, the ETW datasets passed the ADK tests and both both normalized and as-measured datasets met all requirements for pooling when computing the modified CV basis values.

There were no statistical outliers.

Statistics, B-basis values and estimates are given for the OHC1 strength data in Table 4-31. The normalized data and B-basis values are shown graphically in Figure 4-21.

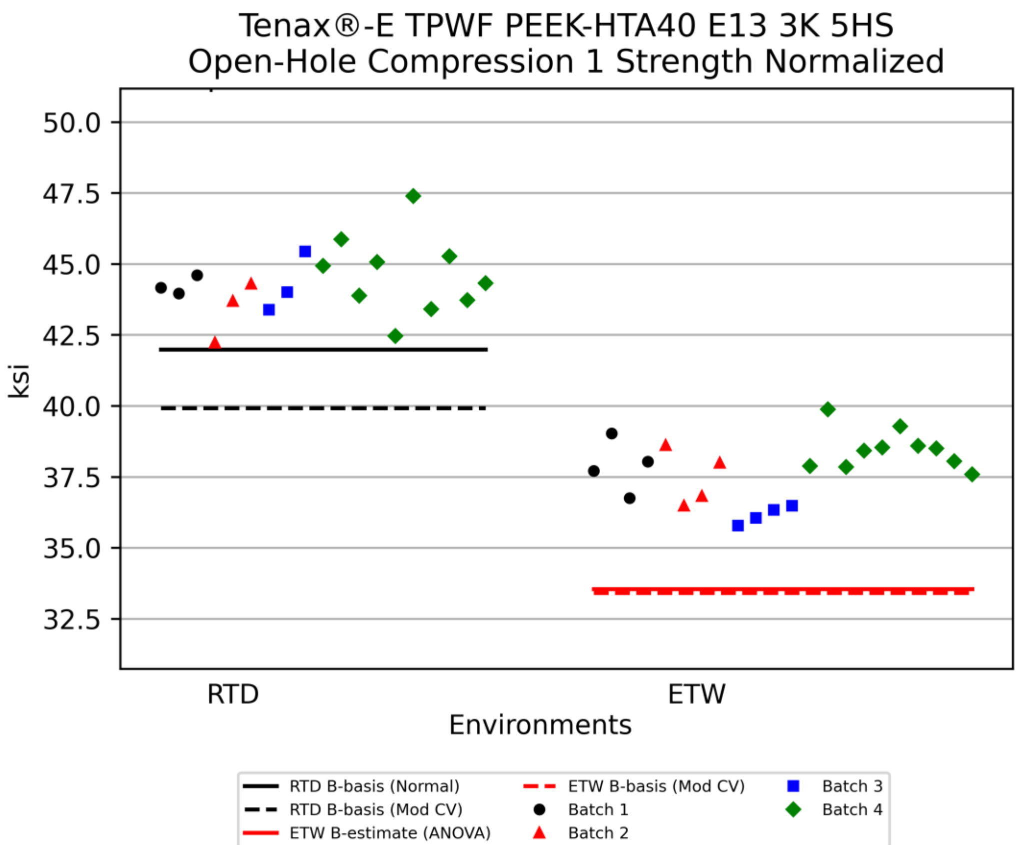

Figure 4-21: Batch plot for OHC1 normalized strength

Open Hole Compression (OHC1) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	44.32	37.76	44.36	37.78
Stdev	1.197	1.107	1.260	1.093
CV	2.701	2.931	2.840	2.893
Modified CV	6.000	6.000	6.000	6.000
Min	42.22	35.78	41.92	35.87
Max	47.39	39.87	47.73	39.83
No. Batches	4	4	4	4
No. Spec.	19	22	19	22
Basis Values and Estimates				
B-Basis	41.99		41.90	
B-Estimate		33.55		33.59
A-Estimate	40.33	30.63	40.16	30.68
Method	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	39.92	33.41	39.95	33.43
A-Estimate	36.93	30.40	36.96	30.42
Method	Pooled	Pooled	Pooled	Pooled

Table 4-31: Statistics and Basis Values for OHC1 Strength Data

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

The OHC2 data is normalized, so both normalized and as-measured statistics are provided. The normalized RTD dataset and both the normalized and as-measured ETW datasets all failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. The normal method was used for the as-measured RTD datasets. After the transformation of data for the modified CV approach, all datasets passed the ADK tests and both normalized and as-measured datasets met all requirements for pooling when computing the modified CV basis values. There was one statistical outlier. The lowest value in batch one of the RTD condition was an outlier for batch one, but not for the RTD condition and not in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHC2 strength data in Table 4-32. The normalized data and B-basis values are shown graphically in Figure 4-22.

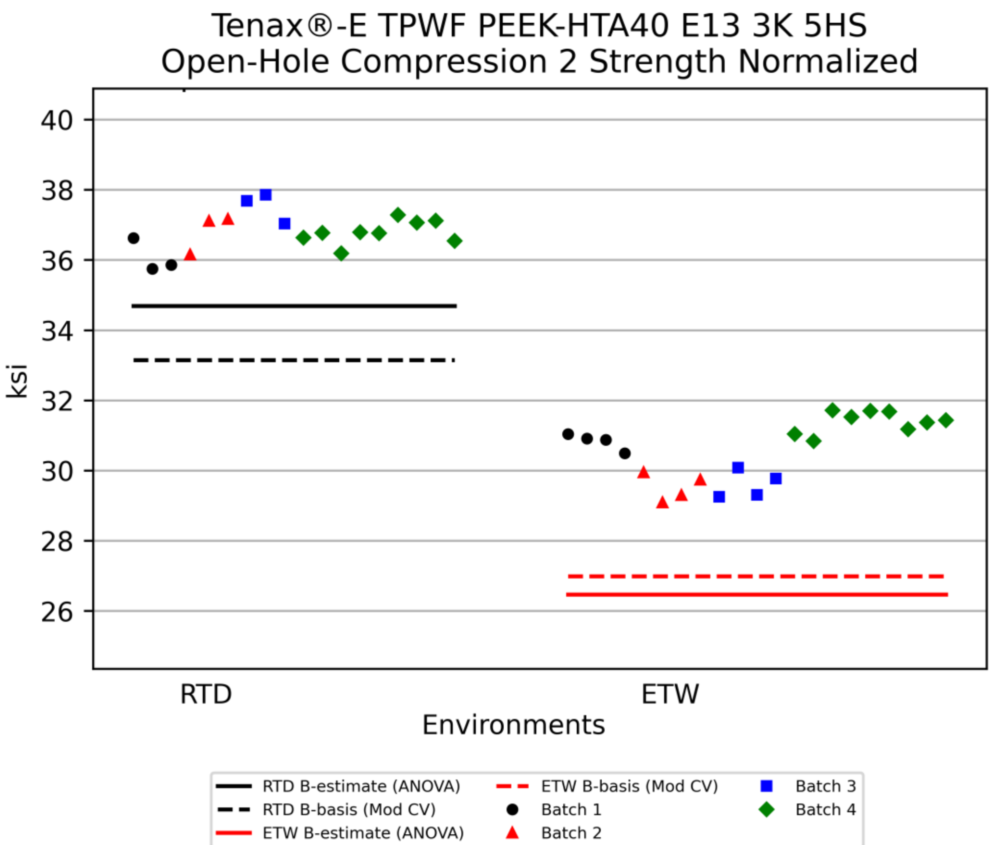

Figure 4-22: Batch plot for OHC2 normalized strength

Open Hole Compression (OHC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)
Mean	36.80	30.58	37.03	30.45
Stdev	0.5685	0.9039	0.5601	0.9909
CV	1.545	2.955	1.512	3.254
Modified CV	6.000	6.000	6.000	6.000
Min	35.75	29.09	36.23	28.80
Max	37.86	31.72	37.94	31.59
No. Batches	4	4	4	4
No. Spec.	18	21	18	21
Basis Values and Estimates				
B-Basis			35.92	
B-Estimate	34.69	26.47		25.93
A-Estimate	33.23	23.63	35.14	22.79
Method	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	33.15	26.99	33.38	26.85
A-Estimate	30.68	24.51	30.91	24.37
Method	Pooled	Pooled	Pooled	Pooled

Table 4-32: Statistics and Basis Values for OHC2 Strength Data

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

The OHC3 data is normalized, so both normalized and as-measured statistics are provided. There were no diagnostic test failures. All requirements for pooling were met.

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

Statistics, basis values and estimates are given for the OHC3 strength data in Table 4-33. The normalized data and B-basis values are shown graphically in Figure 4-23.

