Syensqo (Formerly Solvay) EP2190 IMS65 Unitape Gr 145 RC 35% Material Allowables Statistical Analysis Report

Phase 1, 2, and 3

NCAMP Project Number: NPN 021901

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-	Elizabeth Clarkson	5-4-2022	Report created with Phase 1 data
-	Jorge Chavez-Salas	8-28-2025	Report updated with Phase 2 and Phase 3 data

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1. Introduction

This report contains statistical analysis of the Solvay EP2190 IMS65 Unitape GR 145 RC 35% material property data published in NCAMP Test Report CAM-RP-2022-001 Rev -. The lamina and laminate material property data have been generated with NCAMP oversight NCAMP Project Number NPN 021901 and also meet the requirements outlined in NCAMP Standard Operating Procedure NSP 100. The test panels, test specimens, and test setups have been inspected by NCAMP Authorized Inspection Representatives (AER) and the testing has been witnessed by the NCAMP Authorized Inspection Representatives (AER).

B-Basis values, A-estimates, and B-estimates were calculated using a variety of techniques that are detailed in section two. This revised report (Rev. A) contains Phase 2 and Phase 3 test data which was added to Phase 1 data.

The qualification material was procured to a proprietary material specification which is equivalent to NCAMP Material Specification NMS 219/1 Rev Initial Release dated November 4, 2021. The qualification test panels were fabricated per a proprietary process specification which is equivalent to NCAMP Process Specification NPS 82190 Rev A dated April 1, 2022 using baseline cure cycle “C”. The test panels were fabricated and the testing was performed at Solvay, 1440 N Kraemer Blvd, Anaheim, CA 92806. The NCAMP Test Plan NTP 2190Q1 was used for this qualification program.

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

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

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

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

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

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

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 219/1. NMS 219/1 has additional requirements that are listed in its prepreg process control document (PCD), fiber specification, fiber PCD, and other raw material specifications and PCDs which impose essential quality controls on the raw materials and raw material manufacturing equipment and processes. *Aircraft companies and certifying agencies should assume that the material property data published in this report is not applicable when the material is not procured to NCAMP Material Specification NMS 219/1.* NMS 219/1 is a free, publicly available, non-proprietary aerospace industry material specification.

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

1.1 Symbols and Abbreviations

Test Property	Abbreviation
Longitudinal Compression Strength	LCS
Longitudinal Compression Modulus	LCM
Longitudinal Tension	LT
Transverse Compression Strength	TCS
Transverse Compression Modulus	TCM
Transverse Tension	TT
In-Plane Shear	IPS
Short Beam Strength	SBS
Unnotched Tension	UNT
Unnotched Compression	UNC
0° Flexure	0FLEX
Open Hole Tension	OHT
Open Hole Compression	OHC
Compression After Impact	CAI
Filled-Hole Tension	FHT
Filled-Hole Compression	FHC
Single-Shear Bearing	SSB

Table 1-1: Test Property Abbreviations

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

Table 1-2: Test Property Symbols

Environmental Condition	Abbreviation	Temperature
Cold Temperature Ambient	CTA	–67±5°F
Room Temperature Ambient	RTA	75±5°F
Elevated Temperature Ambient	ETA2	225±5°F
Elevated Temperature Ambient	ETA3	250±5°F
Elevated Temperature Wet	ETW1	180±5°F

Elevated Temperature Wet	ETW2	225±5°F
Elevated Temperature Wet	ETW3	250±5°F

Table 1-3: Environmental Conditions Abbreviations

Tests with a “1” immediately after the abbreviation refers to a 25/50/25 layup. This is also referred to as "Quasi-Isotropic"

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-2022-001.

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

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

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

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

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

2. Background

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

2.1 CMH17 STATS Statistical Formulas and Computations

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

2.1.1 Basic Descriptive Statistics

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

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

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

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

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

2.1.2 Statistics for Pooled Data

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

2.1.2.1 Pooled Standard Deviation

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

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

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

2.1.2.2 Pooled Coefficient of Variation

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

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

2.1.3 Basis Value Computations

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

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

2.1.3.1 K-factor computations

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

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

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

Where

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

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

$$f = N - r$$

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

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

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

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

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

2.1.4 Modified Coefficient of Variation

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

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

This is converted to percent by multiplying by 100%.

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

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

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

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

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

2.1.4.1 Transformation of data based on Modified CV

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

To accomplish this requires a transformation in two steps:

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

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

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

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

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

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

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

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

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

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

2.1.5 Determination of Outliers

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

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

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

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

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

2.1.6 The k-Sample Anderson Darling Test for Batch Equivalency

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

The k-sample Anderson-Darling test statistic is:

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

Where

n_i = the number of test specimens in each batch

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

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

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

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

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

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

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

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

With

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

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

2.1.7 The Anderson Darling Test for Normality

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

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

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

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

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

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

The Anderson Darling test statistic (AD) is:

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

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

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

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

2.1.8 Levene's Test for Equality of Coefficient of Variation

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

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

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

2.1.9 Distribution Tests

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

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

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

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

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

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

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

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

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

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

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

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

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

2.1.9.3 Two-parameter Weibull Distribution

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

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

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

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

2.1.9.3.1 Estimating Weibull Parameters

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

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

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

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

2.1.9.3.2 Goodness-of-fit test for the Weibull distribution

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

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

The Anderson-Darling test statistic is

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

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 ≤ 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

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

where

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

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

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

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

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

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

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

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

Table 2-1: Weibull Distribution Basis Value Factors

2.1.9.4 Lognormal Distribution

A probability distribution for which the probability that an observation selected at random from this population falls between a and b $\left(0 < a < b < \infty\right)$ 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:

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

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

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

2.1.10.2 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

The A-basis value is:

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

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

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

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

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

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

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

2.1.11 Analysis of Variance (ANOVA) Basis Values

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

2.1.11.1 Calculation of basis values using ANOVA

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

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

First, statistics are computed for each batch, which are indicated with a subscript $\left(n_i, \bar{x}_i, s_i^2\right)$ 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-17-1H using a sample size of n (denoted k_0) and a sample size of k (denoted k_1). Whether this value is an A- or B-basis value depends only on whether k_0 and k_1 are computed for A or B-basis values.

Denote the ratio of mean squares by

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

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

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

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

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

2.2 Single Batch and Two Batch Estimates using Modified CV

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

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

2.3 Lamina Variability Method (LVM)

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

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

The LVM B-basis value is then computed as:

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

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

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

With:

$\bar{X}_1$ the mean of the laminate (small dataset)

N_1 the sample size of the laminate (small dataset)

N_2 the sample size of the lamina (large dataset)

CV_1 is the coefficient of variation of the laminate (small dataset)

CV_2 is the coefficient of variation of the lamina (large dataset)

$K_{(N_1,N_2)}$ is given in Table 2-4

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

Table 2-4: B-Basis factors for small datasets using variability of corresponding large dataset

2.4 Specification Limits

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

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

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

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

Then we define:

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

We compute these as the following:

$$W_{mean} = \bar{x} - k_n^{mean}.S \quad \textbf{Equation 64}$$
$$W_{min\ indiv} = \bar{x} - k_n^{min\ indiv}.S \quad \textbf{Equation 65}$$

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

For modulus properties we define:

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

We compute these as the following:

$$W_{lower} = \bar{x} - k.S \quad \textbf{Equation 66}$$
$$W_{upper} = \bar{x} + k.S \quad \textbf{Equation 67}$$

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

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

and

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

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

2.4.1.1 Specification Limits for the Program

The qualification data statistics and specification limits are summarized for Strength properties in Table 2-5 and for Modulus properties in Table 2-6.

Test Method	Test Condition	Mean [ksi]	CV (%)	Mod CV (%)	k_mean	k_min indiv	As-is		Mod CV		Notes
							W_mean [ksi]	W_min indiv [ksi]	W_mean [ksi]	W_min indiv [ksi]	
LC	ETA3 (250°F)	143.3	11.36	11.36	1.143	3.072	124.7	93.28	124.7	93.28	Qualification Data Only
LT	RTA (70°F)	430.6	4.736	6.368	1.143	3.072	407.3	367.9	399.2	346.3	Qualification Data Only
SBS	RTA (70°F)	12.64	1.929	6.000	1.143	3.072	12.36	11.89	11.77	10.31	Qualification Data Only

Table 2-5: Qualification Data Statistics and Specification Limits for Strength normalized

Test Method	Test Condition	Mean [Msi]	CV (%)	Mod CV (%)	t_statistic	As-is		Mod CV		Notes
						Lower Limit [Msi]	Upper Limit [Msi]	Lower Limit [Msi]	Upper Limit [Msi]	
LC	ETA3 (70°F)	20.68	2.416	6.000	2.861	19.97	21.40	18.94	22.42	Qualification Data Only
LT	RTA (70°F)	22.81	1.282	6.000	2.807	22.41	23.22	20.95	24.68	Qualification Data Only

Table 2-6: Qualification Data Statistics and Specification Limits for Modulus normalized

3. Summary of Results

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

3.1 NCAMP Recommended B-basis Values

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

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

NCAMP Recommended B-basis Values for Solvay EP2190 IMS65 Unitape GR 145 RC 35%

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

Values are for normalized data unless otherwise noted

Environment	Statistic	LT	TT*	LC	TC*	SBS*	IPS*		0FLEX
							0.2% Offset	5% Strain	
CTA (-67º F)	B-basis (ksi)	373.0	NA	NA	NA:I	NA:I	8.323	12.41	
	Mean (ksi)	421.0	10.27	242.8	50.70	16.77	9.316	13.69	
	% CV	6.150	23.14	9.678	5.767	3.057	6.000	6.000	
RTA (75º F)	B-basis (ksi)	NA	9.320	187.6	NA:A	11.23	5.526	9.357	NA:A
	Mean (ksi)	430.6	11.14	218.1	41.31	12.64	6.187	10.63	280.5
	% CV	4.736	9.209	7.537	6.287	6.000	6.013	6.000	4.959
ETA2 (250º F)	B-basis (ksi)			NA:I	NA:I	NA:I			NA:I
	Mean (ksi)			163.7	27.14	8.173			218.9
	% CV			10.60	2.339	1.077			1.419
ETA3 (250º F)	B-basis (ksi)	353.9	NA:A	NA:A	NA:A	6.774	NA:I	NA:I	177.2
	Mean (ksi)	401.5	7.926	143.3	27.75	7.724	4.072	6.958	203.9
	% CV	6.000	9.720	11.36	9.208	6.232	1.794	1.418	6.632
ETW1 (180º F)	B-basis (ksi)	344.8	NA:A	144.3	25.03	6.176	3.660	5.517	
	Mean (ksi)	384.0	5.368	169.6	29.15	7.006	3.904	6.259	
	% CV	5.164	14.19	7.562	7.163	6.000	4.167	6.000	
ETW2 (225º F)	B-basis (ksi)	318.7	3.534	112.8	21.89	5.378	2.378	3.988	148.7
	Mean (ksi)	361.9	4.113	132.1	26.37	6.101	2.683	4.524	170.0
	% CV	6.041	7.136	7.413	8.610	6.000	6.597	6.000	6.345
ETW3 (250º F)	B-basis (ksi)			88.06		NA:A	1.934	3.417	
	Mean (ksi)			108.3		5.384	2.237	3.923	
	% CV			9.461		6.696	7.858	6.543	

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
If B-basis is not available then CV corresponds with the original (non modified) CV.
NA implies that tests were run but data did not meet NCAMP recommended requirements.
"NA: A" indicates ANOVA with less than 5 batches, "NA: I" indicates insufficient data,
Shaded empty boxes indicate that no test data is available for that property and condition.
Shaded non-empty boxes indicate Non-Modified CV is provided when Mod CV is not available.
* Data is as-measured rather than normalized

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

NCAMP Recommended B-basis Values for
Solvay EP2190 IMS65 Unitape GR 145 RC 35%
All B-basis values in this table meet the standards for publication in CMH-17H Handbook
Values are for normalized data unless otherwise noted

Lay-up	ENV	Statistic	OHT	OHC	FHT	FHC	UNT	UNC	SSB 2% Offset	SSB Ultimate	CAI1
25/50/25	CTA (-67º F)	B-basis (ksi)	63.62	48.73	NA:A	67.41	NA:A	NA:I	136.4	153.7	NA:I
		Mean (ksi)	71.23	54.20	84.16	74.31	111.6	110.5	150.2	167.9	56.74
		% CV	6.000	6.273	9.065	6.597	10.13	5.954	6.000	6.000	7.140
	RTA (75º F)	B-basis (ksi)	67.14	42.63	NA:A	49.09	NA:A	NA:A	112.8	128.5	41.74
		Mean (ksi)	74.75	48.10	85.23	56.00	135.0	87.63	126.6	142.6	48.40
		% CV	6.000	6.000	7.094	6.222	9.315	9.645	6.260	6.000	6.972
	ETA2 (225º F)	B-basis (ksi)	NA:I	NA:I			NA:I	NA:I			NA:I
		Mean (ksi)	75.01	41.14			146.3	62.48			40.13
		% CV	3.685	2.259			2.726	10.79			4.074
	ETA3 (250º F)	B-basis (ksi)	68.93	NA:A			NA:I	NA:I			NA:I
		Mean (ksi)	78.19	38.67			153.6	74.49			36.33
		% CV	6.000	9.993			1.375	5.027			6.975
	ETW1 (180º F)	B-basis (ksi)	66.14	35.15	74.25	37.23	110.4	56.55	108.8	112.5	34.12
		Mean (ksi)	75.02	39.91	84.50	44.14	125.3	67.02	122.5	126.6	39.83
		% CV	6.000	6.049	6.147	6.964	6.000	7.913	6.124	6.000	7.256
	ETW2 (225º F)	B-basis (ksi)	69.30	30.75	78.09	34.37	113.7	51.88	99.96	104.2	30.61
		Mean (ksi)	78.62	34.88	89.65	39.25	129.0	60.90	113.7	118.3	35.31
		% CV	6.000	6.000	6.527	6.290	6.000	7.504	7.170	6.062	6.745
	ETW3 (250º F)	B-basis (ksi)		28.49				45.41	95.39	100.7	
		Mean (ksi)		32.31				52.64	109.2	114.8	
		% CV		6.000				6.959	6.495	6.159	
10/80/10	CTA (-67º F)	B-basis (ksi)	49.61		56.74		80.78				
		Mean (ksi)	55.39		63.27		89.59				
		% CV	6.000		6.000		6.000				
	RTA (75º F)	B-basis (ksi)	44.56	33.71	49.43	45.89	75.38	58.19	113.2	135.3	
		Mean (ksi)	50.35	38.24	55.96	52.06	84.19	66.01	125.5	148.6	
		% CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	
	ETA2 (225º F)	B-basis (ksi)		NA:I				NA:I			
		Mean (ksi)		30.38				50.91			
		% CV		2.163				6.148			
	ETA3 (250º F)	B-basis (ksi)		NA:I				NA:I			
		Mean (ksi)		28.73				49.70			
		% CV		2.403				2.490			
	ETW1 (180º F)	B-basis (ksi)	NA:I	25.65	NA:I	NA:I	65.60	43.61	100.0	111.0	
		Mean (ksi)	46.95	29.10	52.79	37.94	74.42	49.98	112.3	124.4	
		% CV	1.777	6.000	3.206	3.810	6.000	6.460	6.557	6.079	
	ETW2 (225º F)	B-basis (ksi)	39.69	20.83	43.15	26.34	58.36	NA:A	91.13	100.6	
		Mean (ksi)	45.03	23.63	48.95	30.43	66.20	41.05	103.4	114.0	
		% CV	6.000	6.000	6.000	6.801	6.000	9.551	6.370	6.000	
	ETW3 (250º F)	B-basis (ksi)		18.48				NA:A	80.24	92.90	
		Mean (ksi)		20.96				35.25	92.53	106.3	
		% CV		6.000				7.281	7.154	6.761	
50/40/10	CTA (-67º F)	B-basis (ksi)	112.7		109.1		218.6				
		Mean (ksi)	127.1		123.1		244.2				
		% CV	6.000		6.000		6.000				
	RTA (75º F)	B-basis (ksi)	120.8	60.54	110.8	67.84	217.1	113.7	111.7	131.2	
		Mean (ksi)	135.1	70.00	124.9	80.39	242.7	139.0	124.6	144.2	
		% CV	6.000	6.847	6.408	7.908	6.193	9.670	6.000	6.000	
	ETA2 (225º F)	B-basis (ksi)		NA:I				NA:I			
		Mean (ksi)		62.39				98.30			
		% CV		3.377				7.345			
	ETA3 (250º F)	B-basis (ksi)		NA:I				NA:I			
		Mean (ksi)		57.49				106.3			
		% CV		7.499				9.232			
	ETW1 (180º F)	B-basis (ksi)	NA:I	50.73	NA:I	NA:I	199.5	79.13	97.29	109.4	
		Mean (ksi)	160.3	57.86	136.9	63.57	225.1	99.99	110.2	122.4	
		% CV	1.887	6.239	2.956	3.577	6.809	10.57	6.356	6.000	
	ETW2 (225º F)	B-basis (ksi)	NA:A	42.72	119.1	44.70	201.8	NA:A	86.59	97.85	
		Mean (ksi)	155.5	49.55	135.1	51.86	227.4	80.75	99.48	110.8	
		% CV	6.000	6.985	6.000	6.999	6.000	12.77	6.637	6.000	
	ETW3 (250º F)	B-basis (ksi)		38.50				47.66	73.62	87.55	
		Mean (ksi)		43.67				61.15	86.52	100.5	
		% CV		6.000				11.77	9.666	6.945	

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
If B-basis is not available then CV corresponds with the original (non modified) CV.
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.
Shaded non-empty boxes indicate Non-Modified CV is provided when Mod CV is not available.
* Data is as-measured rather than normalized

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

3.2 Lamina and Laminate Summary Tables

The following tables show the summary of basis values and means for lamina and laminate properties.

Prepreg Material: Solvay EP2190 IMS65 Unitape GR 145 RC 35%
Material Specification: NMS 219/1
Process Specification NPS 82190

Solvay EP2190 IMS65 Unitape GR 145 RC 35% Lamina Properties Summary

Fiber: 24K IMS65 Unitape **Resin:** Solvay EP2190

***Tg(dry):** 370.27˚F **Tg(wet):** 291.48˚F **Tg METHOD:** ASTM D7028

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY - PHASES 1, 2 AND 3
Data reported: As-measured followed by normalized values in parentheses, normalizing tply: 0.0056 in
Values shown in shaded boxes do not meet CMH17 Rev H requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test Condition	CTA (-67˚F)			RTA (75˚F)			ETA2 (225˚F)			ETA3 (250˚F)			ETW1 (180˚F)			ETW2 (225˚F)			ETW3 (250˚F)		
Property	B-Basis	Mod CV B-basis	Mean	B-Basis	Mod CV B-basis	Mean	B-Basis	Mod CV B-basis	Mean	B-Basis	Mod CV B-basis	Mean	B-Basis	Mod CV B-basis	Mean	B-Basis	Mod CV B-basis	Mean	B-Basis	Mod CV B-basis	Mean
F_1^{tu} (ksi)	332.1	361.1	406.7	338.7	370.3	415.8				361.1	342.3	388.3	334.7	NA	380.9	329.6	313.5	355.7			
from LT	(364.9)	(373.0)	(421.0)	(341.5)	NA	(430.6)				(371.4)	(353.9)	(401.5)	344.8	NA	(384.0)	(332.7)	318.7	(361.9)			
E_1^t			21.90			22.04						22.28			22.47			22.35			
(Msi)			(22.68)			(22.81)						(23.04)			(22.67)			(22.74)			
ν_{12}^t			0.3219			0.3299						0.3301			0.3416			0.3363			
F_2^{tu} (ksi)	0.000	NA	10.27	9.320	9.320	11.14				4.207	NA	7.926	1.618	NA	5.368	3.604	3.534	4.113			
E_2^t (Msi)			1.413			1.255						1.078			1.114			0.8621			
ν_{21}^t			0.02446			0.01683						0.01500			0.01722			0.01222			
F_1^{cu} (ksi)	157.9	NA	231.7	165.8	178.0	207.7	105.2	105.5	159.1	50.51	NA	138.1	142.9	NA	166.2	105.6	NA	130.1	85.58	85.58	106.0
from LC	(163.7)	NA	(242.8)	(189.5)	(187.6)	(218.1)	(111.2)	(111.2)	(163.7)	(40.57)	NA	(143.3)	(146.2)	(144.3)	(169.6)	(107.6)	(112.8)	(132.1)	(88.06)	(88.06)	(108.3)
E_1^c			19.42			19.72			19.62			20.33			20.73			20.74			20.87
(Msi)			(20.16)			(20.56)			(20.12)			(20.68)			(21.15)			(20.86)			(21.06)
F_2^{cu} (ksi)	44.22	41.71	50.70	30.00	NA	41.31	25.21	20.56	27.14	10.67	NA	27.75	25.51	25.03	29.15	21.89	21.89	26.37			
E_2^c (Msi)			1.677			1.503			1.199			1.185			1.364			1.194			
$F_{12}^{s5\%strain}$ (ksi)	12.10	12.41	13.69	9.752	9.357	10.63				6.659	5.272	6.958	5.843	5.517	6.259	3.679	3.988	4.524	3.555	3.417	3.923
$F_{12}^{s0.2\%}$ (ksi)	8.809	8.323	9.316	5.328	5.526	6.187				3.850	3.085	4.072	3.660	NA	3.904	2.378	NA	2.683	1.939	1.934	2.237
G_{12}^s (Msi)			0.8078			0.6053						0.4303			0.4169			0.2782			0.2226
SBS (ksi)	15.64	13.80	16.77	11.69	11.23	12.64	7.907	6.193	8.173	5.559	6.774	7.724	6.611	6.176	7.006	4.586	5.378	6.101	3.222	NA	5.384
0FLEX Strength				193.6	NA	258.0	196.5	158.4	209.1	173.9	167.7	191.8				148.1	NA	165.6			
(ksi)				(224.7)	NA	(280.5)	(209.4)	(165.8)	218.9	(152.6)	(177.2)	(203.9)				(155.3)	(148.7)	(170.0)			

*Specimens might absorb moisture at ambient condition prior to testing which resulted in lower dry Tg, DMA testing took place weeks/months after panel fabrication. Based on Syensqo's batch release historical data, dry Tg is ~192°C (377°F) to 208°C (406°F

Table 3-3: Lamina Properties Summary Table

Prepreg Material: Solvay EP2190 IMS65 Unitape GR 145 RC 35%
Material Specification: NMS 219/1
Process Specification NPS 82190

Solvay EP2190 IMS65 Unitape GR 145 RC 35% Laminate Properties Summary

Fiber: 24K IMS65 Unitape **Resin:** Solvay EP2190

***Tg(dry):** 370.27˚F **Tg(wet):** 291.48˚F **Tg METHOD:** ASTM D7028

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY
Data reported as normalized used a normalizing t_{ply} of 0.0056 in
Values shown in shaded boxes do not meet CMH17 Rev H requirements and are estimates only
These values may not be used for certification unless specifically allowed by the certifying agency

Test	Property	Layup:		Quasi Isotropic 25/50/25			"Soft" 10/80/10			"Hard" 50/40/10		
		Test Condition	Unit	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean	B-Basis	Modified CV B-basis	Mean
OHT (normalized)	Strength	CTA(−67˚F)	ksi	62.59	63.62	71.23	51.74	49.61	55.39	103.1	112.7	127.1
		RTA (75˚F)	ksi	70.37	67.14	74.75	47.47	44.56	50.35	114.2	120.8	135.1
		ETA2 (225˚F)	ksi	66.64	56.83	75.01						
		ETA3 (250˚F)	ksi	73.59	68.93	78.19						
		ETW1 (180˚F)	ksi	69.83	66.14	75.02	44.42	35.57	46.95	151.1	121.5	160.3
		ETW2 (225˚F)	ksi	73.23	69.30	78.62	41.21	39.69	45.03	138.2	NA	155.5
OHC (normalized)	Strength	CTA(−67˚F)	ksi	46.55	48.73	54.20						
		RTA (75˚F)	ksi	45.47	42.63	48.10	37.13	33.71	38.24	62.13	60.54	70.00
		ETA2 (225˚F)	ksi	38.32	31.17	41.14	28.39	23.02	30.38	56.00	47.27	62.39
		ETA3 (250˚F)	ksi	17.09	NA	38.67	26.64	21.77	28.73	44.43	43.56	57.49
		ETW1 (180˚F)	ksi	36.68	35.15	39.91	23.84	25.65	29.10	52.74	50.73	57.86
		ETW2 (225˚F)	ksi	32.34	30.75	34.88	22.45	20.83	23.63	36.70	42.72	49.55
		ETW3 (250˚F)	ksi	29.95	28.49	32.31	19.81	18.48	20.96	40.23	38.50	43.67
UNT (normalized)	Strength	CTA(−67˚F)	ksi	0.000	NA	111.6	85.95	80.78	89.59	226.2	218.6	244.2
	Modulus		Msi			8.450			5.485			13.08
	Strength	RTA (75˚F)	ksi	78.55	NA	135.0	80.74	75.38	84.19	224.7	217.1	242.7
	Modulus		Msi			8.384			5.118			13.21
	Strength	ETA2 (225˚F)	ksi	134.2	111.0	146.3						
	Modulus		Msi			8.216						
	Strength	ETA3 (250˚F)	ksi	147.2	116.6	153.6						
	Modulus		Msi			8.343						
	Strength	ETW1 (180˚F)	ksi	109.5	110.4	125.3	62.19	65.60	74.42	207.1	199.5	225.1
	Modulus		Msi			8.263			4.806			13.04
	Strength	ETW2 (225˚F)	ksi	120.1	113.7	129.0	50.68	58.36	66.20	209.3	201.8	227.4
	Modulus		Msi			8.185			4.538			13.18
UNC (normalized)	Strength	CTA(−67˚F)	ksi	95.95	90.93	110.5						
	Modulus		Msi			7.785						
	Strength	RTA (75˚F)	ksi	54.15	NA	87.63	62.31	58.19	66.01	113.7	NA	139.0
	Modulus		Msi			7.913			4.969			12.03
	Strength	ETA2 (225˚F)	ksi	42.06	42.06	62.48	41.43	38.58	50.91	76.43	74.48	98.30
	Modulus		Msi			7.702			4.746			12.24
	Strength	ETA3 (250˚F)	ksi	63.15	56.44	74.49	45.95	37.65	49.70	76.60	76.60	106.3
	Modulus		Msi			7.688			4.703			12.28
	Strength	ETW1 (180˚F)	ksi	56.66	56.55	67.02	45.13	43.61	49.98	79.13	79.13	99.99
	Modulus		Msi			7.296			4.496			11.36
	Strength	ETW2 (225˚F)	ksi	52.47	51.88	60.90	23.04	NA	41.05	35.95	NA	80.75
	Modulus		Msi	.		7.157			4.304			11.15
	Strength	ETW3 (250˚F)	ksi	46.49	45.41	52.64	21.70	NA	35.25	47.66	47.66	61.15
	Modulus		Msi			7.509			3.934			10.98
FHT (normalized)	Strength	CTA (−67˚F)	ksi	33.36	NA	84.16	59.62	56.74	63.27	113.3	109.1	123.1
		RTA (75˚F)	ksi	50.40	NA	85.23	52.31	49.43	55.96	115.0	110.8	124.9
		ETW1 (180˚F)	ksi	77.34	74.25	84.50	47.67	40.00	52.79	124.7	103.7	136.9
		ETW2 (225˚F)	ksi	80.19	78.09	89.65	45.25	43.15	48.95	123.6	119.1	135.1
FHC (normalized)	Strength	CTA (-67˚F)	ksi	58.08	67.41	74.31						
		RTA (70˚F)	ksi	51.87	49.09	56.00	48.07	45.89	52.06	67.98	67.84	80.39
		ETW1 (180˚F)	ksi	40.01	37.23	44.14	33.57	28.75	37.94	56.68	48.17	63.57
		ETW2 (250˚F)	ksi	35.13	34.37	39.25	27.06	26.34	30.43	45.72	44.70	51.86
SSB (normalized)	2% Offset Strength	CTA (-67˚F)	ksi	142.0	136.4	150.2						
		RTA (75˚F)	ksi	98.80	112.8	126.6	116.4	113.2	125.5	117.0	111.7	124.6
		ETW1 (180˚F)	ksi	112.3	108.8	122.5	103.2	100.0	112.3	102.6	97.29	110.2
		ETW2 (225˚F)	ksi	99.50	99.96	113.7	94.34	91.13	103.4	76.25	86.59	99.48
		ETW3 (250˚F)	ksi	98.41	95.39	109.2	83.45	80.24	92.53	71.09	73.62	86.52
	Ultimate Strength	CTA (-67˚F)	ksi	159.9	153.7	167.9						
		RTA (75˚F)	ksi	134.6	128.5	142.6	141.9	135.3	148.6	138.8	131.2	144.2
		ETW1 (180˚F)	ksi	118.6	112.5	126.6	101.0	111.0	124.4	117.0	109.4	122.4
		ETW2 (225˚F)	ksi	110.3	104.2	118.3	105.0	100.6	114.0	94.51	97.85	110.8
		ETW3 (250˚F)	ksi	106.8	100.7	114.8	94.69	92.90	106.3	71.40	87.55	100.5
CAI (normalized)	Strength	CTA(−67˚F)	ksi	44.47	42.99	56.74						
		RTA (75˚F)	ksi	35.45	41.74	48.40						
		ETA2 (225˚F)	ksi	35.18	30.41	40.13						
		ETA3 (250˚F)	ksi	28.65	27.52	36.33						
		ETW1 (180˚F)	ksi	35.01	34.12	39.83						
		ETW2 (225˚F)	ksi	26.70	30.61	35.31						

*Specimens might absorb moisture at ambient condition prior to testing which resulted in lower dry Tg, DMA testing took place weeks/months after panel fabrication. Based on Syensqo's batch release historical data, dry Tg is ~192°C (377°F) to 208°C (406°F

Table 3-4: Laminate Properties Summary Table

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

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

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

When a dataset fails the Anderson-Darling k-sample (ADK) test for batch-to-batch variation, an ANOVA analysis is required. In order for B-basis values to be computed using the ANOVA method, data from five batches are required. Since this qualification dataset has only three batches, the basis values computed using ANOVA are considered estimates only. However, the basis values resulting from the ANOVA method using only three batches may be overly conservative. The ADK test is performed again after a transformation of the data according to the assumptions of the modified CV method (see section 2.1.4 for details). If the dataset still passes the ADK test at this point, modified CV basis values are provided. If the dataset does not pass the ADK test after the transformation, estimates may be computed using the modified CV method per the guidelines of CMH-17-1H section 8.4.4.

