



Stratasys Inc. Additively Manufactured Antero(R) 840CN03 Material Allowables Statistical Analysis Report

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Testing Facility:

National Institute for Aviation Research
Wichita State University
1845 N. Fairmount
Wichita, KS 67260

Test Coupon Print Facility:

Fabricator #1:

NIAR
1845 Fairmount
Wichita, KS. 67260-0093

Fabricator #2:

SDM
815 Kirkley Blvd.
Belton, TX. 76513

Fabricator #3:

Northrop Gruman
1 Space Park Dr.
Redondo Beach, CA. 90278

Fabricator #4:

Raytheon
2000 El Segundo Blvd.
El Segundo, CA. 90245

Fabricator #5:

NAVAIR
48066 Shaw Rd. Bldg. 2188
Patuxent River, MD 20670

Fabricator #6:

Blue Origin
21601 76th Ave. S.
Kent, WA. 98032

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Prepared by:

Sylvina Castillo

Reviewed by:

Jorge Chavez-Salas

Robert Lindsted

Approved by:

Royal Lovingfoss



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1. Introduction

This report contains statistical analysis of the Stratasy Inc. Additively Manufactured Antero(R) 840CN03 material property data published in NCAMP Test Report CAM-RP-2025-031 Rev - . The lamina and laminate material property data have been generated with NCAMP oversight through NCAMP Project Number NPN 062201 and also meet the requirements outlined in NCAMP Standard Operating Procedure NSP 100. The test panels and test specimens have been inspected by NCAMP Authorized Inspection Representatives (AIR) and the testing has been witnessed by NCAMP Authorized Engineering Representatives (AER).

B-Basis values, A-estimates, and B-estimates were calculated using a variety of techniques that are detailed in section 2. The qualification material was procured to NCAMP Material Specification NMS 840/1 Rev N/C , dated 08/16/2023. The qualification test panels were cured in accordance with NCAMP Process Specification NPS 88400, dated 04/24/2024. The NCAMP Test Plan NTP AM-8400Q1 was used for this qualification program.

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

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

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

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

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

Part fabricators that wish to utilize the material property data, allowables, and specifications may be able to do so by demonstrating the capability to reproduce the original material properties; a process known as equivalency. More information about this equivalency process including the test statistics and its limitations can be found in CMH-17 Handbook Volume 7. publicly. 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 CMH-17 Handbook Volume 7. The equivalency process is borrowed from PMC industry's process.

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 840/1 Rev-. NMS 840/1 Rev- has additional requirements that are listed in its material process control document (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 840/1 Rev-. NMS 840/1 Rev- is a free, publicly available, non-proprietary aerospace industry material specification.*

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1.1 Symbols and Abbreviations

Test Property	Abbreviation
Dogbone Tension	T
Compression Cube	C
Flexural	F
Filled Hole Tension	FHT
Open Hole Tension	OHT
Single Shear Bearing	SSB
Rail Shear	RS

Table 1-1: Test Property Abbreviations

Environmental Condition	Abbreviation	Temperature
Cold Temperature Ambient	CTA	$-95 \pm 5^{\circ}\text{F}$
Room Temperature Ambient	RTA	$70 \pm 10^{\circ}\text{F}$
Room Temperature Wet	RTW	$70 \pm 10^{\circ}\text{F}$
Elevated Temperature Ambient	ETA	$250 \pm 5^{\circ}\text{F}$
Elevated Temperature Wet	ETW	$180 \pm 5^{\circ}\text{F}$

Table 1-2: Environmental Conditions Abbreviations

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2025-031 Rev - .

1.2 Pooling Across Environments

When pooling across environments was allowable, the pooled co-efficient of variation was used. CMH-17 STATS (CMH-17 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 CMH-17 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 Vol 1. It is a method of adjusting the original basis values downward in anticipation of the expected additional variation. Composite materials are expected to have a CV of at least 6%. The modified coefficient of variation (CV) method increases the measured coefficient of variation when it is below 8% prior to computing basis values. A higher CV will result in lower or more conservative basis values and lower specification limits. The use of the modified CV method is intended for a temporary period of time when there is minimal data available. When a sufficient number of production batches

(approximately 8 to 15) have been produced and tested, the as-measured CV may be used so that the basis values and specification limits may be adjusted higher.

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

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

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

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

2. Background

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

2.1 CMH-17 STATS Statistical Formulas and Computations

This section contains the details of the specific formulas CMH-17 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:

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

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

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

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

2.1.2 Statistics for Pooled Data

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

2.1.2.1 Pooled Standard Deviation

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

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

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

2.1.2.2 Pooled Coefficient of Variation

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

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

2.1.3 Basis Value Computations

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

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

2.1.3.1 K-factor computations

K_a and K_b are computed according to the methodology documented in Chapter 8 of the CMH-17 Vol 1 Handbook. The approximation formulas are given below:

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

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

Where

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

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

$$f = N-r$$

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

Equation 9

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

Equation 10

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

Equation 11

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

Equation 12

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

Equation 13

2.1.4 Modified Coefficient of Variation

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

$$\text{Modified CV} = CV^* = \begin{cases} .06 & \text{if } CV < .04 \\ \frac{CV}{2} + .04 & \text{if } .04 \leq CV < .08 \\ CV & \text{if } CV \geq .08 \end{cases}$$

Equation 14

This is converted to percent by multiplying by 100%.

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

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

Equation 15

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

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

Equation 16

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

2.1.4.1 Transformation of data based on Modified CV

In order to determine if the data would pass the diagnostic tests under the assumption of the modified CV, the data must be transformed such that the batch means remain the

same while the standard deviation of transformed data (all batches) matches the modified standard deviation.

To accomplish this requires a transformation in two steps:

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

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

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

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

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

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

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

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

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

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

2.1.5 Determination of Outliers

All outliers are identified in text and graphics. If an outlier is removed from the dataset, it will be specified and the reason why will be documented in the text. Outliers are identified as described in section 8.3.3.1 of the CMH-17 Vol 1 Handbook.

$$MNR = \frac{\max_{all\ i} |X_i - \bar{X}|}{S}, i = 1 \dots n \quad \text{Equation 23}$$

$$C = \frac{n-1}{\sqrt{n}} \sqrt{\frac{t^2}{n-2+t^2}}$$

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 $z_{(1)}, z_{(2)}, \dots, z_{(L)}$, 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:

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

Equation 25

Where

n_i = the number of test specimens in each batch

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

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 $\frac{1}{2}$ 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 $\frac{1}{2}$ the number of values in this group which are equal to $z_{(j)}$.

The critical value for the test statistic at $1-\alpha$ level is computed:

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

Equation 26

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

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

Equation 27

With

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

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

2.1.7 The Anderson Darling Test for Normality

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

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

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

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

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

The Anderson Darling test statistic (AD) is:

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

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

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

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

2.1.8 Levene's Test for Equality of Coefficient of Variation

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

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

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

2.1.9 Distribution Tests

In addition to testing for normality using the Anderson-Darling test (see 2.1.7), CMH-17 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, \dots, x_n , and the sample observations ordered from least to greatest by $X(1), \dots, X(n)$.

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

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

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

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

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

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

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

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

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

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

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

2.1.9.3.1 Estimating Weibull Parameters

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

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

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

CMH-17 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

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

The Anderson-Darling test statistic is

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

and the observed significance level is

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

where

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

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

the hypothesis that the population has a two-parameter Weibull distribution is not rejected. For further information on these procedures, see reference 6.

2.1.9.3.3 Basis value calculations for the Weibull distribution

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

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

where

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

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

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

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.

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

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

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

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

Table 2-1: Weibull Distribution Basis Value Factors

2.1.9.4 Lognormal Distribution

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

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

2.1.9.4.1 Goodness-of-fit test for the Lognormal distribution

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

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

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

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

2.1.9.4.2 Basis value calculations for the Lognormal distribution

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

2.1.10 Non-parametric Basis Values

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

2.1.10.1 Non-parametric Basis Values for large samples

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

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

For B-basis values:

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

For A-Basis values:

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

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

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

2.1.10.2 Non-parametric Basis Values for small samples

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

The Hanson-Koopmans B-basis value is:

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

The A-basis value is:

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

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

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

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

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

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

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

2.1.11 Analysis of Variance (ANOVA) Basis Values

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

2.1.11.1 Calculation of basis values using ANOVA

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

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

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

$$SSB = \sum_{i=1}^k n_i \bar{x}_i^2 - n \bar{x}^2 \quad \text{Equation 52}$$

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

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

$$SSE = SST - SSB \quad \text{Equation 54}$$

Next, the mean sums of squares are computed:

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

$$MSE = \frac{SSE}{n-k} \quad \text{Equation 56}$$

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

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

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

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

Two k-factors are computed using the methods described in section 8.3 of the CMH-17 Vol 1 Handbook using a sample size of n (denoted k₀) and a sample size of k (denoted k₁). Whether this value is an A- or B-basis value depends only on whether k₀ and k₁ are computed for A or B-basis values.

Denote the ratio of mean squares by

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

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

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

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

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

2.2 Single Batch and Two Batch Estimates using Modified CV

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

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

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

2.3 Specification Limits

Specification limits are calculated based on the qualification dataset only. In order to compute specification limits we make the following assumptions:

a) The qualification dataset represents the population¹

b) In the future we might run an acceptance test for the new sample statistics (this is a hypothesis testing approach; testing the hypothesis that the sample statistics equal the population parameters with $\alpha = 1\%$). Then, the specification limits are computed as the limits required by the statistics of the future sample to pass the acceptance test. The statistics to be tested are be the modulus mean, the strength mean or the strength minimum individual of the qualification dataset. In the case of modulus mean, a two-tails interval is used. In case of strength mean and strength minimum individual, a one-tail left interval is used.

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:

$W_{\text{mean}} = W_{\text{mean}} = \text{Specification limit for the mean}$

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

We compute these as the following:

$$W_{\text{mean}} = \bar{x} - k_n^{\text{mean}} \cdot S \quad \text{Equation 64}$$

$$W_{\text{min indiv}} = \bar{x} - k_n^{\text{min indiv}} \cdot S \quad \text{Equation 65}$$

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

For modulus properties we define:

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

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

We compute these as the following:

$$W_{\text{lower}} = \bar{x} - k \cdot S \quad \text{Equation 66}$$

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.

$$W_{upper} = \bar{x} + k.S$$

Equation 67

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

$$k = t_c \cdot \sqrt{\left(\frac{1}{N} + \frac{1}{n}\right)}$$

Equation 68

and

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

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.

2.3.1.1 Specification Limits for Program

Specification limits for this program are detailed in Table 2-5 for strength properties and in Table 2-6 for modulus properties.

Test Property	Test Condition	Mean [ksi]	CV (%)	Mod CV (%)	k_mean	k_min indiv	As-is		Mod CV		Notes
							W_mean [ksi]	W_min indiv [ksi]	W_mean [ksi]	W_min indiv [ksi]	
Dogbone Tension XZ Strength As-Measured	RTA (70°F)	13.48	5.118	6.559	1.143	3.072	12.69	11.36	12.47	10.76	Qualification Data Only
Dogbone Tension ZX Strength As-Measured	RTA (70°F)	7.807	11.29	11.29	1.143	3.072	6.800	5.101	6.800	5.101	Qualification Data Only

Table 2-5: Specification Limits for Strength Properties.

Test Property	Test Condition	Mean [Msi]	CV (%)	Mod CV (%)	t_statistic	As-is		Mod CV		Notes
						Lower Limit [Msi]	Upper Limit [Msi]	Lower Limit [Msi]	Upper Limit [Msi]	
Dogbone Tension XZ Modulus As-Measured	RTA (70°F)	0.4850	2.290	6.000	2.744	0.4704	0.4997	0.4469	0.5231	Qualification Data Only
Dogbone Tension ZX Modulus As-Measured	RTA (70°F)	0.4356	3.191	6.000	2.744	0.4172	0.4539	0.4014	0.4698	Qualification Data Only

Table 2-6: Specification Limits for Modulus Properties.

3. Summary of Results

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

3.1 NCAMP Recommended B-Basis Values

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

1. Only B-basis values that meet all requirements of CMH-17 Vol 1 are recommended.
2. Modified CV basis values are preferred. Recommended values will be the modified CV basis value when available. The CV provided with the recommended basis value will be the one used in the computation of the basis value.
3. Only normalized basis values are given for properties that are normalized.
4. ANOVA B-basis values are not recommended since only three batches of material are available and CMH-17 Vol 1 recommends that no less than five batches be used when computing basis values with the ANOVA method.
5. Basis values of 90% or more of the mean value imply that the CV is unusually low and may not be conservative. Caution is recommended with B-Basis values calculated from CMH-17 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-RTW-ETA-ETW trend of the basis values is not consistent with the CTA-RTA-RTW-ETA-ETW trend of the average values), then the B-basis values will not be recommended.

NCAMP Recommended B-Basis Values for STRATASYS INC. ADDITIVELY MANUFACTURED ANTERO(R) 840CN03 All B-Basis Values in this Table Meet the Standards for Publication in the CMH-17 Volume 1 Handbook Values Are for As Measured Data															
				Environmental Condition											
				CTA (-95 °F)			RTA (70 °F)			ETA (250 °F)			ETW (180 °F)		
Method	Orientation	Test	Unit	B-Basis	Mean	CV	B-Basis	Mean	CV	B-Basis	Mean	CV	B-Basis	Mean	CV
Dogbone Tension	XY	0.2% Offset Strength	ksi	7.839	8.885	7.593	6.710	7.754	7.402	NA: A	5.305	6.067	5.288	6.019	6.904
		Strength		NA: A	14.76	10.60	9.818	11.03	6.272	5.274	5.918	6.190	6.751*	7.411	5.063
	XZ	0.2% Offset Strength		8.725	10.28	7.866	8.513	9.295	6.000	6.006	6.788	6.000	6.831	7.613	6.000
		Strength		NA: A	17.24	10.57	11.92	13.48	6.559	6.632	7.413	6.000	8.286	9.386	6.670
	Z45	0.2% Offset Strength		7.586	8.772	7.567	7.283	7.975	6.217	4.808	5.500	6.578	5.652	6.345	6.321
		Strength		NA: A	10.73	15.74	NA: A	11.16	6.769	NA: A	5.972	5.070	6.712	7.590	6.584
	ZX	0.2% Offset Strength		NA: I	8.523	7.099	NA: I	7.861	3.461	4.717	5.289	6.154	5.583	6.263	6.078
		Strength		NA: A	8.274	13.33	6.259	7.807	11.29	5.191	5.859	6.489	NA: A	7.303	9.051
Compression Cube	XY	0.2% Offset Strength	ksi	NA: A	12.91	10.29	NA: A	11.64	14.07	6.467	7.318	6.624	7.862	8.965	7.005
		1% Offset Strength		17.97	19.79	6.423	12.13	13.94	6.241	NA: I	7.776	1.742	NA: I	9.931	3.025
		2% Offset Strength		20.22	22.89	3.878	NA: I	14.08	1.897	NA: I	7.718	2.046			
		Compressive Strength		21.07	23.55	6.000	NA: A	14.52	3.785	7.135	7.977	6.012	9.057	10.21	6.432
	XZ	0.2% Offset Strength		11.49	13.27	7.608	NA: A	11.63	15.71	6.514	7.353	6.494	7.529	8.911	8.826
		1% Offset Strength		17.85	20.20	6.473	12.48	14.04	6.316	NA: I	7.840	1.222	NA: I	9.829	6.412
		2% Offset Strength		NA: I	23.11	2.828	NA: I	14.17	2.772	NA: I	7.788	0.8452			
		Compressive Strength		21.00	23.48	6.000	13.88*	14.62	3.636	7.180	8.026	6.000	8.979	10.16	6.598
	Z45	0.2% Offset Strength		11.31	13.23	10.22	NA: A	11.66	13.62	5.984	6.897	7.535	7.541	8.712	7.651
		1% Offset Strength		NA: A	19.84	6.639	12.34*	13.68	5.570	NA: I	7.265	4.195	8.527	9.615	6.000
		2% Offset Strength		NA: I	22.78	4.778	NA: A	14.12	3.996	NA: I	7.399	3.822	NA: I	9.669	3.115
		Compressive Strength		NA: A	23.19	4.711	13.64*	14.40	3.711	6.461	7.320	6.563	8.684	9.772	6.339
	ZX	0.2% Offset Strength		11.84	13.50	6.967	NA: A	11.66	15.84	6.375	7.168	6.588	7.811	8.955	7.271
		1% Offset Strength		18.18	20.32	6.000	12.94*	13.94	4.085				NA: I	10.07	5.558
		2% Offset Strength		NA: I	23.04	3.255	13.98*	14.49	2.969						
		Compressive Strength		21.37	23.89	6.000	13.87*	14.61	3.318	7.148*	7.890	4.757	9.090	10.24	6.404
FLEX	XY	0.2% Offset Strength	ksi	15.55	17.36	6.795	12.39	14.21	6.978	NA: A	9.919	7.973	10.38	11.65	6.188
		Flexural Strength		17.66	24.86	6.596	17.04*	18.70	5.050	NA: A	11.40	8.289	12.62	14.13	6.096
	XZ	0.2% Offset Strength		20.16*	22.24	6.284	15.87	17.95	6.000	9.644	11.80	6.399	12.81	14.72	6.714
		Flexural Strength		27.62	30.88	6.000	20.76*	22.38	2.936	10.35	12.42	5.820	14.29	16.10	6.406
	Z45	0.2% Offset Strength		NA: I	15.98	7.105	12.51	14.32	6.949	NA: A	8.901	7.827	NA: A	10.91	5.059
		Flexural Strength		9.671	13.57	18.48	11.68	15.58	13.86	NA: A	9.837	7.559	11.26	12.61	6.107
	ZX	0.2% Offset Strength		NA: I	17.78	17.78	NA: I	14.79	3.729	NA: A	9.279	7.065	10.11	11.51	6.931
		Flexural Strength		NA: A	12.65	22.39	9.414	13.58	17.46	NA: A	10.11	7.374	11.31	12.84	6.786
Notes *B-Basis Value is more than 90 % of the mean. The RTW condition was excluded from this table because basis values were not computed for that condition. The CV provided corresponds to the B-Basis value. Shaded B-Basis values indicate that the original CV was used for computation. "NA: A" indicates the use of ANOVA with less than 5 batches. "NA: I" indicates there were insufficient specimens to compute recommended B-Basis values.															