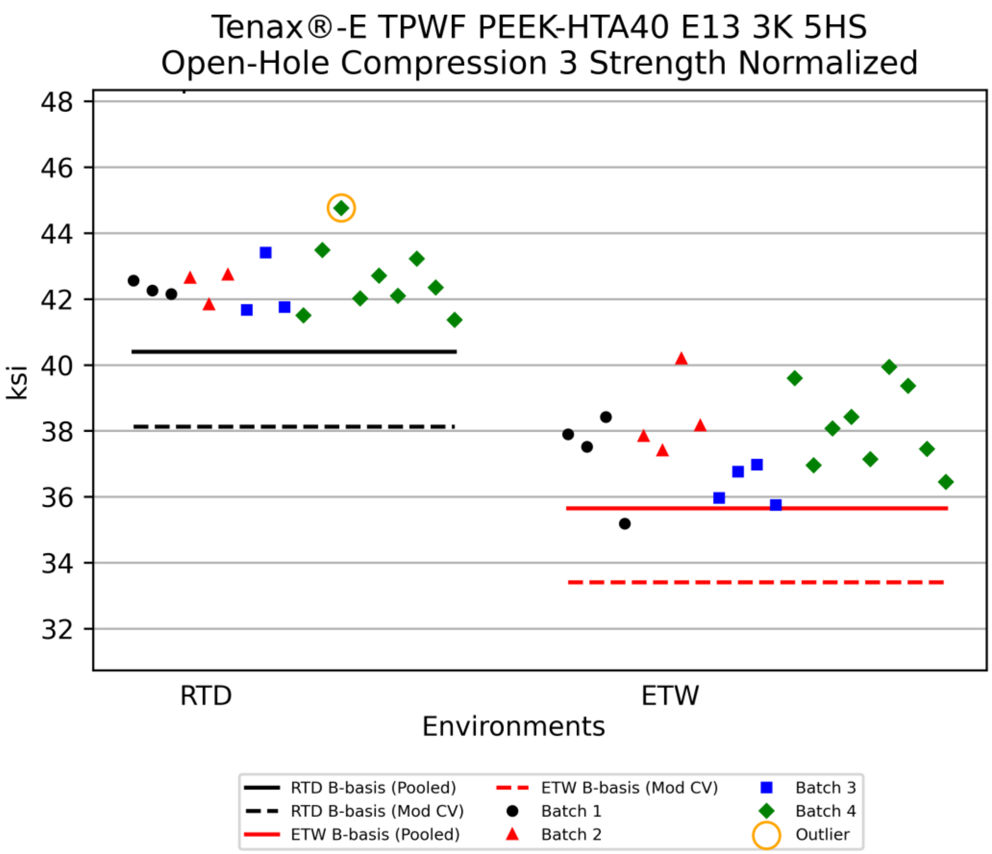

Figure 4-23: Batch plot for OHC3 normalized strength

Open Hole Compression (OHC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)
Mean	42.47	37.69	42.87	37.67
Stdev	0.8436	1.345	0.8664	1.439
CV	1.986	3.570	2.021	3.821
Modified CV	6.000	6.000	6.000	6.000
Min	41.36	35.18	41.51	35.06
Max	44.76	40.19	44.68	40.50
No. Batches	4	4	4	4
No. Spec.	18	21	18	21
Basis Values and Estimates				
B-Basis	40.40	35.65	40.68	35.51
A-Estimate	39.00	34.24	39.20	34.02
Method	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	38.13	33.41	38.52	33.37
A-Estimate	35.20	30.46	35.56	30.40
Method	Pooled	Pooled	Pooled	Pooled

Table 4-33: Statistics and Basis Values for OHC3 Strength Data

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

The FHC1 data is normalized, so both normalized and as-measured statistics are provided. When the FHC1 mean or basis value is greater than the corresponding value for UNC1, the FHC1 data is for informational purposes only and it may not substantial enough to be used for design.

The normalized RTD dataset and both the normalized and as-measured ETW datasets all failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. The normal method was used for the as-measured RTD datasets. After the transformation of data for the modified CV approach, only the normalized RTD dataset passed the ADK test. No modified CV basis values could be computed for the ETW datasets.

There were no statistical outliers.

Statistics, basis values and estimates are given for the FHC1 strength data in Table 4-34. The normalized data and B-basis values are shown graphically in Figure 4-24.

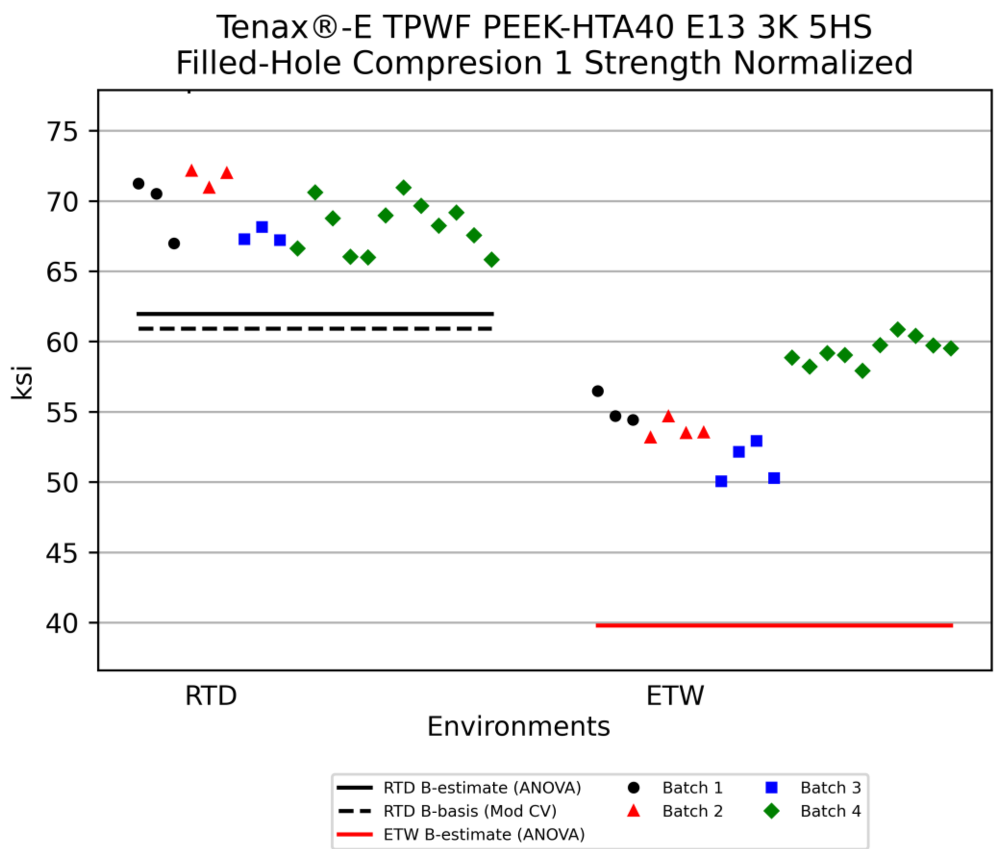

Figure 4-24: Batch plot for FHC1 normalized strength

Filled Hole Compression (FHC1) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	68.80	56.15	68.50	55.92
Stdev	2.037	3.448	2.022	3.174
CV	2.962	6.141	2.952	5.676
Modified CV	6.000	7.070	6.000	6.838
Min	65.81	50.04	64.68	50.68
Max	72.13	60.86	71.35	60.41
No. Batches	4	4	4	4
No. Spec.	21	21	21	21
Basis Values and Estimates				
B-basis			64.65	
B-Estimate	61.97	39.79		41.08
A-Estimate	57.21	28.47	61.90	30.81
Method	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-basis	60.93	NA	60.67	NA
A-Estimate	55.33		55.09	
Method	Normal		Normal	

Table 4-34: Statistics and Basis Values for FHC1 Strength Data

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

The FHC2 data is normalized, so both normalized and as-measured statistics are provided. The RTD dataset has only 17 specimens, so only B-estimates can be provided rather than B-basis values unless the pooled approach can be used. When the FHC2 mean or basis value is greater than the corresponding value for UNC2, the FHC2 data is for informational purposes only and it may not substantial enough to be used for design.

All four datasets failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the transformation of data for the modified CV approach, all four datasets passed the ADK test. Both normalized and as-measured datasets met all requirements for pooling the two environments when computing the modified CV basis values.

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

Statistics, basis values and estimates are given for the FHC2 strength data in Table 4-35. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-25.