4.1 Longitudinal Tension (LT)

The LT data is normalized, so both normalized and as-measured results are provided. Testing was done in five environmental conditions: CTA, RTA, ETA3, ETW1 and ETW2.

For normalized strength non-modified CV, conditions CTA and RTA failed the ADK test, so ANOVA method was used. Since there are less than 5 batches, the results are estimates rather than basis values. Conditions ETA3, ETW1, ETW2 passed ADK and normality test, so normal method was used for these. For modified CV, conditions RTA failed ADK test and ETW1 failed normality test, so basis values are Not Available (NA) while conditions CTA, ETA3, ETW2 passed ADK test and normality test, so normal method was used for these.

For as-measured strength non-modified CV, conditions CTA and RTA failed the ADK test, so ANOVA method was used. Since there are less than 5 batches, the results are estimates rather than basis values. Conditions ETA3, ETW1, ETW2 passed ADK and normality test, so normal method was used for these. For modified CV, condition ETW1 failed normality test, so basis values are Not Available (NA) while condition ETW2 passed ADK test and normality test, so normal method was used for this. Conditions CTA and RTA passed pooling tests, so pooling method was used.

One statistical outlier was detected. The lowest value for ETW2 condition and batch F is a low condition outlier for Strength normalized. The outlier was retained for the computations.

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

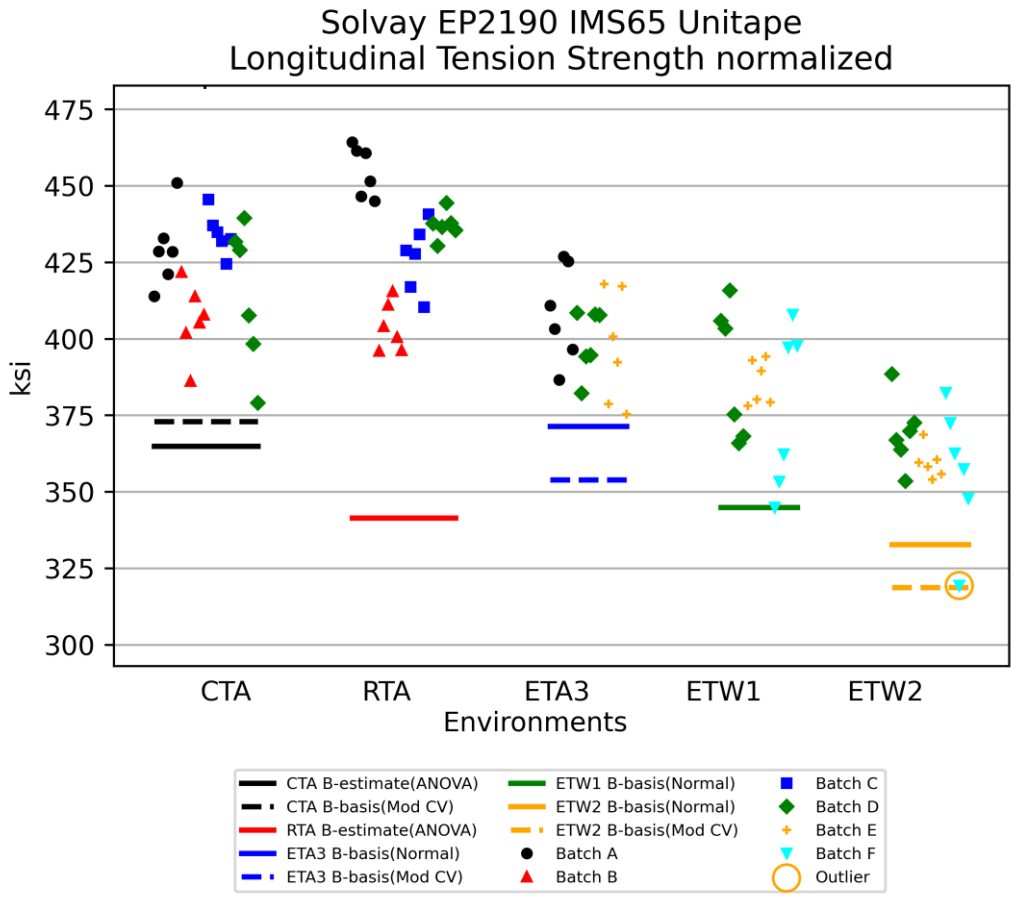

Figure 4-1 Batch plot for LT normalized strength

Longitudinal Tension Basis Values and Statistics					
	Strength normalized [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	421.0	430.6	401.5	384.0	361.9
Stdev	18.10	20.39	15.25	19.83	14.77
CV%	4.300	4.736	3.798	5.164	4.083
Mod CV%	6.150	6.368	6.000	6.582	6.041
Min	379.1	395.9	375.4	344.9	319.3
Max	450.9	464.2	426.9	415.8	388.4
No. Batches	4	4	3	3	3
No. Spec.	24	24	18	18	18
Basis Values and Estimates					
B-Basis			371.4	344.8	332.7
B-Estimate	364.9	341.5			
A-Estimate	325.6	279.7	350.0	317.1	312.0
Method	ANOVA	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates					
B-Basis	373.0	NA	353.9	NA	318.7
A-Estimate	338.6		320.3		288.2
Method	Normal		Normal		Normal

Table 4-1 Statistics and Basis values for LT Strength normalized

Longitudinal Tension Basis Values and Statistics					
	Strength as-measured [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	406.7	415.8	388.3	380.9	355.7
Stdev	21.52	17.63	13.76	23.38	13.18
CV	5.293	4.239	3.545	6.139	3.706
Mod CV	6.646	6.120	6.000	7.069	6.000
Min	366.5	381.5	364.8	343.4	321.5
Max	437.7	438.2	406.1	421.1	381.6
No. Batches	4	4	3	3	3
No. Spec.	24	24	18	18	18
Basis Values and Estimates					
B-Basis			361.1	334.7	329.6
B-Estimate	332.1	338.7			
A-Estimate	280.2	285.3	341.8	302.0	311.2
Method	ANOVA	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates					
B-Basis	361.1	370.3	342.3	NA	313.5
A-Estimate	329.5	338.7	309.7		283.7
Method	Pooled	Pooled	Normal		Normal

Table 4-2 Statistics and Basis values for LT Strength as-measured

Longitudinal Tension Statistics					
	Modulus normalized [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	22.68	22.81	23.04	22.67	22.74
Stdev	0.3453	0.2925	0.4070	0.4163	0.4620
CV	1.523	1.282	1.767	1.837	2.032
Min	21.84	21.98	22.45	21.94	21.62
Max	23.36	23.25	23.81	23.23	23.60
No. Batches	4	4	3	3	3
No. Spec.	24	24	18	18	18

Table 4-3 Statistics from LT Modulus normalized

Longitudinal Tension Statistics					
	Modulus as-measured [Msi]				
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	21.90	22.04	22.28	22.47	22.35
Stdev	0.4831	0.3233	0.4734	0.3810	0.5586
CV	2.206	1.467	2.124	1.695	2.499
Min	21.26	21.18	21.37	21.52	21.05
Max	22.83	22.65	23.22	23.02	23.19
No. Batches	4	4	3	3	3
No. Spec.	24	24	18	18	18

Table 4-4 Statistics from LT Modulus as-measured

4.2 Transverse Tension (TT)

The TT data is not normalized. Testing was done in five environmental conditions: CTA, RTA, ETA3, ETW1 and ETW2.

For non-modified CV, conditions CTA, ETA3 and ETW1 failed ADK test, so ANOVA method was used for these. Since they have less that 5 batches ANOVA method produces estimates values rather than basis values. Conditions RTA and ETW2 passed ADK test and normality test, so normal method was used for these. For modified CV, the results for the statistical test were the same, so conditions CTA, ETA3 and ETW1 have No Available (NA) basis values.

There were three statistical outliers. The lowest value in batch A of the RTA condition was an outlier for the RTA condition, but not for the batch. The lowest value in batch E of the ETA3 condition was an outlier for batch, but not for the ETW3 condition. The highest value in batch D of the CTA condition was an outlier for batch. The outliers were retained for this analysis.

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

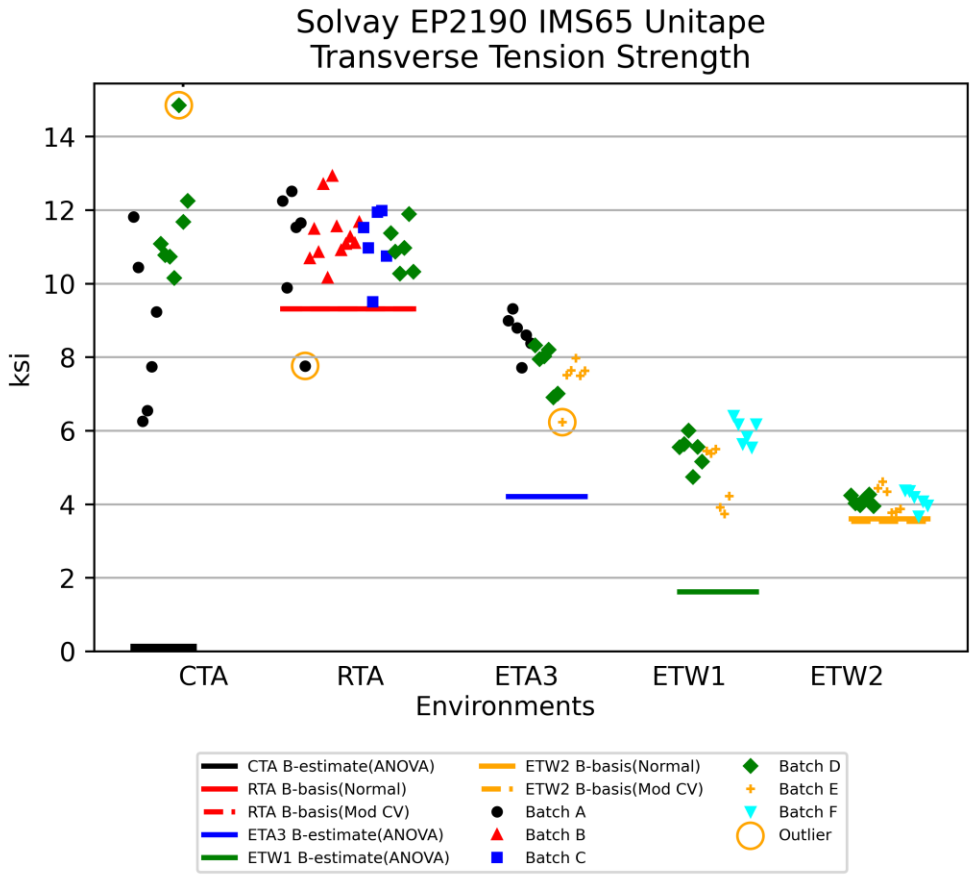

Figure 4-2 Batch Plot for TT as-measured strength

Transverse Tension Basis Values and Statistics					
	Strength as-measured [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	10.27	11.14	7.926	5.368	4.113
Stdev	2.377	1.026	0.7703	0.7616	0.2580
CV	23.14	9.209	9.720	14.19	6.272
Mod CV	23.14	9.209	9.720	14.19	7.136
Min	6.260	7.760	6.230	3.730	3.670
Max	14.85	12.92	9.320	6.410	4.610
No. Batches	2	4	3	3	3
No. Spec.	13	30	18	18	18
Basis Values and Estimates					
B-Basis		9.320			3.604
B-Estimate	0.000		4.207	1.618	
A-Estimate	0.000	8.000	1.556	0.000	3.243
Method	ANOVA	Normal	ANOVA	ANOVA	Normal
Modified CV Basis Values and Estimates					
B-Basis	NA	9.320	NA	NA	3.534
A-Estimate		8.000			3.124
Method		Normal			Normal

Table 4-5 Statistics and Basis Values for TT Strength Data

Transverse Tension Basis Values and Statistics					
	Modulus [Msi]				
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	1.413	1.255	1.078	1.114	0.8621
Stdev	0.03564	0.02918	0.05746	0.02873	0.04734
CV	2.522	2.325	5.332	2.579	5.491
Min	1.350	1.197	1.020	1.052	0.7940
Max	1.481	1.298	1.172	1.171	0.9560
No. Batches	2	4	3	3	3
No. Spec.	13	30	18	18	18

Table 4-6 Statistics from TT Modulus Data

4.3 Longitudinal Compression (LC)

The LC data is normalized, so both normalized and as-measured results are provided. Testing was done in seven environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, ETW2, and ETW3.

For normalized non-modified CV dataset, conditions CTA and ETA3 failed ADK test, so ANOVA method was used. Since they have less than 5 batches the results are estimates rather than basis values. Conditions RTA, ETA2 and ETW3 passed ADK test and normality test, so normal method was used. Conditions ETW1 failed normality test but passed Weibull test, so Weibull method was used for this. Condition ETW2 failed all distribution tests, so Non-parametric method was used for this. For modified CV, conditions CTA and ETA3 failed ADK test, so there are No Available (NA) results for these, while the rest passed normality test, so normal method was used for these.

For as-measured the results for the statistical test were exactly the same as for normalized dataset.

There were four statistical outliers. For strength as measured, the lowest value in batch F of the ETW1 dataset was an outlier for batch F, and for the condition. For strength as measured, the highest value in batch A of the RTA dataset was an outlier for batch A, but not for the condition. For strength normalized, the lowest value in batch F of the ETW1 dataset was an outlier for batch F, and for the condition. For strength normalized, the highest value in batch A of the RTA dataset was an outlier for batch A, but not for the condition. All outliers were retained for this analysis.

Statistics, basis values, and estimates are given for LC strength data in Table 4-7 and Table 4-8 and for the LC modulus data in
Table 4-9 and Table 4-10. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-3.

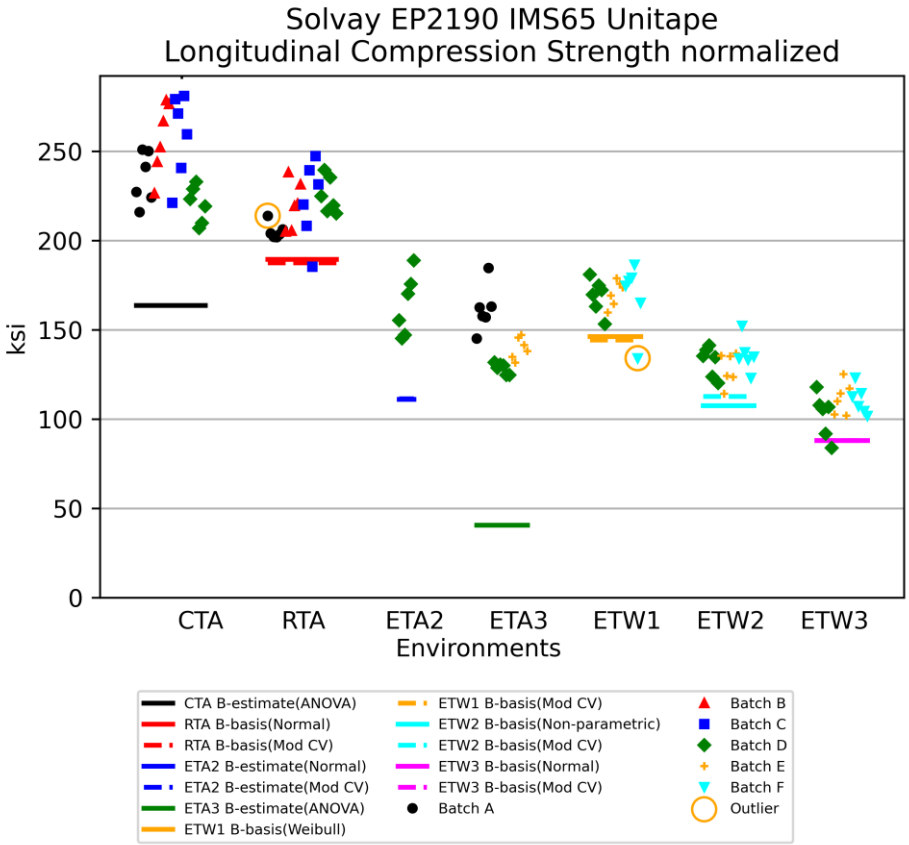

Figure 4-3 Batch plot for LC normalized strength

Longitudinal Compression Basis Values and Statistics							
	Strength normalized [ksi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	242.8	218.1	163.7	143.3	169.6	132.1	108.3
Stdev	23.50	15.43	17.35	16.28	12.08	9.017	10.25
CV	9.678	7.074	10.60	11.36	7.123	6.826	9.461
Mod CV	9.678	7.537	10.60	11.36	7.562	7.413	9.461
Min	206.9	185.2	145.2	124.7	134.1	114.1	83.9
Max	281.0	247.2	188.8	184.6	186.4	152.2	125.2
No. Batches	4	4	1	3	3	3	3
No. Spec.	24	24	6	18	18	18	18
Basis Values and Estimates							
B-Basis		189.5			146.2	107.6	88.06
B-Estimate	163.7		111.2	40.57			
A-Estimate	108.5	169.0	73.80	0.000	123.4	74.22	73.73
Method	ANOVA	Normal	Normal	ANOVA	Weibull	Non-parametric	Normal
Modified CV Basis Values and Estimates							
B-Basis	NA	187.6		NA	144.3	112.8	88.06
B-Estimate			111.2				
A-Estimate		165.8	73.80		126.4	99.10	73.73
Method		Normal	Normal		Normal	Normal	Normal

Table 4-7 Statistics and Basis Values for LC Strength Data normalized

Longitudinal Compression Basis Values and Statistics							
	Strength as-measured [ksi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	231.7	207.7	159.1	138.1	166.2	130.1	106.0
Stdev	22.30	15.43	17.80	14.39	12.55	8.531	10.33
CV	9.626	7.428	11.18	10.42	7.547	6.555	9.745
Mod CV	9.626	7.714	11.18	10.42	7.774	7.277	9.745
Min	201.6	175.1	139.6	122.7	128.9	112.1	82.09
Max	270.2	233.2	183.9	175.2	180.8	149.5	123.8
No. Batches	4	4	1	3	3	3	3
No. Spec.	24	24	6	18	18	18	18
Basis Values and Estimates							
B-Basis					142.9	105.6	85.58
B-Estimate	157.9	165.8	105.2	50.51			
A-Estimate	106.5	136.4	66.89	0.000	120.1	72.92	71.13
Method	ANOVA	ANOVA	Normal	ANOVA	Weibull	Non-parametric	Normal
Modified CV Basis Values and Estimates							
B-Basis	NA	178.0		NA	NA	NA	85.58
B-Estimate			105.5				
A-Estimate		156.7	66.89				71.13
Method		Normal	Normal				Normal

Table 4-8 Statistics and Basis Values for LC Strength Data as-measured

Longitudinal Compression Basis Values and Statistics							
	Modulus normalized [Msi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	20.16	20.56	20.12	20.68	21.15	20.86	21.06
Stdev	0.4880	0.4192	0.2530	0.4998	0.6339	0.4608	0.2264
CV	2.421	2.039	1.257	2.416	2.997	2.209	1.075
Min	19.13	19.63	19.78	19.77	20.38	19.33	20.59
Max	21.03	21.59	20.39	21.69	23.08	21.46	21.48
No. Batches	4	4	1	3	3	3	3
No. Spec.	26	24	6	20	18	18	18

Table 4-9 Statistics from LC Modulus Data normalized

Longitudinal Compression Basis Values and Statistics							
	Modulus as-measured [Msi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	19.42	19.72	19.62	20.33	20.73	20.74	20.87
Stdev	0.5065	0.3567	0.2595	0.5676	0.7188	0.4605	0.5051
CV	2.608	1.809	1.322	2.792	3.467	2.220	2.420
Min	18.28	19.04	19.30	19.22	19.60	19.86	20.14
Max	20.27	20.50	19.95	21.41	22.57	21.52	22.02
No. Batches	4	4	1	3	3	3	3
No. Spec.	26	24	6	20	18	18	18

Table 4-10 Statistics from LC Modulus Data as-measured

4.4 Transverse Compression (TC)

The TC data is not normalized. Testing was done in six environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, and ETW2.

For as-measured non-modified CV dataset, the RTA and ETA3 conditions failed the ADK test for batch to batch variability, which means that ANOVA was required. With fewer than 5 batches, ANOVA results are considered an estimate rather than basis values. The rest of conditions passed ADK test and normality test, so normal method was used for these. For the modified CV dataset, the results of the tests are the same, so RTA and ETA3 have Not Available (NA) results and the rest of conditions use normal method.

One statistical outlier was detected, the highest value for condition ETA2 batch D. The outlier was retained for calculations.

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

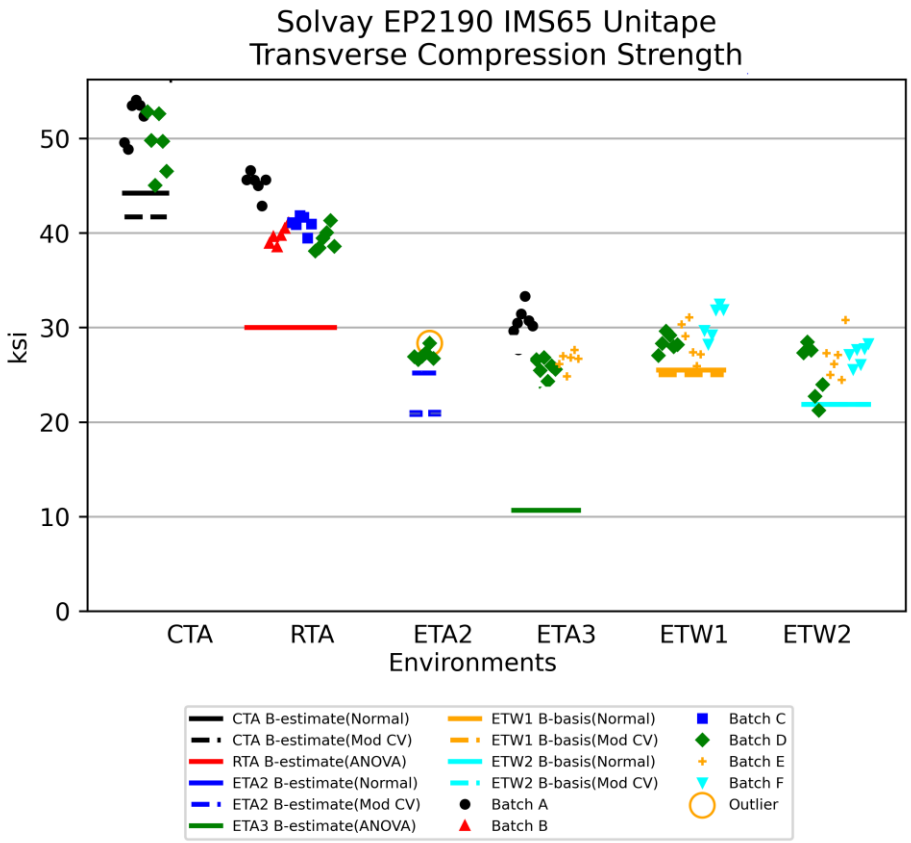

Figure 4-4 Batch Plot for TC as-measured strength

Transverse Compression Basis Values and Statistics						
	Strength [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(250°F)
Mean	50.70	41.31	27.14	27.75	29.15	26.37
Stdev	2.924	2.597	0.6347	2.556	1.844	2.270
CV	5.767	6.287	2.339	9.208	6.326	8.610
Mod CV	8.000	7.143	8.000	9.208	7.163	8.610
Min	45.03	38.09	26.60	24.29	25.91	21.23
Max	54.08	46.61	28.34	33.29	32.49	30.78
No. Batches	2	4	1	3	3	3
No. Spec.	12	24	6	18	18	18
Basis Values and Estimates						
B-Basis					25.51	21.89
B-Estimate	44.22	30.00	25.21	10.67		
A-Estimate	39.68	22.18	23.85	0.000	22.93	18.71
Method	Normal	ANOVA	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis		NA		NA	25.03	21.89
B-Estimate	41.71		20.56			
A-Estimate	35.42		15.89		22.11	18.71
Method	Normal		Normal		Normal	Normal

Table 4-11 Statistics and Basis Values for TC Strength Data

Transverse Compression Basis Values and Statistics						
	Modulus [Msi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	1.677	1.503	1.199	1.185	1.364	1.194
Stdev	0.1229	0.1235	0.03999	0.04225	0.08723	0.05734
CV	7.330	8.216	3.335	3.566	6.396	4.801
Min	1.455	1.292	1.157	1.080	1.209	1.125
Max	1.883	1.811	1.252	1.272	1.514	1.308
No. Batches	2	4	1	3	3	3
No. Spec.	12	24	6	18	18	18

Table 4-12 Statistics from TC Modulus Data

4.5 In-Plane Shear (IPS)

In Plane Shear data is not normalized. Testing was done in six environmental conditions: CTA, RTA, ETA3, ETW1, ETW2, and ETW3 and for two properties 0.2% Offset strength and Strength 5% strain. Condition ETA3 has only 1 batch and 6 specimens, so only estimates were computed for this.

For 0.2% Offset strength as-measured non-modified CV dataset, condition RTA failed the ADK test for batch to batch variability, which means ANOVA analysis was required. With fewer than 5 batches, this ANOVA results are considered an estimate. Condition ETW1 passed ADK, failed normality and other distributions tests, so Non-parametric method was used. The rest of conditions passed ADK and normality test, so normal method was used. For modified CV dataset, ETW1 and ETW2 failed normality test, so there are no results (NA) available for these. The rest of conditions passed ADK and normality test, so normal method was used for them.

For 5% Strain strength as-measured non-modified CV dataset, conditions CTA, RTA and ETW2 failed the ADK test for batch to batch variability, which means ANOVA analysis was required. With fewer than 5 batches, these ANOVA results are considered an estimate. Conditions ETA3 and ETW1 passed ADK and normality test so normality method was used. Condition ETW3 failed ADK test and distributions tests, so Non-parametric method was used. For modified CV dataset, CTA and RTA passed pooling tests, so pooling method was used for these. Conditions ETA3, ETW1, ETW2 and ETW3 passed ADK and normality test, so Normal method was used for these.

There were three outliers. For the 0.2% Offset strength property, the lowest value in batch A of the CTA condition is a batch outlier. For the 0.2% Offset strength property, the lowest value in batch B of the RTA condition is a batch outlier. For the 5% Strain property, the highest value in batch F of the ETW3 condition is a condition outlier. Outliers were retained for this analysis.

Statistics, basis values, and estimates are given for the IPS strength data in Table 4-13 and for the modulus data in Table 4-15. The data, B-basis values, and B-estimates are shown graphically for the 0.2% offset strength in Figure 4-5 and the strength at 5% strain in Figure 4-6.