Table 3-1: NCAMP Recommended B-Basis Values – Part A

3.2 B-Basis Values and Estimates Summary Tables

NCAMP Summary of B-Basis Values for STRATASYS INC. ADDITIVELY MANUFACTURED ANTERO(R) 840CN03 Values shown in shaded boxes do not meet CMH17 Volume 1 requirements and are estimates only. These value may not be used for certification unless specifically allowed by the certifying agency.																		
				Environmental Condition														
				CTA (-95 °F)			RTA (70 °F)			RTW (70 °F)			ETA (250 °F)			ETW (180 °F)		
Method	Orientation	Test	Unit	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
Dogbone Tension	XY	0.2% Offset Strength	ksi	7.757	7.839	8.885	6.837	6.710	7.754	6.717*	5.683	7.175	4.236	NA	5.305	5.288	NA	6.019
		Strength	ksi	9.106	NA	14.76	9.818	NA	11.03	9.783*	8.405	10.61	5.368*	5.274	5.918	6.751*	NA	7.411
		Modulus	Msi			0.4979			0.4416			0.4404				0.4221		
	XZ	0.2% Offset Strength	ksi	8.725	NA	10.28	8.170	8.513	9.295	8.675*	7.137	9.011	5.951	6.006	6.788	7.202*	6.831	7.613
		Strength	ksi	10.90	NA	17.24	11.42	11.92	13.48	12.85*	10.57	13.34	6.568	6.632	7.413	8.223	8.286	9.386
		Modulus	Msi			0.5437			0.4850			0.4892			0.4547			0.4649
	Z45	0.2% Offset Strength	ksi	7.654	7.793	8.772	6.694	7.283	7.975	7.429*	6.244	7.884	4.496	4.808	5.500	5.441	5.652	6.345
		Strength	ksi	5.251	NA	10.73	8.777	NA	11.16	10.85*	9.091	11.48	5.022	NA	5.972	6.388	6.712	7.590
		Modulus	Msi			0.4925			0.4385			0.4475			0.4077			0.4146
	ZX	0.2% Offset Strength	ksi	6.323	7.164	8.523	7.297	6.884	7.861	7.332*	6.213	7.844	4.610	4.717	5.289	5.337	5.583	6.263
		Strength	ksi	4.542	NA	8.274	6.259	6.259	7.807	7.106	7.106	9.537	4.967	5.191	5.859	4.689	NA	7.303
		Modulus	Msi			0.4868			0.4356			0.4487			0.4027			0.4128
Compression Cube	XY	0.2% Offset Strength	ksi	9.857	NA	12.91	4.373	NA	11.64	6.817	6.817	10.36	6.349	6.467	7.318	8.019	7.862	8.965
		1% Offset Strength	ksi	16.34	17.97	19.79	12.57*	12.13	13.94	11.56	10.65	13.69	NA	NA	7.776	8.580	8.383	9.931
		2% Offset Strength	ksi	21.16*	20.22	22.89	12.93	12.30	14.08	12.99*	9.380	13.95	NA	NA	7.718			
		Compressive Strength	ksi	21.18	21.07	23.55	13.50*	NA	14.52	13.17*	11.44	14.44	6.948	7.135	7.977	9.265*	9.057	10.121
	XZ	0.2% Offset Strength	ksi	11.58	11.49	13.27	3.758	NA	11.63	9.368	8.843	11.16	6.708*	6.514	7.353	7.529	7.529	8.911
		1% Offset Strength	ksi	16.68	17.85	20.20	12.89*	12.48	14.04	12.28	11.08	13.99	NA	NA	7.840	8.274	8.081	9.829
		2% Offset Strength	ksi	21.73	20.18	23.11	11.70	12.16	14.17	11.79	9.462	14.07	NA	NA	7.788			
		Compressive Strength	ksi	20.70	21.00	23.48	13.88*	NA	14.62	12.88	11.39	14.38	7.320*	7.180	8.026	9.114	8.979	10.16
	Z45	0.2% Offset Strength	ksi	11.31	NA	13.23	5.047	NA	11.66	9.153	8.755	11.05	6.040	5.984	6.897	7.595	7.541	8.712
		1% Offset Strength	ksi	15.23	NA	19.84	12.34*	NA	13.68	11.57	10.76	13.59	6.544	6.217	7.265	8.602	8.527	9.615
		2% Offset Strength	ksi	20.53	NA	22.78	13.12*	NA	14.12	12.53	9.013	13.41	6.664	5.861	7.399	7.846	8.489	9.669
		Compressive Strength	ksi	18.83	NA	23.19	13.64*	NA	14.40	12.93*	11.23	14.18	6.556	6.461	7.320	9.014*	8.684	9.772
ZX	0.2% Offset Strength	ksi	12.09	11.84	13.50	3.384	NA	11.66	8.288	8.288	11.44	6.375	NA	7.168	7.867	7.811	8.955	
	1% Offset Strength	ksi	19.04*	18.18	20.32	12.94*	NA	13.94	12.45	11.27	14.23				8.614	8.294	10.07	
	2% Offset Strength	ksi	21.51	20.23	23.04	13.98*	NA	14.49	NA	NA	14.23							
	Compressive Strength	ksi	21.89*	21.37	23.89	13.87*	NA	14.61	13.39*	11.64	14.69	7.148*	NA	7.890	9.500*	9.090	10.24	
Rail Shear	XY	0.2% Offset Strength	ksi	4.884	4.773	5.429	2.948	NA	4.493	4.234*	3.497	4.415	2.985	3.123	3.538	3.439	3.602	4.027
		Maximum Strength	ksi	5.794	5.794	8.406	5.402	NA	7.857	7.293*	6.183	7.806	3.754	NA	4.303	4.945	5.035	5.628
		Strength at 5% Strain	ksi	7.974*	7.238	8.496	6.170	NA	7.552	6.867*	5.708	7.206	3.318	2.821	3.883	5.247*	3.626	5.393
		Modulus	Msi			0.2135			0.1913			0.1891			0.1988			0.1885
	XZ	0.2% Offset Strength	ksi	5.064*	4.962*	5.480	4.130	4.136	4.649	4.376*	3.657	4.617	2.819	2.835	3.277	3.560*	3.494	3.905
		Maximum Strength	ksi	6.413	NA	8.456	6.807*	6.466	7.517	7.110*	6.097	7.698	3.235	3.383	3.881	4.592	4.630	5.176
		Strength at 5% Strain	ksi	7.885*	7.554	8.712	6.761*	NA	7.152	6.805*	5.792	7.313	3.185*	3.067	3.535	4.779*	3.951	4.988
		Modulus	Msi			0.2142			0.1913			0.1964			0.1916			0.1882
	Z45	0.2% Offset Strength	ksi	5.039*	4.831	5.400	4.045	4.191	4.713	4.366*	3.726	4.704	2.582	NA	3.335	3.404	3.513	3.926
		Maximum Strength	ksi	5.516	NA	10.03	7.243	7.210	8.060	7.267*	6.324	7.984	3.255	3.535	4.042	4.660	NA	5.391
		Strength at 5% Strain	ksi	8.424*	7.933*	8.795	6.250	6.499	7.405	6.916*	5.977	7.545	2.582	2.387	3.551	5.178*	3.531	5.252
		Modulus	Msi			0.2138			0.1945			0.2003			0.1950			0.1921
ZX	0.2% Offset Strength	ksi	4.813*	4.652	5.229	3.829	NA	4.535	4.176*	3.555	4.489	2.352	NA	3.109	3.360*	3.337	3.731	
	Maximum Strength	ksi	5.894	NA	8.715	6.796*	6.653	7.458	6.596	NA	7.445	2.773	NA	3.636	4.605*	4.378	4.894	
	Strength at 5% Strain	ksi	8.172*	7.585	8.576	6.586*	NA	6.999	6.460*	NA	7.149	3.014	2.833	3.410	4.730*	4.017	4.820	
	Modulus	Msi			0.2089			0.1869			0.1934			0.1842			0.1832	

Notes *B-Basis Value is more than 90% of the mean.

Table 3-3: Summary of B-Basis Values - Part A

				Environmental Condition																							
				CTA (-95 °F)			RTA (70 °F)			ETA (250 °F)			ETW (180 °F)														
FLEX	XY	0.2% Offset Strength	ksi	15.84*	15.55	17.36	12.69	12.39	14.21	7.499	NA	9.919	10.57*	10.38	11.65												
		Flexural Strength		17.66	NA	24.86	17.04*	NA	18.70	8.550	NA	11.40	12.81*	12.62	14.13												
		Modulus	Msi			0.4982			0.4615			0.3817			0.4055												
	XZ	0.2% Offset Strength	ksi	20.85*	20.16*	22.24	16.44*	15.87	17.95	9.644	NA	11.80	12.72	12.81	14.72												
		Flexural Strength		29.21*	27.62	30.88	20.76*	NA	22.38	10.35	NA	12.42	14.27	14.29	16.10												
		Modulus	Msi			0.6076			0.5448			0.4771			0.5022												
	Z45	0.2% Offset Strength	ksi	11.33	10.74	15.98	12.78	12.51	14.32	6.171	NA	8.901	8.754	NA	10.91												
		Flexural Strength		9.671	9.671	13.57	11.68	11.68	15.58	6.949	NA	9.837	10.66	11.26	12.61												
		Modulus	Msi			0.4786			0.4359			0.3494			0.3799												
	ZX	0.2% Offset Strength	ksi	NA	NA	17.78	13.63	12.92	14.79	6.783	NA	9.279	10.10	10.11	11.51												
		Flexural Strength		3.855	NA	12.65	9.414	9.414	13.58	7.281	NA	10.11	11.53	11.31	12.84												
		Modulus	Msi			0.5111			0.4604			0.3779			0.4099												
OHT	XY	Strength	ksi	3.477	NA	7.505	7.316	7.267	8.398				5.083*	4.964	5.619												
	XZ			4.071	NA	6.188	4.362	NA	9.797				6.579	6.636	7.418												
	Z45			3.361	3.361	5.827	6.177	6.157	7.835				5.120	5.541	6.280												
	ZX			3.112	3.162	4.364	3.955	3.955	4.834				4.198	4.198	5.079												
FHT	XY	Strength	ksi	9.803	10.05	11.30	6.970	7.402	8.661				5.708*	5.375	6.008												
	XZ			10.11	NA	12.58	10.71*	10.15*	11.11				7.343*	6.927	7.890												
	Z45			5.554	NA	9.086	7.458	NA	9.210				6.222*	6.116	6.888												
	ZX			4.054	4.054	6.336	3.625	NA	6.456				3.901	NA	5.936												
SSB	XY	2% Offset Strength	ksi																								
		Ultimate Strength														19.81	20.75	23.29				17.08	17.36	19.90			
		Bearing Stiffness														Msi	30.29*	29.54	33.02				22.24*	NA	24.15		
	XZ	2% Offset Strength	ksi													25.52*	24.33*	26.89							18.86	19.80	22.36
		Ultimate Strength														28.50*	27.80	31.60							21.98	22.06	24.66
		Bearing Stiffness														Msi			0.1659								0.1740
	Z45	2% Offset Strength	ksi													23.95*	23.86	26.55							17.97	18.89	21.57
		Ultimate Strength														32.82*	NA	34.87							23.63*	NA	24.74
		Bearing Stiffness														Msi			0.1579								0.1406
	ZX	2% Offset Strength	ksi													21.91	21.64	25.44							19.31*	18.78	21.24
		Ultimate Strength														12.02	NA	26.98							19.37	NA	23.89
		Bearing Stiffness														Msi			0.1528								0.1469

Notes *B-Basis Value is more than 90% of the mean.

Table 3-4: Summary of B-Basis Values - Part B

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

All the statistics included in the tables and graphs are based in as-measured data. 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 four batches, the basis values computed using ANOVA are considered estimates only. However, the basis values resulting from the ANOVA method using only four 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 passes the ADK test at this point, modified CV basis values are provided. If the dataset does not pass the ADK test after the transformation, estimates may be computed using the modified CV method per the guidelines of CMH-17 Vol 1, found in section 8.4.4 of the Handbook.

4.1 Dogbone Tension XY Orientation (T – ASTM D638)

Strength, 0.2% offset strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition.

For the strength dataset, the CTA and ETA conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for RTA, RTW, and ETW. Applying the modified CV, the CTA condition failed the ADK test, while the RTA and ETW conditions failed the normality test, therefore modified CV basis values could not be computed for those conditions. The normal method was used for RTW and ETA.

For the 0.2% offset strength dataset, the RTA and ETA conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The single point normal method was used for CTA, RTW, and ETW. Applying the modified CV, the CTA and RTA conditions met all the requirements for pooling. The normal method was used for RTW. The ETA condition failed the ADK test and the ETW condition failed the normality test, therefore modified CV basis values could not be computed for these conditions.

There were two statistical outliers. For the strength dataset, the lowest value in batch four of the CTA condition was a batch outlier. The lowest value in batch two of the RTA condition was a batch and condition outlier. They were retained for this analysis.

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

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Dogbone Tension XY Strength

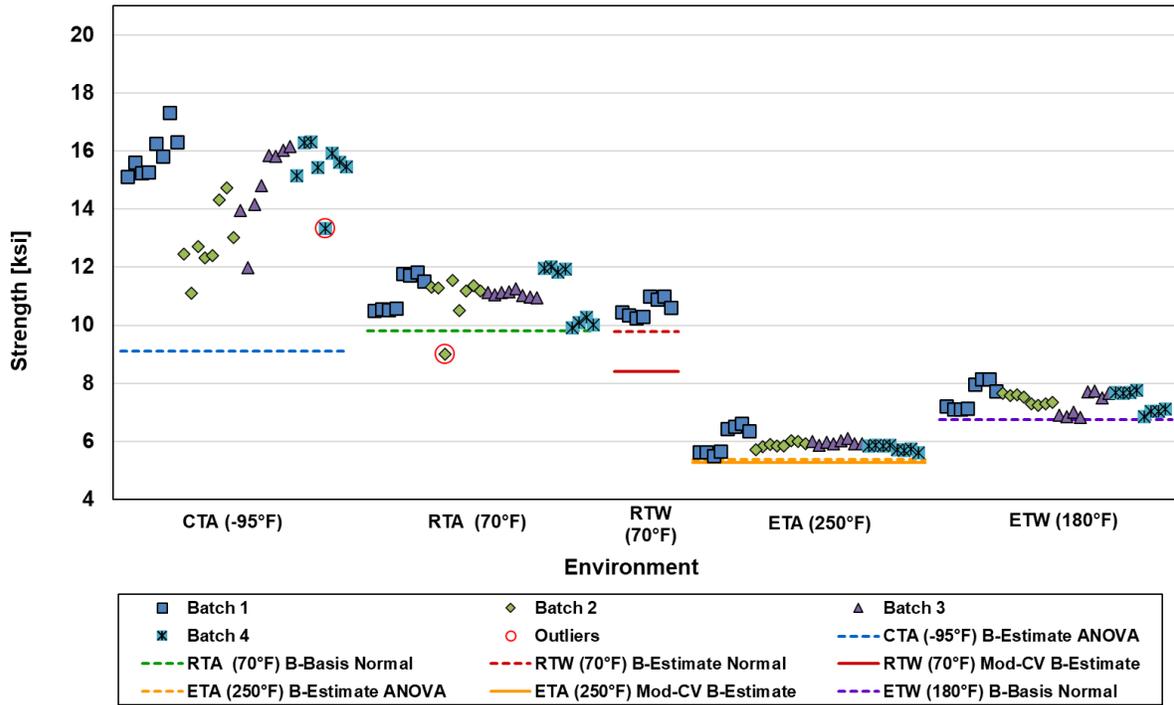


Figure 4-1: Batch Plot for Dogbone Tension XY Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Dogbone Tension XY 0.2% Offset Strength**

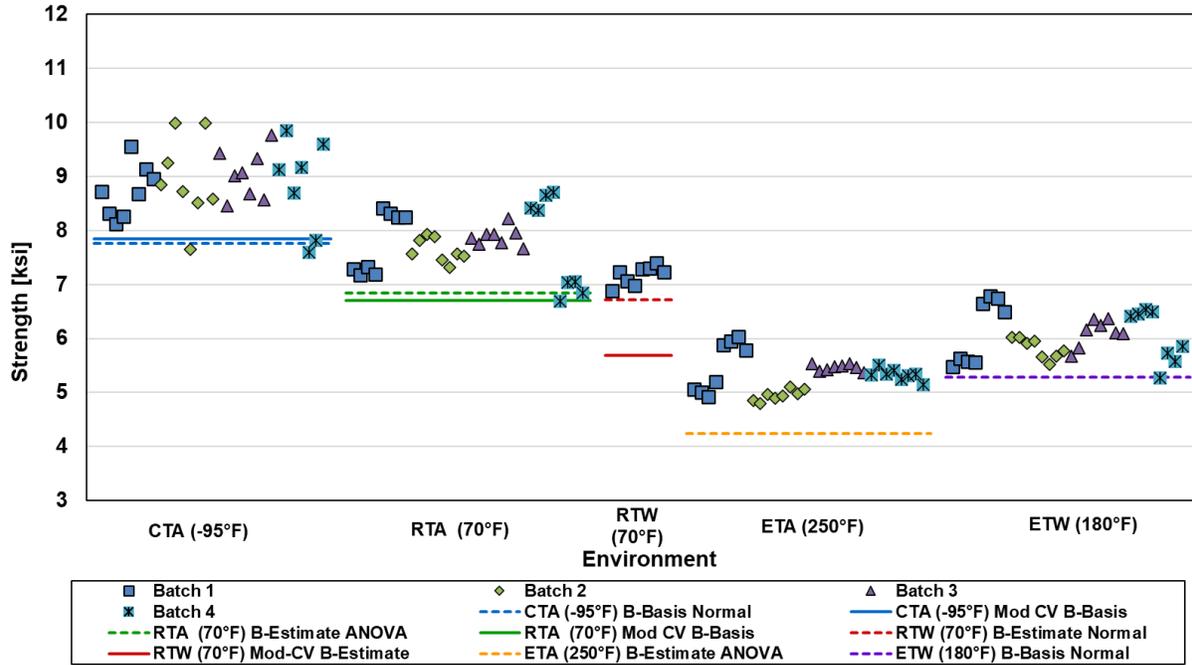


Figure 4-2: Batch Plot for Dogbone Tension XY 0.2% Offset Strength

TXY Strength As-Measured (ksi) Basis Values and Statistics										
Environment	Strength					0.2% Offset Strength				
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	14.76	11.03	10.61	5.918	7.411	8.885	7.754	7.175	5.305	6.019
Std. Dev.	1.564	0.6920	0.3189	0.2592	0.3752	0.6385	0.5275	0.1762	0.3219	0.4155
CV	10.60	6.272	3.005	4.380	5.063	7.187	6.804	2.455	6.067	6.904
Modified CV	10.60	7.136	8.000	6.190	6.531	7.593	7.402	8.000	7.034	7.452
Min	11.11	8.998	10.25	5.517	6.821	7.595	6.686	6.890	4.799	5.272
Max	17.32	12.00	11.01	6.616	8.161	9.982	8.710	7.406	6.034	6.787
No. Batches	4	4	1	4	4	4	4	1	4	4
No. Specimens	32	32	8	32	32	31	32	8	32	32
Basis Values and Estimates										
B-Basis		9.818			6.751	7.757				5.288
B-Estimate	9.106		9.783	5.368			6.837	6.717	4.236	
A-Estimate	5.165	8.936	9.202	4.975	6.273	6.940	6.171	6.397	3.488	4.759
Method	ANOVA	Normal	Normal	ANOVA	Normal	Normal	ANOVA	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates										
B-Basis				5.274		7.839	6.710			
B-Estimate				8.405				5.683		
A-Estimate	NA	NA		6.861	4.807	7.103	5.973	4.639	NA	NA
Method				Normal	Normal	Pooled	Pooled	Normal		

Table 4-1: Statistics and Basis Values for Dogbone Tension XY Strength Data

TXY Tensile Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.4979	0.4416	0.4404	0.4221	0.4263
Std. Dev.	0.01610	0.01552	0.008650	0.01094	0.01554
CV	3.234	3.514	1.964	2.592	3.646
Min	0.4591	0.4091	0.4270	0.4035	0.3717
Max	0.5336	0.4663	0.4493	0.4487	0.4530
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-2: Statistics for Dogbone Tension XY Tensile Modulus Data

4.2 Dogbone Tension XZ Orientation (T – ASTM D638)

Strength, 0.2% offset strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition.