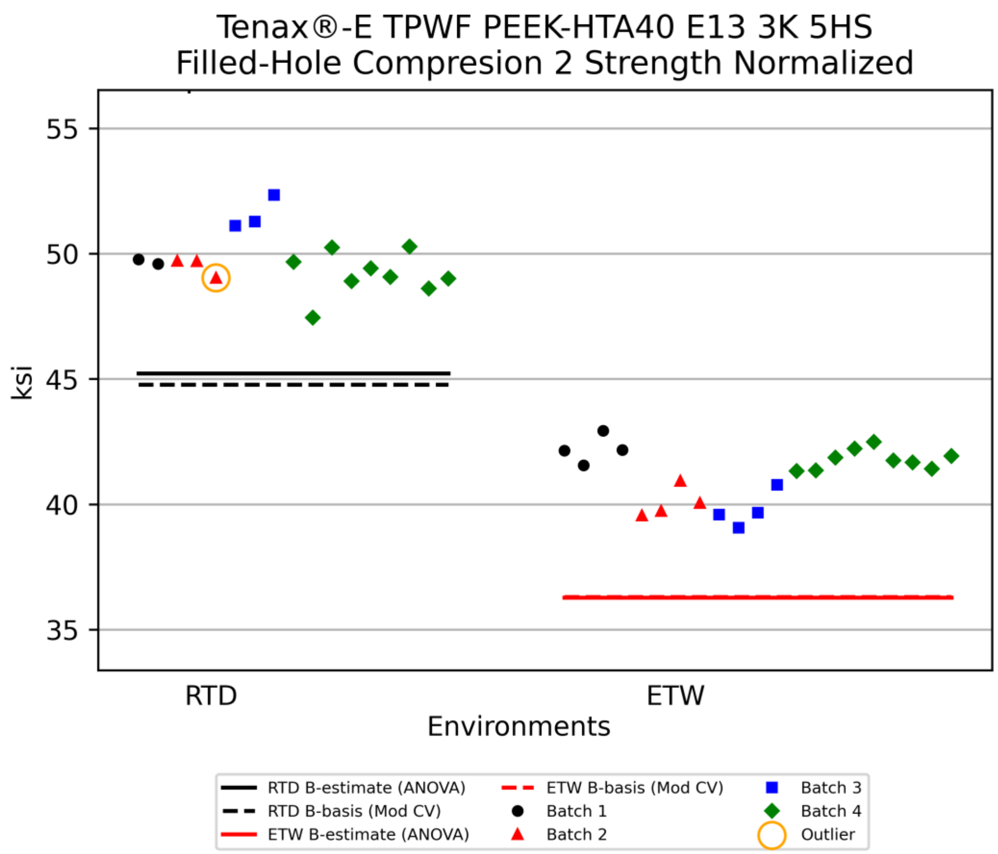

Figure 4-25: Batch plot for FHC2 normalized strength

Filled Hole Compression (FHC2) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	49.71	41.15	49.48	41.23
Stdev	1.130	1.122	1.096	1.297
CV	2.273	2.727	2.214	3.146
Modified CV	6.000	6.000	6.000	6.000
Min	47.44	39.06	47.49	38.95
Max	52.34	42.93	52.02	43.17
No. Batches	4	4	4	4
No. Spec.	17	21	17	21
Basis Values and Estimates				
B-Estimate	45.22	36.28	45.18	35.51
A-Estimate	42.10	32.90	42.19	31.54
Method	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	44.78	36.30	44.55	36.39
A-Estimate	41.45	32.96	41.23	33.05
Method	Pooled	Pooled	Pooled	Pooled

Table 4-35: Statistics and Basis Values for FHC2 Strength Data

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

The FHC3 data is normalized, so both normalized and as-measured statistics are provided. When the FHC3 mean or basis value is greater than the corresponding value for UNC3, the FHC3 data is for informational purposes only and it may not substantial enough to be used for design.

Both the normalized and as-measured ETW datasets failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the transformation of data for the modified CV approach, both ETW datasets passed the ADK test. Both normalized and as-measured datasets met all requirements for pooling the two environments when computing the modified CV basis values. The normalized RTD dataset fail the normal distribution test, but the Weibull distribution had an adequate fit for the data, so the Weibull method was used to compute basis values for that dataset.

There were two statistical outliers. The lowest value in batch three of the RTD condition was an outlier for the RTD condition but not for batch three. It was an outlier for both the normalized and as-measured datasets. The largest value in batch two of the normalized ETW condition was an outlier for batch two but not for the ETW condition and not for the as-measured dataset. Both outliers were retained for calculation purposes.

Statistics, basis values and estimates are given for the FHC3 strength data in Table 4-36. The normalized data and B-basis values are shown graphically in Figure 4-26.

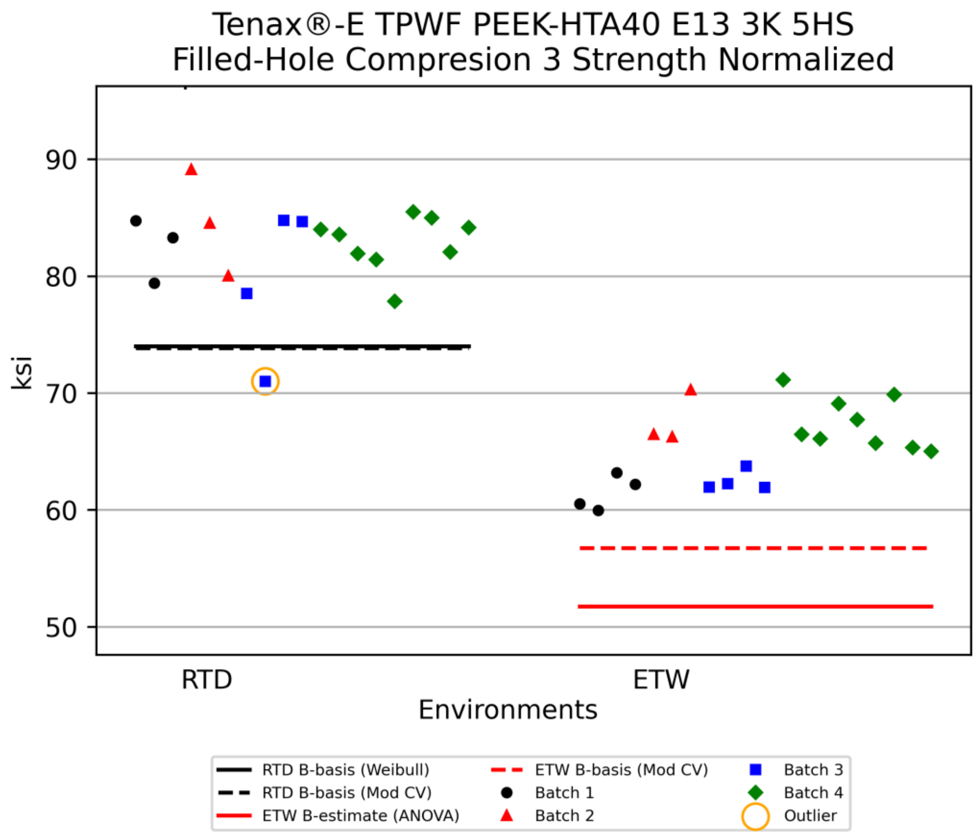

Figure 4-26: Batch plot for FHC3 normalized strength

Filled Hole Compression (FHC3) Strength Basis Values and Statistics				
	Normalized		As-measured	
Env	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)
Mean	82.39	65.25	82.42	65.61
Stdev	3.888	3.277	4.076	3.414
CV	4.719	5.022	4.945	5.203
Modified CV	6.359	6.511	6.473	6.601
Min	70.99	59.96	70.67	60.28
Max	89.13	71.12	88.70	71.04
No. Batches	4	4	4	4
No. Spec.	19	20	19	20
Basis Values and Estimates				
B-Basis	73.99		74.48	
B-Estimate		51.74		51.49
A-Estimate	65.43	42.37	68.84	41.70
Method	Weibull	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	73.83	56.73	73.70	56.93
A-Estimate	67.99	50.88	67.75	50.97
Method	Pooled	Pooled	Pooled	Pooled

Table 4-36: Statistics and Basis Values for FHC3 Strength Data

4.26 “25/50/25” Single-Shear Bearing 1 (SSB1, Proc. C)

The SSB1 data is normalized, so both normalized and as-measured statistics are provided. Data is provided for two properties: 2% Offset Strength and Ultimate Strength. There is insufficient data in the Initial Peak Strength to provide CMH17-Rev G publishable basis values. Thus, the property is not included in this Statistics Report.

The 2% Offset ETW datasets, both normalized and as measured, and the as-measured Ultimate Strength ETW dataset failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the transformation of data for the modified CV approach, the as-measured 2% Offset Strength ETW condition and the Ultimate Strength ETW datasets passed the ADK test, so modified CV basis values are provided for those two datasets.

The as-measured Ultimate Strength ETW dataset did not pass the normal distribution test, but the Weibull distribution had an adequate fit to the data, so the Weibull method was used to compute basis values.

The normalized Ultimate Strength datasets and the as-measured datasets for both 2% Offset Strength and Ultimate Strength met all requirements for pooling the two environments when computing the modified CV basis values.

There were no statistical outliers.

Statistics, basis values and estimates are given for the SSB1 normalized strength data in Table 4-37 and for the as-measured strength data in Table 4-38. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-27 and Figure 4-28.