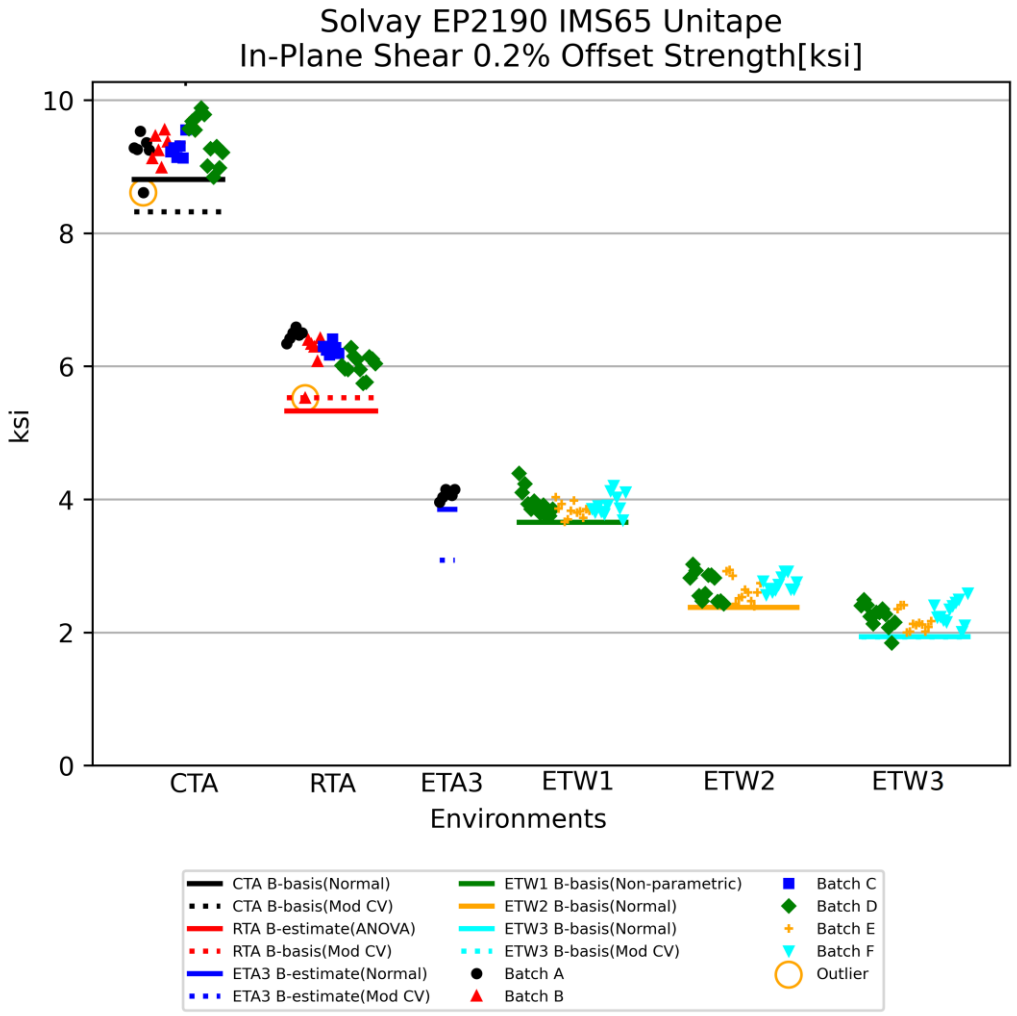

Figure 4-5 Batch plot for IPS 0.2% Offset Strength as-measured

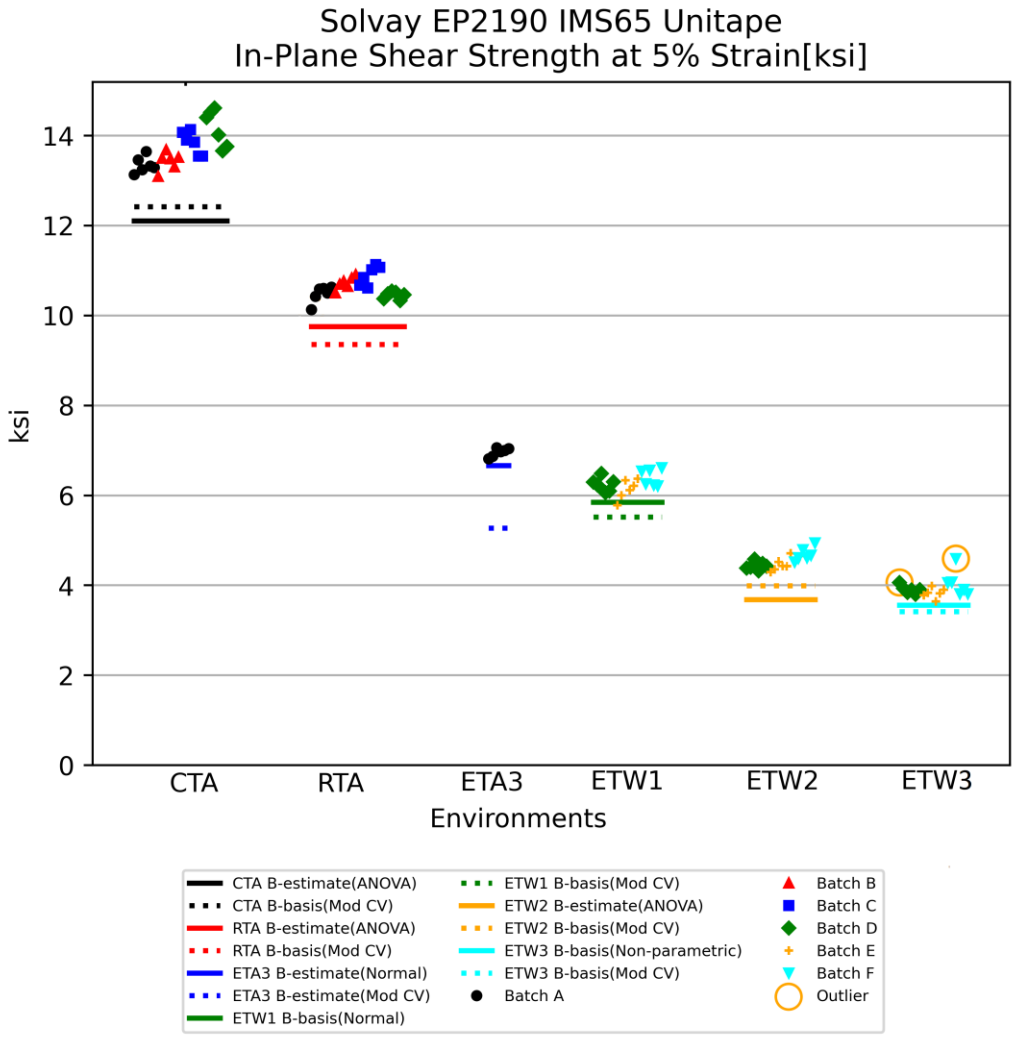

Figure 4-6 Batch plot for IPS Strength at 5% Strain as-measured

In-Plane Shear Basis Values and Statistics						
	0.2% Offset Strength [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	9.316	6.187	4.072	3.904	2.683	2.237
Stdev	0.2852	0.2491	0.07305	0.1627	0.1770	0.1726
CV%	3.062	4.027	1.794	4.167	6.597	7.716
Mod CV%	6.000	6.013	8.000	6.084	7.299	7.858
Min	8.610	5.520	3.960	3.660	2.390	1.840
Max	9.880	6.590	4.150	4.390	3.020	2.590
No. Batches	4	4	1	3	3	3
No. Spec.	30	30	6	36	36	36
Basis Values and Estimates						
B-Basis	8.809			3.660	2.378	1.939
B-Estimate		5.328	3.850			
A-Estimate	8.443	4.728	3.693	3.147	2.155	1.722
Method	Normal	ANOVA	Normal	Non-parametric	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	8.323	5.526		NA	NA	1.934
B-Estimate			3.085			
A-Estimate	7.604	5.048	2.383			1.713
Method	Normal	Normal	Normal			Normal

Table 4-13 Statistics and Basis Values for IPS 0.2% Offset Strength Data

In-Plane Shear Basis Values and Statistics						
	Strength at 5% Strain [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	13.69	10.63	6.958	6.259	4.524	3.923
Stdev	0.4212	0.2404	0.09867	0.2107	0.1737	0.1996
CV%	3.076	2.261	1.418	3.367	3.839	5.086
Mod CV%	6.000	6.000	8.000	6.000	6.000	6.543
Min	13.09	10.13	6.810	5.780	4.290	3.640
Max	14.61	11.13	7.060	6.610	4.940	4.590
No. Batches	4	4	1	3	3	3
No. Spec.	24	24	6	18	18	18
Basis Values and Estimates						
B-Basis				5.843		3.555
B-Estimate	12.10	9.752	6.659		3.679	
A-Estimate	10.99	9.138	6.447	5.548	3.076	2.573
Method	ANOVA	ANOVA	Normal	Normal	ANOVA	Non-parametric
Modified CV Basis Values and Estimates						
B-Basis	12.41	9.357		5.517	3.988	3.417
B-Estimate			5.272			
A-Estimate	11.53	8.471	4.073	4.992	3.609	3.057
Method	Pooled	Pooled	Normal	Normal	Normal	Normal

Table 4-14 Statistics and Basis Values for IPS 5% Strain Data

In-Plane Shear Statistics						
	Modulus [Msi]					
Env	CTA(-67°F)	RTA(75°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	0.8078	0.6053	0.4303	0.4169	0.2782	0.2226
Stdev	0.02754	0.02534	0.007659	0.02302	0.01757	0.01994
CV%	3.409	4.186	1.780	5.520	6.316	8.961
Min	0.7360	0.5150	0.4180	0.3560	0.2300	0.1730
Max	0.8690	0.6400	0.4370	0.4600	0.3070	0.2730
No. Batches	4	4	1	3	3	3
No. Spec.	30	30	6	36	36	36

Table 4-15 Statistics and Basis Values for IPS Modulus Data

4.6 0° Flexural (0FLEX)

The 0FLEX data is normalized, so four properties are provided, strength normalized, strength as-measured, modulus normalized and modulus as-measured. Testing was done in four environmental conditions: RTA, ETA2, ETA3, and ETW2.

For normalized dataset, non-modified CV, conditions RTA and ETA3 fail ADK test, so ANOVA method was used. Since there are less than 5 batches, ANOVA method produces estimates rather than basis values. Condition ETW2 passed ADK test, failed normality test and pass Lognormal test, so Lognormal method was used. For modified CV, condition RTA failed ADK test, so ANOVA method was used for this one. The rest of conditions pass ADK and normality test, so normal method was used.

For as-measured dataset, non-modified CV, conditions RTA fails ADK test, so ANOVA method was used. Since there are less than 5 batches, ANOVA method produces estimates rather than basis values. Condition ETW2 passed ADK test, failed normality test and pass Lognormal test, so Lognormal method was used. For modified CV, conditions RTA failed ADK test, so ANOVA method was used. Condition ETW2 failed normality test so results are not available (NA). The rest of conditions pass ADK and normality test, so normal method was used.

There were two outliers in the ETW2 dataset. The largest value in batch D was a batch and condition outlier for normalized and a batch outlier but not condition outlier for as-measured strength. The largest value in batch E was a condition outlier for the as-measured strength. Both outliers were retained for this analysis.

Statistics, basis values, and estimates for strength data are shown in Table 4-16 and for modulus data in Table 4-16. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-7.

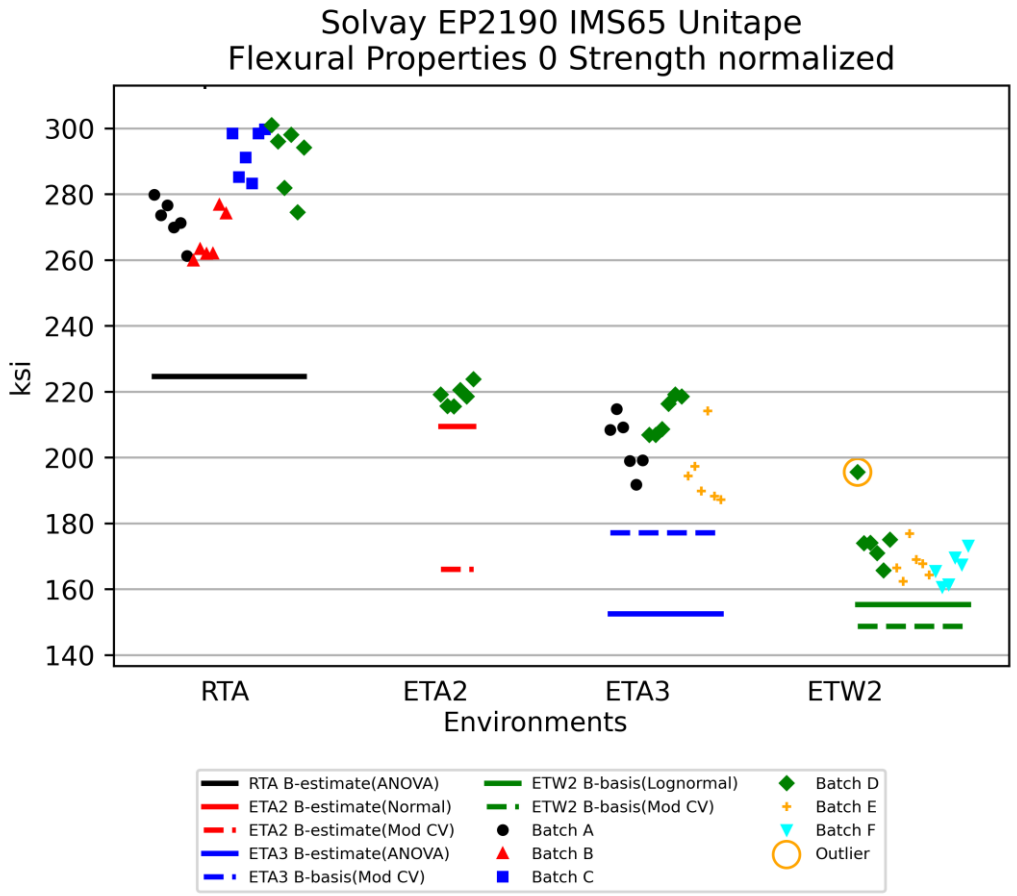

Figure 4-7 Batch Plot for 0FLEX normalized strength

Flexural Properties 0 Basis Values and Statistics								
	Strength normalized [ksi]				Strength as-measured [ksi]			
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW2(225°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW2(225°F)
Mean	280.5	218.9	203.9	170.0	258.0	209.1	191.8	165.6
Stdev	13.91	3.107	10.73	7.973	15.42	4.174	9.069	9.506
CV	4.959	1.419	5.265	4.690	5.976	1.996	4.728	5.739
Mod CV	6.479	8.000	6.632	6.345	6.988	8.000	6.364	6.870
Min	259.8	215.5	187.2	160.7	232.7	203.4	176.7	154.1
Max	301.0	223.8	219.1	195.6	286.3	214.1	204.9	188.2
No. Batches	4	1	3	3	4	1	3	3
No. Spec.	24	6	18	18	24	6	18	18
Basis Values and Estimates								
B-Basis				155.3			173.9	148.1
B-Estimate	224.7	209.4	152.6		193.6	196.5		
A-Estimate	185.9	202.7	116.0	145.8	148.9	187.5	161.2	136.9
Method	ANOVA	Normal	ANOVA	Lognormal	ANOVA	Normal	Normal	Lognormal
Modified CV Basis Values and Estimates								
B-Basis	NA		177.2	148.7	NA		167.7	NA
B-Estimate		165.8				158.4		
A-Estimate		128.1	158.3	133.6		122.4	150.6	
Method		Normal	Normal	Normal		Normal	Normal	

Table 4-16 Statistics and Basis Values for 0FLEX Strength Data

Flexural Properties 0 Statistics								
	Modulus normalized [Msi]				Modulus as-measured [Msi]			
Env	RTA(70°F)	ETA2(225°F)	ETA3(250°F)	ETW2(225°F)	RTA(70°F)	ETA2(225°F)	ETA3(250°F)	ETW2(225°F)
Mean	22.83	20.45	20.12	19.75	21.53	19.54	19.13	19.24
Stdev	0.8736	0.3405	0.8494	0.4621	1.154	0.3219	0.6164	0.8482
CV	3.827	1.664	4.222	2.340	5.361	1.647	3.222	4.408
Min	21.54	19.94	18.84	18.77	19.91	19.08	17.87	18.19
Max	23.74	20.89	21.41	20.42	22.68	19.91	19.84	21.63
No. Batches	1	1	2	3	1	1	2	3
No. Spec.	6	6	12	18	6	6	12	18

Table 4-17 Statistics and Basis Values for 0FLEX Modulus

4.7 Lamina Short-Beam Strength (SBS)

The Short Beam Strength data is not normalized. Testing was done in seven environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, ETW2 and ETW3. The CTA and ETA2 conditions tested specimens from less than three batches of material, so only estimates of basis values can be provided for these conditions.

For non-modified CV Strength property, conditions CTA, ETA2 and ETW1 pass ADK test and normality test, so normal method was used for computing allowables, while the rest of conditions fail ADK test, so ANOVA method was used. For modified CV, all conditions but ETW3 passed ADK test and normality test, so normal method was used and for ETW3 there are not available values (NA).

There was one outlier, the largest value in batch F of the ETW3 dataset was an outlier for batch but not for the condition. It was retained for this analysis.

Statistics, basis values, and estimates are given for SBS data in Table 4-187. The as-measured data, B-estimates, and B-basis values are shown graphically in Figure 4-8.

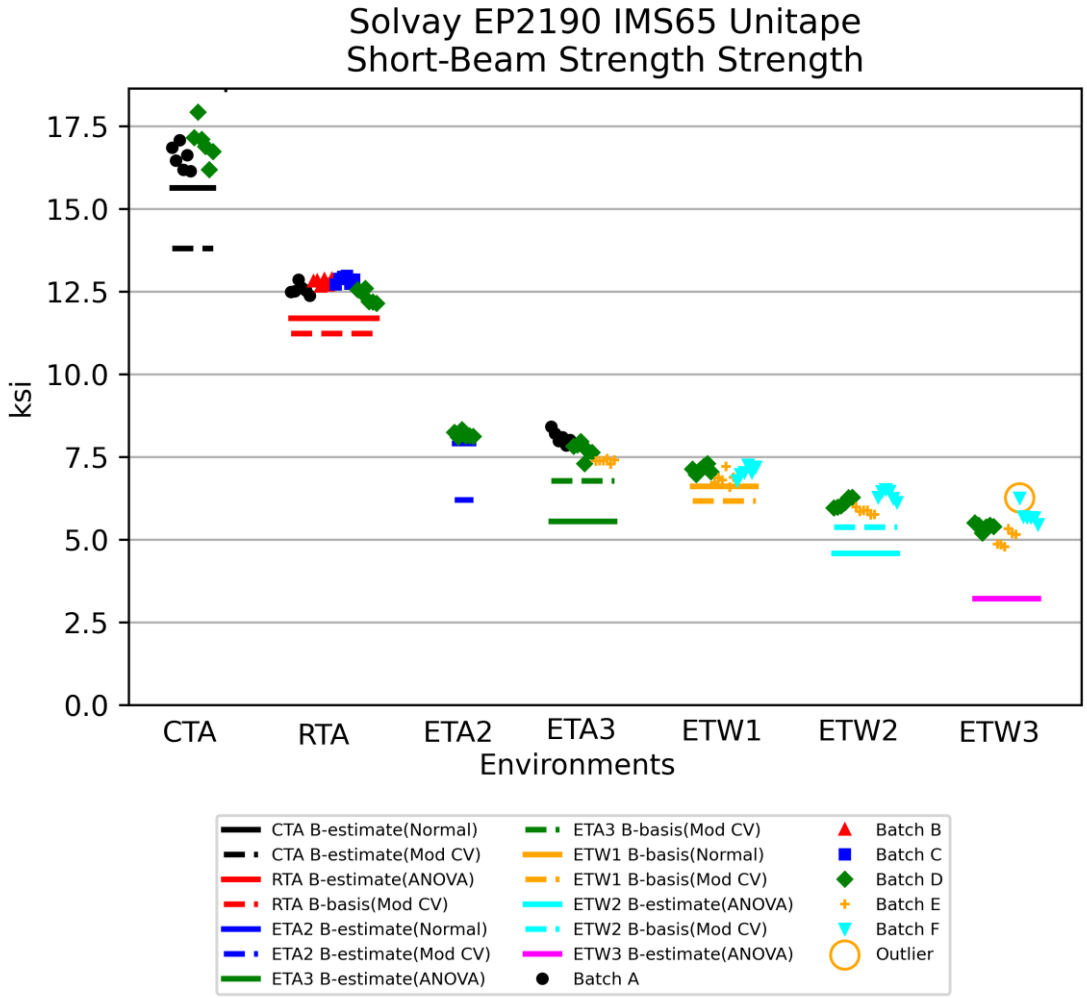

Figure 4-8 Batch plot for SBS as-measured

Short-Beam Strength Basis Values and Statistics							
	Strength [ksi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	16.77	12.64	8.173	7.724	7.006	6.101	5.384
Stdev	0.5127	0.2437	0.08802	0.3448	0.2001	0.2433	0.3605
CV	3.057	1.929	1.077	4.464	2.856	3.988	6.696
Mod CV	8.000	6.000	8.000	6.232	6.000	6.000	7.348
Min	16.14	12.14	8.090	7.280	6.580	5.750	4.780
Max	17.92	12.97	8.320	8.410	7.290	6.520	6.260
No. Batches	2	4	1	3	3	3	3
No. Spec.	12	24	6	18	18	18	18
Basis Values and Estimates							
B-Basis					6.611		
B-Estimate	15.64	11.69	7.907	5.559		4.586	3.222
A-Estimate	14.84	11.03	7.717	4.013	6.331	3.505	1.680
Method	Normal	ANOVA	Normal	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates							
B-Basis		11.23		6.774	6.176	5.378	NA
B-Estimate	13.80		6.193				
A-Estimate	11.72	10.23	4.784	6.101	5.588	4.866	
Method	Normal	Normal	Normal	Normal	Normal	Normal	

Table 4-18 Statistics and Basis Values for SBS Data

4.8 “25/50/25” Unnotched Tension 1 (UNT1)

The UNT1 data is normalized, so both normalized and as-measured results are provided. Testing was done in six environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, and ETW2. The ETA2 and ETA3 conditions tested specimens from only one batch of material, so only estimates of basis values can be provided for those conditions.

For normalized strength, non-modified CV dataset, the CTA, RTA and ETW1 failed the ADK test for batch to batch variability, so ANOVA method was used. With fewer than 5 batches per condition, this is considered an estimate. All the other conditions passed normality test, so normal method was used. For modified CV dataset, CTA and RTA did not pass the ADK test, so no basis values are available (NA) for those, while the rest passed normality test, so normal method was used.

For as-measured strength, non-modified CV dataset, the CTA, RTA failed the ADK test for batch to batch variability, so ANOVA method was used. With fewer than 5 batches per condition, this is considered an estimate. All the other conditions passed ADK test and normality test, except ETW1 that passed ADK test but not normality test, so Weibull method was used for ETW1 and normality method was used for the rest. For modified CV dataset, CTA and RTA did not pass the ADK test, so no basis values are available (NA) for those, while the rest passed normality test, so normal method was used.

There were no statistical outliers.

Statistics, basis values, and estimates are given for UNT1 strength data in Table 4-19 and Table 4-20 and for the modulus data in Table 4-21 and Table 4-22. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-9.

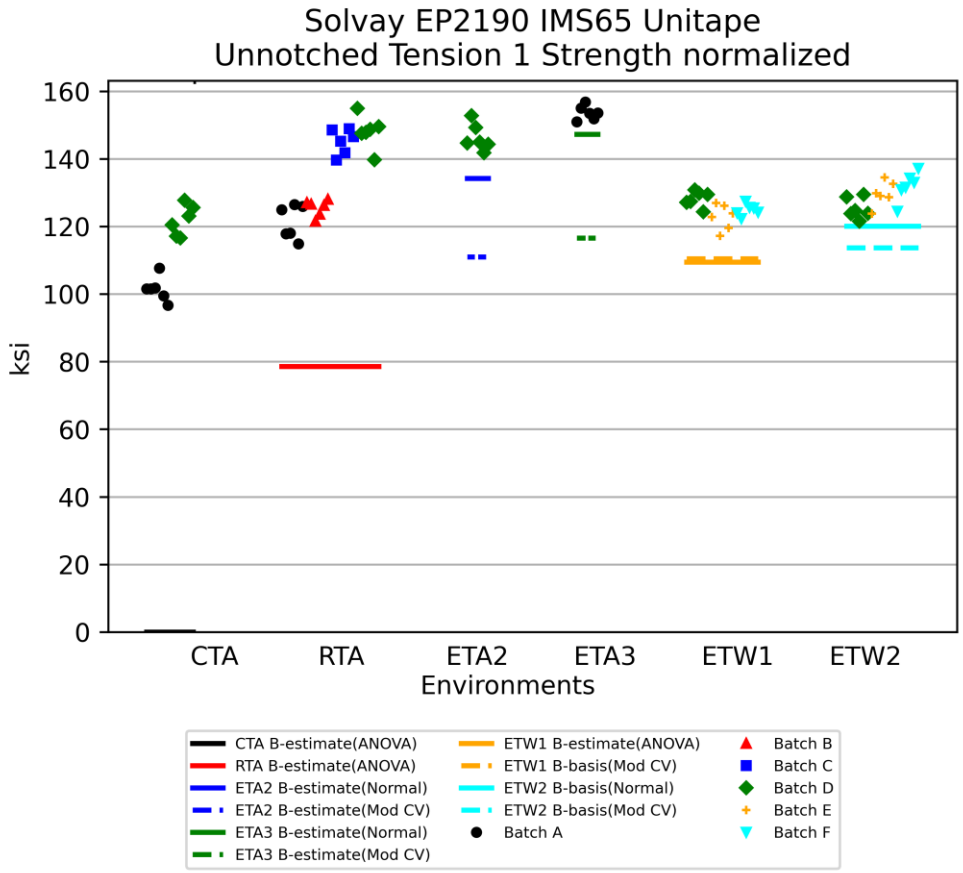

Figure 4-9 Batch Plot for UNT1 normalized strength

Unnotched Tension 1 Basis Values and Statistics						
	Strength normalized [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	111.6	135.0	146.3	153.6	125.3	129.0
Stdev	11.30	12.57	3.988	2.112	3.445	4.489
CV	10.13	9.315	2.726	1.375	2.750	3.480
Mod CV	10.13	9.315	8.000	8.000	6.000	6.000
Min	96.67	114.9	141.8	151.0	117.2	121.5
Max	127.7	154.9	152.8	156.8	130.8	137.2
No. Batches	2	4	1	1	3	3
No. Spec.	12	24	6	6	18	18
Basis Values and Estimates						
B-Basis						120.1
B-Estimate	0.000	78.55	134.2	147.2	109.5	
A-Estimate	0.000	39.47	125.6	142.7	98.23	113.9
Method	ANOVA	ANOVA	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates						
B-Basis	NA	NA			110.4	113.7
B-Estimate			111.0	116.6		
A-Estimate			86.91	91.28	99.93	102.9
Method			Normal	Normal	Normal	Normal

Table 4-19 Statistics and Basis Values for UNT1 Strength Data normalized

Unnotched Tension 1 Basis Values and Statistics						
	Strength as-measured [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	107.3	128.8	142.7	146.2	121.9	126.1
Stdev	12.77	12.73	3.389	1.783	4.704	7.068
CV%	11.89	9.884	2.374	1.219	3.858	5.605
Mod CV%	11.89	9.884	6.000	6.000	6.000	6.802
Min	91.75	111.2	139.9	143.6	112.1	114.5
Max	126.3	150.9	148.5	148.9	127.3	140.6
No. Batches	2	4	1	1	3	3
No. Spec.	12	24	6	6	18	18
Basis Values and Estimates						
B-Basis					112.4	112.2
B-Estimate	0.000	71.69	132.5	140.8		
A-Estimate	0.000	32.12	125.2	137.0	102.3	102.3
Method	ANOVA	ANOVA	Normal	Normal	Weibull	Normal
Modified CV Basis Values and Estimates						
B-Basis	NA	NA			107.5	109.2
B-Estimate			116.8	119.7		
A-Estimate			98.34	100.8	97.25	97.17
Method			Normal	Normal	Normal	Normal

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

Unnotched Tension 1 Statistics						
	Modulus normalized [Msi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	8.450	8.384	8.216	8.343	8.263	8.185
Stdev	0.1412	0.1308	0.1229	0.1057	0.1219	0.1914
CV	1.671	1.561	1.496	1.267	1.475	2.338
Min	8.179	8.163	8.098	8.222	8.070	7.958
Max	8.773	8.591	8.408	8.467	8.433	8.650
No. Batches	2	4	1	1	3	3
No. Spec.	12	24	6	6	18	18

Table 4-21 Statistics from UNT1 Modulus Data normalized

Unnotched Tension 1 Statistics						
	Modulus as-measured					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	8.115	7.999	8.017	7.941	8.042	7.996
Stdev	0.1923	0.1523	0.1174	0.09321	0.2035	0.2217
CV	2.370	1.904	1.464	1.174	2.530	2.773
Min	7.666	7.431	7.853	7.804	7.568	7.524
Max	8.327	8.180	8.171	8.054	8.285	8.415
No. Batches	2	4	1	1	3	3
No. Spec.	12	24	6	6	18	18

Table 4-22 Statistics from UNT1 Modulus Data as-measured

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

The UNT2 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1 and ETW2.

For normalized strength non-modified CV dataset, CTA passed ADK test and normality test, so normal method was used. RTA passed ADK test but not normality test, so Weibull method was used. Conditions ETW1 and ETW2 failed ADK test, so ANOVA method was used for these. Since they have less than 5 batches ANOVA method only produces estimates rather then basis values. For modified CV dataset, CTA, RTA and ETW1 passed the pooling necessary tests, so pooling method was used for this, while ETW2 uses normal method.

For as-measured strength non-modified CV dataset, RTA passed ADK test but not normality test, so Weibull method was used. Conditions CTA, ETW1 and ETW2 failed ADK test, so ANOVA method was used for these. Since they have less than 5 batches ANOVA method only produces estimates rather then basis values. For modified CV dataset, all conditions passed the pooling necessary tests, so pooling method was used for these.

There were five statistical outliers. For strength as-measured, the lowest value for batch E in condition RTA is a batch and condition outlier. For strength as-measured, the highest value for batch F in condition ETW1 is a batch outlier. For strength normalized, the lowest value for batch F in condition CTA is a condition outlier. For strength normalized, the lowest value for batch E in condition RTA is a batch and condition outlier. For strength normalized, the highest value for batch F in condition ETW1 is a batch outlier. All outliers were retained for calculations.

Statistics, basis values, and estimates are given for UNT2 strength data in Table 4-23 and Table 4-24 and for the modulus data in Table 4-25 and Table 4-26. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-10.

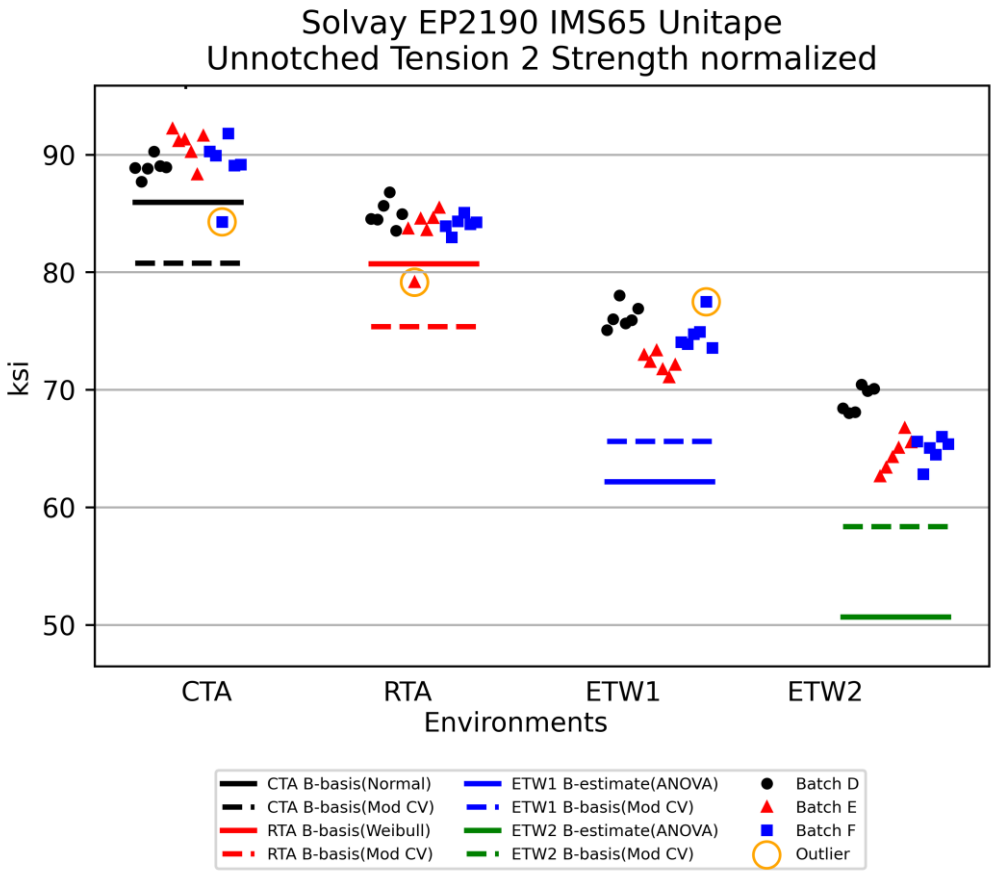

Figure 4-10 Batch Plot for UNT2 normalized strength

Unnotched Tension 2 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	89.59	84.19	74.42	66.20
Stdev	1.847	1.546	2.002	2.451
CV	2.061	1.836	2.691	3.702
Mod CV	6.000	6.000	6.000	6.000
Min	84.27	79.14	71.03	62.62
Max	92.19	86.79	78.01	70.44
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	85.95	80.74		
B-Estimate			62.19	50.68
A-Estimate	83.37	76.99	53.46	39.60
Method	Normal	Weibull	ANOVA	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	80.78	75.38	65.60	58.36
A-Estimate	74.90	69.50	59.72	52.80
Method	Pooled	Pooled	Pooled	Normal

Table 4-23 Statistics and Basis Values for UNT2 Strength Data normalized

Unnotched Tension 2 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	87.06	81.51	72.25	64.28
Stdev	2.083	1.518	1.681	2.107
CV	2.392	1.862	2.326	3.278
Mod CV	6.000	6.000	6.000	6.000
Min	82.29	76.74	69.36	60.99
Max	89.94	83.45	75.65	68.13
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis		78.40		
B-Estimate	78.24		62.91	52.40
A-Estimate	71.96	74.96	56.24	43.92
Method	ANOVA	Weibull	ANOVA	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	79.02	73.47	64.21	56.24
A-Estimate	73.72	68.17	58.91	50.94
Method	Pooled	Pooled	Pooled	Pooled

Table 4-24 Statistics and Basis Values for UNT2 Strength Data as-measured

Unnotched Tension 2 Statistics				
	Modulus normalized [Msi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	5.485	5.118	4.806	4.538
Stdev	0.1249	0.06902	0.06075	0.07745
CV	2.278	1.348	1.264	1.707
Min	5.347	4.995	4.664	4.442
Max	5.782	5.223	4.941	4.713
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-25 Statistics from UNT2 Modulus Data normalized

Unnotched Tension 2 Statistics				
	Modulus as-measured [Msi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	5.330	4.955	4.666	4.407
Stdev	0.1514	0.05660	0.07396	0.07917
CV	2.841	1.142	1.585	1.796
Min	5.127	4.859	4.511	4.284
Max	5.671	5.046	4.816	4.602
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-26 Statistics from UNT2 Modulus Data as-measured

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

The UNT3 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1, and ETW3.