For the strength dataset, the CTA, RTA, and ETA conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The ETW condition failed all the distributions tests, therefore, the non-parametric method was used for this condition. The normal method was used for RTW. Applying the modified CV, the CTA condition failed the ADK test, therefore modified CV basis values could not be computed for this condition. The normal method was used for the remaining conditions.

For the 0.2% offset strength dataset, the CTA condition failed the normality test, but the Weibull distribution was a good fit for the data. the RTA and ETA conditions failed the ADK test. ANOVA was used to compute estimates for these conditions. The normal method was used for RTW and ETW. Applying the modified CV, the CTA condition failed the normality test, therefore modified CV basis values are not available for that condition. The RTA, ETA, and ETW conditions met all the requirements for pooling. The normal method was used for RTW.

There were three statistical outliers. For the strength dataset, the lowest value in batch one of the CTA condition was a batch outlier. The lowest value in batch two of the RTA condition was a condition outlier. For the 0.2% offset strength dataset, the lowest value in batch three of the ETW condition was a condition outlier. They were retained for this analysis.

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

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Dogbone Tension XZ Strength**

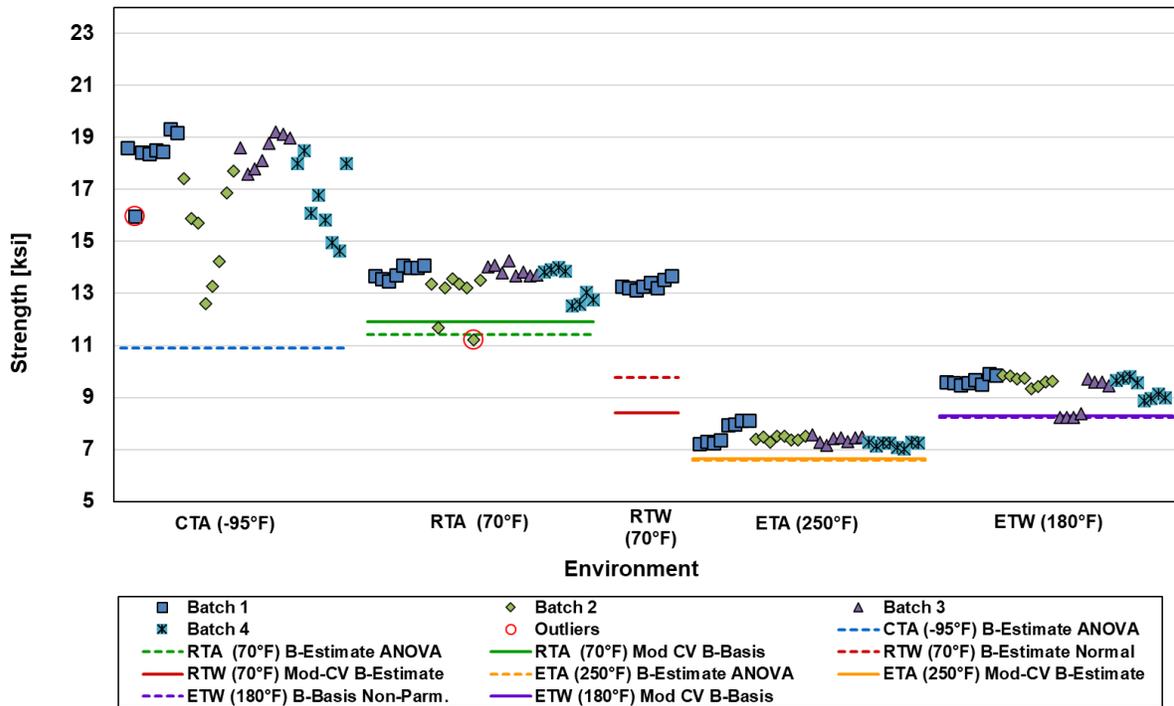


Figure 4-3: Batch Plot for Dogbone Tension XZ Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Dogbone Tension XZ 0.2% Offset Strength**

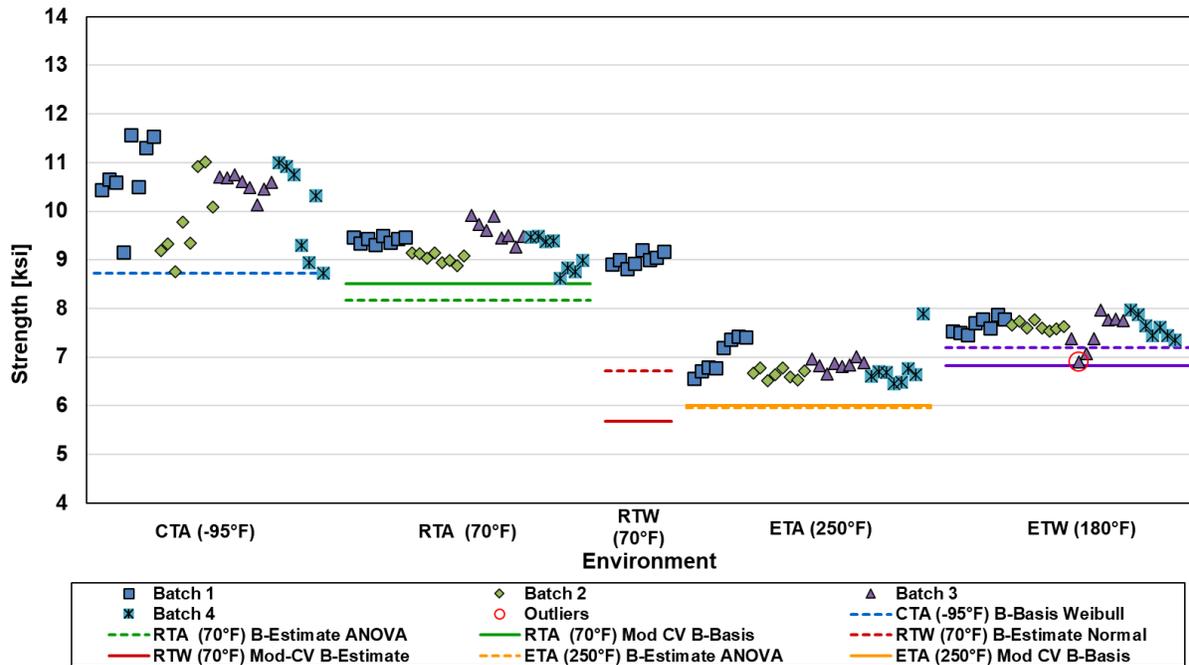


Figure 4-4: Batch Plot for Dogbone Tension XZ 0.2% Offset Strength

TXZ Strength (ksi) As-Measured Basis Values and Statistics											
Environment	Strength					0.2% Offset Strength					
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	
Mean	17.24	13.48	13.34	7.413	9.386	10.28	9.295	9.011	6.788	7.613	
Std. Dev.	1.822	0.6897	0.1875	0.2737	0.5013	0.8083	0.3096	0.1294	0.2546	0.2338	
CV	10.57	5.118	1.405	3.693	5.341	7.866	3.331	1.436	3.750	3.072	
Modified CV	10.57	6.559	8.000	6.000	6.670	7.933	6.000	8.000	6.000	6.000	
Min	12.60	11.21	13.13	7.025	8.223	8.727	8.624	8.815	6.451	6.908	
Max	19.33	14.25	13.68	8.115	9.917	11.56	9.909	9.199	7.426	7.971	
No. Batches	4	4	1	4	4	4	4	1	4	4	
No. Specimens	32	32	8	32	32	31	32	8	32	32	
Basis Values and Estimates											
B-Basis					8.223	8.725				7.202	
B-Estimate	10.90	11.42	12.85	6.568			8.170	8.675	5.951		
A-Estimate	6.479	9.974	12.51	5.974	6.923	7.193	7.386	8.439	5.365	6.904	
Method	ANOVA	ANOVA	Normal	ANOVA	Non-Par.	Weibull	ANOVA	Normal	ANOVA	Normal	
Modified CV Basis Values and Estimates											
B-Basis	NA	11.92		6.632	8.286	NA	8.513		6.006	6.831	
B-Estimate			10.57					7.137			
A-Estimate		10.80	8.625	6.064	7.488			7.969	5.826	5.462	6.287
Method		Normal	Normal	Normal	Normal			Pooled	Normal	Pooled	Pooled

Table 4-3: Statistics and Basis Values for Dogbone Tension XZ Strength Data

TXZ Tensile Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.5437	0.4850	0.4892	0.4547	0.4649
Std. Dev.	0.01413	0.01111	0.006795	0.007617	0.01503
CV	2.599	2.290	1.389	1.675	3.234
Min	0.5108	0.4566	0.4804	0.4397	0.4211
Max	0.5685	0.5006	0.4990	0.4706	0.4831
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-4: Statistics for Dogbone Tension XZ Tensile Modulus Data

4.3 Dogbone Tension Z45 Orientation (T – ASTM D638)

Strength, 0.2% offset strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition.

For the strength dataset, the CTA, RTA, ETA, and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for RTW. Applying the modified CV, the CTA and RTA conditions failed the ADK test, and the ETA condition failed the normality test, therefore modified CV basis values were not computed for these conditions. The normal method was used for RTW and ETW.

For the 0.2% offset strength dataset, the normal method was used for CTA and RTW. The RTA, ETA, and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. Applying the modified CV, the RTA, ETA, and ETW conditions met all the requirements for pooling. The normal method was used for CTA and RTW.

There were two statistical outliers. For the strength dataset, the lowest value in batch four of the RTA condition was a condition outlier. For the 0.2% offset strength dataset. The lowest value in batch two of the CTA condition was a batch outlier. They were retained for this analysis.

Statistics, estimates, and basis values are given for the TZ45 strength data in Table 4-5 and for the modulus data in Table 4-6. The data, B-estimates, and B-basis values are shown graphically in Figure 4-5 and Figure 4-6.

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Dogbone Tension Z45 Strength

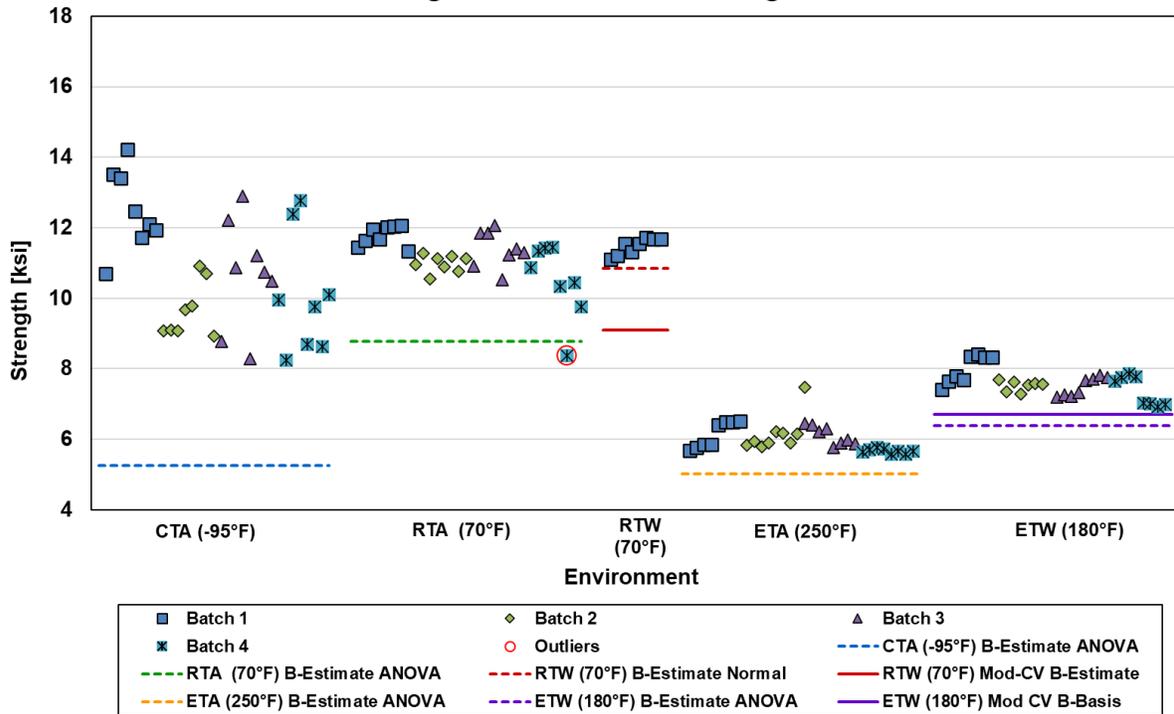


Figure 4-5: Batch Plot for Dogbone Tension Z45 Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Dogbone Tension Z45 0.2% Offset Strength**

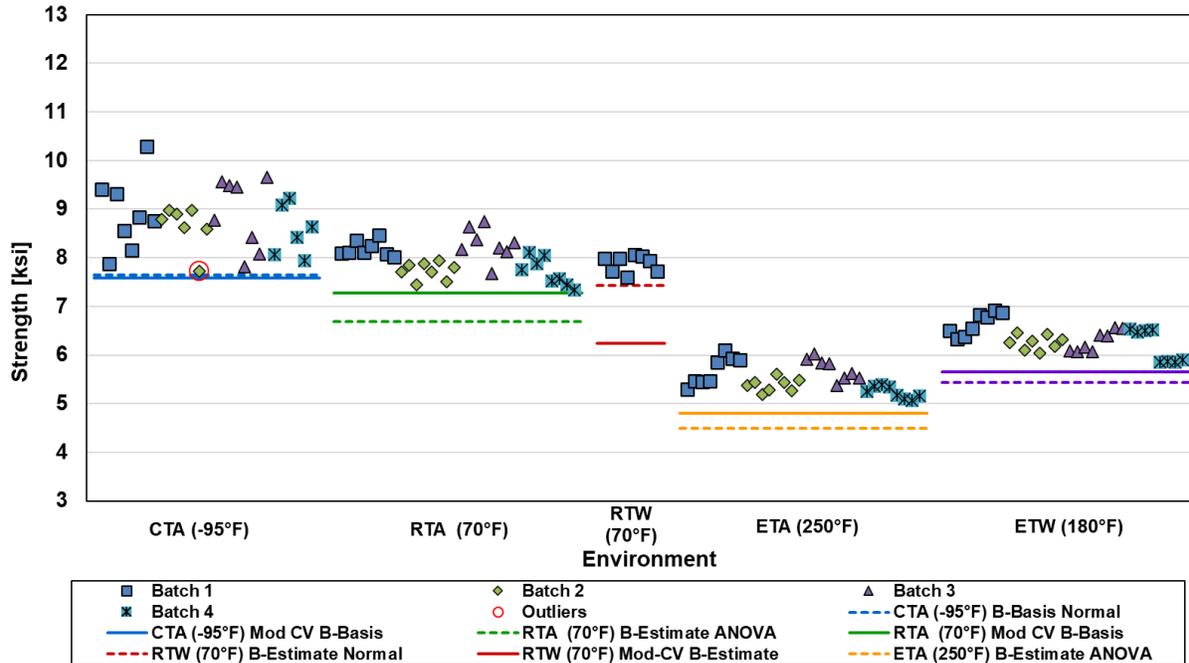


Figure 4-6: Batch Plot for Dogbone Tension Z45 0.2% Offset Strength

TZ45 Strength As-Measured (ksi) Basis Values and Statistics											
Environment	Strength					0.2% Offset Strength					
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	
Mean	10.73	11.16	11.48	5.972	7.590	8.772	7.975	7.884	5.500	6.345	
Std. Dev.	1.688	0.7556	0.2395	0.3028	0.3923	0.6258	0.3536	0.1751	0.2836	0.2945	
CV	15.74	6.769	2.086	5.070	5.168	7.134	4.434	2.221	5.157	4.642	
Modified CV	15.74	7.385	8.000	6.535	6.584	7.567	6.217	8.000	6.578	6.321	
Min	8.246	8.377	11.10	5.564	6.916	7.726	7.330	7.601	5.060	5.856	
Max	14.22	12.07	11.72	6.518	8.404	10.29	8.750	8.067	6.105	6.921	
No. Batches	4	4	1	4	4	4	4	1	4	4	
No. Specimens	32	32	8	32	32	29	32	8	32	32	
Basis Values and Estimates											
B-Basis						7.654					
B-Estimate	5.251	8.777	10.85	5.022	6.388		6.694	7.429	4.496	5.441	
A-Estimate	1.416	7.106	10.42	4.355	5.545	6.846	5.800	7.110	3.796	4.807	
Method	ANOVA	ANOVA	Normal	ANOVA	ANOVA	Normal	ANOVA	Normal	ANOVA	ANOVA	
Modified CV Basis Values and Estimates											
B-Basis						6.712	7.586	7.283		4.808	5.652
B-Estimate			9.091						6.244		
A-Estimate	NA	NA	7.420	NA		6.075	6.729	6.801	5.097	4.326	5.170
Method			Normal			Normal	Normal	Pooled	Normal	Pooled	Pooled

Table 4-5: Statistics and Basis Values for Dogbone Tension Z45 Strength Data

TZ45 Tensile Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.4925	0.4385	0.4475	0.4077	0.4146
Std. Dev.	0.01708	0.01278	0.008657	0.009958	0.01206
CV	3.469	2.915	1.934	2.442	2.907
Min	0.4530	0.4025	0.4303	0.3879	0.3845
Max	0.5351	0.4523	0.4574	0.4366	0.4311
No. Batches	4	4	1	4	4
No. Specimens	31	32	8	32	32

Table 4-6: Statistics for Dogbone Tension Z45 Modulus Data

4.4 Dogbone Tension ZX Orientation (T – ASTM D638)

Strength, 0.2% offset strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition.