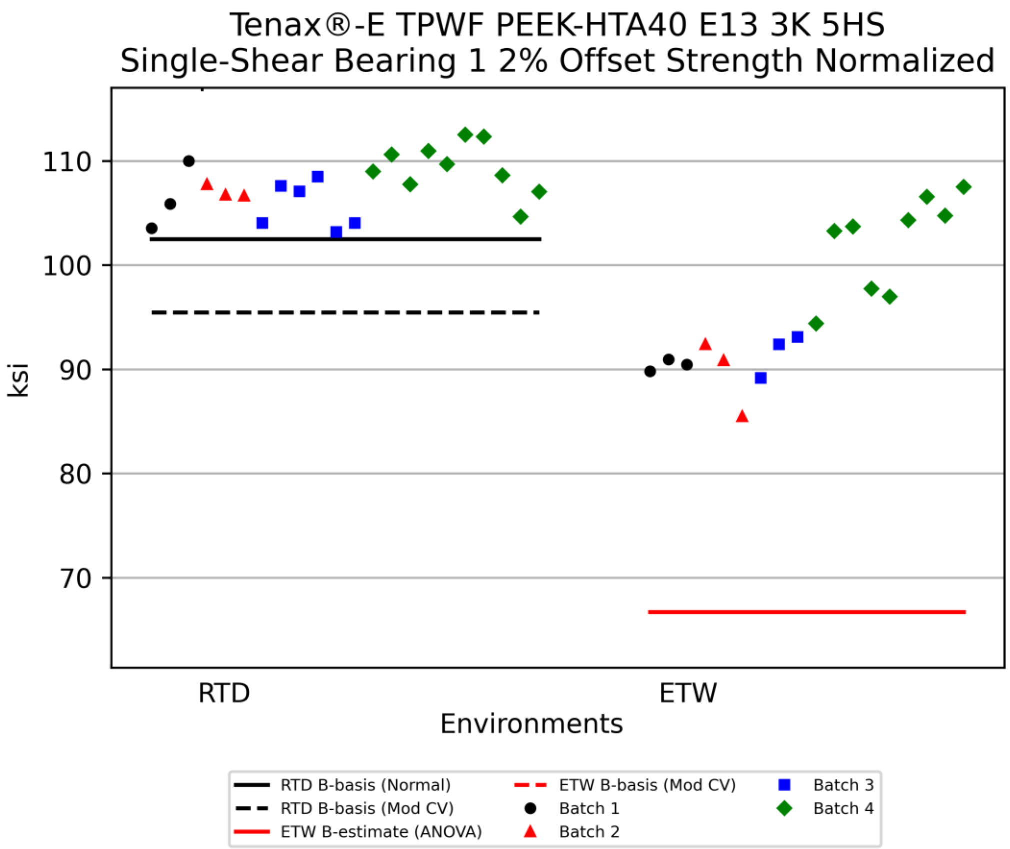

Figure 4-27: Batch plot for SSB1 Proc. C 2% Offset Strength normalized

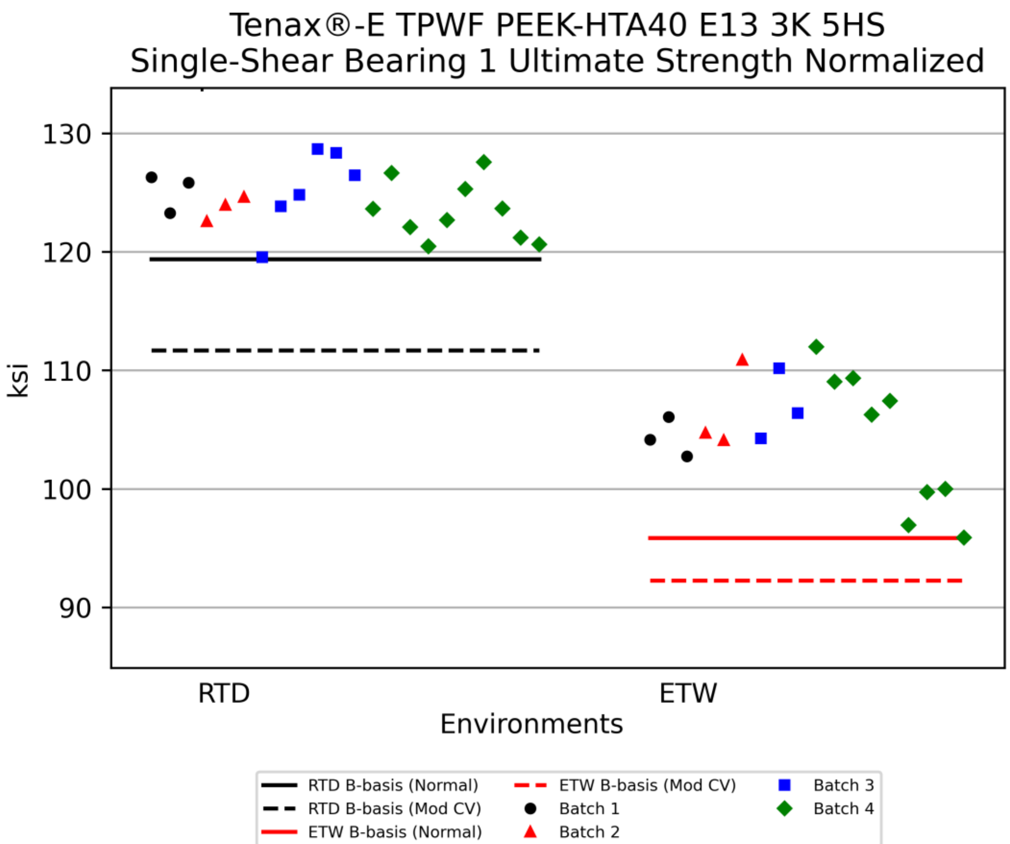

Figure 4-28: Batch plot for SSB1 Proc. C Ultimate Strength normalized

Single Shear Bearing (SSB1 Proc C) Strength Basis Values and Statistics				
	Normalized			
Property	2% Offset Strength		Ultimate Strength	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	107.6	96.31	124.2	105.0
Stdev	2.726	6.942	2.555	4.627
CV	2.533	7.208	2.058	4.407
Modified CV	6.000	7.604	6.000	6.203
Min	103.2	85.47	119.5	95.9
Max	112.5	107.49	128.7	112.0
No. Batches	4	4	4	4
No. Spec.	22	18	22	18
Basis Values and Estimates				
B-Basis	102.5		119.4	95.87
B-Estimate		66.69		
A-Estimate	98.82	46.16	115.9	89.40
Method	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates				
B-Basis	95.45	NA	111.7	92.28
B-estimate				
A-Estimate	86.76		103.0	83.67
Method	Normal		Pooled	Pooled

Table 4-37: Statistics and Basis Values for SSB1 Proc. C Normalized Strength Data

Single Shear Bearing (SSB1 Proc C) Strength Basis Values and Statistics				
	As-measured			
Property	2% Offset Strength		Ultimate Strength	
Env	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)
Mean	108.8	97.12	125.5	105.9
Stdev	3.048	6.290	3.675	4.723
CV	2.802	6.476	2.927	4.458
Modified CV	6.000	7.238	6.000	6.229
Min	102.5	87.26	118.7	96.44
Max	113.3	108.1	131.9	113.2
No. Batches	4	4	4	4
No. Spec.	22	18	22	18
Basis Values and Estimates				
B-Basis	103.0			95.69
B-Estimate		72.50	111.0	
A-Estimate	98.93	55.40	101.0	85.15
Method	Normal	ANOVA	ANOVA	Weibull
Modified CV Basis Values and Estimates				
B-Basis	96.80	84.92	112.9	93.07
B-Estimate				
A-Estimate	88.50	76.67	104.1	84.37
Method	Pooled	Pooled	Pooled	Pooled

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

4.27 “10/80/10” Single-Shear Bearing 2 (SSB2, Proc. C)

The SSB2 data is normalized, so both normalized and as-measured statistics are provided. Data is provided for three properties: Initial Peak Bearing Strength, 2% Offset Strength and Ultimate Strength. There is insufficient data (RTD - one specimens and ETW – 2 specimens) in the Initial Peak Bearing Strength to provide estimates of basis values.

The 2% Offset Strength ETW datasets, both normalized and as measured failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the transformation of data for the modified CV approach, the as-measured 2% Offset Strength ETW condition and the Ultimate Strength ETW datasets passed the ADK test, so modified CV basis values are provided for those two datasets.

The normalized and the as-measured datasets for both 2% Offset Strength and Ultimate Strength met all requirements for pooling the two environments when computing the modified CV basis values.

There were no statistical outliers.

Statistics, basis values and estimates are given for the SSB2 strength data in Table 4-39. The normalized data, B-estimates and B-basis values are shown graphically in Figures 4-29 and 4-30.