For normalized strength non-modified CV dataset, all conditions pass pooling tests, so pooling was used. For modified CV dataset, also pooling method was used. For as-measured strength non-modified CV dataset, all conditions pass pooling tests, so pooling was used. For modified CV, CTA and RTA pass pooling test, so pooling method was used for these. ETW1 failed normality test, so there is no available result (NA) while ETW2 passed normality test, so normal method was used.

For strength as-measured, the lowest value for batch E in condition ETW1 is a batch outlier. For strength normalized, the lowest value for batch E in condition ETW1 is a batch outlier. All outliers were retained for calculations.

Statistics, basis values, and estimates are given for UNT3 strength data in Table 4-27 and Table 4-28 and for the modulus data in Table 4-29 and Table 4-30. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-11.

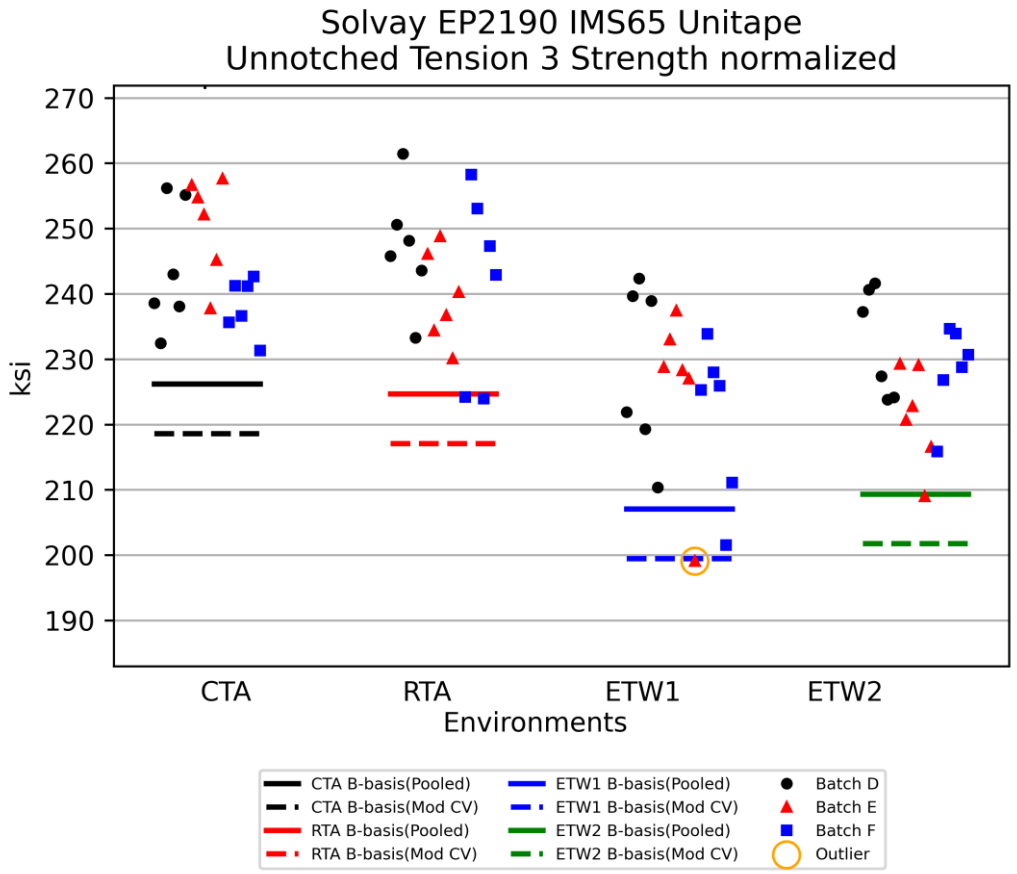

Figure 4-11 Batch Plot for UNT3 normalized strength

Unnotched Tension 3 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	244.2	242.7	225.1	227.4
Stdev	8.885	10.64	12.65	8.638
CV	3.638	4.385	5.618	3.799
Mod CV	6.000	6.193	6.809	6.000
Min	231.3	224.0	199.1	209.0
Max	257.6	261.4	242.4	241.6
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	226.2	224.7	207.1	209.3
A-Estimate	214.3	212.8	195.2	197.5
Method	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	218.6	217.1	199.5	201.8
A-Estimate	201.7	200.2	182.6	184.9
Method	Pooled	Pooled	Pooled	Pooled

Table 4-27 Statistics and Basis Values for UNT3 Strength Data normalized

Unnotched Tension 3 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	237.2	235.4	218.5	221.0
Stdev	8.929	9.907	11.90	7.877
CV	3.764	4.209	5.446	3.565
Mod CV	6.000	6.105	6.723	6.000
Min	223.3	218.2	194.4	205.0
Max	252.7	251.8	233.2	231.9
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	220.1	218.3	201.5	203.9
A-Estimate	208.9	207.1	190.2	192.7
Method	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	211.1	209.3	NA	194.8
A-Estimate	193.4	191.6		176.3
Method	Pooled	Pooled		Normal

Table 4-28 Statistics and Basis Values for UNT3 Strength Data as-measured

Unnotched Tension 3 Statistics				
	Modulus normalized [Msi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	13.08	13.21	13.04	13.18
Stdev	0.1521	0.4323	0.1827	0.2727
CV	1.163	3.273	1.401	2.070
Min	12.83	12.61	12.65	12.73
Max	13.39	14.11	13.41	13.68
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-29 Statistics from UNT3 Modulus Data normalized

Unnotched Tension 3 Statistics				
	Modulus as-measured [Msi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	12.70	12.81	12.66	12.80
Stdev	0.1360	0.4316	0.1976	0.1922
CV	1.071	3.369	1.561	1.501
Min	12.49	12.27	12.34	12.44
Max	12.99	13.74	13.06	13.13
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-30 Statistics from UNT3 Modulus Data as-measured

4.11 “25/50/25” Unnotched Compression 1 (UNC1)

The UNC1 data is normalized, so both normalized and as-measured results are provided. Testing was done in seven environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, ETW2, and ETW3.

For normalized strength non-modified CV dataset, all conditions except RTA pass ADK test and normality test, so normal method was used for these. RTA fails ADK test, so ANOVA method was used. Since RTA has less than 5 batches the results are estimates rather than basis values. For modified CV, the tests results are the same, so RTA has basis values not available (NA) and the rest of conditions use normal method. For as-measured strength the test results are the same as for normalized strength.

There were two outliers. For normalized property, the lowest value in batch E of ETW3 condition is outlier for the condition but not the batch. For as-measured property the lowest value in batch E of ETW3 condition is outlier for the condition but not the batch. Outliers were retained for this analysis.

Statistics, basis values, and estimates are given for UNC1 strength data in Table 4-31 and Table 4-32 and for the UNC1 modulus data in Table 4-33 and Table 4-34. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-12.

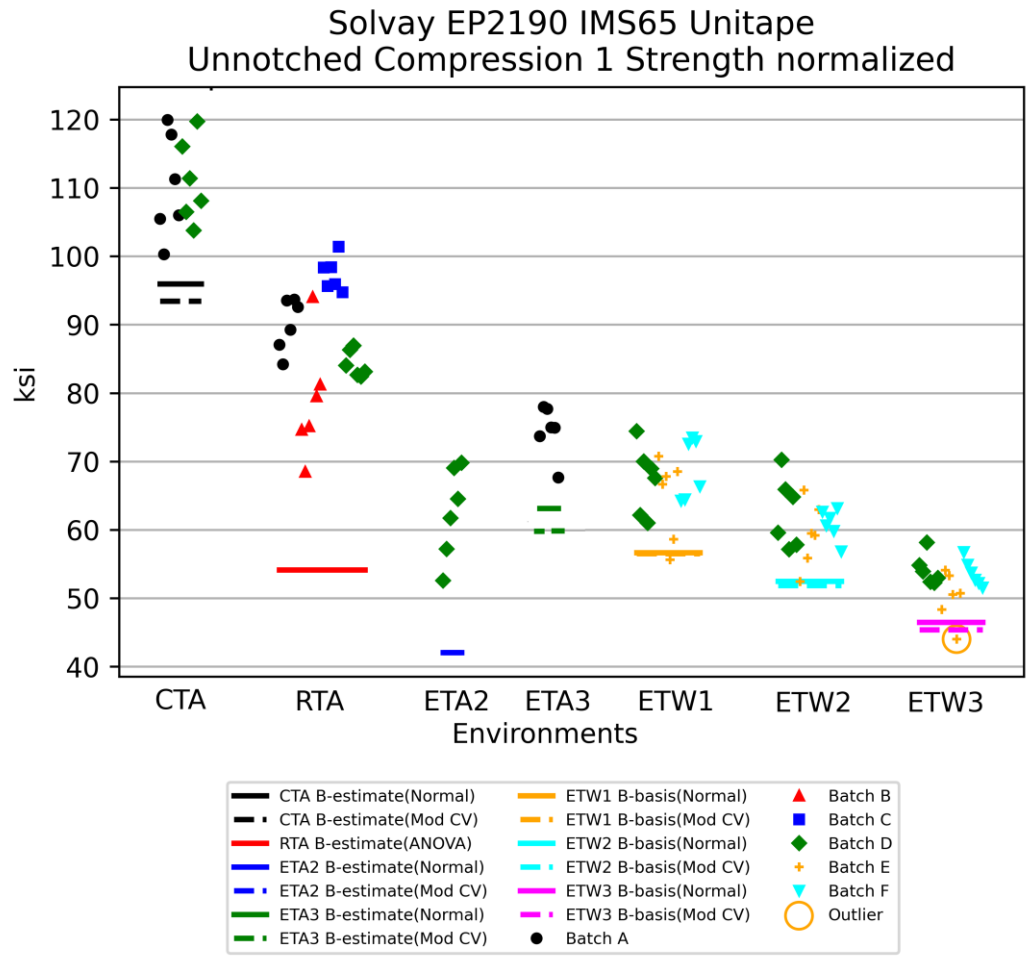

Figure 4-12 Batch plot for UNC1 normalized strength

Unnotched Compression 1 Basis Values and Statistics							
	Strength normalized [ksi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	110.5	87.63	62.48	74.49	67.02	60.90	52.64
Stdev	6.581	8.452	6.741	3.744	5.244	4.268	3.115
CV	5.954	9.645	10.79	5.027	7.825	7.008	5.919
Mod CV	8.000	9.645	10.79	8.000	7.913	7.504	6.959
Min	100.3	68.48	52.59	67.66	55.62	52.45	44.03
Max	120.0	101.4	69.82	77.97	74.40	70.24	58.17
No. Batches	2	4	1	1	3	3	3
No. Spec.	12	24	6	6	18	18	18
Basis Values and Estimates							
B-Basis					56.66	52.47	46.49
B-Estimate	95.95	54.15	42.06	63.15			
A-Estimate	85.74	30.90	27.54	55.08	49.33	46.50	42.13
Method	Normal	ANOVA	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates							
B-Basis		NA			56.55	51.88	45.41
B-Estimate	90.93		42.06	56.44			
A-Estimate	77.22		27.54	43.60	49.13	45.48	40.28
Method	Normal		Normal	Normal	Normal	Normal	Normal

Table 4-31 Statistics and Basis Values for UNC1 Strength Data normalized

Unnotched Compression 1 Basis Values and Statistics							
	Strength as-measured [ksi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	107.0	84.28	61.06	71.18	66.23	60.26	51.83
Stdev	6.561	7.476	6.437	3.644	5.589	4.194	2.960
CV	6.133	8.870	10.54	5.120	8.439	6.960	5.711
Mod CV	8.000	8.870	10.54	8.000	8.439	7.480	6.855
Min	96.44	66.19	51.67	64.91	55.01	51.93	43.54
Max	117.3	95.92	68.00	74.80	74.69	68.86	56.96
No. Batches	2	4	1	1	3	3	3
No. Spec.	12	24	6	6	18	18	18
Basis Values and Estimates							
B-Basis					55.19	51.98	45.99
B-Estimate	92.43	56.03	41.56	60.14			
A-Estimate	82.26	36.39	27.69	52.29	47.37	46.11	41.85
Method	Normal	ANOVA	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates							
B-Basis		NA			55.19	51.36	44.82
B-Estimate	88.01		41.56	53.93			
A-Estimate	74.74		27.69	41.67	47.37	45.06	39.84
Method	Normal		Normal	Normal	Normal	Normal	Normal

Table 4-32 Statistics and Basis Values for UNC1 Strength Data as-measured

Unnotched Compression 1 Statistics							
	Modulus normalized [Msi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	7.785	7.913	7.702	7.688	7.296	7.157	7.509
Stdev	0.1057	0.2746	0.07385	0.1074	0.5400	0.7162	0.08833
CV	1.357	3.470	0.9589	1.397	7.401	10.01	1.176
Min	7.661	7.632	7.612	7.535	6.497	5.162	7.357
Max	7.989	8.549	7.798	7.857	7.787	7.762	7.675
No. Batches	2	4	1	1	3	3	3
No. Spec.	12	24	6	6	18	18	18

Table 4-33 Statistics from UNC1 Modulus Data normalized

Unnotched Compression 1 Statistics							
	Modulus as-measured [Msi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	7.533	7.613	7.529	7.346	7.201	7.084	7.396
Stdev	0.08368	0.1838	0.08690	0.08840	0.4560	0.7299	0.1184
CV	1.111	2.414	1.154	1.203	6.332	10.30	1.601
Min	7.418	7.393	7.438	7.244	6.494	5.077	7.239
Max	7.685	8.003	7.661	7.473	7.610	7.948	7.779
No. Batches	2	4	1	1	3	3	3
No. Spec.	12	24	6	6	18	18	18

Table 4-34 Statistics from UNC1 Modulus Data as-measured

4.12 “10/80/10” Unnotched Compression 2 (UNC2)

The UNC2 data is normalized, so both normalized and as-measured results are provided. Testing was done in six environmental conditions: RTA, ETA2, ETA3, ETW1, ETW2, and ETW3.

For normalized strength non-modified CV, conditions ETW2 and ETW3 failed ADK test, so ANOVA method was used for these. Since the conditions have less than 5 batches the results are estimates rather than basis values. The rest of conditions passed ADK test and normality test, so normal method was used. For modified CV the results of the tests were the same, so ETW2 and ETW3 have no available (NA) allowables and the rest use normal method.

For as-measured strength non-modified CV, condition ETW2 failed ADK test, so ANOVA method was used for this. Since the condition has less than 5 batches the results are estimates rather than basis values. The rest of conditions passed ADK test and normality test, so normal method was used. For modified CV the results of the tests were the same, so ETW2 has no available (NA) allowables and the rest use normal method.

There were seven statistical outliers detected. For strength normalized, the lowest value for batch D in condition RTA is a batch outlier. For strength normalized, the highest value for batch E in condition RTA is a batch outlier. For strength normalized, the lowest value for batch F in condition ETW3 is a batch outlier. For strength normalized, the lowest value for batch D in condition ETA3 is a batch and condition outlier. For strength as-measured, the lowest value for batch D in condition RTA is a batch outlier. For strength as-measured, the highest value for batch E in condition RTA is a batch outlier. For strength as-measured, the lowest value for batch F in condition ETW3 is a batch outlier.

Statistics, basis values, and estimates are given for UNC2 strength data in Table 4-35 and Table 4-36 and for the UNC2 modulus data in Table 4-37 and Table 4-38. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-13.

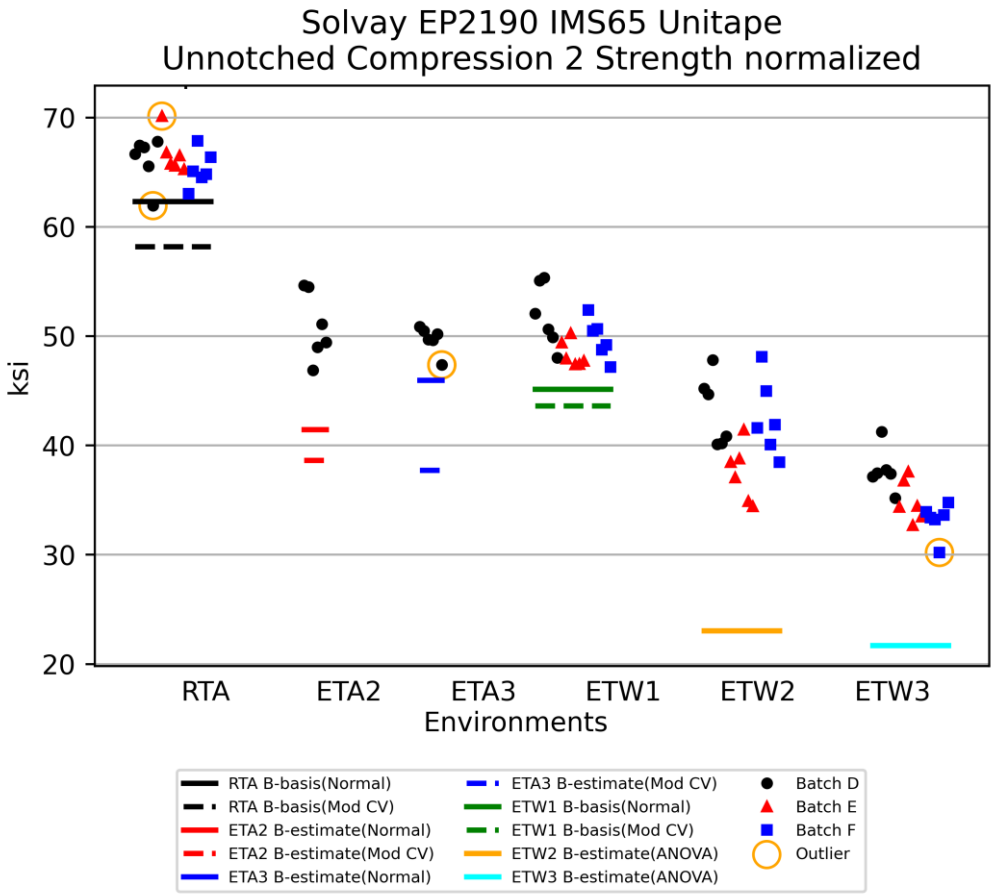

Figure 4-13 Batch plot for UNC2 normalized strength

Unnotched Compression 2 Basis Values and Statistics						
	Strength normalized [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	66.01	50.91	49.70	49.98	41.05	35.25
Stdev	1.875	3.130	1.237	2.459	3.920	2.567
CV	2.840	6.148	2.490	4.920	9.551	7.281
Mod CV	6.000	8.000	8.000	6.460	9.551	7.641
Min	61.93	46.87	47.36	47.15	34.40	30.20
Max	70.12	54.63	50.87	55.35	48.09	41.24
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	62.31			45.13		
B-Estimate		41.43	45.95		23.04	21.70
A-Estimate	59.69	34.69	43.28	41.69	10.20	12.04
Method	Normal	Normal	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates						
B-Basis	58.19			43.61	NA	NA
B-Estimate		38.58	37.65			
A-Estimate	52.65	29.80	29.09	39.09		
Method	Normal	Normal	Normal	Normal		

Table 4-35 Statistics and Basis Values for UNC2 Strength Data normalized

Unnotched Compression 2 Basis Values and Statistics						
	Strength as-measured [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	63.90	48.68	47.48	48.40	39.83	34.15
Stdev	2.095	3.139	1.373	2.297	3.759	2.334
CV	3.278	6.450	2.891	4.746	9.437	6.834
Mod CV	6.000	8.000	8.000	6.373	9.437	7.417
Min	58.68	45.10	44.99	45.61	33.74	29.28
Max	68.89	52.52	48.86	53.35	47.08	39.65
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	59.77			43.87		29.54
B-Estimate		39.17	43.32		24.20	
A-Estimate	56.84	32.41	40.37	40.65	13.07	26.28
Method	Normal	Normal	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates						
B-Basis	56.33			42.31	32.41	29.15
B-Estimate		36.88	35.98			
A-Estimate	50.97	28.49	27.80	38.00	27.15	25.60
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-36 Statistics and Basis Values for UNC2 Strength Data as-measured

Unnotched Compression 2 Statistics						
	Modulus normalized [Msi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	4.969	4.746	4.703	4.496	4.304	3.934
Stdev	0.05921	0.04305	0.05864	0.2298	0.2266	0.2895
CV	1.192	0.9069	1.247	5.112	5.265	7.360
Min	4.900	4.690	4.668	4.207	3.974	3.531
Max	5.105	4.789	4.822	4.820	4.612	4.388
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18

Table 4-37 Statistics from UNC2 Modulus Data normalized

Unnotched Compression 2 Statistics						
	Modulus as-measured [Msi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	4.810	4.537	4.494	4.353	4.176	3.811
Stdev	0.06416	0.05150	0.05002	0.2101	0.2178	0.2761
CV	1.334	1.135	1.113	4.827	5.216	7.244
Min	4.677	4.448	4.439	4.108	3.867	3.436
Max	4.919	4.608	4.581	4.696	4.472	4.226
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18

Table 4-38 Statistics from UNC2 Modulus Data as-measured

4.13 “50/40/10” Unnotched Compression 3 (UNC3)

The UNC3 data is normalized, so both normalized and as-measured results are provided. Testing was done in five environmental conditions: RTA, ETA2, ETA3, ETW1, ETW2, and ETW3.

For normalized strength non-modified CV dataset, ETW2 failed ADK test, so ANOVA method was used. Since ETW2 has less than 5 batches, the results are estimates rather then basis values. RTA passes ADK test but fails normality, so Weibull is used for this. The rest of conditions passed ADK test and normality tests, so normal method was used. For modified CV dataset, RTA and ETW2 failed ADK test, so allowables are not available (NA). The rest of conditions pass ADK and normality, so normal method was used.

For as-measured strength non-modified CV dataset, all conditions passed ADK test but RTA failed normality test, so RTA use non-parametric method. The rest of conditions passed ADK test and normality tests, so normal method was used. For modified CV dataset, RTA failed ADK test, so allowables are not available (NA). The rest of conditions pass ADK and normality, so normal method was used.

Four statistical outliers were detected. For strength as-measured, the lowest value in batch D of the as measured RTA dataset was an outlier for the batch. For strength as-measured, the highest value in batch D of the as measured ETW2 dataset was an outlier for the batch. For strength normalized, the lowest value in batch D of the as measured RTA dataset was an outlier for the batch. For strength normalized, the highest value in batch D of the as measured ETW2 dataset was an outlier for the batch. Outliers were retained for this analysis.

Statistics, basis values, and estimates are given for UNC3 strength data in Table 4-39 and Table 4-40 and for the UNC3 modulus data in Table 4-41 and Table 4-42. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-14.

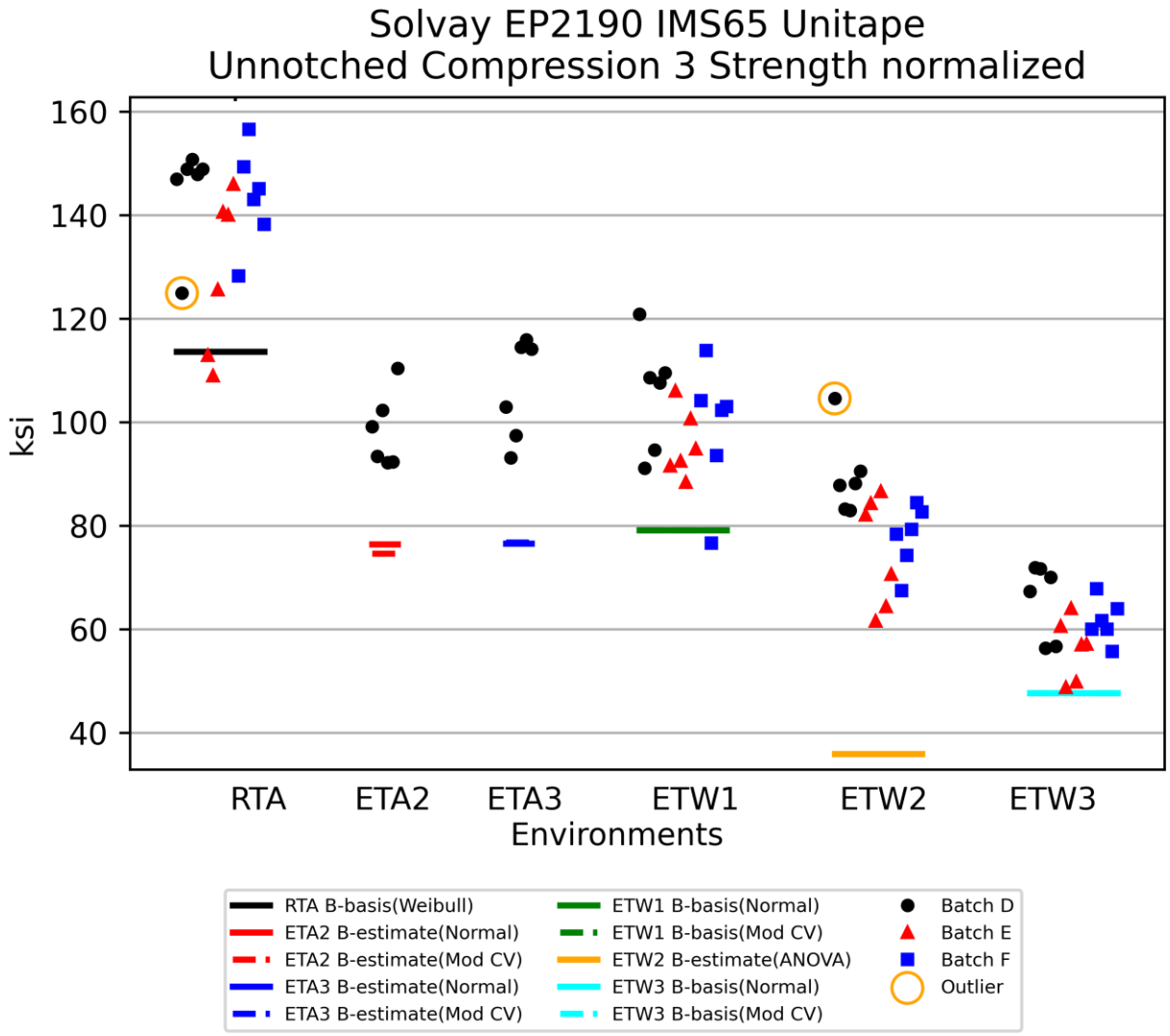

Figure 4-14 Batch plot for UNC3 normalized strength

Unnotched Compression 3 Basis Values and Statistics						
	Strength normalized [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	139.0	98.30	106.3	99.99	80.75	61.15
Stdev	13.44	7.221	9.817	10.57	10.32	6.832
CV	9.670	7.345	9.232	10.57	12.77	11.17
Mod CV	9.670	8.000	9.232	10.57	12.77	11.17
Min	108.9	92.17	93.15	76.64	61.59	48.76
Max	156.5	110.4	115.9	120.8	104.6	71.89
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	113.7			79.13		47.66
B-Estimate		76.43	76.60		35.95	
A-Estimate	90.20	60.88	55.46	64.34	4.017	38.10
Method	Weibull	Normal	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates						
B-Basis	NA			79.13	NA	47.66
B-Estimate		74.48	76.60			
A-Estimate		57.54	55.46	64.34		38.10
Method		Normal	Normal	Normal		Normal

Table 4-39 Statistics and Basis Values for UNC3 Strength Data normalized

Unnotched Compression 3 Basis Values and Statistics						
	Strength as-measured [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	134.7	93.54	101.5	96.96	78.19	59.24
Stdev	12.74	6.822	8.903	9.957	9.532	6.379
CV	9.453	7.293	8.768	10.27	12.19	10.77
Mod CV	9.453	8.000	8.768	10.27	12.19	10.77
Min	105.9	86.75	89.63	75.23	60.19	47.57
Max	152.4	103.9	109.8	116.5	100.7	68.94
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	96.06			77.30	59.37	46.64
B-Estimate		72.88	74.57			
A-Estimate	61.41	58.18	55.40	63.37	46.04	37.72
Method	Non-parametric	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	NA			77.30	59.37	46.64
B-Estimate		70.88	74.57			
A-Estimate		54.76	55.40	63.37	46.04	37.72
Method		Normal	Normal	Normal	Normal	Normal

Table 4-40 Statistics and Basis Values for UNC3 Strength Data as-measured

Unnotched Compression 3 Statistics						
	Modulus normalized [Msi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	12.03	12.24	12.28	11.36	11.15	10.98
Stdev	0.1317	0.03937	0.1129	0.5614	0.7550	0.7552
CV	1.095	0.3216	0.9200	4.944	6.770	6.876
Min	11.83	12.21	12.19	10.84	10.00	9.811
Max	12.31	12.31	12.49	12.22	12.31	12.10
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18

Table 4-41 Statistics from UNC3 Modulus Data normalized

Unnotched Compression 3 Statistics						
	Modulus as-measured [Msi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	11.66	11.65	11.73	11.02	10.81	10.64
Stdev	0.1460	0.1285	0.1052	0.5606	0.7154	0.7317
CV	1.252	1.103	0.8967	5.089	6.620	6.874
Min	11.43	11.49	11.53	10.41	9.741	9.580
Max	12.04	11.78	11.81	11.94	11.82	11.60
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18

Table 4-42 Statistics from UNC3 Modulus Data as-measured

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

The OHT1 data is normalized, so both normalized and as-measured results are provided. Testing was done in six environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, and ETW3.