For the strength dataset, the CTA, ETA, and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for RTA and RTW. Applying the modified CV, the CTA, RTA, RTW, and ETW conditions have original CVs greater than 8%. The CTA and ETW conditions failed the ADK test, therefore modified CV basis values are not available for these conditions. The normal method was used for RTA, RTW, and ETA. Only the original CV line was graphed.

For the 0.2% offset strength dataset, the CTA, ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for RTA and RTW. Applying the modified CV, the normal method was used for all conditions.

There was one statistical outlier. For 0.2% offset strength, the highest value in batch two of the RTA condition was a batch outlier. It was retained for this analysis.

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

Stratasys Inc. Additively Manufactured Antero(R) 840CN03 Dogbone Tension ZX Strength

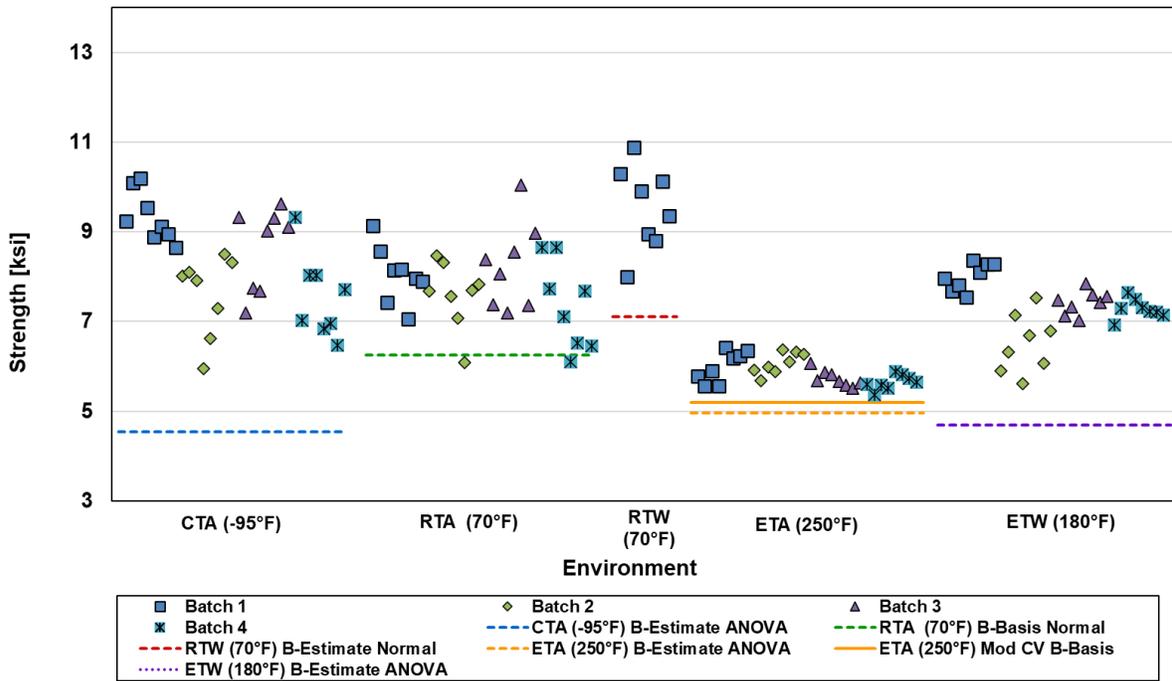


Figure 4-7: Batch Plot for Dogbone Tension ZX Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03

Dogbone Tension ZX 0.2% Offset Strength

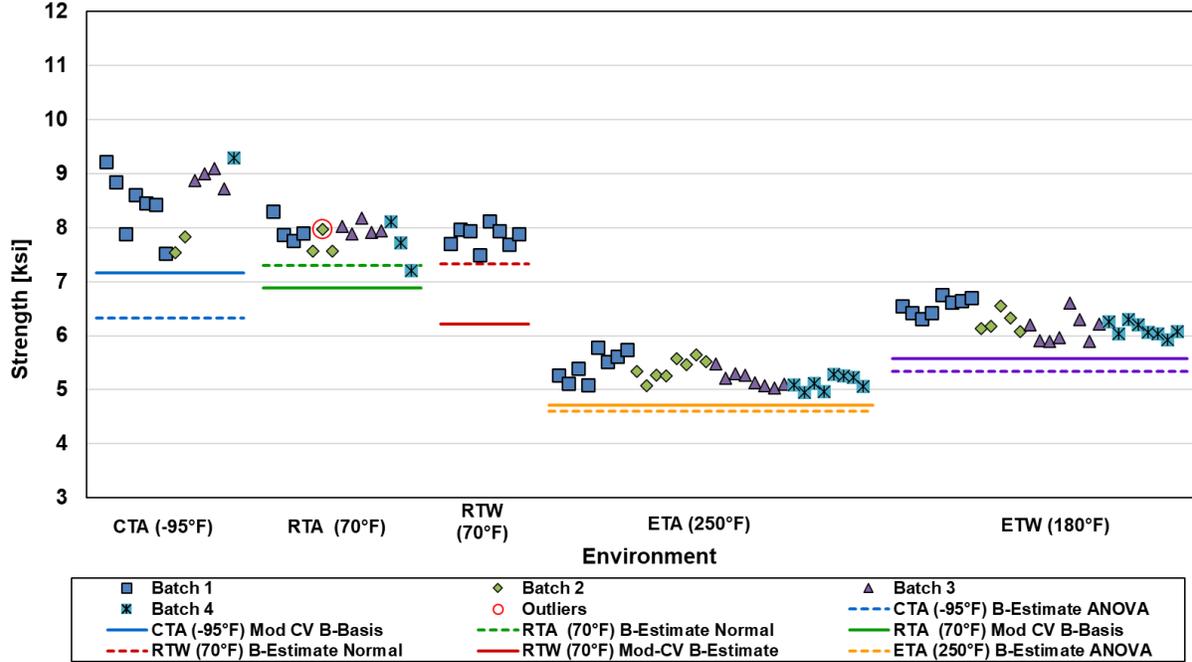


Figure 4-8: Batch Plot for Dogbone Tension ZX 0.2% Offset Strength

TZX Strength (ksi) As-Measured Basis Values and Statistics										
Environment	Strength					0.2% Offset Strength				
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	8.274	7.807	9.537	5.859	7.303	8.523	7.861	7.844	5.289	6.263
Std. Dev.	1.103	0.8811	0.9352	0.2917	0.6610	0.6050	0.2721	0.1971	0.2279	0.2603
CV	13.33	11.29	9.806	4.979	9.051	7.099	3.461	2.513	4.309	4.157
Modified CV	13.33	11.29	9.806	6.489	9.051	7.549	6.000	8.000	6.154	6.078
Min	5.948	6.092	8.003	5.367	5.622	7.530	7.204	7.502	4.947	5.899
Max	10.19	10.04	10.88	6.412	8.360	9.290	8.303	8.122	5.784	6.764
No. Batches	4	4	1	4	4	4	4	1	4	4
No. Specimens	32	32	8	32	32	14	15	8	32	29
Basis Values and Estimates										
B-Basis		6.259								
B-Estimate	4.542		7.106	4.967	4.689	6.323	7.297	7.332	4.610	5.337
A-Estimate	1.933	5.136	5.405	4.340	2.872	4.798	6.901	6.974	4.133	4.692
Method	ANOVA	Normal	Normal	ANOVA	ANOVA	ANOVA	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis		6.259		5.191					4.717	5.583
B-Estimate	NA		7.106		NA	7.164	6.884	6.213		
A-Estimate		5.136	5.405	4.706		6.209	6.197	5.072	4.302	5.091
Method		Normal	Normal	Normal		Normal	Normal	Normal	Normal	Normal

Table 4-7: Statistics and Basis Values for Dogbone Tension ZX Strength Data

TZX Tensile Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.4868	0.4356	0.4487	0.4027	0.4128
Std. Dev.	0.01868	0.01390	0.01620	0.01135	0.01292
CV	3.838	3.191	3.609	2.819	3.131
Min	0.4515	0.4005	0.4299	0.3785	0.3777
Max	0.5220	0.4536	0.4808	0.4398	0.4295
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-8: Statistics for Dogbone Tension ZX Modulus Data

4.5 Compression Cube XY Orientation (C – ASTM D695)

0.2% offset strength, compressive strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. 1% offset strength tests were performed in the following environmental conditions: CTA, RTA, RTW and ETW. 2% offset strength tests were performed in the following environmental conditions: CTA, RTA, and RTW. The RTW condition for all tests consists of a single batch with eight specimens or less, therefore only basis value estimates are provided for that condition.

For the 0.2% offset strength dataset, the CTA, RTA and ETA conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for RTW and ETW. Applying the modified CV, the CTA, RTA, and RTW conditions have an original CV greater than 8%. The CTA and RTA conditions failed the ADK test, therefore modified CV basis values were not computed for these conditions. The normal method was used for RTW, ETA and ETW. For RTW, only the original CV line was graphed.

For the 1% offset strength dataset, the CTA, RTA, and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. Basis values were not computed for ETA, as it consists of a single batch of data with only three specimens. Applying the modified CV, the CTA and RTA met all the requirement for pooling, and the normal method was used for RTW and ETW.

For the 2% offset strength dataset, the normal method was used for CTA and RTW. The RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Basis values were not computed for ETA, as it consists of a single batch of data with only three specimens. Applying the modified CV, the normal method was used for all conditions.

For the compressive strength dataset, the CTA, RTA, and ETA conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The ETW condition failed the normality test, but the Weibull distribution was a good fit for the dataset. Applying the modified CV, the RTA condition failed the normality test, therefore modified CV basis values were not computed for that condition. The normal method was used for the remaining conditions.

There were three statistical outliers. For 0.2% offset strength, the lowest value in batch one of the of the CTA condition was a batch outlier. For 0.2% offset strength and 1% offset strength, the highest value in batch three of the CTA condition was a batch outlier. They were retained for this analysis.

Statistics, estimates and basis values are given for the CXY strength data in Table 4-9 and for the modulus data in Table 4-10. The data, B-estimates and the B-basis values are shown graphically in Figure 4-9 through Figure 4-12.

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Compression Cube XY 0.2% Offset Strength

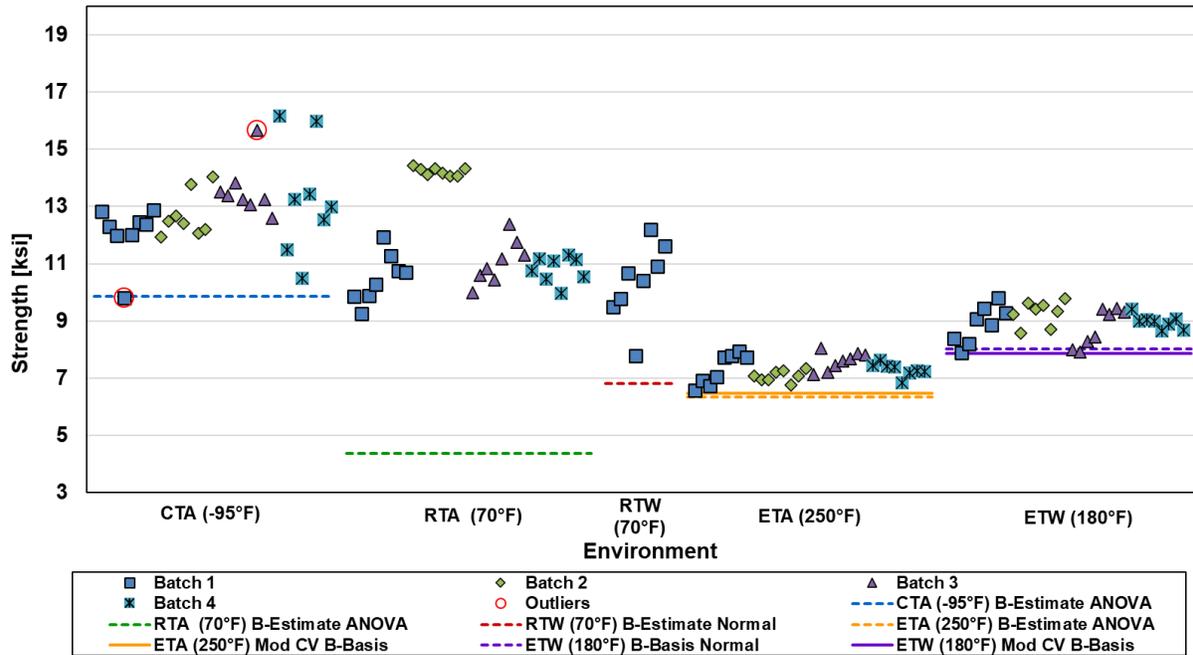


Figure 4-9: Batch Plot for Compression Cube XY 0.2% Offset Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Compression Cube XY 1% Offset Strength

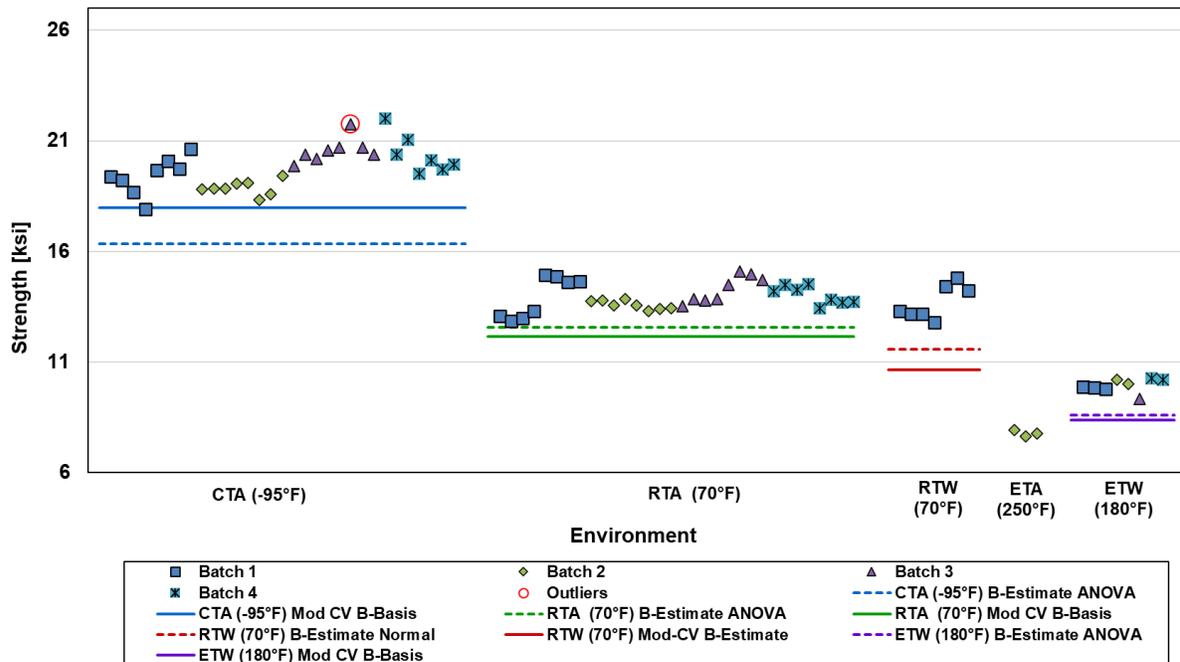


Figure 4-10: Batch Plot for Compression Cube XY 1% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube XY 2% Offset Strength**

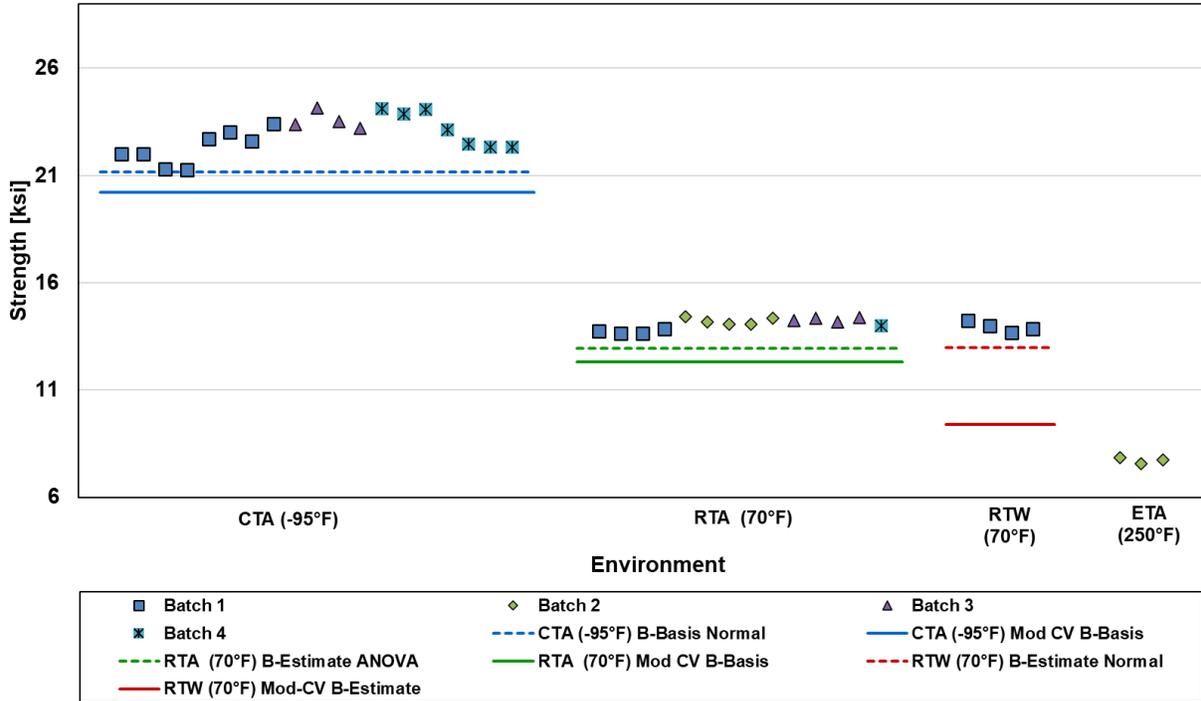


Figure 4-11: Batch Plot for Compression Cube XY 2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube XY Compressive Strength**