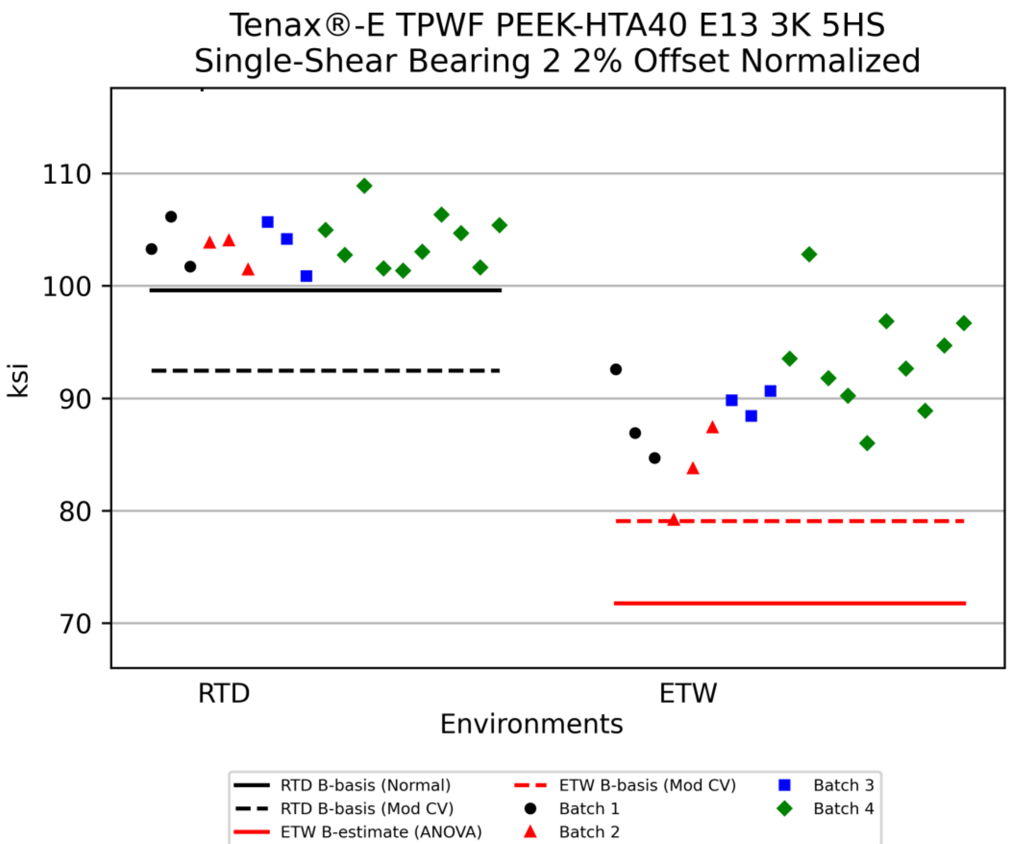

Figure 4-29: Batch plot for SSB2 Proc. C 2% Offset strength normalized

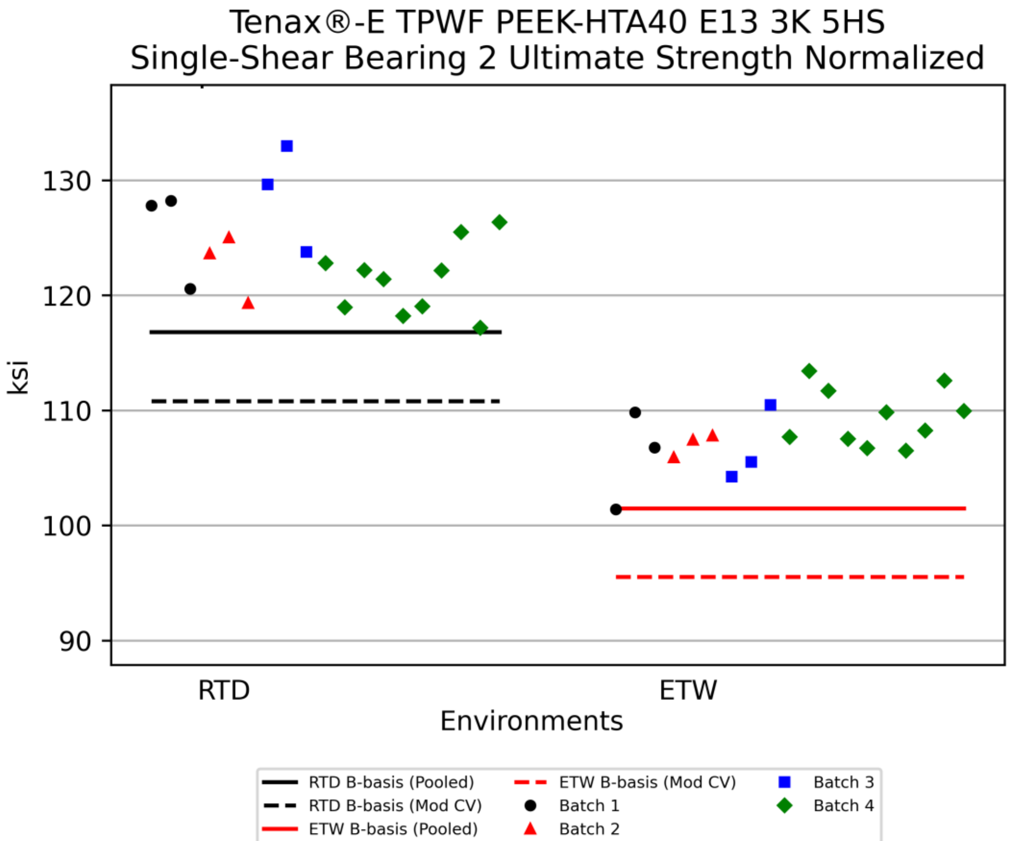

Figure 4-30: Batch plot for SSB2 Proc. C Ultimate strength normalized

Single Shear Bearing (SSB2 Proc C) Strength Basis Values and Statistics								
	Normalized				As-measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	103.8	90.39	123.4	108.1	104.0	90.89	123.6	108.7
Stdev	2.140	5.400	4.250	2.931	2.440	5.330	4.530	2.929
CV	2.060	5.970	3.450	2.712	2.340	5.860	3.660	2.696
Modified CV	6.000	6.985	6.000	6.000	6.000	6.932	6.000	6.000
Min	100.8	79.17	117.2	101.4	99.99	79.50	116.6	103.4
Max	108.9	102.8	133.0	113.4	109.2	102.1	132.2	113.7
No. Batches	4	4	4	4	4	4	4	4
No. Spec.	19	19	19	19	19	19	19	19
Basis Values and Estimates								
B-Basis	99.60		116.8	101.5	99.22		116.8	101.8
B-Estimates		71.76				73.46		
A-Estimate	96.63	58.79	112.3	96.99	95.85	61.30	112.1	97.09
Method	Normal	ANOVA	Pooled	Pooled	Normal	ANOVA	Pooled	Pooled
Modified CV Basis Values and Estimates								
B-Basis	92.46	79.08	110.8	95.52	92.65	79.57	111.0	96.07
A-Estimate	84.74	71.35	102.3	86.95	84.93	71.85	102.4	87.47
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-39: Statistics and Basis Values for SSB2 Proc. C Strength Data

Note: There is insufficient data in the Initial Peak Bearing Strength (RTD - one specimen and ETW – two specimens) to provide estimates of basis values and hence, these two environments have not been included in the table above.

4.28 “40/20/40” Single-Shear Bearing 3 (SSB3, Proc. C)

The SSB3 data is normalized, so both normalized and as-measured statistics are provided. Data is provided for two properties: Initial Peak Bearing Strength, 2% Offset Strength and Ultimate Strength. There is insufficient data (RTD - nine specimens and ETW – 16 specimens) in the Initial Peak Bearing Strength to provide CMH17-Rev G publishable basis values.

The Initial Peak Bearing Strength ETW datasets, both normalized and as measured, failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the transformation of data for the modified CV approach, the Initial Peak Bearing Strength ETW datasets passed the ADK test, so modified CV basis values are provided for those two datasets.

The normalized and the as-measured datasets for 2% Offset Strength and as measured Ultimate Strength met all requirements for pooling the two environments when computing the modified CV basis values. The normalized Ultimate Strength datasets failed the normality test when the two conditions were combined, so pooling was not appropriate.

There were no statistical outliers.

Statistics, basis values and estimates are given for the SSB3 normalized strength data in Table 4-40 and as-measured strength data in Table 4-41. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-31, 4-32 and 4-33.