For normalized strength non-modified CV dataset, CTA failed ADK test, so ANOVA method was used. Since it has less than 5 batches, the results are estimates rather then basis values. The rest of conditions passed ADK test and normality tests, so normal method was used. For modified CV dataset, CTA and RTA passed pooling tests, so pooling method is used for these. The rest of conditions pass ADK and normality, so normal method was used.

For as-measured strength non-modified CV dataset, CTA failed ADK test, so ANOVA method was used. Since it has less than 5 batches, the results are estimates rather then basis values. The rest of conditions passed ADK test and normality tests, so normal method was used. For modified CV dataset, CTA and RTA passed pooling tests, so pooling method is used for these. The rest of conditions pass ADK and normality, so normal method was used.

Two statistical outliers were detected. For strength as-measured, the lowest value in batch B of the as measured RTA dataset was an outlier for the batch. For strength as-measured, the highest value in batch D of the as measured ETW2 dataset was an outlier for the batch. Outliers were retained for this analysis.

Statistics, basis values, and estimates are given for OHT1 strength data in Table 4-43 and Table 4-44. The normalized data, B-basis values, and B-estimates are shown graphically in Figure 4-15.

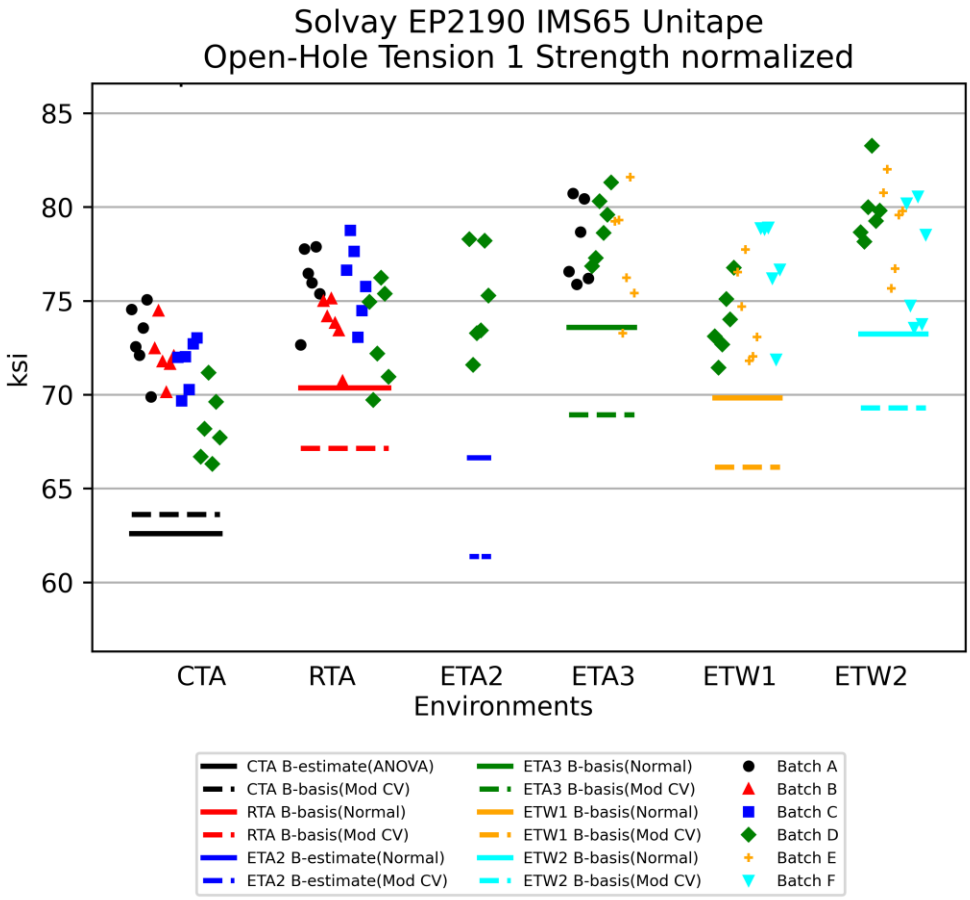

Figure 4-15 Batch Plot for OHT1 normalized strength

Open-Hole Tension 1 Basis Values and Statistics						
	Strength normalized [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	71.23	74.75	75.01	78.19	75.02	78.62
Stdev	2.367	2.363	2.764	2.328	2.631	2.726
CV	3.323	3.161	3.685	2.978	3.507	3.467
Mod CV	6.000	6.000	8.000	6.000	6.000	6.000
Min	66.31	69.72	71.59	73.27	71.43	73.57
Max	75.06	78.76	78.29	81.59	78.92	83.26
No. Batches	4	4	1	3	3	3
No. Spec.	24	24	6	18	18	18
Basis Values and Estimates						
B-Basis		70.37		73.59	69.83	73.23
B-Estimate	62.59		66.64			
A-Estimate	56.58	67.24	60.68	70.34	66.15	69.42
Method	ANOVA	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	63.62	67.14		68.93	66.14	69.30
B-Estimate			56.83			
A-Estimate	58.35	61.87	43.91	62.37	59.84	62.70
Method	Pooled	Pooled	Normal	Normal	Normal	Normal

Table 4-43 Statistics and Basis Values for OHT1 Strength Data normalized

Open-Hole Tension 1 Basis Values and Statistics						
	Strength as-measured [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	69.07	71.94	73.72	76.08	73.53	77.90
Stdev	1.998	2.096	2.569	2.503	2.531	2.142
CV	2.893	2.913	3.484	3.289	3.442	2.749
Mod CV	6.000	6.000	8.000	6.000	6.000	6.000
Min	65.00	67.55	70.49	71.20	69.40	74.01
Max	72.79	74.87	76.92	80.05	77.37	81.29
No. Batches	4	4	1	3	3	3
No. Spec.	24	24	6	18	18	18
Basis Values and Estimates						
B-Basis		68.06		71.14	68.53	73.68
B-Estimate	62.52		65.94			
A-Estimate	57.95	65.27	60.40	67.64	64.99	70.68
Method	ANOVA	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	61.72	64.59		67.07	64.82	68.68
B-Estimate			55.85			
A-Estimate	56.63	59.50	43.15	60.68	58.65	62.14
Method	Pooled	Pooled	Normal	Normal	Normal	Normal

Table 4-44 Statistics and Basis Values for OHT1 Strength Data as-measured

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

The OHT2 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1, and ETW2.

For the normalized strength non-modified CV dataset, conditions RTA and ETW2 failed the ADK test for batch to batch variability, so ANOVA method was used for these. With fewer than 5 batches, the results are considered estimates rather than basis values. Condition CTA passed ADK test but failed normality test, so Weibull method was used. Condition ETW1 passed ADK test and normality test, so normal method was used. For modified CV dataset, CTA and RTA passed the pooling tests, so pooling was acceptable for these, while ETW1 and ETW2 passed ADK test and normality test, so normal method was used for these two conditions.

For the as-measured strength non-modified CV dataset, condition CTA passed ADK test but failed normality test, so Weibull method was used for this one. Conditions RTA, ETW1 and ETW2 passed ADK test and normality test, so normal method was used for these. For modified CV dataset, CTA and RTA passed the pooling tests, so pooling was acceptable for these, while ETW1 and ETW2 passed ADK test and normality test, so normal method was used for these two conditions.

There were three outliers detected. For as-measured strength the highest value of batch D in condition RTA is a batch and condition outlier. For normalized strength the highest value of batch D in condition RTA is a batch and condition outlier. For normalized strength the lowest value of batch E in condition RTA is a batch outlier. All outliers were retained for this analysis.

Statistics, basis values, and estimates are given for OHT2 strength data in Table 4-45 and Table 4-46. The normalized data, B-basis values, and B-estimates are shown graphically in Figure 4-16.

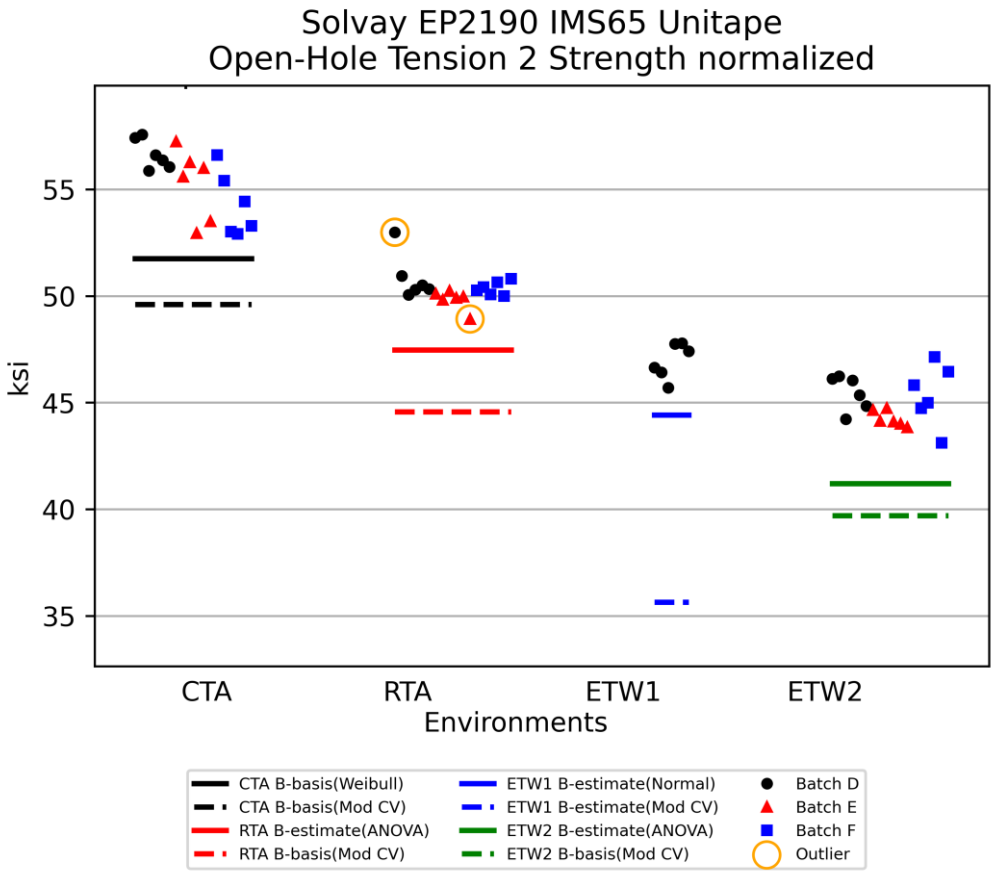

Figure 4-16 Batch Plot for OHT2 normalized strength

Open-Hole Tension 2 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	55.39	50.35	46.95	45.03
Stdev	1.622	0.7928	0.8345	1.077
CV	2.928	1.575	1.777	2.393
Mod CV	6.000	6.000	8.000	6.000
Min	52.91	48.92	45.70	43.12
Max	57.57	52.99	47.78	47.15
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Basis	51.74			
B-Estimate		47.47	44.42	41.21
A-Estimate	47.83	45.42	42.63	38.49
Method	Weibull	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	49.61	44.56		39.69
B-Estimate			35.57	
A-Estimate	45.67	40.63	27.48	35.91
Method	Pooled	Pooled	Normal	Normal

Table 4-45 Statistics and Basis Values for OHT2 Strength Data normalized

Open-Hole Tension 2 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	53.71	48.90	45.08	43.66
Stdev	1.541	0.6327	0.7848	0.9902
CV	2.870	1.294	1.741	2.268
Mod CV	6.000	6.000	8.000	6.000
Min	51.00	47.81	43.90	41.74
Max	55.70	50.81	45.95	45.56
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Basis	50.34	47.66		41.70
B-Estimate			42.70	
A-Estimate	46.70	46.77	41.01	40.32
Method	Weibull	Normal	Normal	Normal
Modified CV Basis Values and Estimates				
B-Basis	48.10	43.29		38.49
B-Estimate			34.16	
A-Estimate	44.28	39.47	26.39	34.82
Method	Pooled	Pooled	Normal	Normal

Table 4-46 Statistics and Basis Values for OHT2 Strength Data as-measured

4.16 “50/40/10” Open-Hole Tension 3 (OHT3)

The OHT3 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1, and ETW2.

For the normalized strength non-modified CV dataset, conditions CTA, RTA and ETW2 failed the ADK test for batch to batch variability, so ANOVA method was used for these. With fewer than 5 batches, the results are considered estimates rather than basis values. Condition ETW1 passed ADK test and normality test, so normal method was used. For modified CV dataset, CTA and RTA passed the pooling tests, so pooling was acceptable for these, while ETW1 passed ADK test and normality test, so normal method was used for this and ETW2 failed ADK test, so ANOVA method has no available (NA) results.

For the normalized strength non-modified CV dataset, conditions RTA failed the ADK test for batch to batch variability, so ANOVA method was used for this. With fewer than 5 batches, the results are considered estimates rather than basis values. Condition CTA, ETW1 and ETW2 passed ADK test and normality test, so normal method was used. For modified CV dataset, CTA and RTA passed the pooling tests, so pooling was acceptable for these, while ETW1 passed ADK test and normality test, so normal method was used for this and ETW2 failed ADK test, so ANOVA method has no available (NA) results.

One statistical outlier was detected. For as-measured strength, the highest value in batch E of the ETW2 condition is a batch outlier. It was retained for this analysis.

Statistics, basis values, and estimates are given for OHT3 strength data in Table 4-47 and Table 4-48. The normalized data, B-basis values, and B-estimates are shown graphically in Figure 4-17.

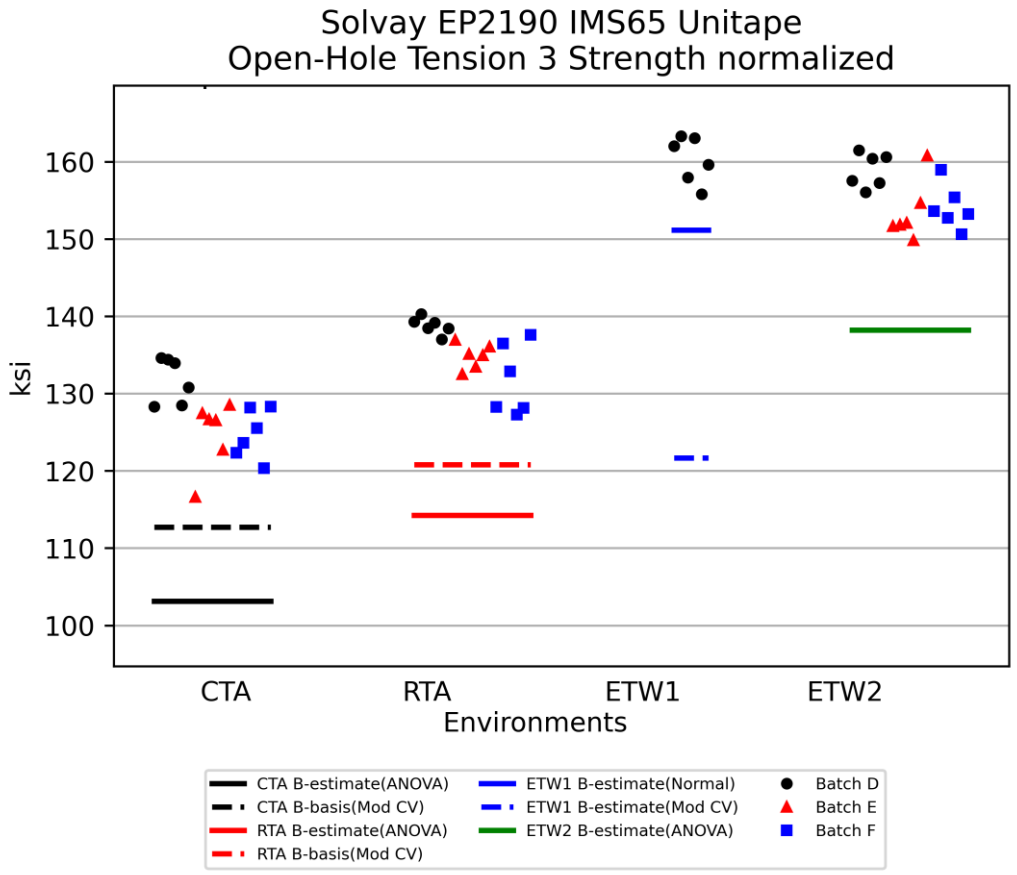

Figure 4-17 Batch Plot for OHT3 normalized strength

Open-Hole Tension 3 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	127.1	135.1	160.3	155.5
Stdev	4.803	3.993	3.024	3.807
CV	3.780	2.955	1.887	2.449
Mod CV	6.000	6.000	8.000	6.000
Min	116.6	127.3	155.8	149.8
Max	134.6	140.3	163.3	161.5
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Estimate	103.1	114.2	151.1	138.2
A-Estimate	86.04	99.36	144.6	125.9
Method	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	112.7	120.8		NA
B-Estimate			121.5	
A-Estimate	103.0	111.0	93.8	
Method	Pooled	Pooled	Normal	

Table 4-47 Statistics and Basis Values for OHT3 Strength Data normalized

Open-Hole Tension 3 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	123.6	131.2	154.5	151.3
Stdev	4.190	3.508	3.127	2.939
CV	3.391	2.674	2.024	1.943
Mod CV	6.000	6.000	8.000	6.000
Min	113.6	124.3	150.1	147.1
Max	129.6	135.0	157.7	157.0
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Basis	115.3			145.5
B-Estimate		114.9	145.0	
A-Estimate	109.4	103.3	138.3	141.3
Method	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates				
B-Basis	109.6	117.3		NA
B-Estimate			117.0	
A-Estimate	100.2	107.8	90.4	
Method	Pooled	Pooled	Normal	

Table 4-48 Statistics and Basis Values for OHT3 Strength Data as-measured

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

The FHT1 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1, and ETW2.

For the normalized strength non-modified CV dataset, conditions CTA, RTA failed the ADK test for batch to batch variability, so ANOVA method was used for these. With fewer than 5 batches, the results are considered estimates rather than basis values. Condition ETW1 passed ADK test and normality test, so normal method was used. Condition ETW2 passed ADK test but failed normality test, so Weibull method was used. For modified CV dataset, CTA and RTA failed the ADK test, so ANOVA method has no available (NA) results, while ETW1 and ETW2 passed ADK test and normality test, so normal method was used for these.

For the as-measured strength non-modified CV dataset, conditions CTA, RTA and ETW2 failed the ADK test for batch to batch variability, so ANOVA method was used for these. With fewer than 5 batches, the results are considered estimates rather than basis values. Condition ETW1 passed ADK test and normality test, so normal method was used. For modified CV dataset, CTA and RTA failed ADK test, so results are Not Available (NA) for these, while ETW1 and ETW2 passed ADK test and normality test, so normal method was used for these.

There were no statistical outliers.

Statistics, basis values, and estimates are given for FHT1 strength data in Table 4-49 and Table 4-50. The normalized data, B-basis values, and B-estimates are shown graphically in Figure 4-18.

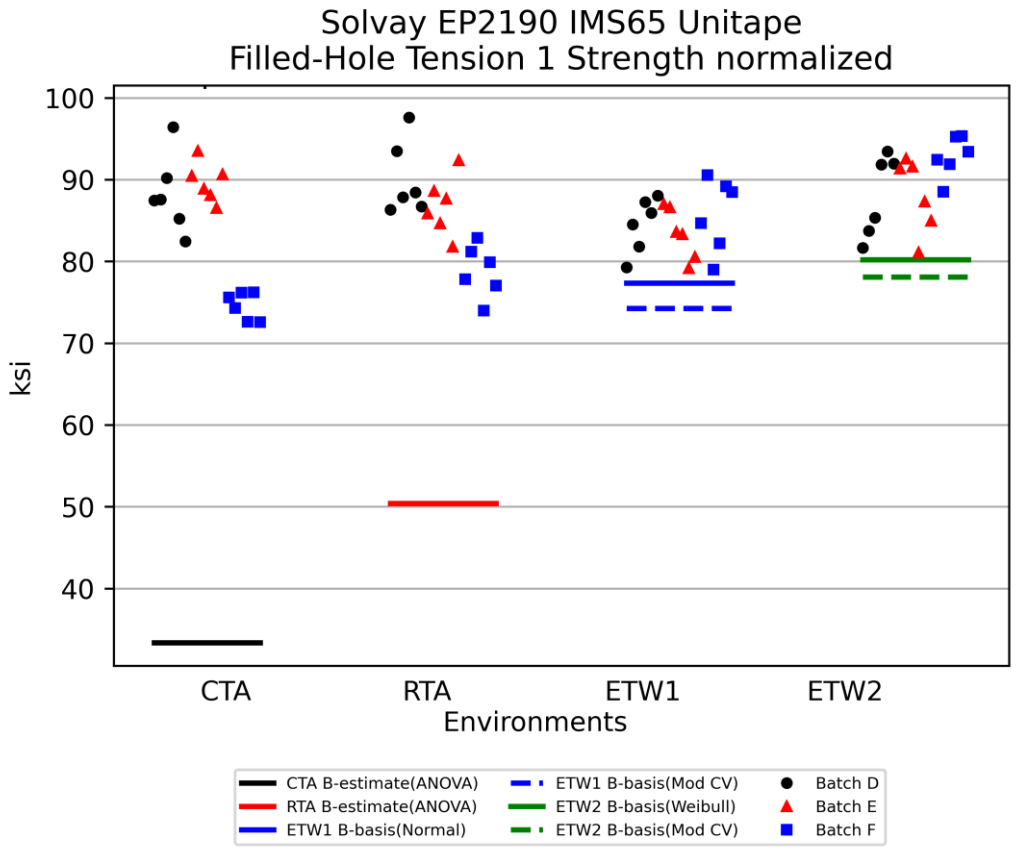

Figure 4-18 Batch Plot for FHT1 normalized strength

Filled-Hole Tension 1 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	84.16	85.23	84.50	89.65
Stdev	7.629	6.046	3.629	4.531
CV	9.065	7.094	4.295	5.055
Mod CV	9.065	7.547	6.147	6.527
Min	72.56	73.99	79.01	81.08
Max	96.43	97.62	90.55	95.32
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis			77.34	80.19
B-Estimate	33.36	50.40		
A-Estimate	0.000	25.54	72.26	70.51
Method	ANOVA	ANOVA	Normal	Weibull
Modified CV Basis Values and Estimates				
B-Basis	NA	NA	74.25	78.09
A-Estimate			66.98	69.91
Method			Normal	Normal

Table 4-49 Statistics and Basis Values for FHT1 Strength Data normalized

Filled-Hole Tension 1 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	82.71	84.32	83.77	89.12
Stdev	7.589	5.383	3.881	5.267
CV	9.175	6.385	4.633	5.910
Mod CV	9.175	7.192	6.317	6.955
Min	71.60	75.63	77.88	80.25
Max	93.91	96.33	91.99	97.86
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis			76.11	
B-Estimate	31.63	55.35		63.69
A-Estimate	0.000	34.69	70.68	45.55
Method	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	NA	NA	73.33	76.88
A-Estimate			65.92	68.21
Method			Normal	Normal

Table 4-50 Statistics and Basis Values for FHT1 Strength Data as-measured

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

The FHT2 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1, and ETW2.

For the normalized strength non-modified CV dataset, conditions CTA, RTA passed the pooling the tests, so pooling method was used. Condition ETW1 passed ADK test and normality test, so normal method was used. Condition ETW2 failed ADK test, so ANOVA method was used. For modified CV dataset, conditions CTA, RTA passed the pooling the tests. Condition ETW1 and ETW2 passed ADK test and normality test, so normal method was used.

For the as-measured strength non-modified CV dataset, conditions CTA, RTA passed the pooling the tests, so pooling method was used. Condition ETW1 and ETW2 passed ADK test and normality test, so normal method was used. For modified CV dataset, conditions CTA, RTA passed the pooling the tests, so pooling method was used. Condition ETW1 passed ADK test and normality test, so normal method was used. Condition ETW2 failed ADK test, so results are not available (NA).

There was one outlier. For as-measured strength, the highest value in batch E of condition CTA was an outlier for the condition but not the batch. It was retained for this analysis.

Statistics, basis values, and estimates are given for FHT2 strength data in Table 4-51 and Table 4-52. The normalized data, B-basis values, and B-estimates are shown graphically in Figure 4-19.

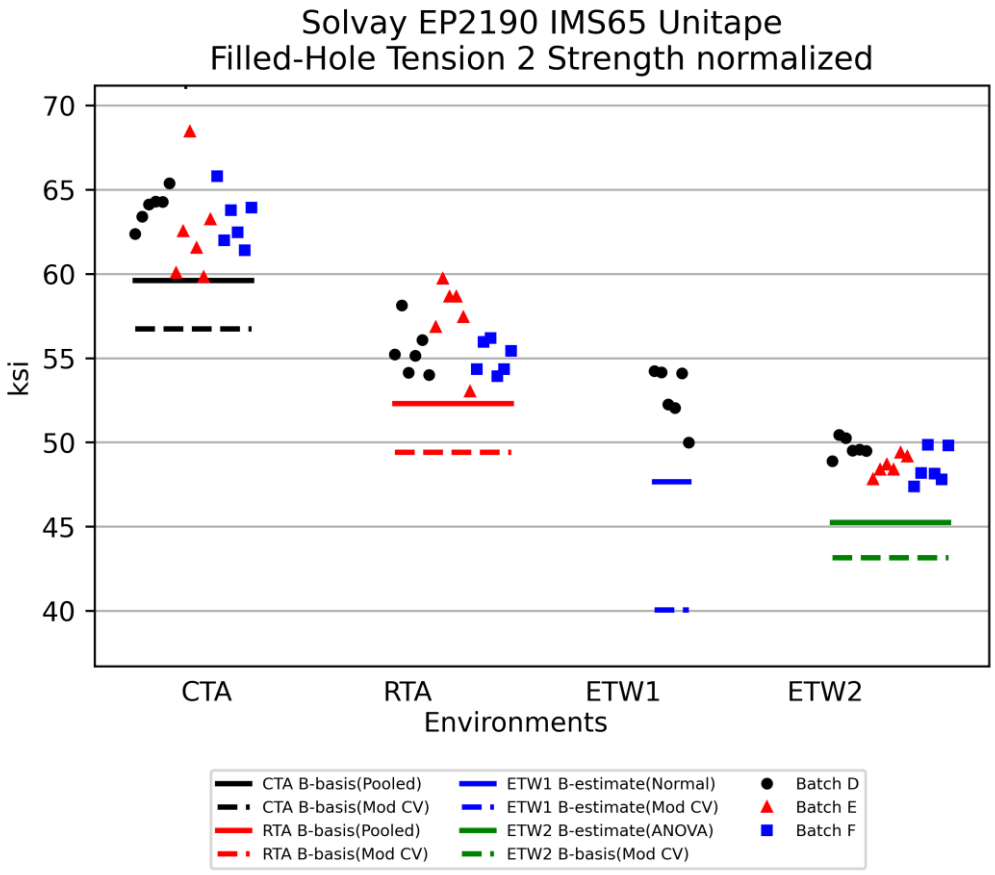

Figure 4-19 Batch Plot for FHT2 normalized strength

Filled-Hole Tension 2 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	63.27	55.96	52.79	48.95
Stdev	2.080	1.924	1.692	0.9025
CV	3.288	3.439	3.206	1.844
Mod CV	6.000	6.000	8.000	6.000
Min	59.80	53.02	49.99	47.38
Max	68.44	59.72	54.22	50.45
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Basis	59.62	52.31		
B-Estimate			47.67	45.25
A-Estimate	57.13	49.82	44.02	42.61
Method	Pooled	Pooled	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	56.74	49.43		43.15
B-Estimate			40.00	
A-Estimate	52.30	44.99	30.90	39.04
Method	Pooled	Pooled	Normal	Normal

Table 4-51 Statistics and Basis Values for FHT2 Strength Data normalized

Filled-Hole Tension 2 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	61.25	54.20	50.50	47.44
Stdev	1.976	2.074	1.774	0.7849
CV	3.226	3.827	3.512	1.655
Mod CV	6.000	6.000	8.000	6.000
Min	58.29	51.39	47.61	46.26
Max	66.77	58.26	52.22	48.98
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Basis	57.56	50.51		45.89
B-Estimate			45.13	
A-Estimate	55.05	48.00	41.31	44.79
Method	Pooled	Pooled	Normal	Normal
Modified CV Basis Values and Estimates				
B-Basis	54.93	47.88		NA
B-Estimate			38.26	
A-Estimate	50.63	43.58	29.56	
Method	Pooled	Pooled	Normal	

Table 4-52 Statistics and Basis Values for FHT2 Strength Data as-measured

4.19 “50/40/10” Filled-Hole Tension 3 (FHT3)

The FHT3 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1, and ETW3.

For the normalized strength non-modified CV dataset, conditions CTA, RTA passed the pooling the tests, so pooling method was used. Condition ETW1 passed ADK test and normality test, so normal method was used. Condition ETW2 failed ADK test, so ANOVA method was used. For modified CV dataset, conditions CTA, RTA passed the pooling the tests, so pooling method was used. Condition ETW1 and ETW2 passed ADK test and normality test, so normal method was used.

For the as-measured strength non-modified CV dataset, conditions CTA, RTA passed the pooling the tests, so pooling method was used. Condition ETW1 and ETW2 passed ADK test and normality test, so normal method was used. For modified CV dataset, conditions CTA, RTA passed the pooling the tests, so pooling method was used. Condition ETW1 and ETW2 passed ADK test and normality test, so normal method was used.

There was one outlier. For normalized strength, the lowest value in batch F of condition ETW2 was an outlier for the batch but not the condition. It was retained for this analysis.

Statistics, basis values, and estimates are given for FHT3 strength data in Table 4-53 and Table 4-54. The normalized data, B-basis values, and B-estimates are shown graphically in Figure 4-20.