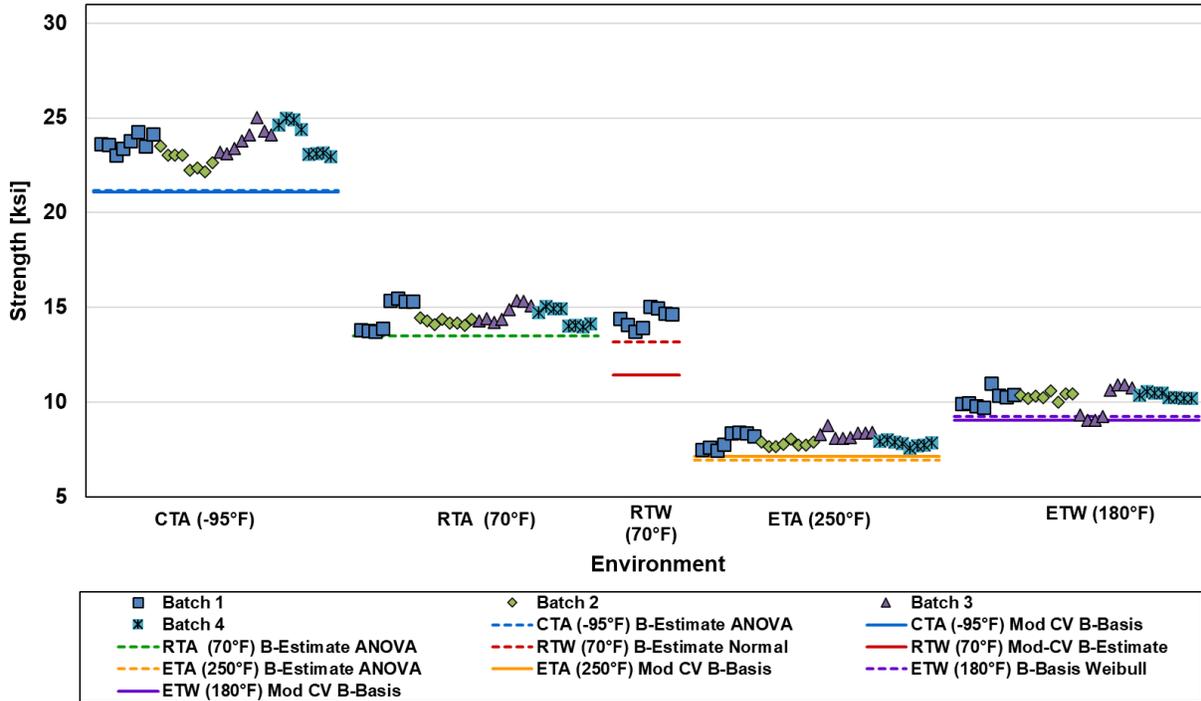


Figure 4-12: Batch Plot for Compression Cube XY Compressive Strength

CXY Strength (ksi) As-Measured Basis Values and Statistics																								
Environment	0.2% Offset Strength					1% Offset Strength					2% Offset Strength					Compressive Strength								
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)				
Mean	12.91	11.64	10.36	7.318	8.965	19.79	13.94	13.69	7.776	9.931	22.89	14.08	13.95	7.718	23.55	14.52	14.44	7.977	10.21					
Std. Dev.	1.328	1.638	1.364	0.3841	0.5389	0.9590	0.6249	0.7698	0.1355	0.3004	0.8878	0.2872	0.2344	0.1579	0.7673	0.5495	0.4890	0.3209	0.4968					
CV	10.29	14.07	13.16	5.249	6.010	4.846	4.482	5.621	1.742	3.025	3.878	1.897	1.680	2.046	3.258	3.785	3.386	4.023	4.865					
Modified CV	10.29	14.07	13.16	6.624	7.005	6.423	6.241	8.000	8.000	6.000	6.000	6.000	8.000	8.000	6.000	6.000	8.000	6.012	6.432					
Min	9.816	9.259	7.791	6.563	7.895	17.90	12.84	12.80	7.640	9.330	21.27	13.63	13.69	7.549	22.18	13.72	13.74	7.479	9.064					
Max	16.18	14.42	12.20	8.047	9.818	22.00	15.09	14.81	7.911	10.24	24.15	14.42	14.25	7.862	25.03	15.49	15.07	8.755	10.99					
No. Batches	4	4	1	4	4	4	4	1	1	4	3	4	1	1	4	4	1	4	4					
No. Specimens	32	32	8	32	32	31	32	7	3	8	19	14	4	3	32	32	8	32	32					
Basis Values and Estimates																								
B-Basis					8.019													9.265						
B-Estimate	9.857	4.373	6.817	6.349					16.34	12.57	11.56					8.580	21.16	12.93	12.99					
A-Estimate	7.682	0.000	4.336	5.662	7.332	13.94	11.60	10.05									7.646	19.94	12.14	12.26				
Method	ANOVA	ANOVA	Normal	ANOVA	Normal	ANOVA	ANOVA	Normal									ANOVA	Normal	ANOVA	Normal				
Modified CV Basis Values and Estimates																								
B-Basis			6.467	7.862	17.97	12.13													21.07					
B-Estimate	NA	NA	6.817					10.65									8.383	20.22	12.30	9.380				
A-Estimate			4.336	5.848	7.061	16.69	10.85	8.513									7.299	18.32	11.04	5.916				
Method			Normal	Normal	Normal	Pooled	Pooled	Normal									Normal	Normal	Normal	Normal				

Table 4-9: Statistics and Basis Values for Compression Cube XY Strength Data

CXY Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.5850	0.4918	0.5037	0.4667	0.5122
Std. Dev.	0.03283	0.01833	0.05791	0.02050	0.08620
CV	5.612	3.728	11.50	4.393	16.83
Min	0.5280	0.4633	0.4347	0.4346	0.4517
Max	0.6718	0.5368	0.6100	0.5117	0.9517
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-10: Statistics for Compression Cube XY Modulus Data

4.6 Compression Cube XZ Orientation (C – ASTM D695)

0.2% offset strength, 1% offset strength, compressive strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. 2% offset strength tests were performed in the following environmental conditions: CTA, RTA, and RTW. The RTW condition for all tests consists of a single batch with eight specimens or less, therefore only basis value estimates are provided for that condition.

For the 0.2% offset strength dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the modification was not applicable to the RTA condition because the dataset's original CV was greater than 8%. The normal method was used for the remaining conditions. The ETW condition has the same results because the dataset's original CV was greater than 8% therefore no modification was made and only the original CV line is visible in the graph.

For the 1% offset strength dataset, the ETA condition consists of a single batch of data with 2 specimens therefore basis values were not computed for that condition. The ETW condition has less than eighteen specimens, therefore only estimates are provided for that condition. The CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for RTA, RTW, and ETW. Applying the modified CV, the normal method was used for all conditions.

For the 2% offset strength dataset, all conditions have less than 18 specimens, therefore only estimates were computed. The ETA condition consists of a single batch of data with 2 specimens therefore basis values were not computed for that condition. The RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition and the normal method was used for CTA and RTW. Applying the modified CV, the normal method was used for all conditions.

For the compressive strength dataset, the CTA, ETA and ETW condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The RTA condition failed all the distribution tests, therefore the non-parametric method was used for that condition. The normal method was used for the RTW condition. Applying the modified CV, the RTA condition failed the normality test, therefore modified CV basis values are not available for that condition. The normal method was used for the remaining conditions.

There were four statistical outliers. For 1% offset strength, the highest value in batch two of the CTA condition was a batch outlier. For 2% offset strength, the highest value in batch one of the RTW condition was a single batch outlier. For compressive strength, the highest value in batch two of the ETA condition was a batch outlier, and the highest value in batch two of the ETW condition was a batch outlier. They were retained for this analysis.

Statistics, estimates and basis values are given for the CXZ strength data in Table 4-11 and for the modulus data in Table 4-12. The data, B-estimates and the B-basis values are shown graphically in Figure 4-13 through Figure 4-16.

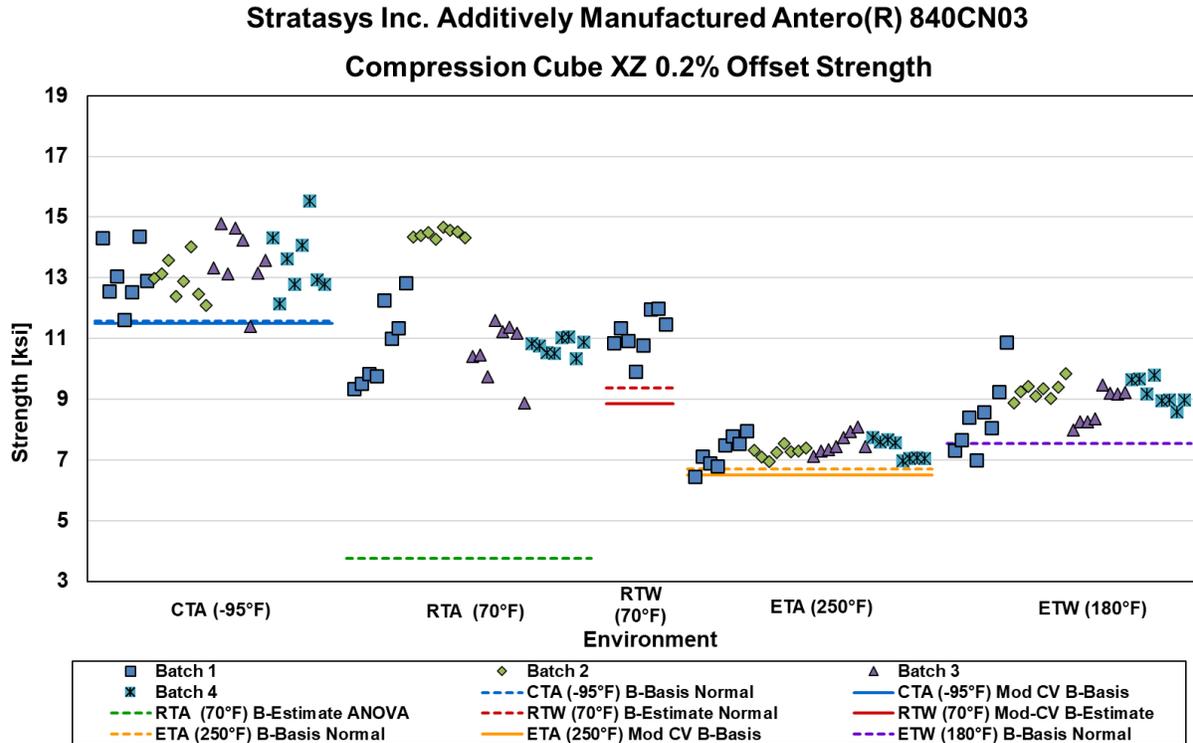


Figure 4-13: Batch Plot for Compression Cube XZ 0.2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube XZ 1% Offset Strength**

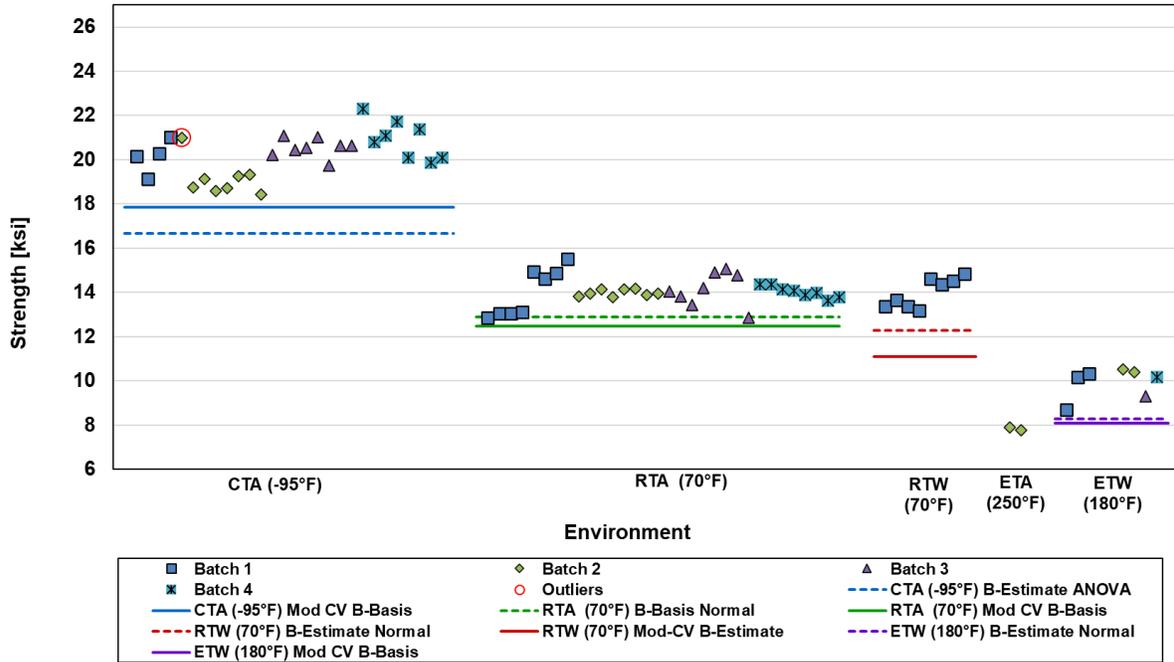


Figure 4-14: Batch Plot for Compression Cube XZ 1% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube XZ 2% Offset Strength**