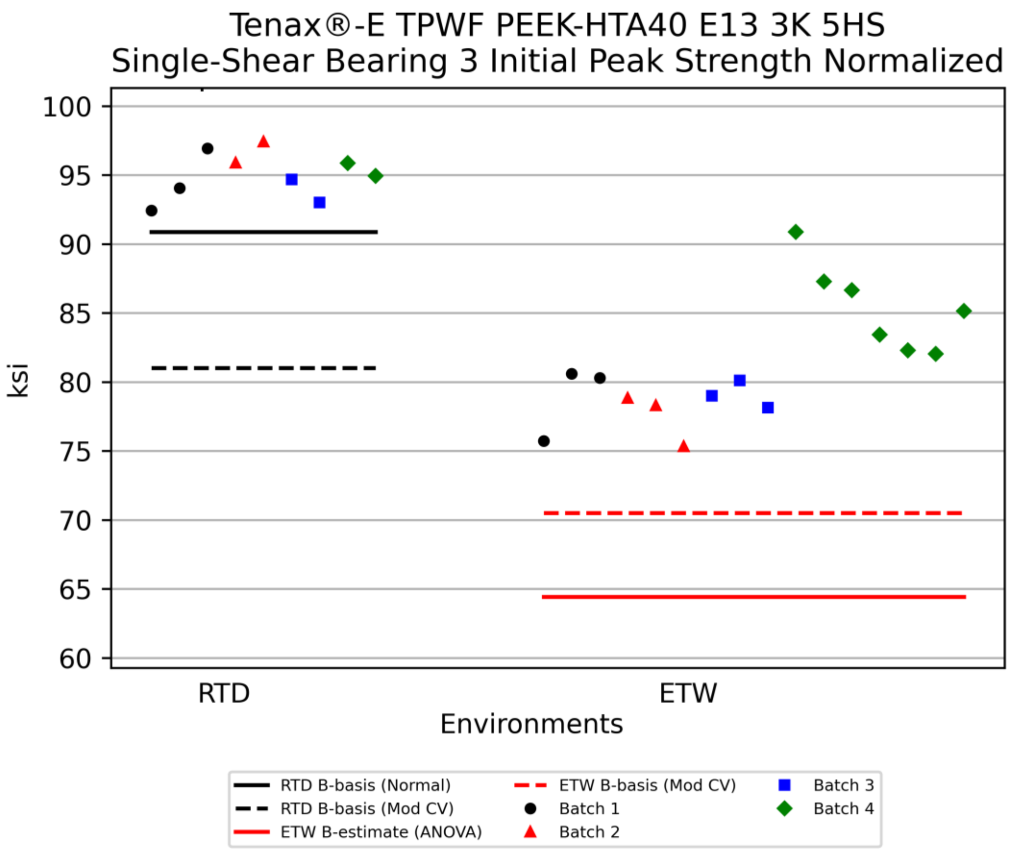

Figure 4-31: Batch plot for SSB3 Proc. C Initial Peak Strength normalized

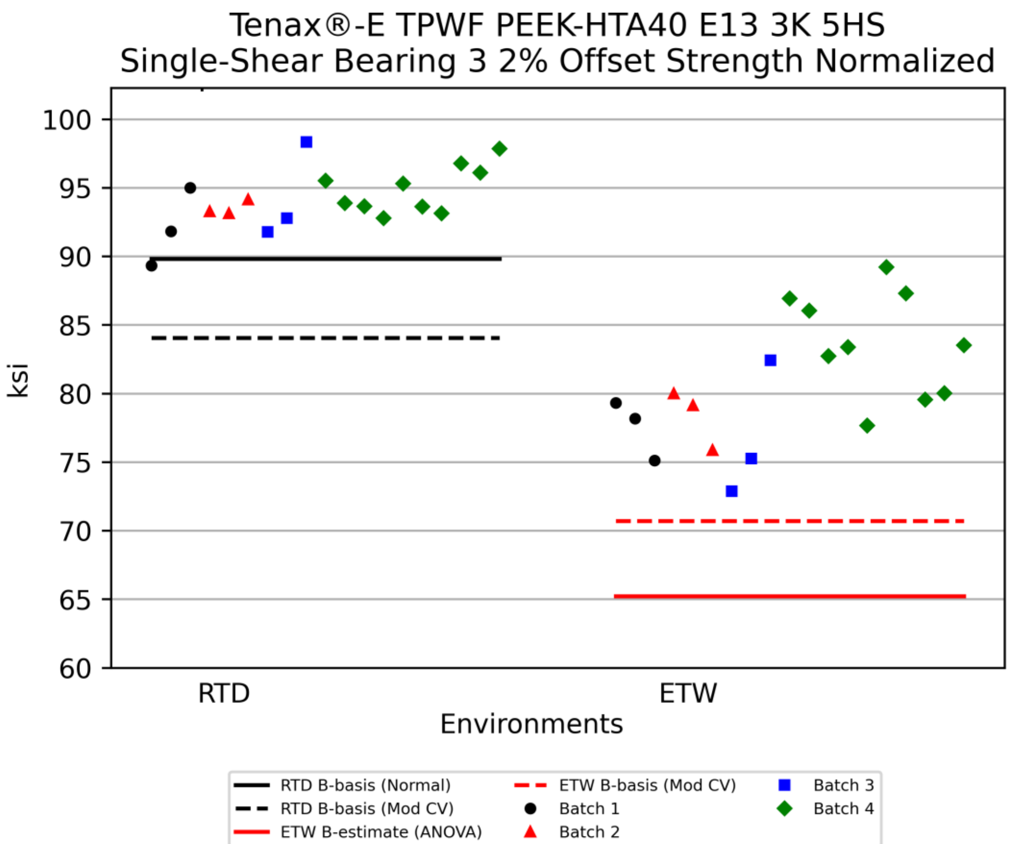

Figure 4-32: Batch plot for SSB3 Proc. C 2% Offset Strength normalized

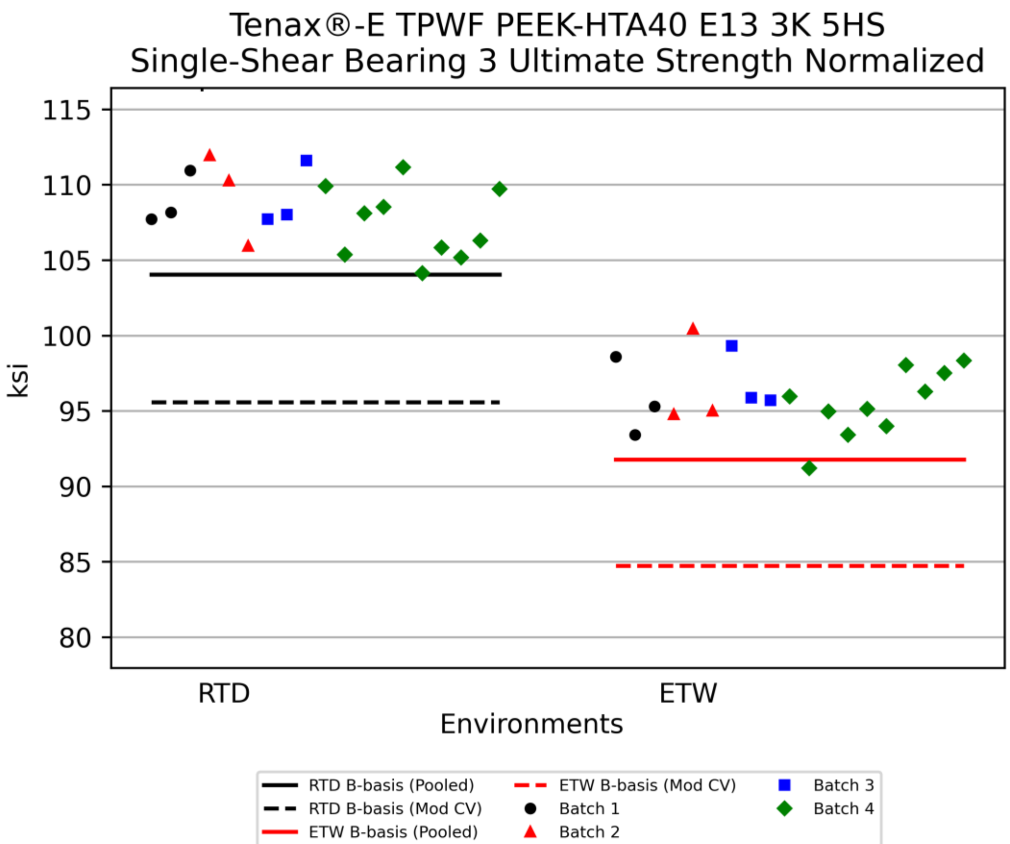

Figure 4-33: Batch plot for SSB3 Proc. C Ultimate Strength normalized

Single Shear Bearing (SSB3 Proc C) Strength Basis Values and Statistics						
	Normalized					
Property	Initial Peak Strength		2% Offset Strength		Ultimate Strength	
Env	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)	RTD (70° F)	ETW (180° F)
Mean	95.02	81.50	94.11	80.76	108.2	95.96
Stdev	1.684	4.293	2.203	4.551	2.357	2.294
CV	1.772	5.267	2.341	5.635	2.178	2.390
Modified CV	6.000	6.633	6.000	6.817	6.000	6.000
Min	92.44	75.33	89.32	72.86	104.1	91.21
Max	97.42	90.87	98.34	89.22	111.9	100.4
No. Batches	4	4	4	4	4	4
No. Spec.	9	16	19	19	19	19
Basis Values and Estimates						
B-Basis			89.82		104.0	91.77
B-Estimate	90.87	64.43		65.21		
A-Estimate	87.96	52.58	86.77	54.37	101.2	88.90
Method	Normal	ANOVA	Normal	ANOVA	Pooled	Pooled
Modified CV Basis Values and Estimates						
B-Basis			84.05	70.70	95.58	84.74
B-Estimate	81.02	70.51				
A-Estimate	71.38	62.77	77.18	63.83	86.60	76.78
Method	Normal	Normal	Pooled	Pooled	Normal	Normal

Table 4-40: Statistics and Basis Values for SSB3 Proc. C Normalized Strength Data

Single Shear Bearing (SSB3 Proc C) Strength Basis Values and Statistics						
	As-measured					
Property	Initial Peak Strength		2% Offset Strength		Ultimate Strength	
Env	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)	RTD (70˚ F)	ETW (180˚ F)
Mean	96.39	82.36	94.95	81.56	109.2	96.93
Stdev	1.778	3.927	2.000	4.326	2.858	2.692
CV	1.845	4.768	2.106	5.305	2.617	2.777
Modified CV	6.000	6.384	6.000	6.652	6.000	6.000
Min	93.22	77.30	92.44	73.11	104.5	91.06
Max	99.68	90.44	98.68	89.75	114.1	100.8
No. Batches	4	4	4	4	4	4
No. Spec.	9	16	19	19	19	19
Basis Values and Estimates						
B-Basis			91.06		104.2	91.92
B-Estimate	92.01	66.28		66.99		
A-Estimate	88.94	55.14	88.29	56.83	100.8	88.50
Method	Normal	ANOVA	Normal	ANOVA	Pooled	Pooled
Modified CV Basis Values and Estimates						
B-Basis			84.92	71.52	98.04	85.76
B-Estimate	82.19	71.66				
A-Estimate	72.41	64.14	78.07	64.67	90.41	78.12
Method	Normal	Normal	Pooled	Pooled	Pooled	Pooled

Table 4-41: Statistics and Basis Values for SSB3 Proc. C as-measured Strength Data

4.29 Interlaminar Tension (ILT) and Curved Beam Strength (CBS)[1]

The Interlaminar Tension test reports data on two properties: Interlaminar Tension Strength and Curved Beam Strength. The data is not normalized. There is insufficient data to compute CMH17-Rev G publishable basis values so only estimates are provided.
The Interlaminar Shear CTD and RTD condition datasets and the Curved Beam Strength CTD condition dataset failed the ADK test, requiring the use of the ANOVA method to compute basis values. Since ANOVA method requires five batches, only B-estimates can be computed for this dataset. After the transformation of data for the modified CV approach, Curved Beam Strength CTD condition dataset passed the ADK test, so modified CV basis values are provided for that dataset.