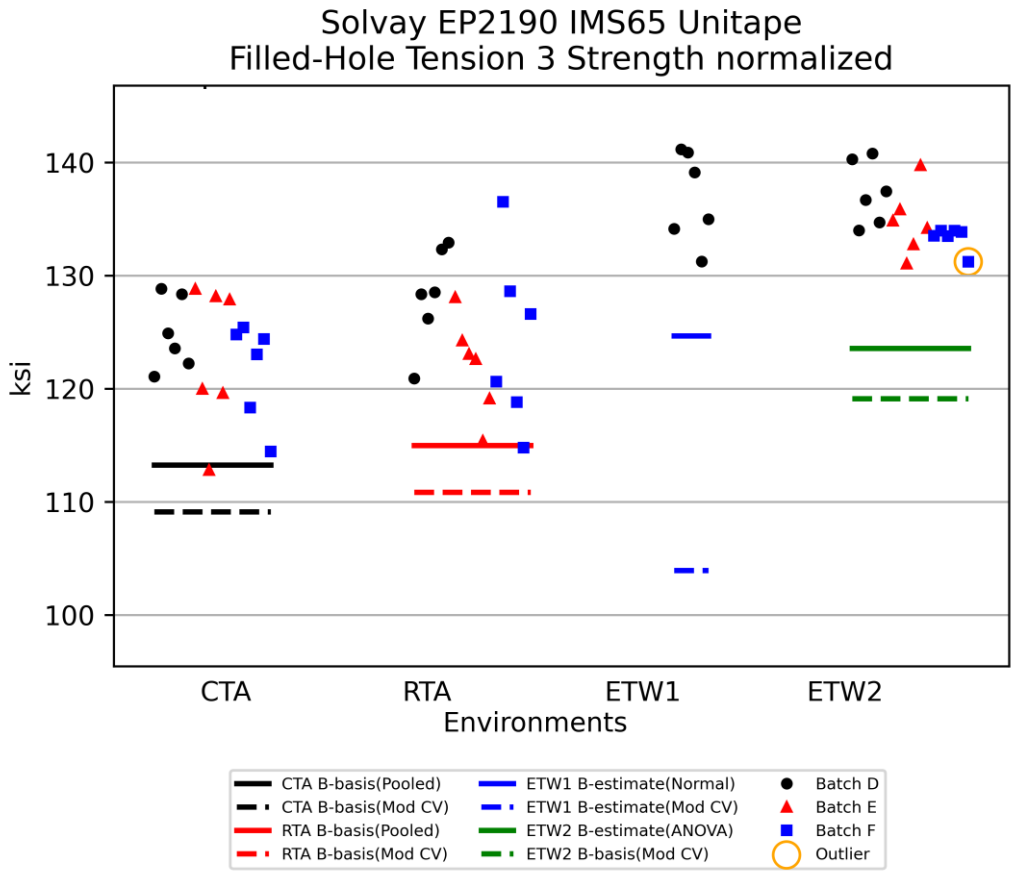

Figure 4-20 Batch Plot for FHT3 normalized strength

Filled-Hole Tension 3 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	123.1	124.9	136.9	135.1
Stdev	4.764	6.013	4.047	2.852
CV	3.869	4.815	2.956	2.111
Mod CV	6.000	6.408	8.000	6.000
Min	112.8	114.8	131.3	131.0
Max	128.8	136.5	141.2	140.8
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Basis	113.3	115.0		
B-Estimate			124.7	123.6
A-Estimate	106.5	108.3	115.9	115.3
Method	Pooled	Pooled	Normal	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	109.1	110.8		119.1
B-Estimate			103.7	
A-Estimate	99.57	101.3	80.15	107.8
Method	Pooled	Pooled	Normal	Normal

Table 4-53 Statistics and Basis Values for FHT3 Strength Data normalized

Filled-Hole Tension 3 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)
Mean	119.7	121.4	131.6	131.6
Stdev	4.582	5.458	3.932	2.360
CV	3.827	4.495	2.989	1.794
Mod CV	6.000	6.248	8.000	6.000
Min	109.9	112.6	125.8	128.0
Max	126.1	133.8	135.7	137.1
No. Batches	3	3	1	3
No. Spec.	18	18	6	18
Basis Values and Estimates				
B-Basis	110.5	112.2		126.9
B-Estimate			119.7	
A-Estimate	104.3	106.0	111.2	123.6
Method	Pooled	Pooled	Normal	Normal
Modified CV Basis Values and Estimates				
B-Basis	106.3	108.0		116.0
B-Estimate			99.69	
A-Estimate	97.12	98.81	77.02	104.9
Method	Pooled	Pooled	Normal	Normal

Table 4-54 Statistics and Basis Values for FHT3 Strength Data as-measured

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

The OHC1 data is normalized, so both normalized and as-measured results are provided. Testing was done in seven environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, ETW2, and ETW3.

For normalized strength non-modified CV dataset, conditions CTA and ETA3 failed ADK test, so ANOVA method was used, while the rest of conditions passed ADK test and normality test, so normal method was used. For modified CV, CTA and RTA passed pooling tests so pooling method was used. ETA3 failed ADK test, so allowables are not available (NA) for this one. For the rest of conditions normal method was used.

For as-measured strength non-modified CV dataset, conditions CTA, ETA3 and ETW1 failed ADK test, so ANOVA method was used. ETW2 passed ADK test but failed the distribution tests, so non-parametric method was used for this. The rest of conditions passed ADK test and normality test, so normal method was used. For modified CV, CTA and RTA passed pooling tests so pooling method was used. ETA3 and ETW2 failed ADK test, so allowables are not available (NA) for these. For the rest of conditions normal method was used.

Four statistical outliers were detected. For as-measured strength, the lowest value in batch A and condition ETA3 is a batch outlier. For as-measured strength, the highest value in batch F and condition ETW3 is a batch outlier. For normalized strength, the lowest value in batch A and condition ETA3 is a batch outlier. For normalized strength, the highest value in batch E and condition ETW2 is a batch outlier.

Statistics, B-basis values, and estimates are given for OHC1 strength data in Table 4-55 and Table 4-56. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-21.

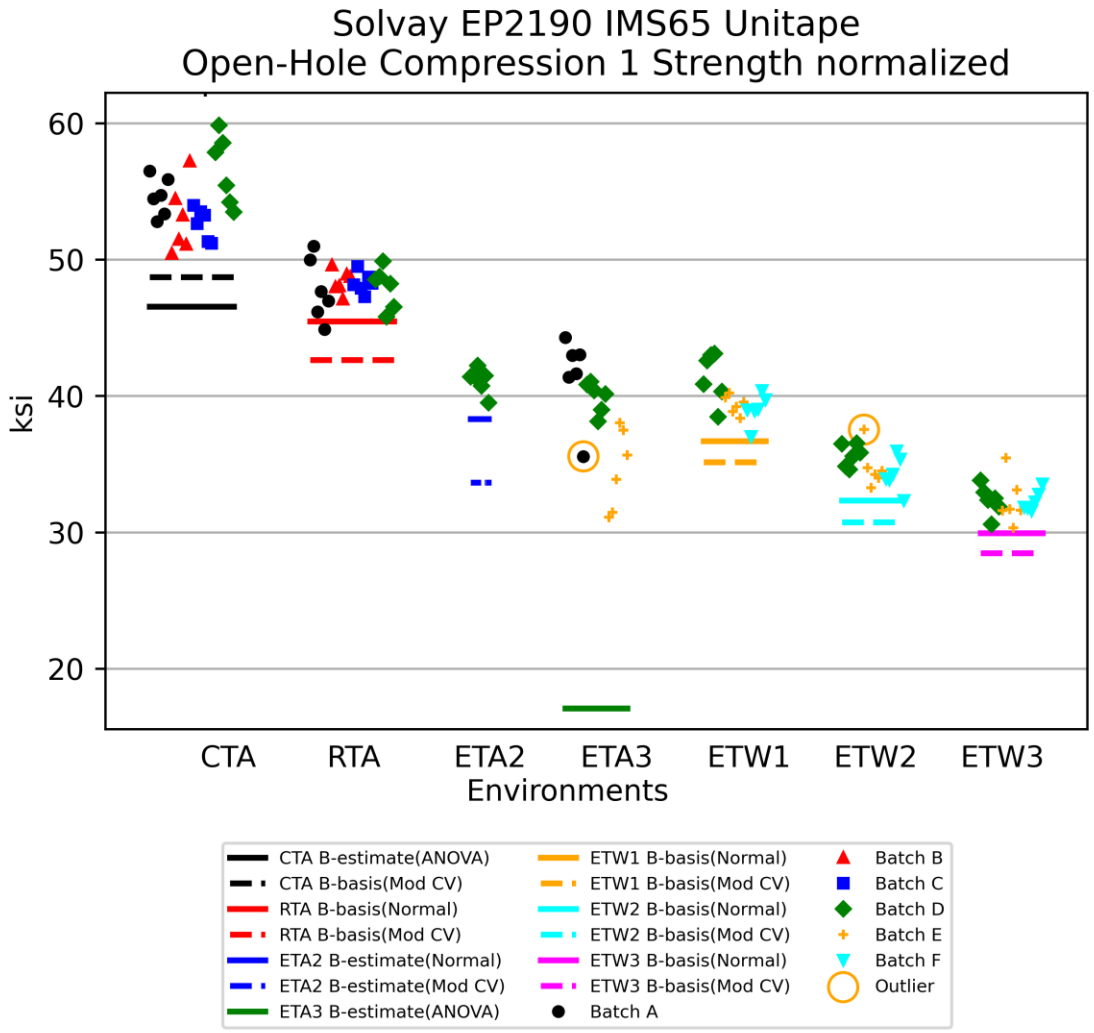

Figure 4-21 Batch plot for OHC1 normalized strength

Open-Hole Compression 1 Basis Values and Statistics							
	Strength normalized [ksi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	54.20	48.10	41.14	38.67	39.91	34.88	32.31
Stdev	2.464	1.419	0.9292	3.864	1.636	1.284	1.197
CV	4.546	2.951	2.259	9.993	4.099	3.680	3.705
Mod CV	6.273	6.000	8.000	9.993	6.049	6.000	6.000
Min	50.43	44.88	39.50	31.11	37.03	32.33	30.32
Max	59.84	50.97	42.24	44.28	43.09	37.53	35.45
No. Batches	4	4	1	3	3	3	3
No. Spec.	24	24	6	18	18	18	18
Basis Values and Estimates							
B-Basis		45.47			36.68	32.34	29.95
B-Estimate	46.55		38.32	17.09			
A-Estimate	41.19	43.59	36.32	1.694	34.40	30.55	28.28
Method	ANOVA	Normal	Normal	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates							
B-Basis	48.73	42.63		NA	35.15	30.75	28.49
B-Estimate			31.17				
A-Estimate	44.93	38.83	24.08		31.77	27.82	25.77
Method	Pooled	Pooled	Normal		Normal	Normal	Normal

Table 4-55 Statistics and Basis Values for OHC1 Strength Data normalized

Open-Hole Compression 1 Basis Values and Statistics							
	Strength as-measured [ksi]						
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	52.30	46.28	40.42	37.62	39.59	34.47	32.06
Stdev	2.616	1.441	0.8620	3.512	1.472	1.199	1.290
CV	5.002	3.112	2.133	9.335	3.718	3.477	4.025
Mod CV	6.501	6.000	8.000	9.335	6.000	6.000	6.013
Min	48.59	42.92	38.94	30.67	37.36	32.57	29.85
Max	58.60	48.94	41.54	42.21	42.15	36.39	34.90
No. Batches	4	4	1	3	3	3	3
No. Spec.	24	24	6	18	18	18	18
Basis Values and Estimates							
B-Basis		43.62				32.10	29.51
B-Estimate	43.24		37.80	19.25	34.26		
A-Estimate	36.92	41.70	35.95	6.143	30.47	27.59	27.70
Method	ANOVA	Normal	Normal	ANOVA	ANOVA	Non-parametric	Normal
Modified CV Basis Values and Estimates							
B-Basis	46.91	40.89		NA	34.90	NA	28.25
B-Estimate			30.62				
A-Estimate	43.17	37.16	23.66		31.57		25.55
Method	Pooled	Pooled	Normal		Normal		Normal

Table 4-56 Statistics and Basis Values for OHC1 Strength Data as-measured

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

The OHC2 data is normalized, so both normalized and as-measured results are provided. Testing was done in six environmental conditions: RTA, ETA2, ETA3, ETW1, ETW2, and ETW3. The ETA2 and ETA3 condition tested specimens from only one batch of material, so only estimates of basis values can be provided for that conditions.

For normalized strength non-modified CV dataset, condition ETW1 failed ADK test, so ANOVA method was used and therefore results are estimates, while the rest of conditions passed ADK test and normality test, so normal method was used. For modified CV, all conditions passed ADK test and normality test, so normal method was used.

For as-measured strength non-modified CV dataset, condition ETW1 failed ADK test, so ANOVA method was used and therefore results are estimates. The rest of conditions passed ADK test and normality test, so normal method was used. For modified CV, RTA failed normality test, so allowables are not available (NA) for this. For the rest of conditions normal method was used.

No statistical outliers were detected.

Statistics, B-basis values, and estimates are given for OHC2 strength data in Table 4-57 and Table 4-58. The normalized data, B-estimates, and B-basis values are shown graphically in F
igure 4-22.

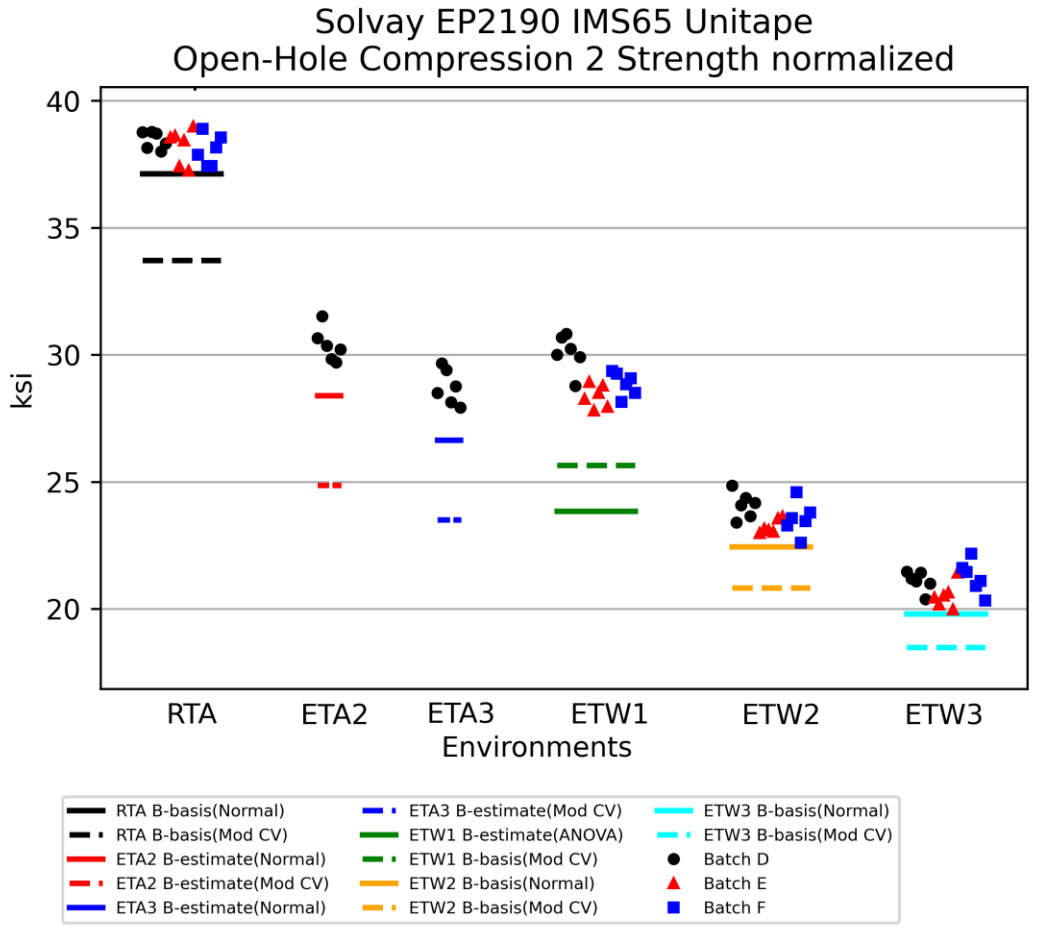

Figure 4-22 Batch plot for OHC2 normalized strength

Open-Hole Compression 2 Basis Values and Statistics						
	Strength normalized [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	38.24	30.38	28.73	29.10	23.63	20.96
Stdev	0.5596	0.6571	0.6904	0.9064	0.5956	0.5848
CV	1.463	2.163	2.403	3.115	2.521	2.790
Mod CV	6.000	8.000	8.000	6.000	6.000	6.000
Min	37.25	29.71	27.92	27.81	22.60	19.97
Max	38.98	31.52	29.66	30.83	24.85	22.17
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	37.13				22.45	19.81
B-Estimate		28.39	26.64	23.84		
A-Estimate	36.35	26.98	25.15	20.09	21.62	18.99
Method	Normal	Normal	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	33.71			25.65	20.83	18.48
B-Estimate		23.02	21.77			
A-Estimate	30.50	17.78	16.82	23.21	18.84	16.72
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-57 Statistics and Basis Values for OHC2 Strength Data normalized

Open-Hole Compression 2 Basis Values and Statistics						
	Strength as-measured [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	37.11	29.17	27.62	28.22	22.92	20.34
Stdev	0.5820	0.5636	0.6601	0.7086	0.5350	0.5672
CV	1.568	1.932	2.390	2.511	2.334	2.789
Mod CV	6.000	8.000	8.000	6.000	6.000	6.000
Min	36.26	28.56	26.80	27.30	21.82	19.59
Max	38.13	30.12	28.49	29.64	24.05	21.61
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	35.96				21.86	19.22
B-Estimate		27.47	25.62	24.64		
A-Estimate	35.15	26.25	24.20	22.09	21.11	18.42
Method	Normal	Normal	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	NA			24.87	20.20	17.93
B-Estimate		22.10	20.93			
A-Estimate		17.08	16.17	22.51	18.28	16.22
Method		Normal	Normal	Normal	Normal	Normal

Table 4-58 Statistics and Basis Values for OHC2 Strength Data as-measured

4.22 “50/40/10” Open-Hole Compression 3 (OHC3)

The OHC3 data is normalized, so both normalized and as-measured results are provided. Testing was done in six environmental conditions: RTA, ETA2, ETA3, ETW1, ETW2, and ETW3. The ETA2 and ETA3 conditions tested specimens from only one batch of material, so only estimates of basis values can be provided for those conditions.

For normalized strength non-modified CV dataset, condition ETW2 failed ADK test, so ANOVA method was used, while the rest of conditions passed ADK test and normality test, so normal method was used. For modified CV, all conditions passed ADK test and normality test, so normal method was used.

For as-measured strength non-modified CV dataset, all conditions passed ADK test and normality test, so normal method was used. For modified CV, RTA failed normality test, so allowables are not available (NA) for this. For the rest of conditions normal method was used.

Three statistical outliers were detected. For as-measured strength, the lowest value in batch D of condition RTA is a batch outlier. For as-measured strength, the highest value in batch D of condition ETA2 is a batch and condition outlier. For normalized strength, the highest value in batch D of condition ETA2 is a batch and condition outlier. All outliers were retained for this analysis.

Statistics, B-basis values, and estimates are given for OHC3 strength data in Table 4-59 and Table 4-60. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-23.

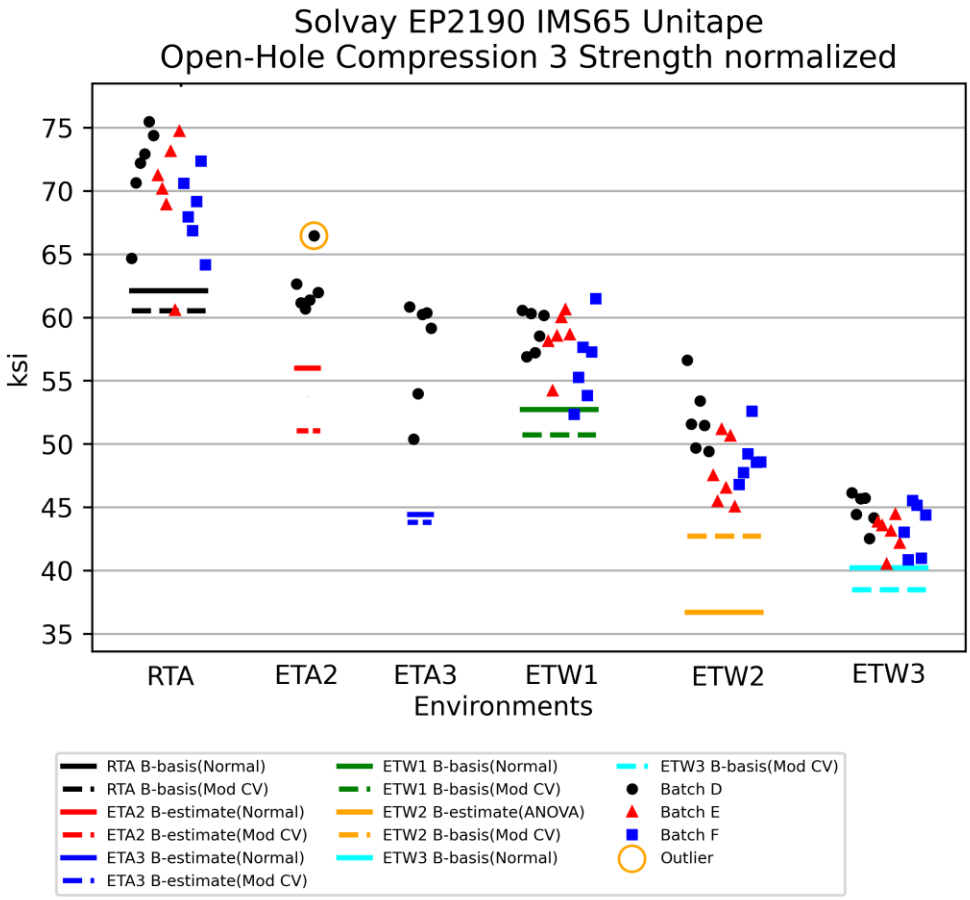

Figure 4-23 Batch plot for OHC3 normalized strength

Open-Hole Compression 3 Basis Values and Statistics						
	Strength normalized [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	70.00	62.39	57.49	57.86	49.55	43.67
Stdev	3.986	2.107	4.311	2.591	2.959	1.742
CV	5.694	3.377	7.499	4.478	5.971	3.988
Mod CV	6.847	8.000	8.000	6.239	6.985	6.000
Min	60.55	60.69	50.37	52.33	45.04	40.50
Max	75.48	66.46	60.84	61.48	56.61	46.14
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	62.13			52.74		40.23
B-Estimate		56.00	44.43		36.70	
A-Estimate	56.56	51.47	35.15	49.12	27.53	37.80
Method	Normal	Normal	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates						
B-Basis	60.54			50.73	42.72	38.50
B-Estimate		47.27	43.56			
A-Estimate	53.83	36.52	33.65	45.68	37.87	34.83
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-59 Statistics and Basis Values for OHC3 Strength Data normalized

Open-Hole Compression 3 Basis Values and Statistics						
	Strength as-measured [ksi]					
Env	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	67.76	59.82	55.04	56.02	47.94	42.25
Stdev	3.699	1.861	3.884	2.401	2.627	1.631
CV	5.459	3.112	7.056	4.287	5.479	3.860
Mod CV	6.729	8.000	8.000	6.144	6.739	6.000
Min	58.92	58.50	48.59	51.59	44.20	39.41
Max	72.82	63.40	58.49	59.31	54.47	44.47
No. Batches	3	1	1	3	3	3
No. Spec.	18	6	6	18	18	18
Basis Values and Estimates						
B-Basis	60.46			51.28	42.75	39.03
B-Estimate		54.18	43.28			
A-Estimate	55.28	50.17	34.91	47.92	39.08	36.75
Method	Normal	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	NA			49.22	41.56	37.25
B-Estimate		45.32	41.70			
A-Estimate		35.02	32.22	44.41	37.04	33.70
Method		Normal	Normal	Normal	Normal	Normal

Table 4-60 Statistics and Basis Values for OHC3 Strength Data as-measured

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

The FHC1 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: CTA, RTA, ETW1, and ETW2. All conditions tested 18 specimens from three batches of material.

For normalized strength non-modified CV dataset, condition CTA failed ADK test, so ANOVA method was used, while the rest of conditions passed the pooling tests, so pooling method was used for these. For modified CV, all conditions but ETW2 passed pooling tests, so pooling method was used. Condition ETW2 passed ADK test and normality test, so normal method was used.

For as-measured strength non-modified CV dataset, condition CTA failed ADK test, so ANOVA method was used, while the rest of conditions passed the pooling tests, so pooling method was used for these. For modified CV, all conditions but ETW2 passed pooling tests, so pooling method was used. Condition ETW2 passed ADK test and normality test, so normal method was used.

No statistical outliers were detected.

Statistics, B-basis values, and estimates are given for FHC1 strength data in Table 4-61 and Table 4-62. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-24.

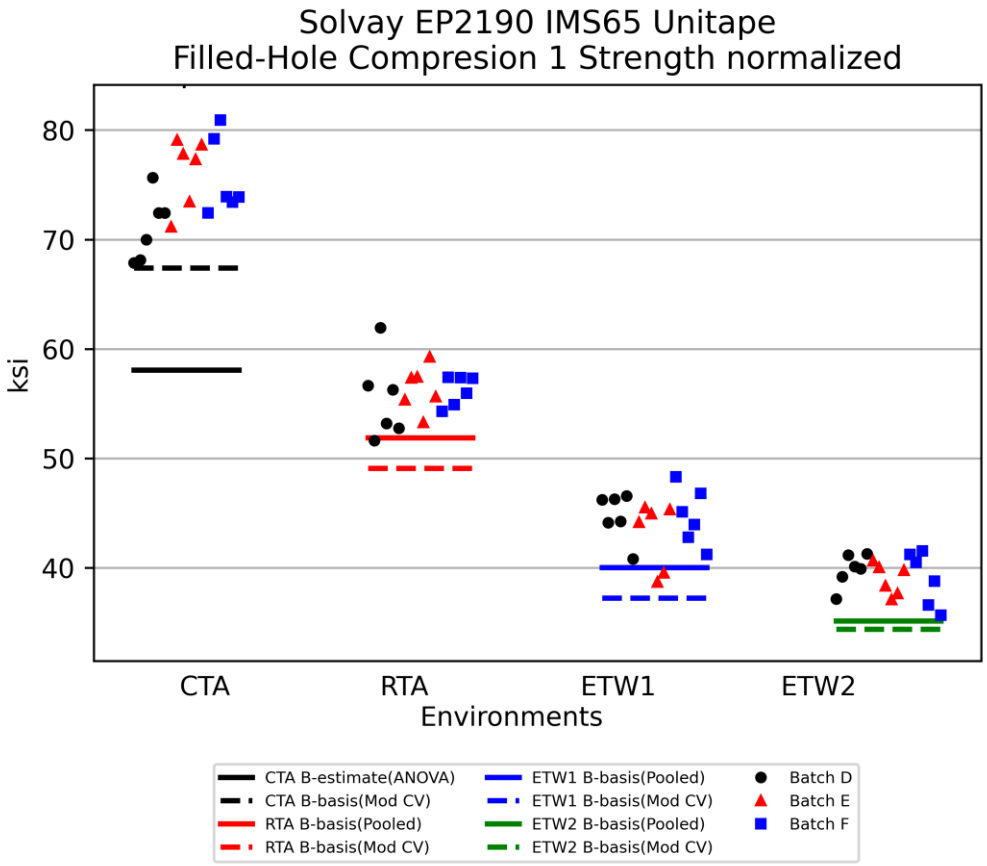

Figure 4-24 Batch plot for FHC1 normalized strength

Filled-Hole Compresion 1 Basis Values and Statistics				
	Strength normalized [ksi]			
Env	CTA(-67°F)	RTA(70°F)	ETW1(180°F)	ETW2(250°F)
Mean	74.31	56.00	44.14	39.25
Stdev	3.860	2.489	2.617	1.798
CV	5.195	4.444	5.928	4.581
Mod CV	6.597	6.222	6.964	6.290
Min	67.86	51.63	38.67	35.65
Max	80.90	61.92	48.30	41.53
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis		51.87	40.01	35.13
B-Estimate	58.08			
A-Estimate	46.50	49.12	37.26	32.37
Method	ANOVA	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	67.41	49.09	37.23	34.37
A-Estimate	62.80	44.48	32.62	30.92
Method	Pooled	Pooled	Pooled	Normal

Table 4-61 Statistics and Basis Values for FHC1 Strength Data normalized

Filled-Hole Compresion 1 Basis Values and Statistics				
	Strength as-measured [ksi]			
Env	CTA(-67°F)	RTA(70°F)	ETW1(180°F)	ETW2(250°F)
Mean	73.37	55.19	43.49	38.57
Stdev	3.995	2.554	2.704	1.885
CV	5.444	4.628	6.217	4.887
Mod CV	6.722	6.314	7.109	6.443
Min	66.16	50.67	37.91	34.99
Max	79.66	61.24	48.30	41.76
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis		50.93	39.23	34.31
B-Estimate	53.69			
A-Estimate	39.65	48.08	36.39	31.47
Method	ANOVA	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	66.44	48.25	36.56	33.67
A-Estimate	61.81	43.63	31.93	30.20
Method	Pooled	Pooled	Pooled	Normal

Table 4-62 Statistics and Basis Values for FHC1 Strength Data as-measured

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

The FHC2 data is normalized, so both normalized and as-measured results are provided. Testing was done in three environmental conditions: RTA, ETW1, and ETW2. The ETW1 condition tested specimens from only one batch of material, so only estimates of basis values can be provided for this condition.

For normalized strength non-modified CV dataset, all conditions passed ADK test and normality test, so normal method was used for computing allowables. For modified CV, the same test results are obtained.

For as-measured strength non-modified CV dataset, all conditions passed ADK test and normality test, so normal method was used for computing allowables. For modified CV, the same test results are obtained.

One statistical outlier was detected. The lowest value of batch F in the RTA dataset was a batch outlier for as-measured strength. It was retained for this analysis.

Statistics, B-basis values, and estimates are given for FHC2 strength data in Table 4-63. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-25.