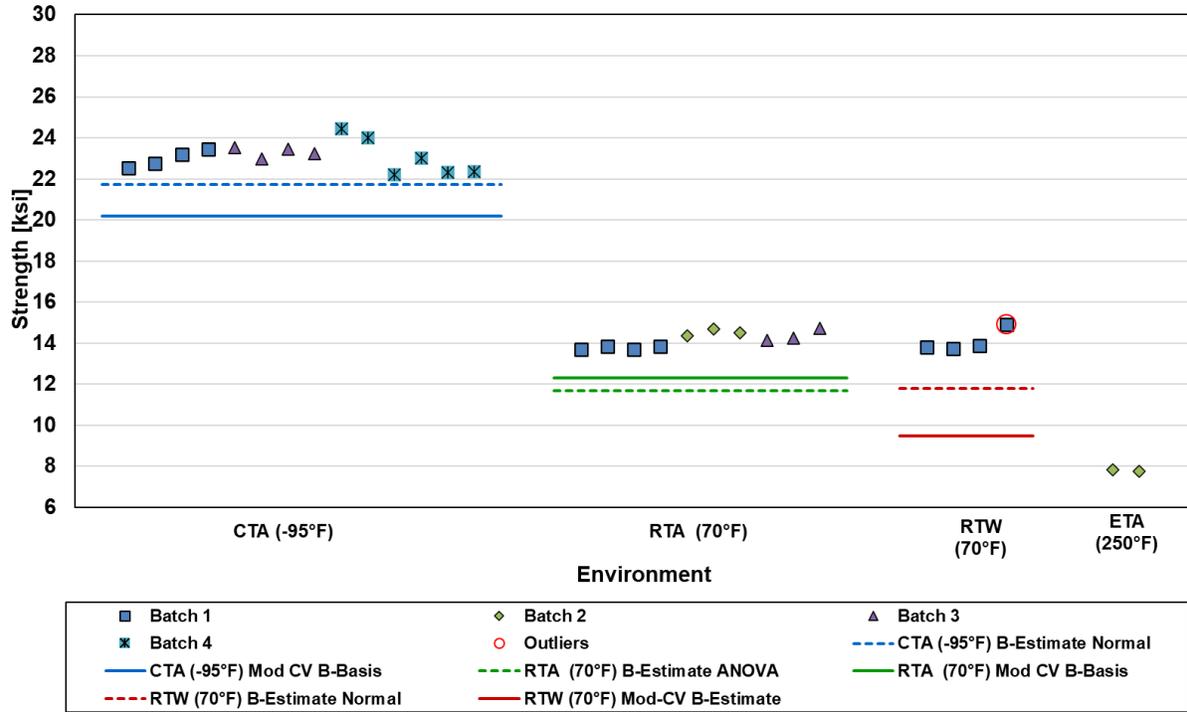


Figure 4-15: Batch Plot for Compression Cube XZ 2% Offset Strength

**Stratasy Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube XZ Compressive Strength**

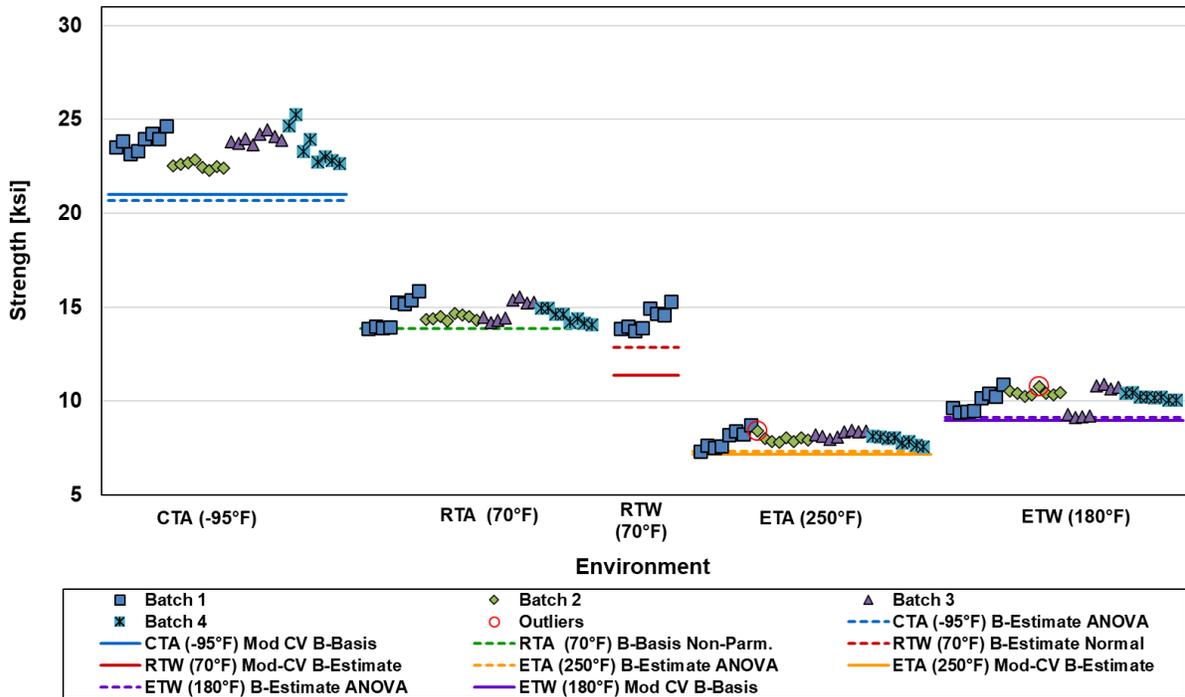


Figure 4-16: Batch Plot for Compression Cube XZ Compressive Strength

CXZ Strength (ksi) As-Measured Basis Values and Statistics																				
Environment	0.2% Offset Strength					1% Offset Strength					2% Offset Strength					Compressive Strength				
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	13.27	11.63	11.16	7.353	8.911	20.20	14.04	13.99	7.840	9.829	23.11	14.17	14.07	7.788	23.48	14.62	14.38	8.026	10.16	
Std. Dev.	0.9577	1.828	0.6913	0.3667	0.7864	0.9989	0.6502	0.6579	0.09579	0.6302	0.6535	0.3927	0.5589	0.06583	0.7845	0.5316	0.5766	0.3168	0.5277	
CV	7.217	15.71	6.192	4.988	8.826	4.946	4.633	4.703	1.222	6.412	2.828	2.772	3.971	0.8452	3.341	3.636	4.011	3.947	5.195	
Modified CV	7.608	15.71	8.000	6.494	8.826	6.473	6.316	8.000	8.000	7.206	6.000	6.000	8.000	8.000	6.000	6.000	6.000	8.000	6.000	
Min	11.41	8.867	9.910	6.458	7.003	18.44	12.84	13.19	7.772	8.679	22.19	13.69	13.72	7.742	22.30	13.88	13.73	7.339	9.136	
Max	15.53	14.67	12.00	8.086	10.88	22.32	15.51	14.83	7.907	10.51	24.45	14.71	14.91	7.835	25.25	15.88	15.31	8.747	10.91	
No. Batches	4	4	1	4	4	4	4	1	1	4	3	3	1	1	4	4	4	1	4	
No. Specimens	31	32	8	32	32	28	32	8	2	9	14	10	4	2	32	32	8	32	32	
Basis Values and Estimates																				
B-Basis	11.58			6.708	7.529		12.89										13.88			
B-Estimate		3.758	9.368				16.68		12.28			8.274	21.73	11.70	11.79		20.70		12.88	
A-Estimate	10.35	0.000	8.110	6.241	6.526	14.23	12.06	11.08			NA	7.188	20.76	9.937	10.05	NA	18.76	12.27	11.83	
Method	Normal	ANOVA	Normal	Normal	Normal	ANOVA	Normal	Normal			Normal	Normal	ANOVA	Normal		ANOVA	Non-Param.	Normal	ANOVA	
Modified CV Basis Values and Estimates																				
B-Basis	11.49			6.514	7.529	17.85	12.48										21.00		7.180	
B-Estimate				8.843				11.08				8.081	20.18	12.16	9.462				11.39	
A-Estimate	10.19			7.218	5.905	6.526	16.15	11.35	9.045		NA	6.861	18.12	10.75	5.968	NA	19.21	NA	9.294	
Method	Normal			Normal	Normal	Normal	Normal	Normal			Normal	Normal	Normal	Normal		Normal			Normal	

Table 4-11: Statistics and Basis Values for Compression Cube XZ Strength Data

CXZ Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.5757	0.5075	0.4887	0.4637	0.5018
Std. Dev.	0.03016	0.02551	0.02575	0.01487	0.04568
CV	5.238	5.027	5.268	3.207	9.104
Min	0.5256	0.4741	0.4482	0.4389	0.4328
Max	0.6387	0.5757	0.5271	0.4953	0.6377
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-12: Statistics for Compression Cube XZ Modulus Data

4.7 Compression Cube Z45 Orientation (C – ASTM D695)

0.2% offset strength, 1% offset strength 2% offset strength, compressive strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition for all tests consists of a single batch with eight specimens or less, therefore only basis value estimates are provided for that condition.

For the 0.2% offset strength dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The CTA condition failed all the distribution tests, therefore the non-parametric method was used for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the CTA condition failed the normality test and the RTA condition failed the ADK test, therefore modified CV basis values are not available for these conditions. The normal method was used for the remaining conditions.

For the 1% offset strength dataset, the CTA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for the remaining conditions. Applying the modified CV, the CTA condition failed the ADK test and the RTA condition failed the normality test, therefore modified CV basis values are not available for these conditions. The normal method was used for the remaining conditions.

For the 2% offset strength dataset, the ETA condition consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition. The RTA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The CTA condition has less than 18 specimens, therefore only estimates are provided for that condition using the normal distribution. The normal method was used for the RTW condition. Applying the modified CV, the CTA and RTA conditions failed the normality test, therefore modified CV basis values are not available for these conditions. The normal method was used for the remaining conditions.

For the compressive strength dataset, the CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTA, ETA and ETW conditions met all the requirements for pooling. The normal method was used for RTW. Applying the modified CV, the CTA condition failed the normality test and the RTA condition failed the ADK test, therefore modified CV basis values are not available for these conditions. The normal method was used for the remaining conditions.

There was one statistical outlier. The highest value in batch four of the CTA condition was a condition outlier. It was retained for this analysis.

Statistics, estimates and basis values are given for the CZ45 strength data in Table 4-13 and for the modulus data in Table 4-14. The data, B-estimates and the B-basis values are shown graphically in Figure 4-17 through Figure 4-20.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube Z45 0.2% Offset Strength**

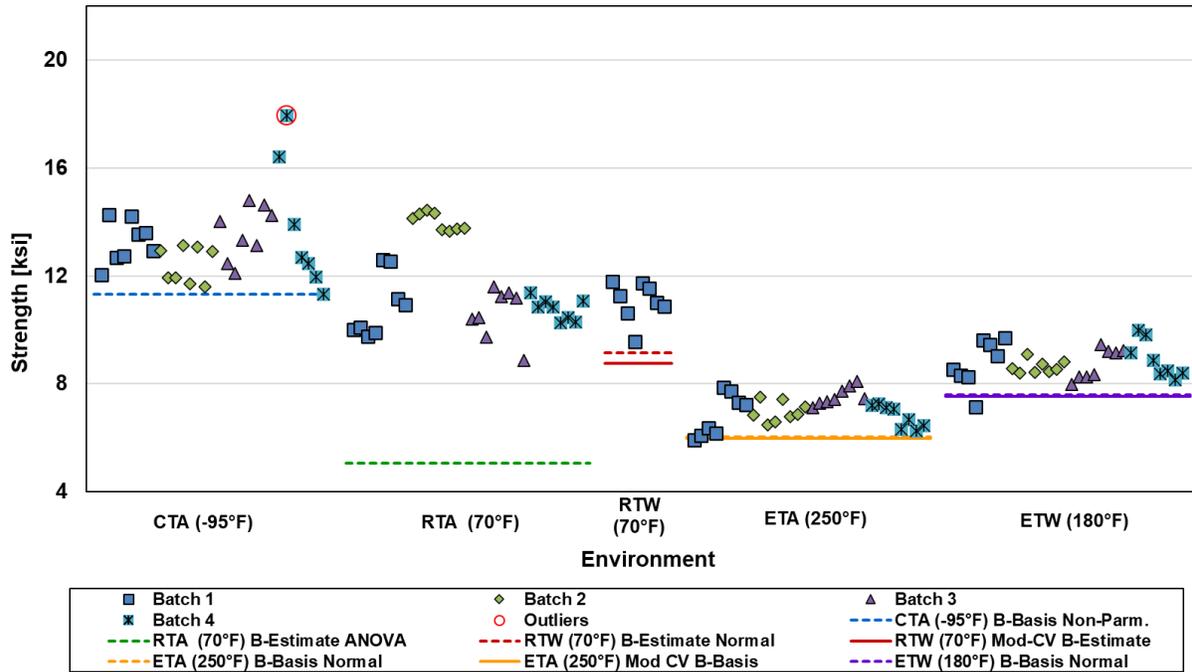


Figure 4-17: Batch Plot for Compression Cube Z45 0.2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube Z45 1% Offset Strength**

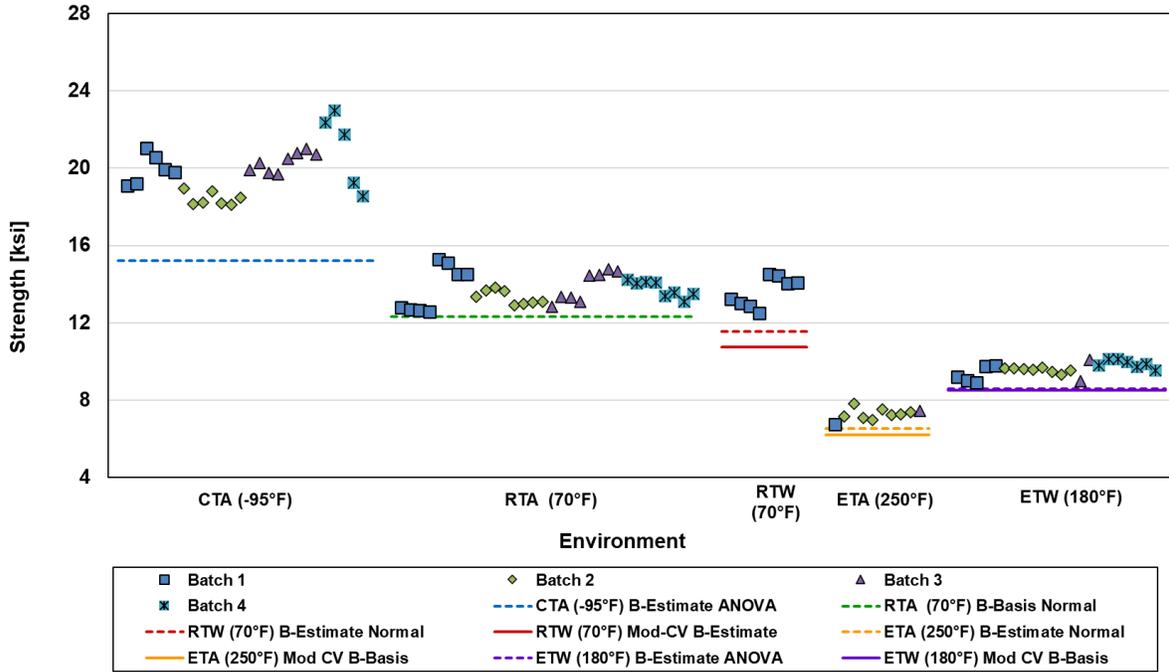


Figure 4-18: Batch Plot for Compression Cube Z45 1% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube Z45 2% Offset Strength**

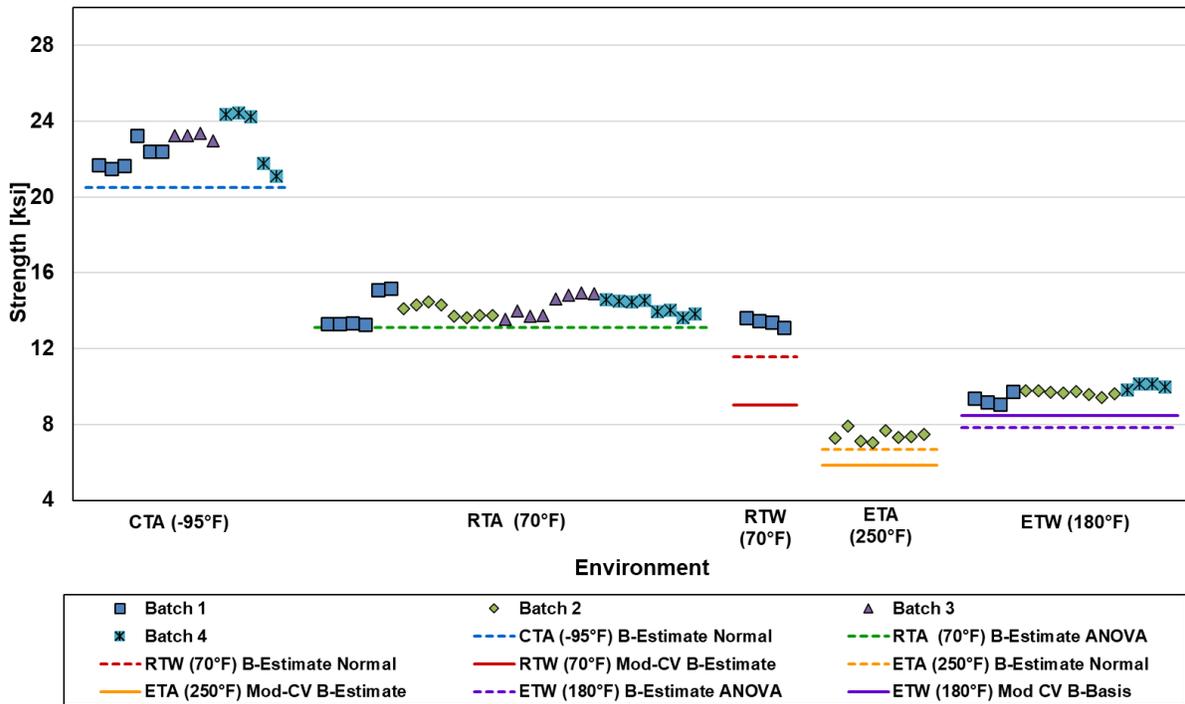


Figure 4-19: Batch Plot for Compression Cube Z45 2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube Z45 Compressive Strength**

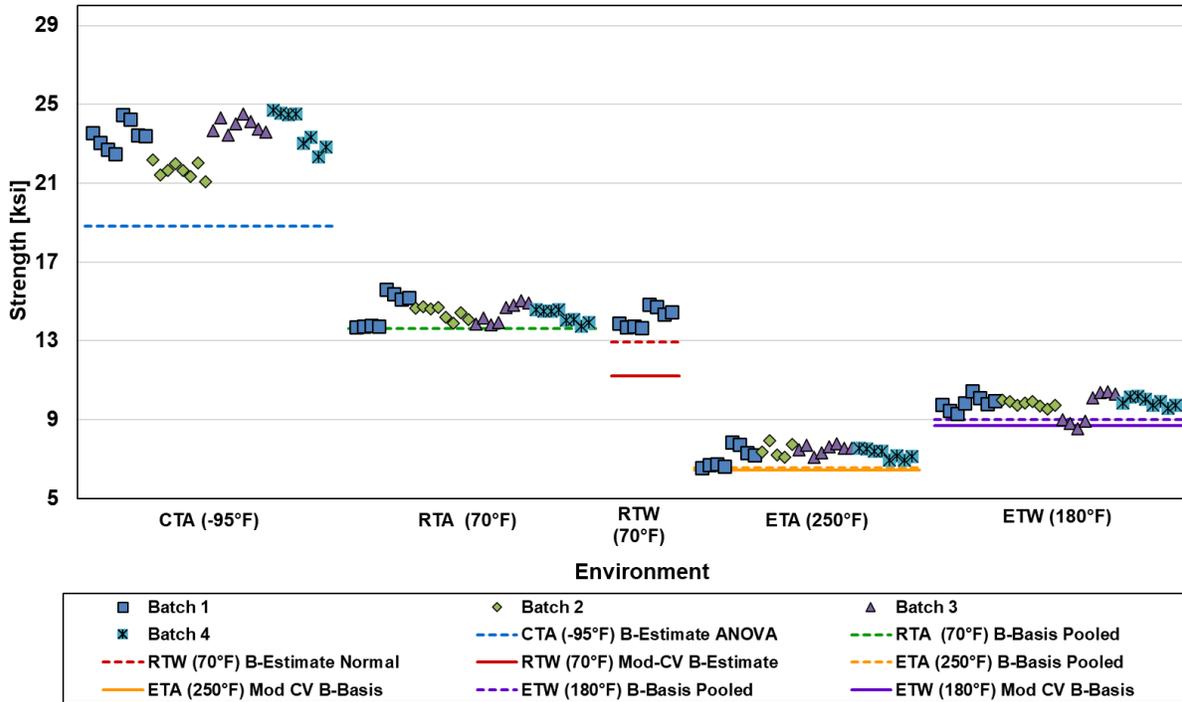


Figure 4-20: Batch Plot for Compression Cube Z45 Compressive Strength

CZ45 Strength (ksi) As-Measured Basis Values and Statistics																					
Environment	0.2% Offset Strength					1% Offset Strength					2% Offset Strength					Compressive Strength					
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	
Mean	13.23	11.66	11.05	6.897	8.712	19.84	13.68	13.59	7.265	9.615	22.78	14.12	13.41	7.399	9.669	23.19	14.40	14.18	7.320	9.772	
Std. Dev.	1.352	1.589	0.7313	0.4877	0.6361	1.317	0.7618	0.7754	0.3048	0.3481	1.088	0.5641	0.2150	0.2828	0.3012	1.093	0.5345	0.4804	0.3753	0.4571	
CV	10.22	13.62	6.616	7.071	7.301	6.639	5.570	5.708	4.195	3.621	4.778	3.996	1.604	3.822	3.115	4.711	3.711	3.389	5.127	4.678	
Modified CV	10.22	13.62	8.000	7.535	7.651	7.319	6.785	8.000	6.098	6.000	6.389	6.000	8.000	8.000	6.000	6.356	6.000	8.000	6.563	6.339	
Min	11.31	9.507	9.566	5.918	7.146	18.10	12.58	12.49	6.746	8.922	21.11	13.27	13.13	7.043	9.057	21.08	13.71	13.68	6.549	8.550	
Max	17.95	14.45	11.79	7.871	9.982	22.96	15.29	14.51	7.817	10.13	24.43	15.18	13.65	7.896	10.140	24.70	15.60	14.86	7.940	10.44	
No. Batches	4	4	1	4	4	4	4	1	3	4	3	4	1	1	3	4	4	1	4	4	
No. Specimens	31	32	8	32	32	26	32	8	10	22	15	30	4	8	16	32	32	8	29	32	
Basis Values and Estimates																					
B-Basis	11.31			6.040	7.595		12.34										13.64		6.556	9.014	
B-Estimate		5.047	9.153			15.23		11.57	6.544	8.602	20.53	13.12	12.53	6.664	7.846	18.83		12.93			
A-Estimate	7.320	0.4579	7.822	5.418	6.784	12.02	11.37	10.16	6.041	7.892	18.94	12.40	11.86	6.150	6.546	15.80	13.12	12.05	6.029	8.486	
Method	Non-Param.	ANOVA	Normal	Normal	Normal	ANOVA	Normal	Normal	Normal	ANOVA	Normal	ANOVA	Normal	Normal	ANOVA	ANOVA	Pooled	Normal	Pooled	Pooled	
Modified CV Basis Values and Estimates																					
B-Basis				5.984	7.541				8.527										6.461	8.684	
B-Estimate				8.755				10.76	6.217					9.013	5.861	8.489			11.23		
A-Estimate	NA	NA		7.146	5.321	6.691	NA	NA	8.783	5.485	7.750	NA	NA	5.684	4.784	7.656	NA	NA	9.165	5.841	7.894
Method				Normal	Normal	Normal			Normal	Normal	Normal			Normal	Normal	Normal			Normal	Normal	Normal