The Curved Beam Strength RTD condition dataset did not pass any of the three distribution tests (normal, lognormal, Weibull) and required the use of the non-parametric approach to compute basis values. Since the CV of that dataset was above 8%, modified CV basis values could not be computed.

There was one statistical outlier. The lowest value in batch five of the CTD condition for ILT dataset was an outlier for batch five but not for the CTD condition and not for the CBS dataset. It was retained for this analysis.

Summary statistics are presented in Table 4-42 and the as-measured data are displayed graphically in Figures 4-34 and 4-35.

[1] The NCAMP layup for ILT/CBS is [0]7s. Informational only, please refer to NPS 84013 Section 4.5 for processing information.

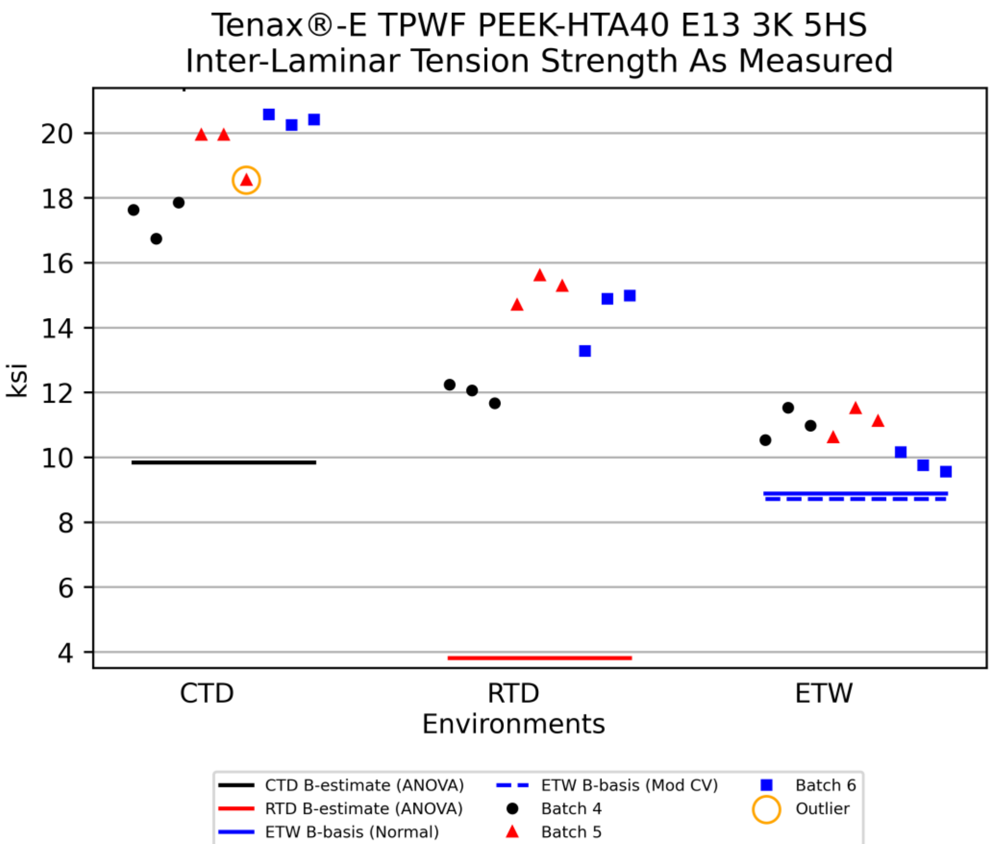

Figure 4-34: Batch plot for ILT as measured

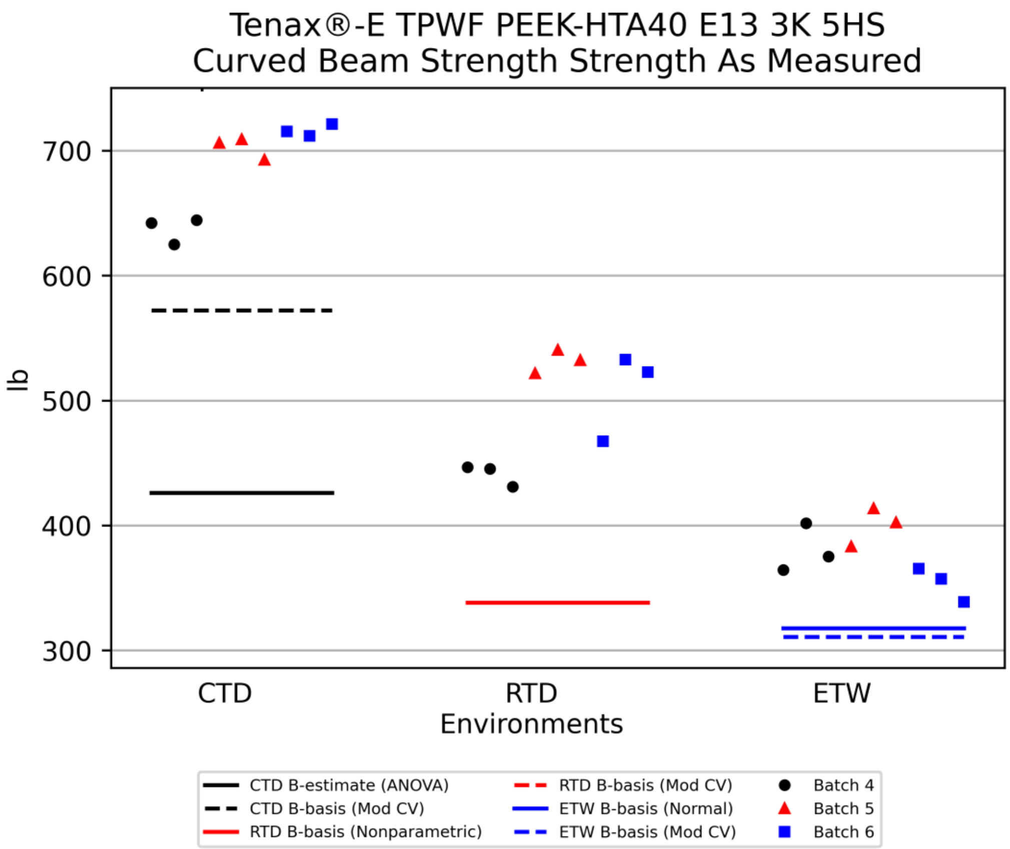

Figure 4-35: Batch plot for CBS as measured

Interlaminar Tension (ILT) and Curved Beam Strength (CBS) Statistics						
	ILT (ksi)			CBS (lbs)		
Env	CTD (−65° F)	RTD (70° F)	ETW (180° F)	CTD (−65° F)	RTD (70° F)	ETW (180° F)
Mean	19.10	13.86	10.64	685.3	493.4	378.0
Stdev	1.421	1.543	0.7123	37.37	44.71	24.39
CV	7.443	11.14	6.695	5.453	9.062	6.452
Mod CV	7.722	11.14	7.348	6.727	9.062	7.226
Min	16.74	11.67	9.560	624.9	430.9	338.9
Max	20.57	15.61	11.53	721.4	540.3	413.6
No. Batches	3	3	3	3	3	3
No. Spec.	9	9	9	9	9	9
Basis Values and Estimates						
B-Estimate	9.841	3.812	8.882	426.2	338.2	317.8
A-Estimate	3.244	NA	7.654	241.3	225.4	275.8
Method	ANOVA	ANOVA	Normal	ANOVA	Nonparametric	Normal
Modified CV Basis Values and Estimates						
B-Estimate	NA	NA	8.719	572.1	NA	310.9
A-Estimate			7.398	494.2		264.8
Method			Normal	Normal		Normal

Table 4-42: Statistics for ILT and CBS Data

4.30 "25/50/25" Compression After Impact 1 (CAI1)

The CAI1 data is normalized, so both normalized and as-measured statistics are provided. Testing is done only for the RTD condition. Only two batches of material were tested, so only estimates of basis values could be computed. The normalized dataset fit the normal distribution well enough to compute basis values. The as-measured dataset failed ADK tests even after the modified CV transformation, basis values were not able to be computed for that dataset. There were no statistical outliers.

Summary statistics are presented in Table 4-43 and the normalized data are displayed graphically in Figure 4-36.