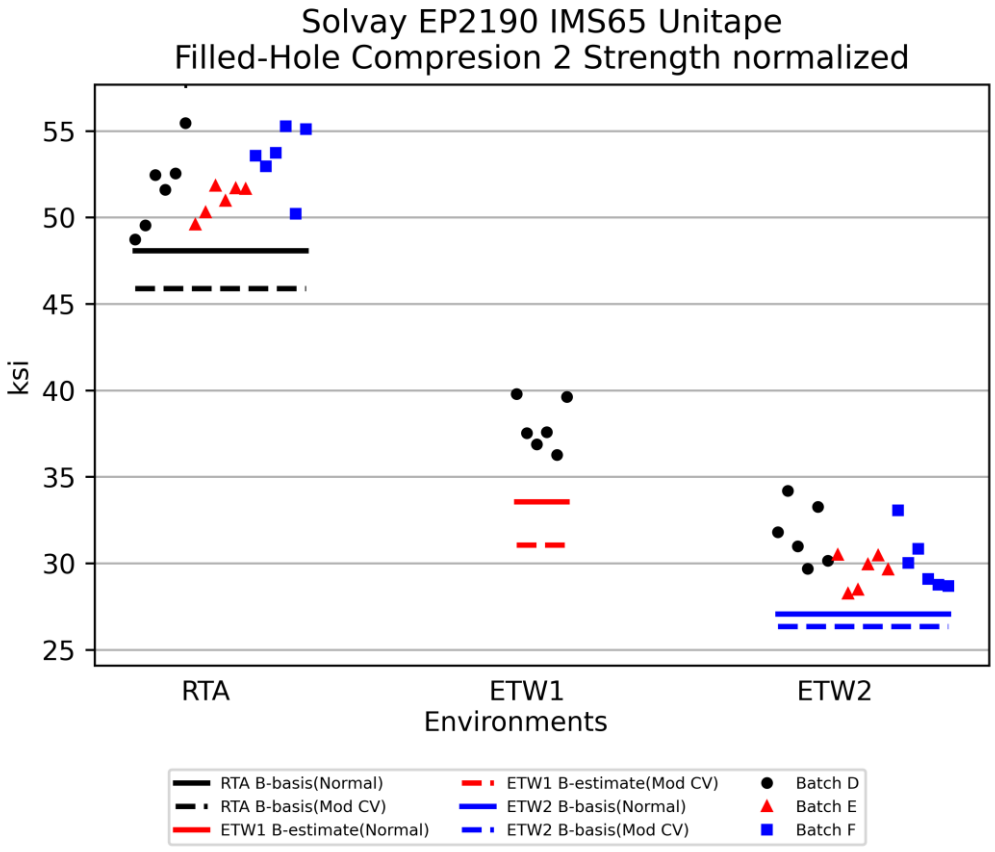

Figure 4-25 Batch plot for FHC2 normalized strength

Filled-Hole Compresion 2 Basis Values and Statistics						
	Strength normalized [ksi]			Strength as-measured [ksi]		
Env	RTA(70°F)	ETW1(180°F)	ETW2(250°F)	RTA(70°F)	ETW1(180°F)	ETW2(250°F)
Mean	52.06	37.94	30.43	50.43	36.34	29.46
Stdev	2.020	1.446	1.704	1.946	1.520	1.609
CV	3.880	3.810	5.601	3.858	4.184	5.460
Mod CV	6.000	8.000	6.801	6.000	8.000	6.730
Min	48.73	36.27	28.24	46.85	34.51	27.55
Max	55.46	39.79	34.18	53.55	38.45	32.89
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and Estimates						
B-Basis	48.07		27.06	46.59		26.29
B-Estimate		33.57			31.73	
A-Estimate	45.25	30.45	24.68	43.87	28.46	24.03
Method	Normal	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	45.89		26.34	44.46		25.55
B-Estimate		28.75			27.53	
A-Estimate	41.52	22.21	23.45	40.23	21.27	22.77
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-63 Statistics and Basis Values for FHC2 Strength Data

4.25 “50/40/10” Filled-Hole Compression 3 (FHC3)

The FHC3 data is normalized, so both normalized and as-measured results are provided. Testing was done in three environmental conditions: RTA, ETW1, and ETW2. The ETW1 condition tested specimens from only one batch of material, so only estimates of basis values can be provided for that conditions.

For normalized strength non-modified CV dataset, all conditions passed ADK test and normality test, so normal method was used for computing allowables. For modified CV, the same test results are obtained.

For as-measured strength non-modified CV dataset, all conditions passed ADK test and normality test, so normal method was used for computing allowables. For modified CV, the same test results are obtained.

No statistical outliers were detected.

Statistics, B-basis values, and estimates are given for FHC3 strength data in Table 4-64. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-26.

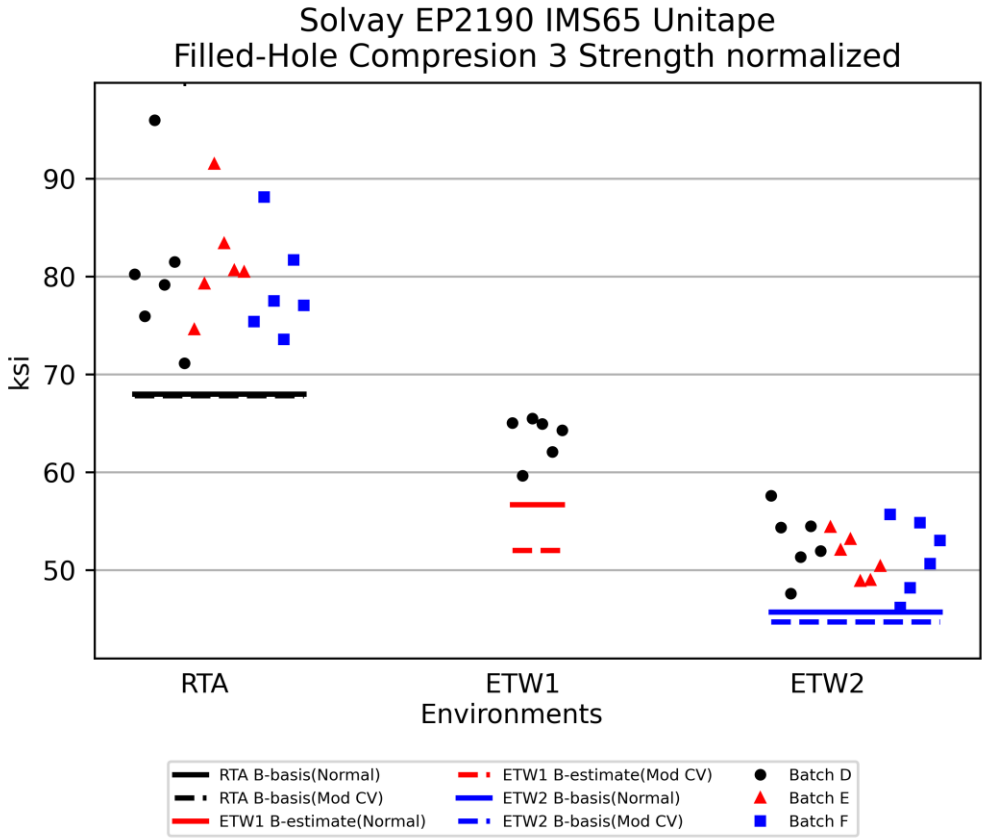

Figure 4-26 Batch plot for FHC3 normalized strength

Filled-Hole Compresion 3 Basis Values and Statistics						
	Strength normalized [ksi]			Strength as-measured [ksi]		
Env	RTA(70°F)	ETW1(180°F)	ETW2(250°F)	RTA(70°F)	ETW1(180°F)	ETW2(250°F)
Mean	80.39	63.57	51.86	77.85	60.74	50.21
Stdev	6.282	2.274	3.110	6.236	2.223	2.910
CV	7.815	3.577	5.997	8.010	3.660	5.796
Mod CV	7.908	8.000	6.999	8.010	8.000	6.898
Min	71.13	59.64	46.18	67.57	57.34	44.82
Max	95.97	65.48	57.60	92.18	63.00	55.42
No. Batches	3	1	3	3	1	3
No. Spec.	18	6	18	18	6	18
Basis Values and Estimates						
B-Basis	67.98		45.72	65.54		44.46
B-Estimate		56.68			54.01	
A-Estimate	59.19	51.79	41.37	56.82	49.22	40.39
Method	Normal	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates						
B-Basis	67.84		44.70	65.54		43.37
B-Estimate		48.17			46.02	
A-Estimate	58.94	37.21	39.62	56.82	35.55	38.52
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-64 Statistics and Basis Values for FHC3 Strength Data

4.26 “25/50/25” Single Shear Bearing 1 (SSB1)

The SSB1 data is normalized, so both normalized and as-measured results are provided. Testing was done in five environmental conditions: CTA, RTA, ETW1, ETW2, and ETW3 and for two material properties 2% Offset Strength and Ultimate Strength.

For 2% Offset Strength normalized non-modified CV dataset, condition CTA passed ADK test but failed distribution tests, so non-parametric method was used for this. Condition RTA failed ADK test, so ANOVA method was used. Since RTA has less than 5 batches, the results are estimates rather than basis values. The rest of conditions passed ADK and normality tests, so normal method was used. For modified CV, all conditions passed pooling tests, so pooling method was used.

For 2% Offset Strength as-measured non-modified CV dataset, condition RTA failed ADK test, so ANOVA method was used. Since RTA has less than 5 batches, the results are estimates rather than basis values. The rest of conditions passed ADK and normality tests, so normal method was used. For modified CV, RTA failed ADK test, so results are not available (NA). The rest of conditions passed normality test, so normal method was used.

For Ultimate Strength normalized non-modified CV dataset, all conditions passed the pooling tests, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used.

For Ultimate Strength as-measured non-modified CV dataset, all conditions passed the pooling tests, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used.

Six statistical outliers were detected. For 2% Offset strength normalized, the highest value in batch F for condition CTA is a batch outlier. For 2% Offset strength normalized, the highest value in batch F for condition ETW1 is a batch and condition outlier. For 2% Offset strength as-measured, the highest value in batch F for condition CTA is a batch outlier. For 2% Offset strength as-measured, the highest value in batch F for condition ETW1 is a batch and condition outlier. For Ultimate strength as-measured, the lowest value in batch D for condition RTA is a batch outlier. For Ultimate strength normalized, the highest value in batch D for condition CTA is a condition outlier. All outliers were retained for this analysis.

Statistics, B-basis values, and estimates are given for SSB1 strength data in Table 4-65, Table 4-66, Table 4-67, and Table 4-68. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-27 and Figure 4-28.

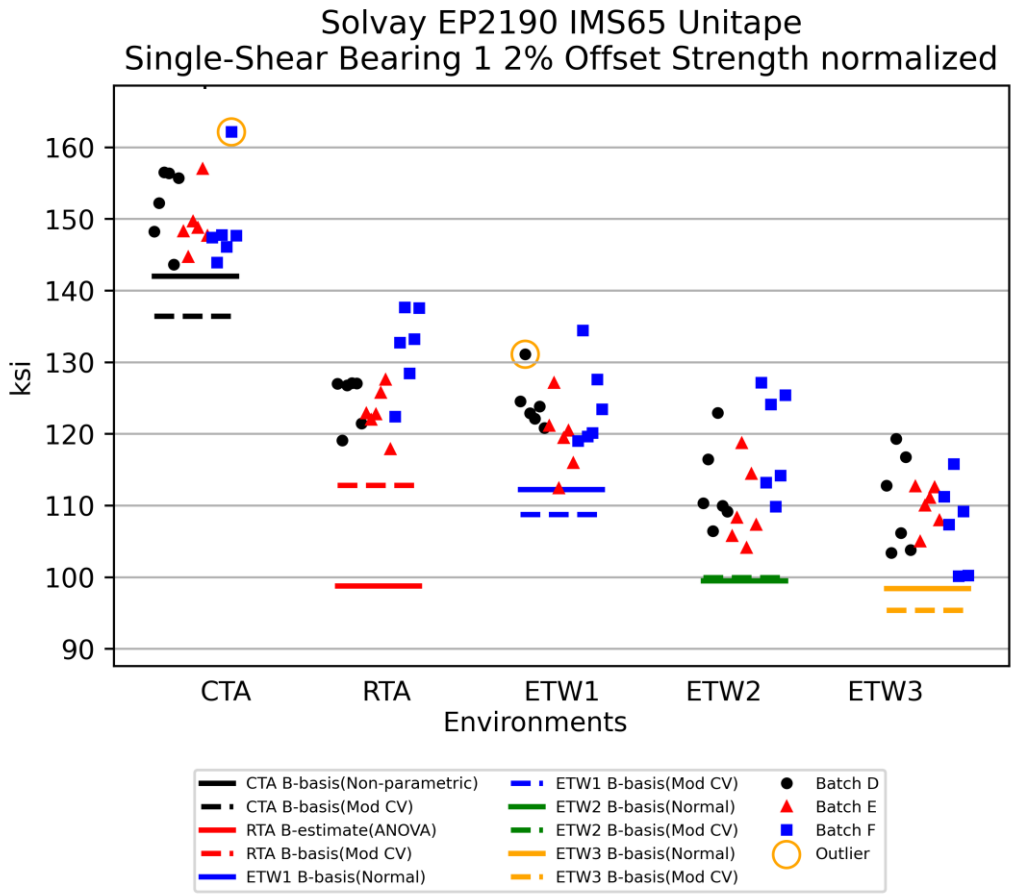

Figure 4-27 Batch plot for SSB1 2% Offset Strength normalized

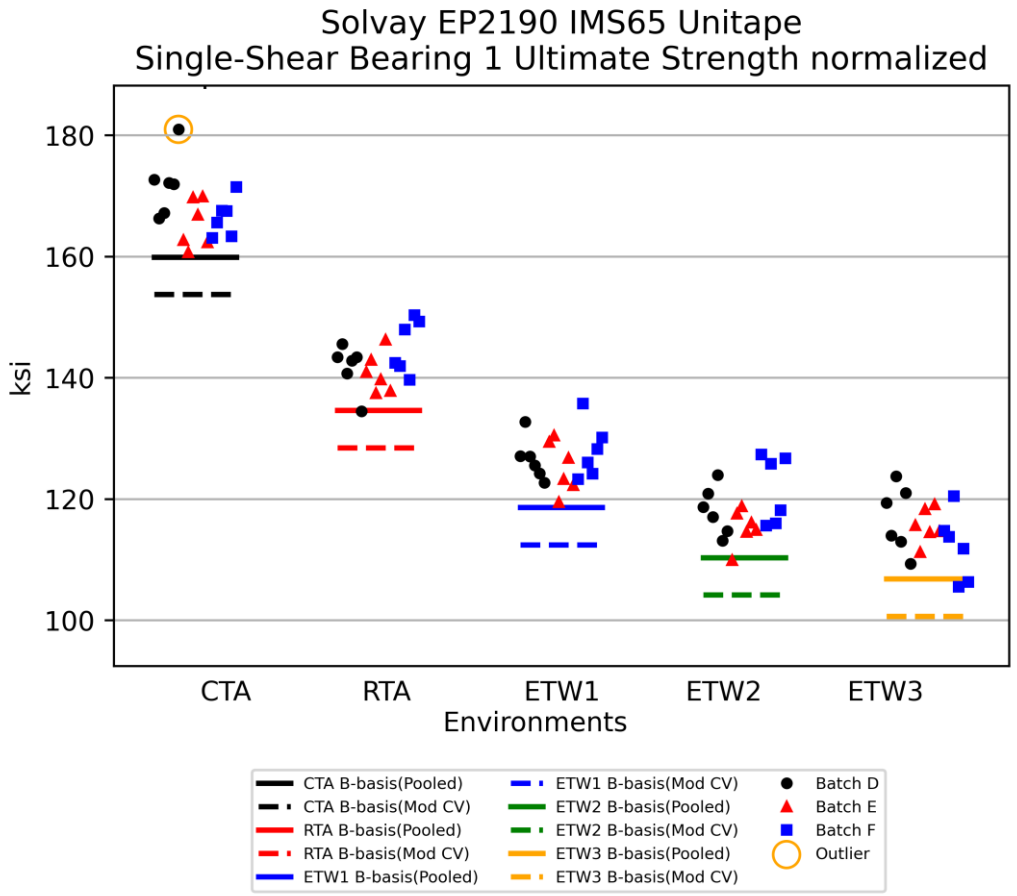

Figure 4-28 Batch plot for SSB1 Ultimate Strength normalized

Single-Shear Bearing 1 Basis Values and Statistics					
	2% Offset Strength normalized [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	150.2	126.6	122.5	113.7	109.2
Stdev	5.250	5.723	5.206	7.212	5.447
CV	3.496	4.521	4.249	6.341	4.989
Mod CV	6.000	6.260	6.124	7.170	6.495
Min	143.6	117.8	112.4	104.1	100.1
Max	162.1	137.6	134.4	127.1	119.3
No. Batches	3	3	3	3	3
No. Spec.	18	18	18	18	18
Basis Values and Estimates					
B-Basis	142.0		112.3	99.50	98.41
B-Estimate		98.80			
A-Estimate	119.8	78.97	104.97	89.41	90.79
Method	Non-parametric	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates					
B-Basis	136.4	112.8	108.8	99.96	95.39
A-Estimate	127.4	103.8	99.75	90.96	86.38
Method	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-65 Statistics and Basis Values for SSB1 2% Offset Strength normalized

Single-Shear Bearing 1 Basis Values and Statistics					
	2% Offset Strength as-measured [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	147.8	125.0	121.1	112.0	107.7
Stdev	4.909	6.893	5.712	7.352	5.593
CV	3.320	5.516	4.718	6.566	5.194
Mod CV	6.000	6.758	6.359	7.283	6.597
Min	139.1	115.1	110.7	102.8	98.58
Max	160.2	139.4	136.7	125.7	117.0
No. Batches	3	3	3	3	3
No. Spec.	18	18	18	18	18
Basis Values and Estimates					
B-Basis	138.2		109.8	97.45	96.65
B-Estimate		87.37			
A-Estimate	131.3	60.54	101.8	87.16	88.82
Method	Normal	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates					
B-Basis	130.3	NA	105.9	95.86	93.67
A-Estimate	117.9		95.10	84.45	83.73
Method	Normal		Normal	Normal	Normal

Table 4-66 Statistics and Basis Values for SSB1 2% Offset Strength as-measured

Single-Shear Bearing 1 Basis Values and Statistics					
	Ultimate Strength normalized [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	167.9	142.6	126.6	118.3	114.8
Stdev	4.926	4.177	4.053	4.879	4.957
CV	2.934	2.929	3.202	4.124	4.318
Mod CV	6.000	6.000	6.000	6.062	6.159
Min	160.7	134.5	119.5	109.9	105.5
Max	181.0	150.3	135.7	127.4	123.7
No. Batches	3	3	3	3	3
No. Spec.	18	18	18	18	18
Basis Values and Estimates					
B-Basis	159.9	134.6	118.6	110.3	106.8
A-Estimate	154.7	129.4	113.4	105.1	101.6
Method	Pooled	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates					
B-Basis	153.7	128.5	112.5	104.2	100.7
A-Estimate	144.5	119.2	103.2	94.94	91.43
Method	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-67 Statistics and Basis Values for SSB1 Ultimate Strength normalized

Single-Shear Bearing 1 Basis Values and Statistics					
	Ultimate Strength as-measured [ksi]				
Env	CTA(-67°F)	RTA(75°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	165.4	140.8	125.1	116.5	113.2
Stdev	4.353	5.400	4.896	5.185	5.033
CV	2.632	3.836	3.915	4.451	4.444
Mod CV	6.000	6.000	6.000	6.226	6.222
Min	157.5	131.2	117.6	107.8	103.9
Max	175.5	153.4	138.0	127.0	121.5
No. Batches	3	3	3	3	3
No. Spec.	18	18	18	18	18
Basis Values and Estimates					
B-Basis	156.8	132.1	116.5	107.8	104.6
A-Estimate	151.1	126.5	110.8	102.2	98.99
Method	Pooled	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates					
B-Basis	151.4	126.7	111.1	102.5	99.23
A-Estimate	142.2	117.6	101.9	93.28	90.06
Method	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-68 Statistics and Basis Values for SSB1 Ultimate Strength as-measured

4.27 “10/80/10” Single Shear Bearing 2 (SSB2)

The SSB2 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: RTA, ETW1, ETW2, and ETW3.

For 2% Offset Strength normalized non-modified CV dataset, all conditions passed the pooling tests, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used. For 2% Offset Strength as-measured non-modified CV dataset, all conditions passed the pooling tests, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used.

For Ultimate Strength normalized non-modified CV dataset, condition ETW1 failed ADK test, so ANOVA method was used. The rest of conditions passed normality test, so normal method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used. For Ultimate Strength as-measured non-modified CV dataset, all conditions passed the pooling tests, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used.

No statistical outliers were detected.

Statistics, B-basis values, and estimates are given for SSB2 strength data in Table 4-69, Table 4-70, Table 4-71, and Table 4-72. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-29 and Figure 4-30.

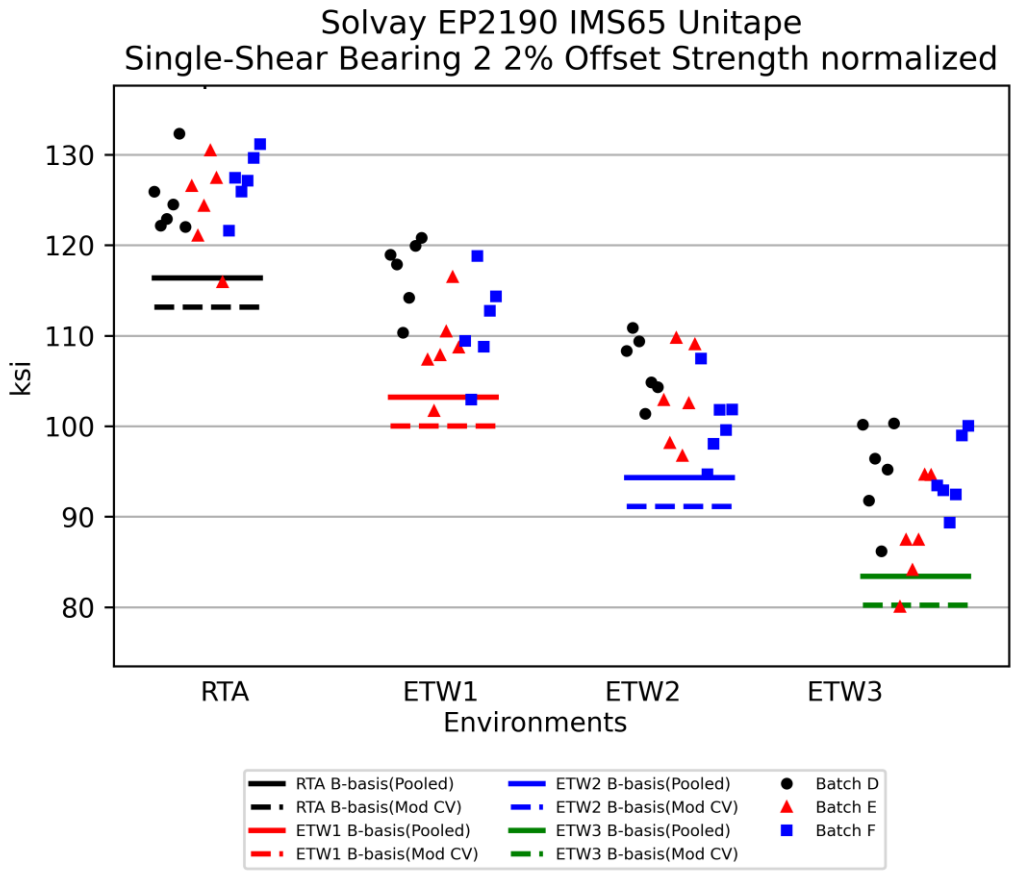

Figure 4-29 Batch plot for SSB2 2% Offset Strength normalized

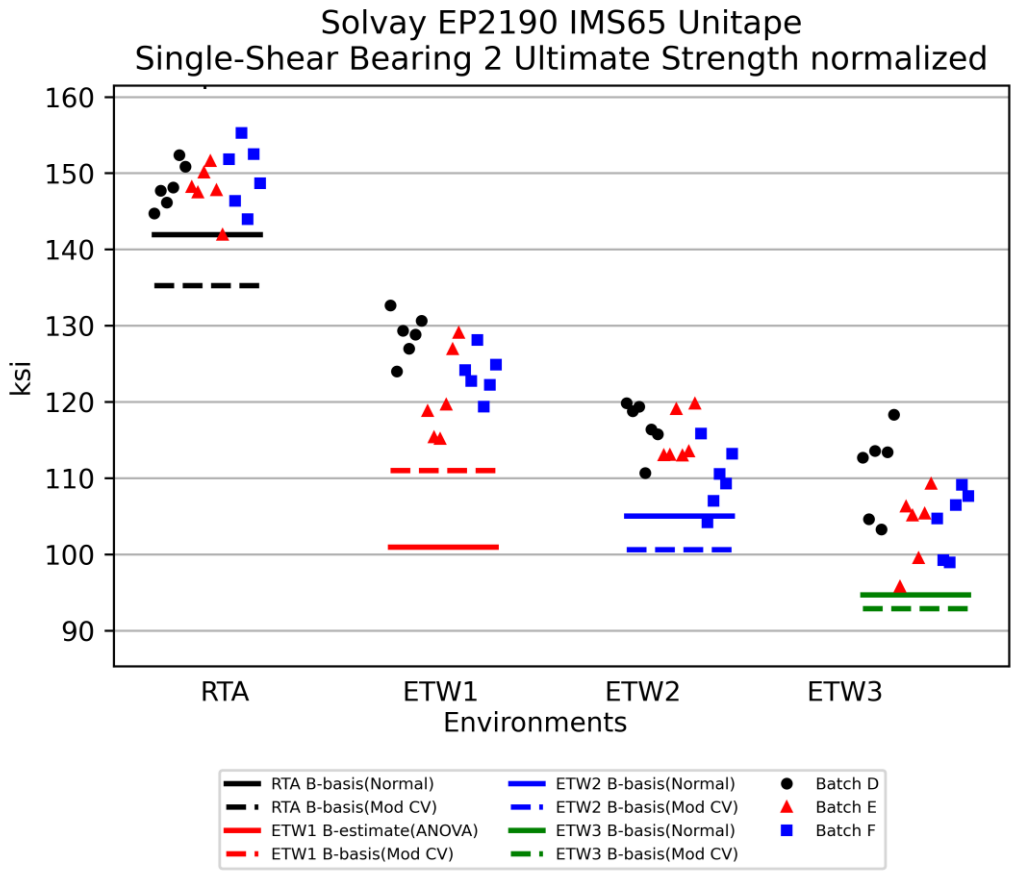

Figure 4-30 Batch plot for SSB2 Ultimate Strength normalized

Single-Shear Bearing 2 Basis Values and Statistics				
	2% Offset Strength normalized [ksi]			
Env	RTA(70°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	125.5	112.3	103.4	92.53
Stdev	4.144	5.743	4.902	5.837
CV	3.303	5.114	4.740	6.309
Mod CV	6.000	6.557	6.370	7.154
Min	115.9	101.7	94.70	80.03
Max	132.3	120.8	110.9	100.3
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	116.4	103.2	94.34	83.45
A-Estimate	110.4	97.25	88.35	77.46
Method	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	113.2	100.0	91.13	80.24
A-Estimate	105.1	91.93	83.04	72.15
Method	Pooled	Pooled	Pooled	Pooled

Table 4-69 Statistics and Basis Values for SSB2 2% Offset Strength normalized

Single-Shear Bearing 2 Basis Values and Statistics				
	2% Offset Strength as-measured [ksi]			
Env	RTA(75°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	121.4	108.7	99.92	89.53
Stdev	4.115	4.852	4.824	5.471
CV	3.391	4.465	4.828	6.111
Mod CV	6.000	6.232	6.414	7.055
Min	113.8	98.83	92.15	78.08
Max	127.6	116.2	107.1	96.99
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	112.9	100.2	91.47	81.09
A-Estimate	107.3	94.65	85.90	75.52
Method	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	109.7	96.96	88.21	77.83
A-Estimate	101.9	89.25	80.50	70.12
Method	Pooled	Pooled	Pooled	Pooled

Table 4-70 Statistics and Basis Values for SSB2 2% Offset Strength as-measured

Single-Shear Bearing 2 Basis Values and Statistics				
	Ultimate Strength normalized [ksi]			
Env	RTA(70°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	148.6	124.4	114.0	106.3
Stdev	3.394	5.172	4.542	5.870
CV	2.283	4.159	3.984	5.523
Mod CV	6.000	6.079	6.000	6.761
Min	141.9	115.1	104.2	95.75
Max	155.3	132.7	119.8	118.3
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	141.9		105.0	94.69
B-Estimate		101.0		
A-Estimate	137.2	84.27	98.68	86.48
Method	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates				
B-Basis	135.3	111.0	100.6	92.90
A-Estimate	126.4	102.2	91.80	84.08
Method	Pooled	Pooled	Pooled	Pooled

Table 4-71 Statistics and Basis Values for SSB2 Ultimate Strength normalized

Single-Shear Bearing 2 Basis Values and Statistics				
	Ultimate Strength as-measured [ksi]			
Env	RTA(70°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	143.8	120.4	110.1	102.8
Stdev	3.760	4.496	4.544	4.905
CV	2.615	3.736	4.126	4.770
Mod CV	6.000	6.000	6.063	6.385
Min	138.7	112.1	101.4	93.41
Max	152.3	127.8	116.9	111.6
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	136.0	112.6	102.4	95.06
A-Estimate	130.9	107.5	97.27	89.94
Method	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	131.0	107.6	97.37	90.04
A-Estimate	122.6	99.17	88.95	81.63
Method	Pooled	Pooled	Pooled	Pooled

Table 4-72 Statistics and Basis Values for SSB2 Ultimate Strength as-measured

4.28 “50/40/10” Single Shear Bearing 3 (SSB3)

The SSB3 data is normalized, so both normalized and as-measured results are provided. Testing was done in four environmental conditions: RTA, ETW1, ETW2, and ETW3.

For 2% Offset Strength normalized non-modified CV dataset, condition RTA and ETW1 passed the pooling tests, so pooling method was used. Condition ETW2 failed ADK test, so ANOVA method was used. Condition ETW3 passed ADK test but failed normality test, so Weibull method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used. For 2% Offset Strength as-measured non-modified CV dataset, condition ETW3 passed ADK test but failed normality test, so Weibull method was used. The rest of conditions passed the pooling tests, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used.