Table 4-13: Statistics and Basis Values for Compression Cube Z45 Strength Data

CZ45 Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.5590	0.4848	0.4789	0.4364	0.4737
Std. Dev.	0.02426	0.02193	0.03631	0.01680	0.03908
CV	4.341	4.524	7.583	3.850	8.250
Min	0.5079	0.4526	0.4277	0.4030	0.4074
Max	0.5981	0.5390	0.5258	0.4659	0.5716
No. Batches	4	4	1	4	4
No.	32	32	8	32	32

Table 4-14: Statistics for Compression Cube Z45 Modulus Data

4.8 Compression Cube ZX Orientation (C – ASTM (D695))

0.2% offset strength, compressive strength and modulus tests were performed in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. 1% offset strength tests were performed in the following environmental conditions: CTA, RTA, RTW and ETW. 2% offset strength tests were performed in the following environmental conditions: CTA, RTA, and RTW. The RTW condition for all tests consists of a single batch with eight specimens or less, therefore only basis value estimates are provided for that condition.

For the 0.2% offset strength dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The ETA and ETW conditions failed the normality test, but the lognormal distribution was a good fit for the ETA data and the Weibull was a good fit for the ETW data. The normal method was used for CTA and RTW. Applying the modified CV, the RTA condition failed the ADK test and the ETA condition failed the normality test, therefore modified CV basis values are not available for these conditions. The normal method was used for the remaining conditions.

For the 1% offset strength dataset, the ETW condition has less than eighteen specimens, therefore only basis value estimates are provided for that condition. The normal method was used for all conditions. Applying the modified CV, the RTA condition failed the normality test, therefore modified CV basis values are not available for that condition. The normal method was used for the remaining conditions.

For the 2% offset strength dataset, the CTA condition consists of less than eighteen specimens, therefore only estimates are provided for that condition. The normal method was used for CTA. The RTA condition failed all the distribution tests, therefore the non-parametric method was used for that condition. The RTW conditions consists of only three specimens therefore only simple statistics are provided for that condition. Applying the modified CV, the RTA condition failed the normality test, therefore modified CV basis values are not available for that condition and the normal method was used for CTA.

For the compressive strength dataset, the CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTA, ETA, and ETW conditions met all the requirements for pooling. The normal method was used for RTW. Applying the modified CV, the RTA and ETA conditions failed the normality test, therefore modified CV basis values are not available for these conditions. The normal method was used for the remaining conditions.

There were two statistical outliers. For 0.2% offset strength, the lowest value in batch three of the ETW condition was a condition outlier. For 1% offset strength, the lowest value in batch three of the ETW condition was a condition outlier. They were retained for this analysis.

Statistics, estimates and basis values are given for the CZX strength data in Table 4-15 and for the modulus data in Table 4-16. The data, B-estimates and the B-basis values are shown graphically in Figure 4-21 through Figure 4-24.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube ZX 0.2% Offset Strength**

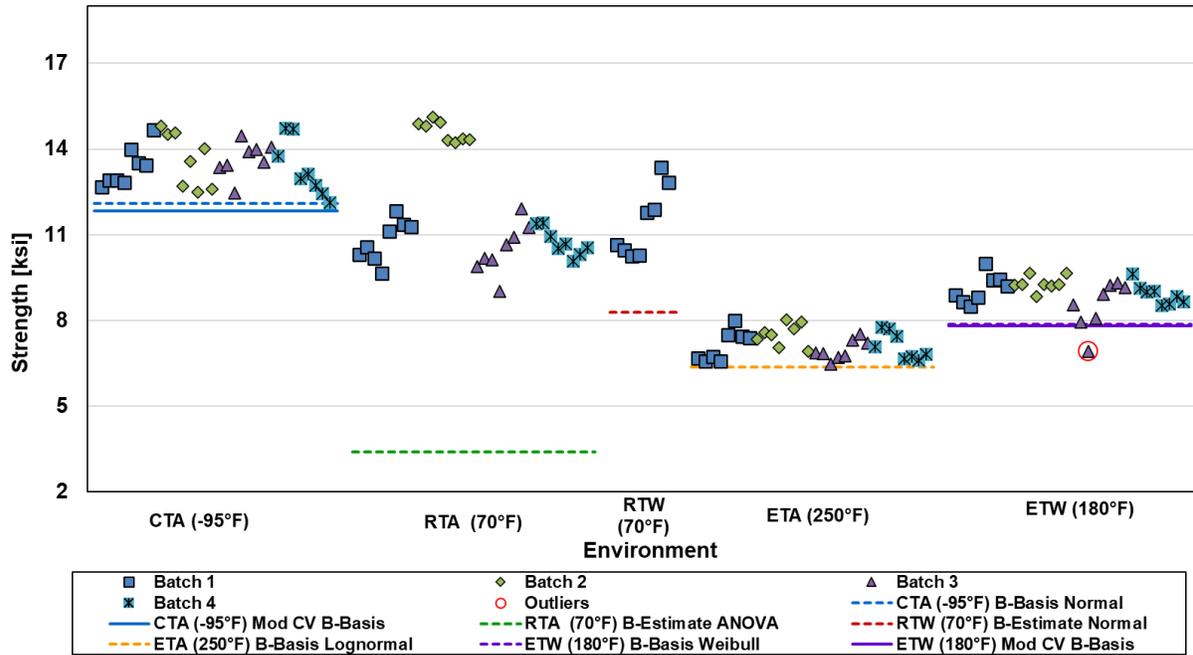


Figure 4-21: Batch Plot for Compression Cube ZX 0.2% Offset Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Compression Cube ZX 1% Offset Strength

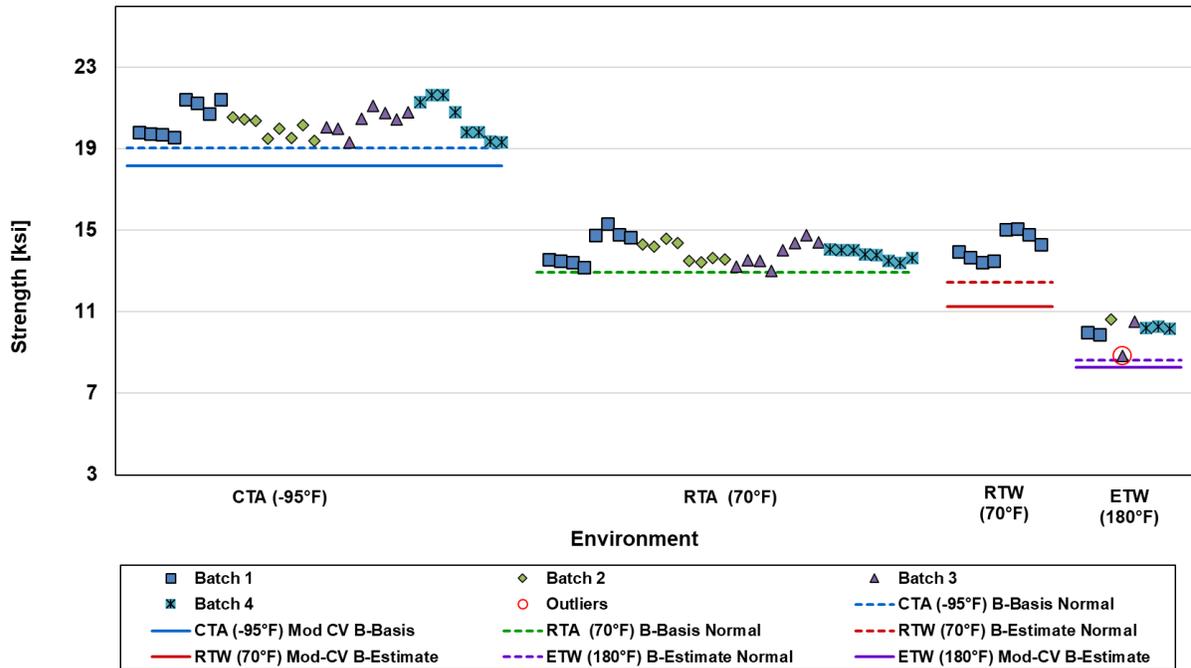


Figure 4-22: Batch Plot for Compression Cube ZX 1% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube ZX 2% Offset Strength**

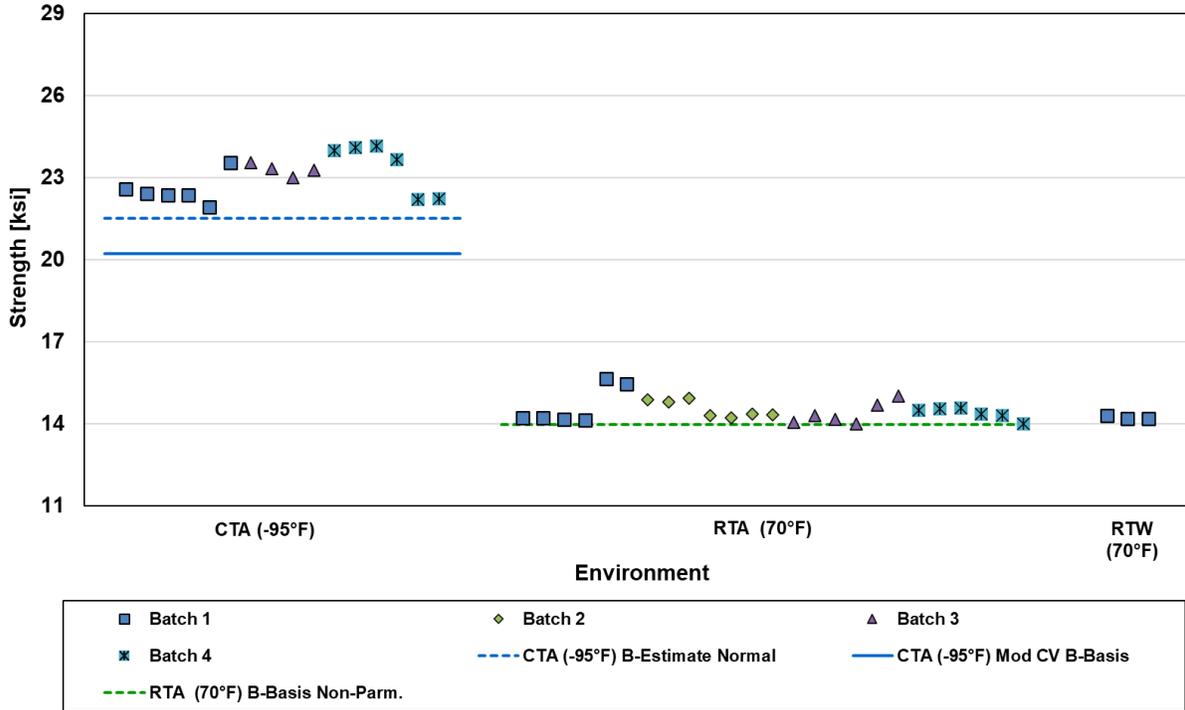


Figure 4-23: Batch Plot for Compression Cube ZX 2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Compression Cube ZX Compressive Strength**

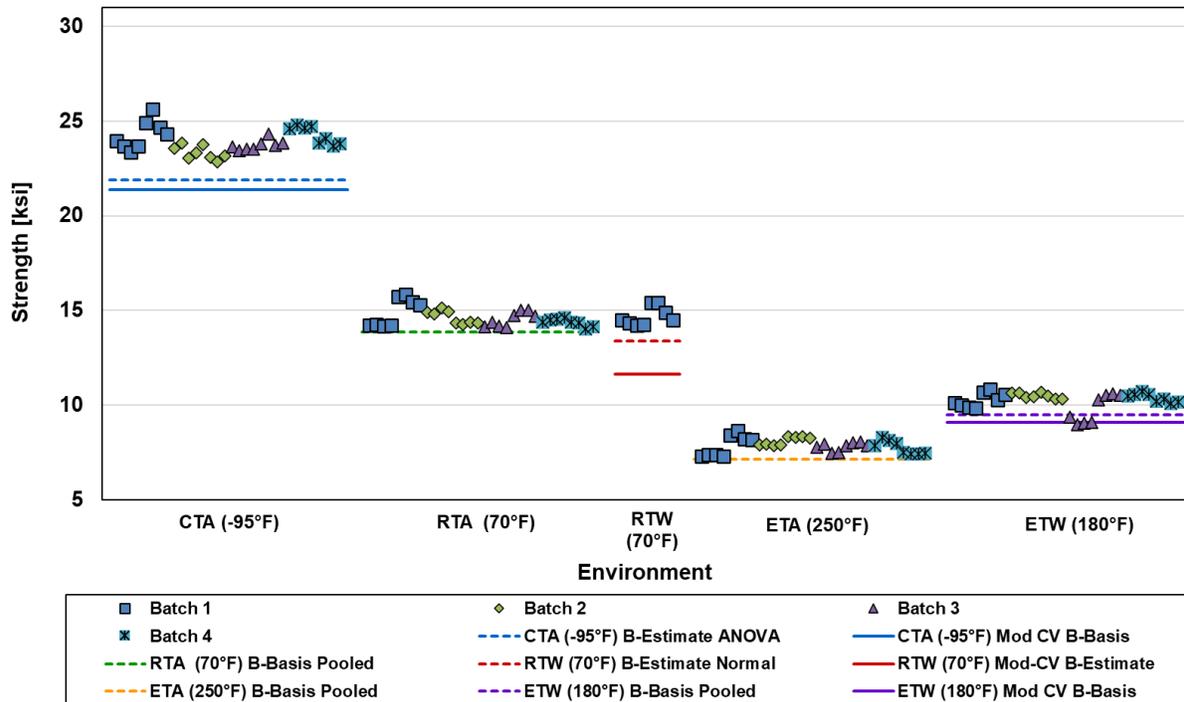


Figure 4-24: Batch Plot for Compression Cube ZX Compressive Strength

CZX Strength (ksi) As-Measured Basis Values and Statistics																		
Environment	0.2% Offset Strength					1% Offset Strength				2% Offset Strength			Compressive Strength					
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	
Mean	13.50	11.66	11.44	7.168	8.955	20.32	13.94	14.23	10.07	23.04	14.49	14.23	23.89	14.61	14.69	7.890	10.24	
Std. Dev.	0.8009	1.847	1.211	0.4722	0.5859	0.7315	0.5694	0.6816	0.5596	0.7500	0.4301	0.06638	0.6242	0.4848	0.5005	0.3753	0.4924	
CV	5.935	15.84	10.59	6.588	6.543	3.600	4.085	4.791	5.558	3.255	2.969	0.4664	2.612	3.318	3.407	4.757	4.808	
Modified CV	6.967	15.84	10.59	7.294	7.271	6.000	6.042	8.000	6.779	6.000	6.000	8.000	6.000	6.000	8.000	6.378	6.404	
Min	12.11	9.013	10.25	6.465	6.912	19.31	13.00	13.44	8.824	21.91	14.01	14.18	22.84	14.02	14.22	7.318	8.996	
Max	14.80	15.11	13.36	8.024	9.988	21.64	15.32	15.08	10.63	24.16	15.65	14.31	25.63	15.87	15.43	8.659	10.825	
No. Batches	4	4	1	4	4	4	4	1	4	3	4	1	4	4	1	4	4	
No. Specimens	32	32	8	32	32	32	32	8	8	16	25	3	32	32	8	32	32	
Basis Values and Estimates																		
B-Basis	12.09			6.375	7.867	19.04	12.94					13.98			13.87		7.148	9.500
B-Estimate		3.384	8.288					12.45	8.614	21.51			NA	21.89	13.39			
A-Estimate	11.07	0.000	6.085	5.864	6.750	18.10	12.21	11.21	7.596	20.44	12.35		NA	20.49	13.35	12.48	6.631	8.983
Method	Normal	ANOVA	Normal	Log Normal	Weibull	Normal	Normal	Normal	Normal	Normal	Normal	Non-Par.		ANOVA	Pooled	Normal	Pooled	Pooled
Modified CV Basis Values and Estimates																		
B-Basis	11.84				7.811	18.18									21.37			9.090
B-Estimate			8.288				NA	11.27	8.294	20.23			NA	NA		NA	11.64	
A-Estimate	10.64		6.085		6.981	16.62		9.197	7.052	18.24			NA	NA	19.55		9.497	8.254
Method	Normal		Normal		Normal	Normal		Normal	Normal	Normal			Normal	Normal	Normal		Normal	Normal

Table 4-15: Statistics and Basis Values for Compression Cube ZX Strength Data

CZX Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.5619	0.4679	0.4992	0.4262	0.4756
Std. Dev.	0.01923	0.02025	0.01659	0.02223	0.03630
CV	3.423	4.328	3.323	5.217	7.633
Min	0.5255	0.4225	0.4780	0.3793	0.4179
Max	0.6033	0.5211	0.5207	0.4624	0.5696
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-16: Statistics for Compression Cube ZX Modulus Data

4.9 Flexural XY Orientation (F Proc. B– ASTM D790)

0.2% offset strength, flexural strength and modulus tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW.