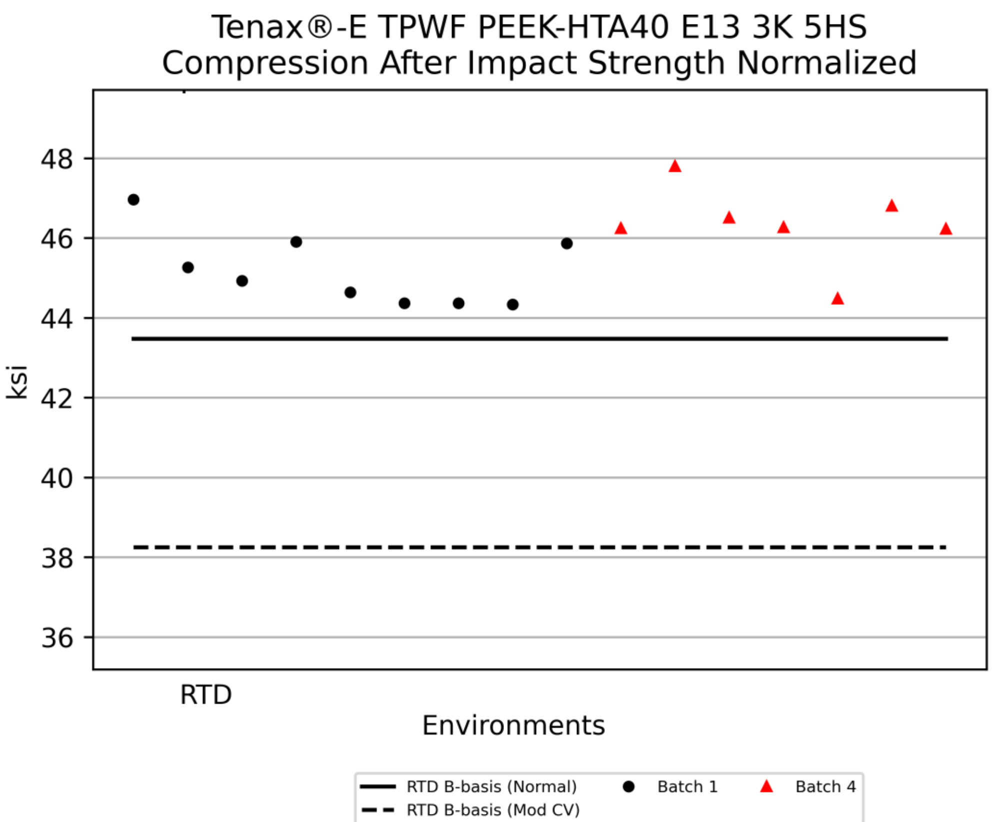

Figure 4-356: Plot for CAI1 normalized strength

Compression After Impact Strength (ksi) Basis Values and Statistics		
	Normalized	As-measured
Env	RTD (70° F)	RTD (70° F)
Mean	45.69	46.54
Stdev	1.084	0.8491
CV %	2.373	1.824
Modified CV %	8.000	8.000
Min	44.34	45.50
Max	47.80	48.02
No. Batches	2	2
No. Spec.	16	16
Basis Value Estimates		
B-Estimate	43.48	NA
A-Estimate	41.92	
Method	Normal	
Modified CV Basis Value Estimates		
B-Estimate	38.25	NA
A-Estimate	33.02	
Method	Normal	

Table 4-43: Statistics for CAI1 Strength Data

5. Outliers

Outliers were identified according to the standards documented in section 2.1.5, which are in accordance with the guidelines developed in section 8.3.3 of CMH-17-1G. An outlier may be an outlier in the normalized data, the as-measured data, or both. A specimen may be an outlier for the batch only (before pooling the three batches within a condition together) or for the condition (after pooling the three batches within a condition together) or both.

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

All outliers identified were investigated to determine if a cause could be found. Outliers with causes were removed from the dataset and the remaining specimens were analyzed for this report. Information about specimens that were removed from the dataset along with the cause for removal is documented in the material property data report, NCAMP Test Report CAM-RP-2019-007 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
FHC2	RTD (70F)	2	NTP4013Q1-TTX-T40-E-FHC2-B-M2-RTD-59	49.03	Not oulier	Low	Yes	No
FHC3	RTD (70F)	3	NTP4013Q1-TTX-T40-E-FHC3-C-M2-RTD-58	70.99	70.67	Low	No	Yes
FHC3	ETW (180F)	2	NTP4013Q1-TTX-T40-E-FHC3-B-M2-ETW-64	Not oulier	70.07	High	Yes	No
FHT2	RTD (70F)	1	NTP4013Q1-TTX-T40-E-FHT2-A-M2-RTD-42	41.69	Not oulier	Low	Yes	No
FHT3	RTD (70F)	1	NTP4013Q1-TTX-T40-E-FHT3-A-M2-RTD-41	Not oulier	60.18	High	Yes	No
FHT3	RTD (70F)	2	NTP4013Q1-TTX-T40-E-FHT3-B-M2-RTD-42	58.88	Not oulier	High	Yes	No
FT	CTD (-65F)	4	NTP4013Q1-TTX-T40-E-FT-D-M3-CTD-4	119.9	122.6	Low	Yes	No
FT	RTD (70F)	4	NTP4013Q1-TTX-T40-E-FT-D-M3-RTD-9	113.6	Not oulier	Low	Yes	No
ILT	CTD (-65F)	5	NTP4013Q1-TTX-T40-E-ILT-E-M3-CTD-4	NA	18.54	Low	Yes	No
IPS 0.2% Offset	CTD (-65F)	3	NTP4013Q1-TTX-T40-E-IPS-C-M2-CTD-1	NA	7.359	High	Yes	No
IPS 4% Strain	ETW (180F)	1	NTP4013Q1-TTX-T40-E-IPS-A-M2-ETW-9	NA	7.488	High	No	Yes
OHC2	RTD (70F)	1	NTP4013Q1-TTX-T40-E-OHC2-A-M2-RTD-49	NA	37.94	High	Yes	No
OHC3	RTD (70F)	4	NTP4013Q1-TTX-T40-E-OHC3-D-M3-RTD-3	44.76	Not oulier	High	No	Yes
OHT1	RTD (70F)	3	NTP4013Q1-TTX-T40-E-OHT1-C-M2-RTD-30	49.44	Not oulier	High	Yes	No
OHT2	CTD (-65F)	2	NTP4013Q1-TTX-T40-E-OHT2-B-M2-CTD-25	NA	44.78	High	Yes	No
OHT2	ETW (180F)	2	NTP4013Q1-TTX-T40-E-OHT2-B-M2-ETW-36	36.18	36.24	High	Yes	No
OHT3	CTD (-65F)	2	NTP4013Q1-TTX-T40-E-OHT3-B-M2-CTD-27	Not oulier	53.08	Low	Yes	No
OHT3	RTD (70F)	3	NTP4013Q1-TTX-T40-E-OHT3-C-M2-RTD-29	49.79	49.88	Low	Yes	No
OHT3	ETW (180F)	4	NTP4013Q1-TTX-T40-E-OHT3-D-M4-ETW-3	52.96	52.91	Low	Yes	No
SBS	RTD (70F)	4	NTP4013Q1-TTX-T40-E-SBS-D-M3-RTD-2	NA	12.81	Low	Yes	No
SBS	ETD (180F)	2	NTP4013Q1-TTX-T40-E-SBS-B-M2-1-ETD-1	NA	10.79	Low	Yes	No
SBS	ETW (180F)	1	NTP4013Q1-TTX-T40-E-SBS-A-M2-1-ETW-1	NA	9.970	High	Yes	No
SBS1	ETW (180F)	3	NTP4013Q1-TTX-T40-E-SBS1-C-M2-1-ETW-3	NA	8.401	Low	No	Yes
UNC1	RTD (70F)	1	NTP4013Q1-TTX-T40-E-UNC1-A-M2-RTD-13	NA	61.95	Low	No	Yes
UNC2	RTD (70F)	1	NTP4013Q1-TTX-T40-E-UNC2-A-M2-RTD-13	NA	48.80	Low	Yes	No
UNC3	RTD (70F)	4	NTP4013Q1-TTX-T40-E-UNC3-D-M4-RTD-2	92.29	93.17	High	Yes	No
UNT1	CTD (-65F)	3	NTP4013Q1-TTX-T40-E-UNT1-C-M2-CTD-1	92.70	Not oulier	Low	Yes	No
UNT1	ETW (180F)	3	NTP4013Q1-TTX-T40-E-UNT1-C-M2-ETW-12	75.54	75.48	Low	Yes	No - As-Measured Yes - Normalized
UNT3	RTD (70F)	2	NTP4013Q1-TTX-T40-E-UNT3-B-M2-RTD-6	112.2	Not oulier	Low	Yes	No
UNT3	RTD (70F)	1	NTP4013Q1-TTX-T40-E-UNT3-A-M2-RTD-5	Not oulier	121.4	High	Yes	No
UNT3	ETW (180F)	4	NTP4013Q1-TTX-T40-E-UNT3-D-M3-ETW-4	100.9	99.92	Low	No	Yes
WC	CTD (-65F)	1	NTP4013Q1-TTX-T40-E-WC-A-M2-CTD-2	Not oulier	97.75	Low	Yes	No
WC	CTD (-65F)	2	NTP4013Q1-TTX-T40-E-WC-B-M2-CTD-3	Not oulier	108.6	Low	Yes	No
WC	RTD (70F)	3	NTP4013Q1-TTX-T40-E-WC-C-M2-RTD-7	81.06	79.61	Low	No	Yes
WC	ETW (180F)	1	NTP4013Q1-TTX-T40-E-WC-A-M2-ETW-3	71.69	73.65	Low	Yes	Yes
WT	RTD (70F)	2	NTP4013Q1-TTX-T40-E-WT-B-M2-RTD-7	133.3	133.1	Low	Yes	No
WT	RTD (70F)	4	NTP4013Q1-TTX-T40-E-WT-D-M3-RTD-5	Not oulier	146.7	High	Yes	No
WT	ETW (180F)	3	NTP4013Q1-TTX-T40-E-WT-C-M2-ETW-9	121.4	Not oulier	Low	Yes	No

Table 5-1: List of Outliers

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