For Ultimate Strength normalized non-modified CV dataset, conditions ETW2 and ETW3 failed ADK test, so ANOVA method was used. The rest of conditions passed pooling test, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used. For Ultimate Strength as-measured non-modified CV dataset, all conditions passed the pooling tests, so pooling method was used. For modified CV, all conditions passed the pooling tests, so pooling method was used.

Six statistical outliers were detected. For 2% Offset strength normalized, the highest value in batch F for condition RTA is a batch outlier. For 2% Offset strength normalized, the highest value in batch F for condition ETW2 is a batch outlier. For 2% Offset strength normalized, the lowest value in batch D for condition ETW1 is a batch outlier. For 2% Offset strength as-measured, the highest value in batch F for condition ETW2 is a batch and condition outlier. For Ultimate strength as-measured, the highest value in batch F for condition ETW2 is a condition outlier. For Ultimate strength normalized, the highest value in batch F for condition ETW2 is a batch outlier. All outliers were retained for this analysis.

Statistics, B-basis values, and estimates are given for SSB3 strength data in Table 4-73, Table 4-74, Table 4-75, and Table 4-76. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-31 and Figure 4-32.

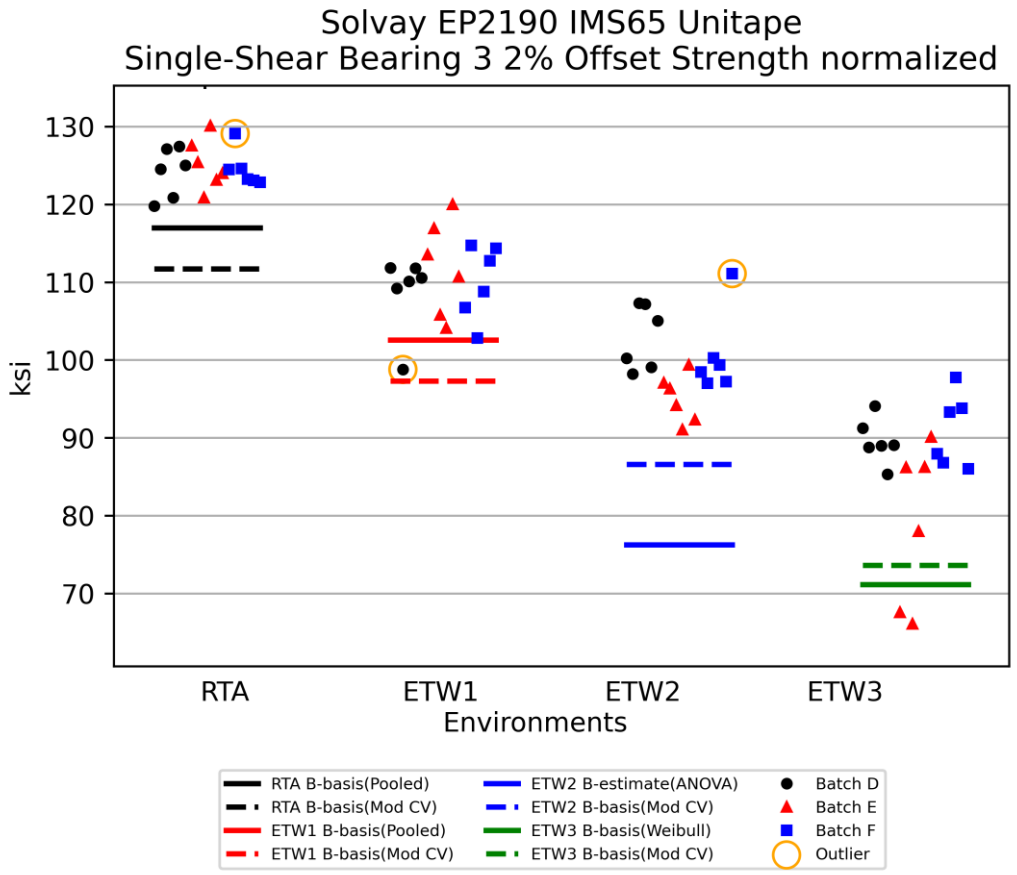

Figure 4-31 Batch plot for SSB3 2% Offset Strength normalized

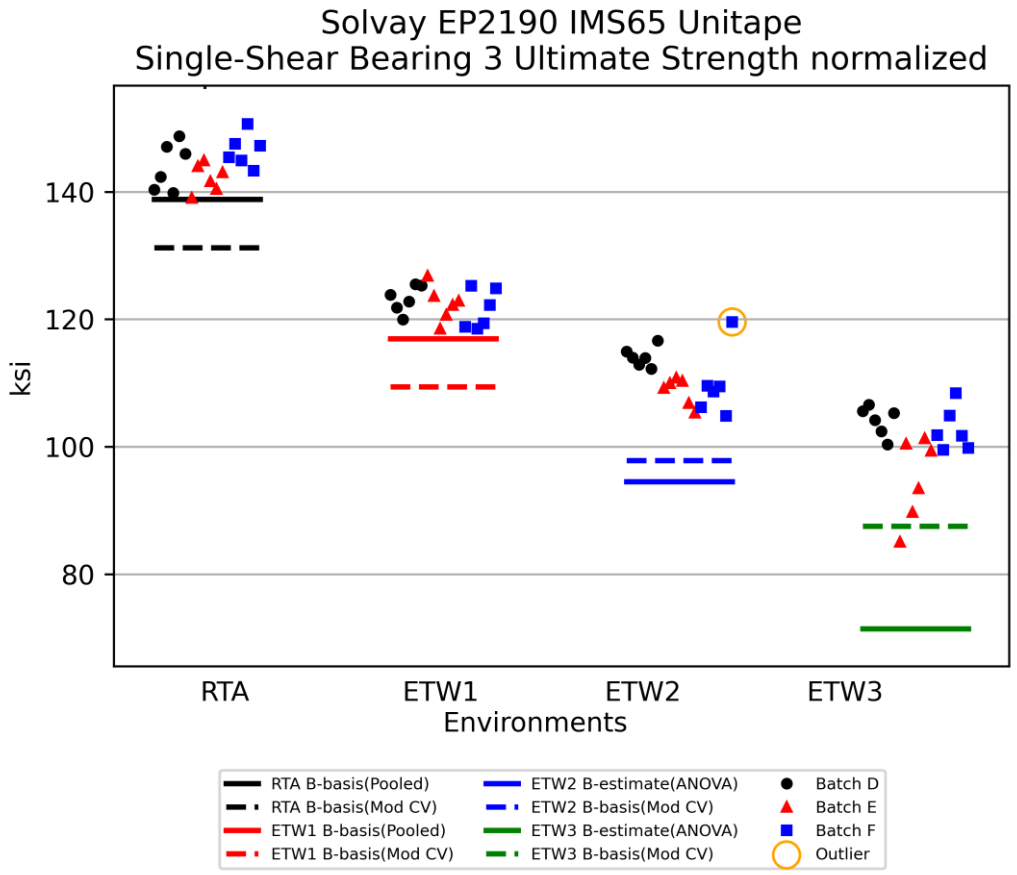

Figure 4-32 Batch plot for SSB3 Ultimate Strength normalized

Single-Shear Bearing 3 Basis Values and Statistics				
	2% Offset Strength normalized [ksi]			
Env	RTA(70°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	124.6	110.2	99.48	86.52
Stdev	2.817	5.192	5.247	8.363
CV	2.261	4.712	5.274	9.666
Mod CV	6.000	6.356	6.637	9.666
Min	119.8	98.78	91.03	66.09
Max	130.1	120.0	111.1	97.75
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	117.0	102.6		71.09
B-Estimate			76.25	
A-Estimate	111.8	97.41	59.70	56.76
Method	Pooled	Pooled	ANOVA	Weibull
Modified CV Basis Values and Estimates				
B-Basis	111.7	97.29	86.59	73.62
A-Estimate	103.2	88.79	78.08	65.12
Method	Pooled	Pooled	Pooled	Pooled

Table 4-73 Statistics and Basis Values for SSB3 2% Offset Strength normalized

Single-Shear Bearing 3 Basis Values and Statistics				
	2% Offset Strength as-measured [ksi]			
Env	RTA(75°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	120.5	106.5	95.89	83.58
Stdev	3.849	5.253	4.492	8.011
CV	3.195	4.933	4.684	9.584
Mod CV	6.000	6.466	6.342	9.584
Min	111.9	95.54	89.43	64.65
Max	127.8	117.1	108.0	94.79
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	112.4	98.41	87.80	68.01
A-Estimate	107.0	93.02	82.41	53.75
Method	Pooled	Pooled	Pooled	Weibull
Modified CV Basis Values and Estimates				
B-Basis	108.1	94.13	83.53	71.22
A-Estimate	99.93	85.98	75.37	63.07
Method	Pooled	Pooled	Pooled	Pooled

Table 4-74 Statistics and Basis Values for SSB3 2% Offset Strength as-measured

Single-Shear Bearing 3 Basis Values and Statistics				
	Ultimate Strength normalized [ksi]			
Env	RTA(70°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	144.2	122.4	110.8	100.5
Stdev	3.288	2.630	3.973	5.922
CV	2.279	2.149	3.584	5.890
Mod CV	6.000	6.000	6.000	6.945
Min	139.0	118.5	104.8	85.06
Max	150.7	126.8	119.6	108.4
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis	138.8	117.0		
B-Estimate			94.51	71.40
A-Estimate	135.1	113.3	82.87	50.62
Method	Pooled	Pooled	ANOVA	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	131.2	109.4	97.85	87.55
A-Estimate	122.7	100.8	89.29	78.98
Method	Pooled	Pooled	Pooled	Pooled

Table 4-75 Statistics and Basis Values for SSB3 Ultimate Strength normalized

Single-Shear Bearing 3 Basis Values and Statistics				
	Ultimate Strength as-measured			
Env	RTA(75°F)	ETW1(180°F)	ETW2(225°F)	ETW3(250°F)
Mean	139.4	118.3	106.9	97.13
Stdev	4.007	2.508	3.340	5.530
CV	2.874	2.120	3.126	5.694
Mod CV	6.000	6.000	6.000	6.847
Min	129.4	114.0	101.3	82.99
Max	145.5	123.4	116.3	105.1
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Values and Estimates				
B-Basis		113.3	100.3	86.22
B-Estimate	119.1			
A-Estimate	104.7	109.8	95.59	78.48
Method	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates				
B-Basis	126.9	105.8	94.35	84.62
A-Estimate	118.7	97.51	86.10	76.37
Method	Pooled	Pooled	Pooled	Pooled

Table 4-76 Statistics and Basis Values for SSB3 Ultimate Strength as-measured

4.29 “25/50/25” Compression After Impact 1 (CAI1)

The CAI1 data is normalized, so both normalized and as-measured results are provided. Testing was done in six environmental conditions: CTA, RTA, ETA2, ETA3, ETW1, and ETW3. Only the RTA, ETW1 and ETW2 conditions tested specimens from three batches of material, so estimates of basis values can be provided for remaining conditions.

For the normalized dataset, RTA and ETW2 conditions failed the Anderson Darling k-sample test (ADK test) for batch to batch variability. So, ANOVA method was used. With fewer than five batches, results are considered estimates. ETW1 condition passed ADK test but failed normality test, so Weibull method was used. The rest of conditions passed ADK and normality tests, so normal method was used. When the dataset was transformed according to the assumptions of the modified CV method, all conditions passed ADK test and normality test, so normal method was used.

For the as-measured dataset, RTA and ETW2 conditions failed the Anderson Darling k-sample test (ADK test) for batch to batch variability. So, ANOVA method was used. With fewer than five batches, results are considered estimates. ETW1 condition passed ADK test but failed normality and all distribution tests, so Non-parametric method was used. The rest of conditions passed ADK and normality tests, so normal method was used. When the dataset was transformed according to the assumptions of the modified CV method, all conditions passed ADK test and normality test, so normal method was used.

There were two statistical outliers, the lowest value for batch D in condition ETW1 is a batch outlier for both normalized and as-measured.

Statistics, B-basis values, and estimates are given for CAI1 strength data in Table 4-77 and Table 4-78. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-33.

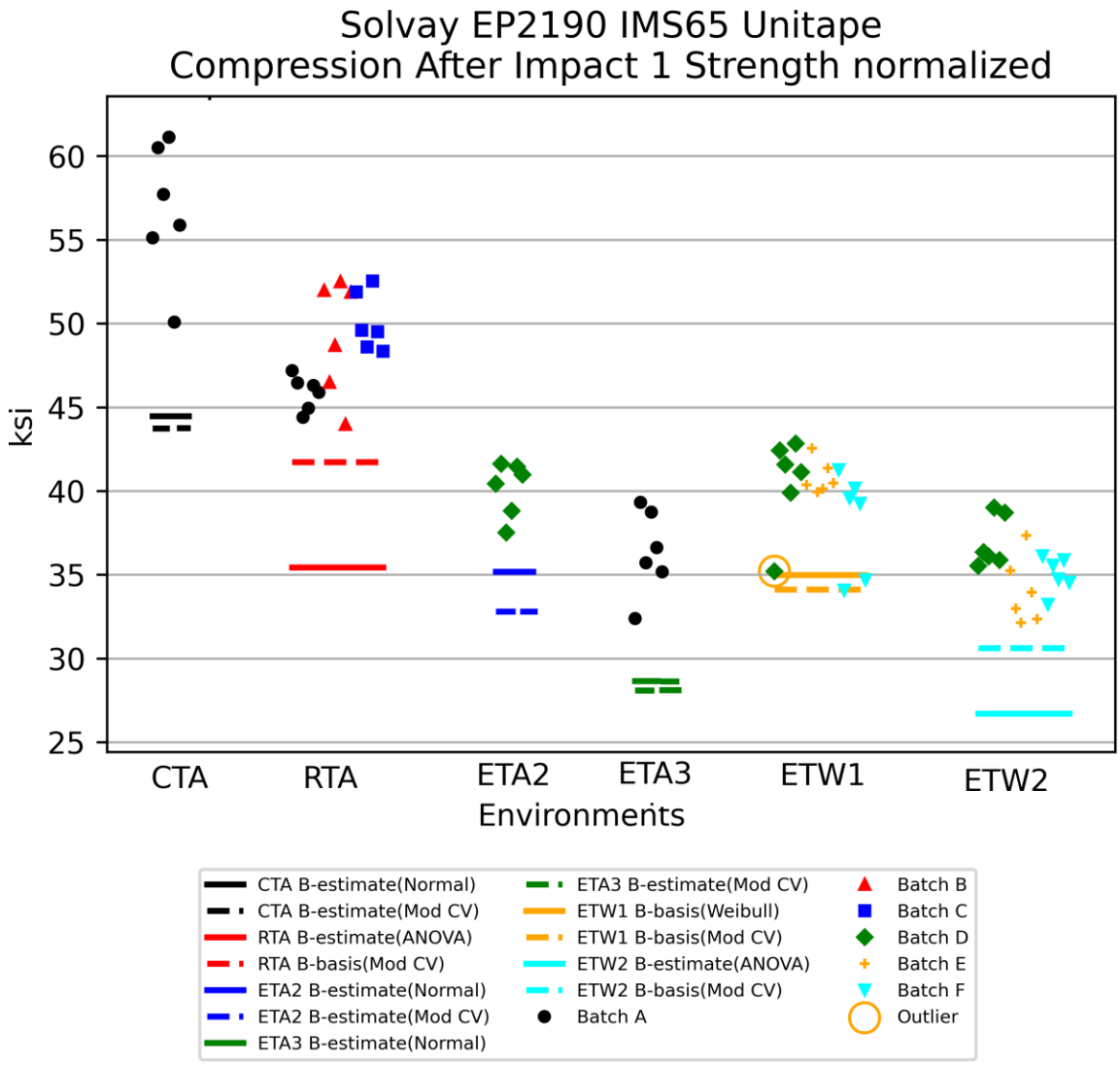

Figure 4-33 Batch plot for CAI1 Strength normalized

Compression After Impact 1 Basis Values and Statistics						
	Strength normalized [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	56.74	48.40	40.13	36.33	39.83	35.31
Stdev	4.052	2.877	1.635	2.534	2.593	1.938
CV	7.140	5.943	4.074	6.975	6.511	5.489
Mod CV	8.000	6.972	8.000	8.000	7.256	6.745
Min	50.09	43.96	37.51	32.38	34.07	32.13
Max	61.13	52.54	41.62	39.32	42.83	39.00
No. Batches	1	3	1	1	3	3
No. Spec.	6	18	6	6	18	18
Basis Values and Estimates						
B-Basis					35.01	
B-Estimate	44.47	35.45	35.18	28.65		26.70
A-Estimate	35.74	26.21	31.66	23.20	30.15	20.57
Method	Normal	ANOVA	Normal	Normal	Weibull	ANOVA
Modified CV Basis Values and Estimates						
B-Basis		41.74			34.12	30.61
B-Estimate	42.99		30.41	27.52		
A-Estimate	33.22	37.02	23.49	21.26	30.08	27.28
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-77 Statistics and Basis Values for CAI1 Strength normalized

Compression After Impact 1 Basis Values and Statistics						
	Strength as-measured [ksi]					
Env	CTA(-67°F)	RTA(75°F)	ETA2(225°F)	ETA3(250°F)	ETW1(180°F)	ETW2(225°F)
Mean	54.19	46.13	38.99	34.82	39.25	34.77
Stdev	3.881	2.682	1.549	2.467	2.303	1.877
CV	7.161	5.814	3.974	7.084	5.866	5.398
Mod CV	8.000	6.907	8.000	8.000	6.933	6.699
Min	47.69	42.13	36.57	31.00	34.31	31.46
Max	58.33	50.13	40.56	37.82	41.80	37.98
No. Batches	1	3	1	1	3	3
No. Spec.	6	18	6	6	18	18
Basis Values and Estimates						
B-Basis					32.60	31.07
B-Estimate	42.43	34.31	34.29	27.35		
A-Estimate	34.08	25.89	30.96	22.04	25.53	28.44
Method	Normal	ANOVA	Normal	Normal	Non-parametric	Normal
Modified CV Basis Values and Estimates						
B-Basis		39.84			33.88	30.17
B-Estimate	41.06		29.54	26.38		
A-Estimate	31.72	35.38	22.82	20.38	30.07	26.92
Method	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-78 Statistics and Basis Values for CAI1 Strength as-measured

5. Outliers

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

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

All outliers identified were investigated to determine if a cause could be found. Outliers with causes were removed from the dataset and the remaining specimens were analyzed for this report. Information about specimens that were removed from the dataset along with the cause for removal is documented in the material property data report, NCAMP Test Report CAM-RP-2022-001.

Outliers for which no causes could be identified are listed in tables 5-1 to 5-5. These outliers were included in the analysis for their respective test properties.

Test Method	Condition	Batch	Specimen Number	Property	Value	High/Low	Batch Outlier	Condition Outlier
OHC1	ETA3	A	TR7694389-P4-OHC1-A-C1-ETA3-6	Strength as-measured	34.01	Low	Yes	No
OHC1	ETW3	F	NTP2190Q1-WRX-IMS-SOL-OHC1-F-C2-1-ETW3-3	Strength as-measured	34.04	High	Yes	No
OHC1	ETA3	A	TR7694389-P4-OHC1-A-C1-ETA3-6	Strength normalized	35.57	Low	Yes	No
OHC1	ETW2	E	NTP2190Q1-WRX-IMS-SOL-OHC1-E-C1-1-ETW2-1	Strength normalized	37.53	High	Yes	No
OHC3	RTA	D	NTP2190Q1-WRX-IMS-SOL-OHC3-D-C1-1-RTA-1	Strength as-measured	62.39	Low	Yes	No
OHC3	ETA2	D	NTP2190Q1-WRX-IMS-SOL-OHC3-D-C2-1-ETA2-2	Strength as-measured	63.40	High	Yes	Yes
OHC3	ETA2	D	NTP2190Q1-WRX-IMS-SOL-OHC3-D-C2-1-ETA2-2	Strength normalized	66.46	High	Yes	Yes
OHT1	RTA	B	TR7702826-P2-OHT1-B-C1-RTA-6	Strength as-measured	67.55	Low	Yes	No
OHT1	ETW2	D	NTP2190Q1-WRX-IMS-SOL-OHT1-D-C2-1-ETW2-1	Strength as-measured	80.91	High	Yes	No
OHT2	RTA	D	NTP2190Q1-WRX-IMS-SOL-OHT2-D-C1-1-RTA-1	Strength as-measured	50.81	High	Yes	Yes
OHT2	RTA	D	NTP2190Q1-WRX-IMS-SOL-OHT2-D-C1-1-RTA-1	Strength normalized	52.99	High	Yes	Yes
OHT2	RTA	E	NTP2190Q1-WRX-IMS-SOL-OHT2-E-C2-1-RTA-3	Strength normalized	48.92	Low	Yes	No
OHT3	ETW2	E	NTP2190Q1-WRX-IMS-SOL-OHT3-E-C2-1-ETW2-4	Strength as-measured	157.0	High	Yes	No

Table 5-1 List of Outliers for OHC & OHT

Test Method	Condition	Batch	Specimen Number	Property	Value	High/Low	Batch Outlier	Condition Outlier
SSB1	CTA	F	NTP2190Q1-WRX-IMS-SOL-SSB1-F-C2-1-CTA-2	2% Offset Strength as-measured	160.2	High	Yes	No
SSB1	ETW1	F	NTP2190Q1-WRX-IMS-SOL-SSB1-F-C1-1-ETW1-2	2% Offset Strength as-measured	136.7	High	Yes	Yes
SSB1	RTA	D	NTP2190Q1-WRX-IMS-SOL-SSB1-D-C2-1-RTA-3	Ultimate Strength as-measured	131.2	Low	Yes	No
SSB1	CTA	F	NTP2190Q1-WRX-IMS-SOL-SSB1-F-C2-1-CTA-2	2% Offset Strength normalized	162.1	High	Yes	No
SSB1	ETW1	D	NTP2190Q1-WRX-IMS-SOL-SSB1-D-C1-1-ETW1-2	2% Offset Strength normalized	131.1	High	Yes	No
SSB1	CTA	D	NTP2190Q1-WRX-IMS-SOL-SSB1-D-C2-1-CTA-3	Ultimate Strength normalized	181.0	High	No	Yes
SSB3	ETW2	F	NTP2190Q1-WRX-IMS-SOL-SSB3-F-C2-1-ETW2-3	2% Offset Strength as-measured	108.0	High	Yes	Yes
SSB3	ETW2	F	NTP2190Q1-WRX-IMS-SOL-SSB3-F-C2-1-ETW2-3	Ultimate Strength as-measured	116.3	High	No	Yes
SSB3	RTA	F	NTP2190Q1-WRX-IMS-SOL-SSB3-F-C1-1-RTA-2	2% Offset Strength normalized	129.1	High	Yes	No
SSB3	ETW1	D	NTP2190Q1-WRX-IMS-SOL-SSB3-D-C1-1-ETW1-3	2% Offset Strength normalized	98.78	Low	Yes	No
SSB3	ETW2	F	NTP2190Q1-WRX-IMS-SOL-SSB3-F-C2-1-ETW2-3	2% Offset Strength normalized	111.1	High	Yes	No
SSB3	ETW2	F	NTP2190Q1-WRX-IMS-SOL-SSB3-F-C2-1-ETW2-3	Ultimate Strength normalized	119.6	High	Yes	No

Table 5-2 List of Outliers for SSB

Test Method	Condition	Batch	Specimen Number	Property	Value	High/Low	Batch Outlier	Condition Outlier
UNC1	ETW3	E	NTP2190Q1-WRX-IMS-SOL-UNC1-E-C2-1-ETW3-2	Strength as-measured	43.54	Low	No	Yes
UNC1	ETW3	E	NTP2190Q1-WRX-IMS-SOL-UNC1-E-C2-1-ETW3-2	Strength normalized	44.03	Low	No	Yes
UNC2	RTA	D	NTP2190Q1-WRX-IMS-SOL-UNC2-D-C2-1-RTA-2	Strength as-measured	58.68	Low	Yes	No
UNC2	RTA	E	NTP2190Q1-WRX-IMS-SOL-UNC2-E-C1-1-RTA-1	Strength as-measured	68.89	High	Yes	No
UNC2	ETW3	F	NTP2190Q1-WRX-IMS-SOL-UNC2-F-C2-1-ETW3-1	Strength as-measured	29.28	Low	Yes	No
UNC2	RTA	D	NTP2190Q1-WRX-IMS-SOL-UNC2-D-C2-1-RTA-2	Strength normalized	61.93	Low	Yes	No
UNC2	RTA	E	NTP2190Q1-WRX-IMS-SOL-UNC2-E-C1-1-RTA-1	Strength normalized	70.12	High	Yes	No
UNC2	ETA3	D	NTP2190Q1-WRX-IMS-SOL-UNC2-D-C2-1-ETA3-3	Strength normalized	47.36	Low	Yes	Yes
UNC2	ETW3	F	NTP2190Q1-WRX-IMS-SOL-UNC2-F-C2-1-ETW3-1	Strength normalized	30.20	Low	Yes	No
UNC3	RTA	D	NTP2190Q1-WRX-IMS-SOL-UNC3-D-C1-1-RTA-2	Strength as-measured	120.0	Low	Yes	No
UNC3	ETW2	D	NTP2190Q1-WRX-IMS-SOL-UNC3-D-C1-1-ETW2-1	Strength as-measured	100.7	High	Yes	No
UNC3	RTA	D	NTP2190Q1-WRX-IMS-SOL-UNC3-D-C1-1-RTA-2	Strength normalized	124.9	Low	Yes	No
UNC3	ETW2	D	NTP2190Q1-WRX-IMS-SOL-UNC3-D-C1-1-ETW2-1	Strength normalized	104.6	High	Yes	No

Table 5-3 List of Outliers for UNC

Test Method	Condition	Batch	Specimen Number	Property	Value	High/Low	Batch Outlier	Condition Outlier
UNT2	RTA	E	NTP2190Q1-WRX-IMS-SOL-UNT2-E-C1-1-RTA-2	Strength as-measured	76.74	Low	Yes	Yes
UNT2	ETW1	F	NTP2190Q1-WRX-IMS-SOL-UNT2-F-C2-1-ETW1-2	Strength as-measured	75.65	High	Yes	No
UNT2	CTA	F	NTP2190Q1-WRX-IMS-SOL-UNT2-F-C1-1-CTA-3	Strength normalized	84.27	Low	No	Yes
UNT2	RTA	E	NTP2190Q1-WRX-IMS-SOL-UNT2-E-C1-1-RTA-2	Strength normalized	79.14	Low	Yes	Yes
UNT2	ETW1	F	NTP2190Q1-WRX-IMS-SOL-UNT2-F-C2-1-ETW1-2	Strength normalized	77.47	High	Yes	No
UNT3	ETW1	E	NTP2190Q1-WRX-IMS-SOL-UNT3-E-C2-1-ETW1-3	Strength as-measured	194.4	Low	Yes	No
UNT3	ETW1	E	NTP2190Q1-WRX-IMS-SOL-UNT3-E-C2-1-ETW1-3	Strength normalized	199.1	Low	Yes	No

Table 5-4 List of Outliers for UNT

Test Method	Condition	Batch	Specimen Number	Property	Value	High/Low	Batch Outlier	Condition Outlier
CAI1	ETW1	D	NTP2190Q1-WRX-IMS-SOL-CAI1-D-C1-1-ETW1-1	Strength as-measured	34.31	Low	Yes	No
CAI1	ETW1	D	NTP2190Q1-WRX-IMS-SOL-CAI1-D-C1-1-ETW1-1	Strength normalized	35.21	Low	Yes	No
FHC2	RTA	F	NTP2190Q1-WRX-IMS-SOL-FHC2-F-C2-1-RTA-2	Strength as-measured	48.35	Low	Yes	No
FHT2	CTA	E	NTP2190Q1-WRX-IMS-SOL-FHT2-E-C1-1-CTA-3	Strength as-measured	66.77	High	No	Yes
FHT3	ETW2	F	NTP2190Q1-WRX-IMS-SOL-FHT3-F-C2-1-ETW2-3	Strength normalized	131.2	Low	Yes	No
FLEX0	ETW2	D	NTP2190Q1-WRX-IMS-SOL-0FLEX-D-C1-1-ETW2-1	Strength as-measured	188.2	High	Yes	No
FLEX0	ETW2	E	NTP2190Q1-WRX-IMS-SOL-0FLEX-E-C1-1-ETW2-3	Strength as-measured	170.2	High	Yes	No
FLEX0	ETW2	D	NTP2190Q1-WRX-IMS-SOL-0FLEX-D-C1-1-ETW2-1	Strength normalized	195.6	High	Yes	Yes
IPS	CTA	A	TR7694211-P2-IPS-A-C1-CTA-4	0.2% Offset Strength	8.610	Low	Yes	No
IPS	RTA	B	TR7702799-P1-IPS-B-C1-RTA-1	0.2% Offset Strength	5.520	Low	Yes	No
IPS	ETW3	F	NTP2190Q1-WRX-IMS-SOL-IPS-F-C1-1-ETW3-6	Strength at 5% Strain	4.590	High	No	Yes
LC	RTA	A	TR7602786-P1-LCS-A-C1-RTA-1	Strength as-measured	204.8	High	Yes	No
LC	ETW1	F	NTP2190Q1-WRX-IMS-SOL-LCS-F-C2-1-ETW1-3	Strength as-measured	128.9	Low	Yes	Yes
LC	RTA	A	TR7602786-P1-LCS-A-C1-RTA-1	Strength normalized	213.9	High	Yes	No
LC	ETW1	F	NTP2190Q1-WRX-IMS-SOL-LCS-F-C2-1-ETW1-3	Strength normalized	134.1	Low	Yes	Yes
LT	ETW2	F	NTP2190Q1-WRX-IMS-SOL-LT-F-C2-1-ETW2-1	Strength normalized	319.3	Low	No	Yes
SBS	ETW3	F	NTP2190Q1-WRX-IMS-SOL-SBS-F-C1-1-ETW3-1	Strength	6.260	High	Yes	No
TC	ETA2	D	NTP2190Q1-WRX-IMS-SOL-TCS-D-C2-1-ETA2-2	Strength	28.34	High	Yes	Yes
TT	CTA	D	NTP2190Q1-WRX-IMS-SOL-TT-D-C2-1-CTA-2	Strength	14.85	High	Yes	No
TT	RTA	A	TR7602701-P1-TT-A-C1-RTA-6	Strength	7.760	Low	No	Yes
TT	ETA3	E	NTP2190Q1-WRX-IMS-SOL-TT-E-C1-1-ETA3-1	Strength	6.230	Low	Yes	No

Table 5-5 List of Outliers for Remaining Properties

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