For the 0.2% offset strength dataset, the CTA and RTA conditions met all the requirements for pooling. The ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. Applying the modified CV, the CTA and RTA conditions met all the requirements for pooling. The ETA condition failed the ADK test, therefore modified CV basis values are not available for that condition. The normal method was used for ETW.

For the flexural strength dataset, the ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The CTA condition failed all the distributions tests, therefore the non-parametric method was used for that condition and the normal method was used for RTA. Applying the modified CV, the CTA and RTA conditions failed the normality test and the ETA condition failed the ADK test, therefore modified CV basis values are not available for these conditions. The normal method was used for ETW.

There were four statistical outliers. For 0.2% offset strength, the lowest value in batch one of the ETW condition was a condition outlier. For flexural strength, the lowest value in batch one of the CTA condition was a batch outlier. The lowest value in batch three of the CTA condition was a batch outlier. The lowest value in batch four of the CTA condition was a batch and condition outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the FXY strength data in Table 4-17 and for the modulus data in Table 4-18. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-25 and Figure 4-26.

Stratasys Inc. Additively Manufactured Antero(R) 840CN03

Flexural XY 0.2% Offset Strength

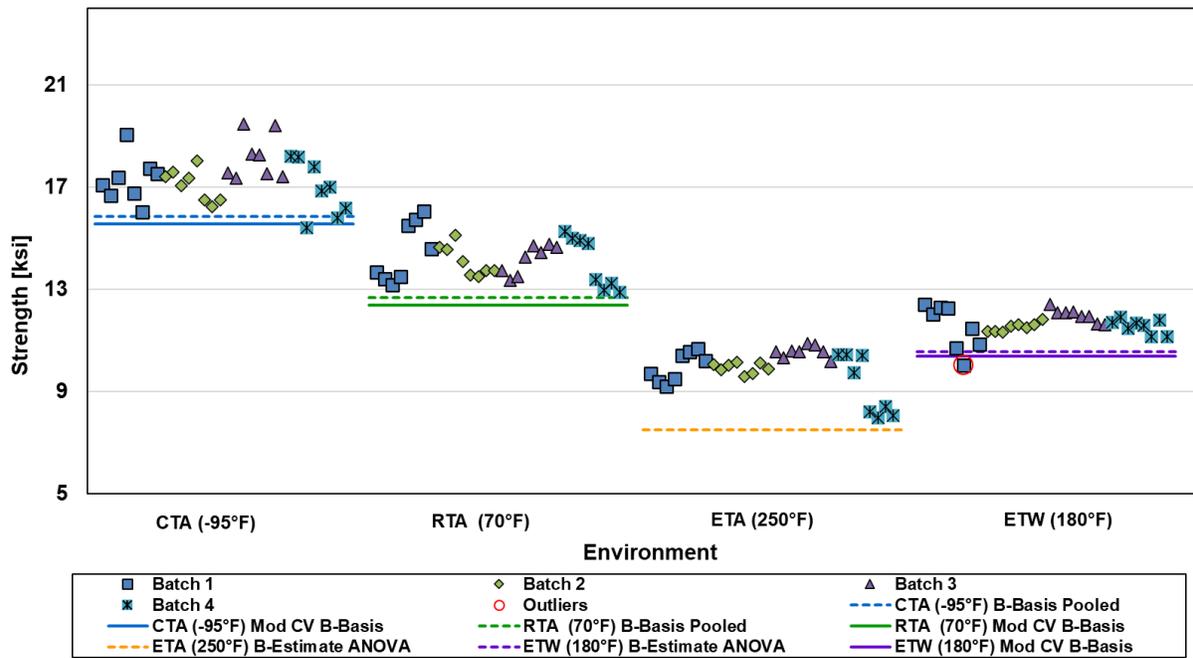


Figure 4-25: Batch Plot for Flexural XY 0.2% Offset Strength

**Stratays Inc. Additively Manufactured Antero(R) 840CN03
Flexural XY Strength**

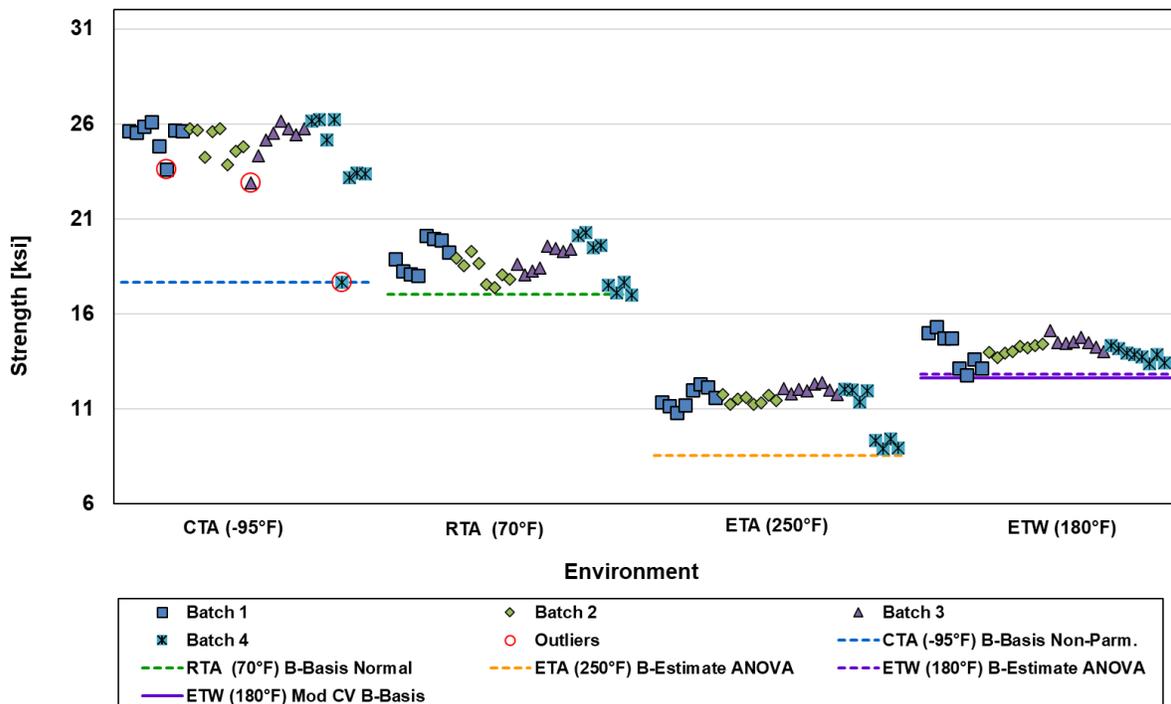


Figure 4-26: Batch Plot for Flexural XY Strength

FX Y Strength (ksi) As-Measured Basis Values and Statistics								
Environment	0.2% Offset Strength				Flexural Strength			
	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	17.36	14.21	9.919	11.65	24.86	18.70	11.40	14.13
Std. Dev.	0.9705	0.8462	0.7908	0.5096	1.639	0.9445	0.9447	0.5923
CV	5.590	5.957	7.973	4.376	6.596	5.050	8.289	4.192
Modified CV	6.795	6.978	7.986	6.188	7.298	6.525	8.289	6.096
Min	15.41	12.89	7.995	10.05	17.66	17.00	8.907	12.78
Max	19.47	16.07	10.89	12.43	26.23	20.27	12.41	15.33
No. Batches	4	4	4	4	4	4	4	4
No. Specimens	32	32	32	32	32	32	32	32
Basis Values and Estimates								
B-Basis	15.84	12.69			17.66	17.04		
B-Estimate			7.499	10.57			8.550	12.81
A-Estimate	14.77	11.62	5.801	9.795	12.29	15.84	6.551	11.87
Method	Pooled	Pooled	ANOVA	ANOVA	Non-Parm.	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis	15.55	12.39		10.38				12.62
A-Estimate	14.26	11.11	NA	9.461	NA	NA	NA	11.52
Method	Pooled	Pooled		Normal				Normal

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

FX Y Modulus (Msi) Statistics				
Environment	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.4982	0.4615	0.3817	0.4055
Std. Dev.	0.02959	0.02926	0.02802	0.01962
CV	5.940	6.341	7.343	4.839
Min	0.4450	0.3988	0.3111	0.3572
Max	0.5509	0.5229	0.4310	0.4568
No. Batches	4	4	4	4
No. Specimens	32	32	32	32

Table 4-18: Statistics for Flexural XY Modulus Data

4.10 Flexural XZ Orientation (F Proc. B – ASTM D790)

0.2% offset strength, flexural strength and modulus tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW.

For the 0.2% offset strength dataset, the CTA, RTA and ETA condition failed all the distributions tests, therefore the non-parametric method was used for these conditions. The ETW condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, the CTA, RTA and ETW conditions met all the requirements for pooling. The ETA condition failed the normality test, therefore modified CV basis values are not available for that condition.

For the flexural strength dataset, the CTA, RTA and ETA condition failed all the distributions tests, therefore the non-parametric method was used for these conditions. The ETW condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, the RTA and ETA conditions failed the normality test, therefore modified CV basis values are not available for these conditions. The normal method was used for CTA and ETW.

There were four statistical outliers. For 0.2% offset strength, the highest value in batch one of the CTA condition was a batch outlier. The lowest value in batch two of the ETW condition was a batch and condition outlier. For flexural strength, the lowest value in batch two of the CTA condition was a batch outlier. The lowest value in batch two of the ETW condition was a batch and condition outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the FXZ strength data in Table 4-19 and for the modulus data in Table 4-20. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-27 and Figure 4-28.

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Flexural XZ 0.2% Offset Strength

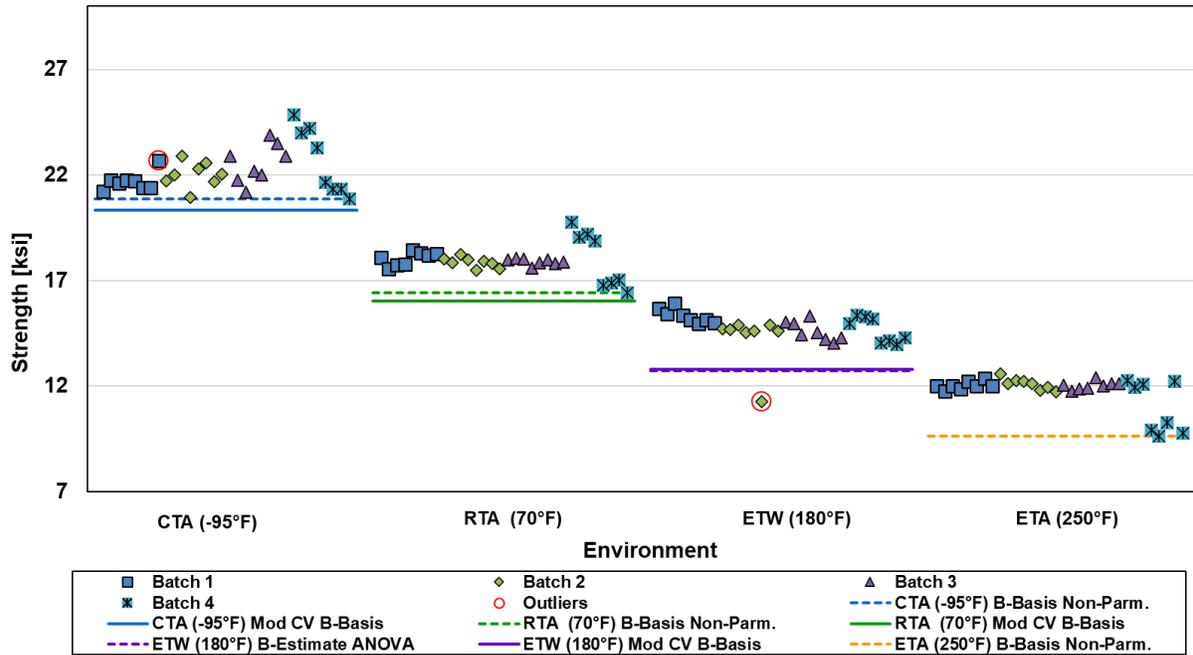


Figure 4-27: Batch Plot for Flexural XZ 0.2% Offset Strength

Stratasy Inc. Additively Manufactured Antero(R) 840CN03
Flexural XZ Strength

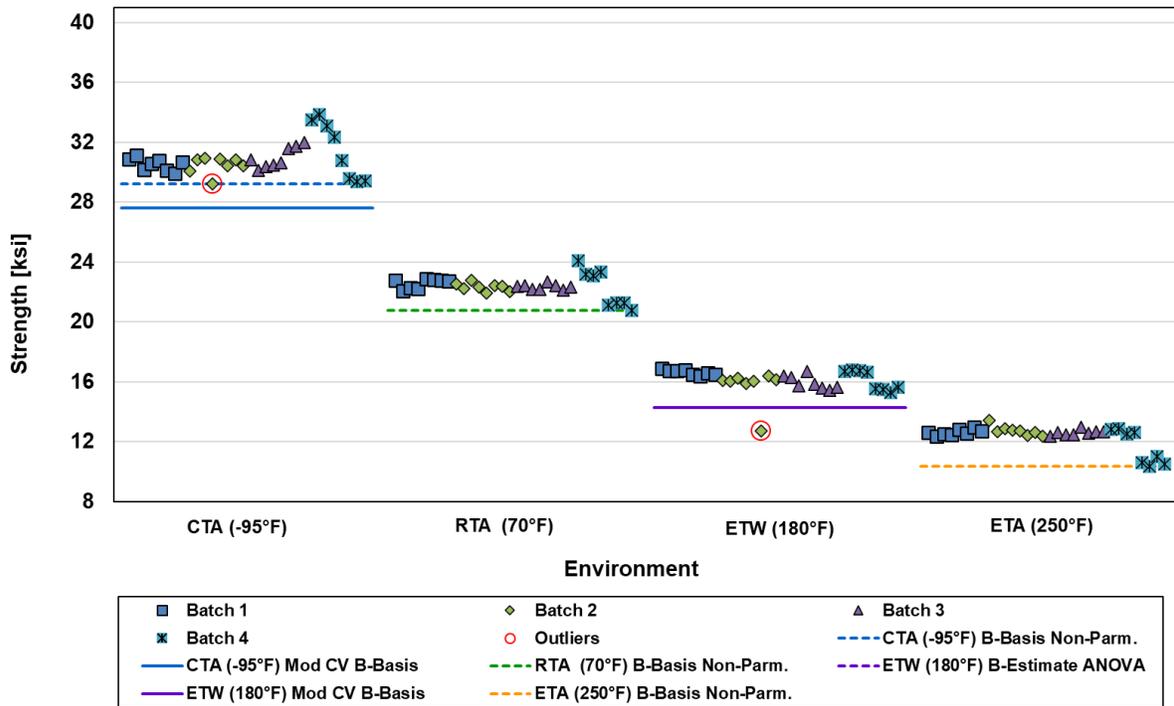


Figure 4-28: Batch Plot for Flexural XZ Strength

FXZ Strength (ksi) As-Measured Basis Values and Statistics								
Environment	0.2% Offset Strength				Flexural Strength			
	CTA (-95 °F)	RTA (70 °F)	ETW (180 °F)	ETA (250 °F)	CTA (-95 °F)	RTA (70 °F)	ETW (180 °F)	ETA (250 °F)
Mean	22.24	17.95	14.72	11.80	30.88	22.38	16.10	12.42
Std. Dev.	1.016	0.6692	0.7989	0.7548	1.116	0.6572	0.7747	0.7227
CV	4.568	3.727	5.427	6.399	3.613	2.936	4.811	5.820
Modified CV	6.284	6.000	6.714	7.199	6.000	6.000	6.406	6.910
Min	20.85	16.44	11.28	9.644	29.21	20.76	12.75	10.35
Max	24.84	19.76	15.93	12.57	33.88	24.08	16.88	13.42
No. Batches	4	4	4	4	4	4	4	4
No. Specimens	32	32	32	32	32	32	32	32
Basis Values and Estimates								
B-Basis	20.85	16.44		9.644	29.21	20.76		10.35
B-Estimate			12.72				14.27	
A-Estimate	17.76	13.88	11.31	7.560	25.48	18.11	12.97	8.155
Method	Non-Parm.	Non-Parm.	ANOVA	Non-Parm.	Non-Parm.	Non-Parm.	ANOVA	Non-Parm.
Modified CV Basis Values and Estimates								
B-Basis	20.16	15.87	12.81	NA	27.62	NA	14.29	NA
A-Estimate	18.69	14.41	11.48		25.26		12.97	
Method	Pooled	Pooled	Pooled		Normal		Normal	

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

FXZ Modulus (Msi) Statistics				
Environment	CTA (-95 °F)	RTA (70 °F)	ETW (180 °F)	ETA (250 °F)
Mean	0.6076	0.5448	0.5022	0.4771
Std. Dev.	0.01719	0.01605	0.02390	0.02534
CV	2.830	2.946	4.759	5.312
Min	0.5789	0.5020	0.3993	0.4055
Max	0.6429	0.5776	0.5259	0.5039
No. Batches	4	4	4	4
No. Specimens	32	32	32	32

Table 4-20: Statistics for Flexural XZ Modulus Data

4.11 Flexural Z45 Orientation (F Proc. B – ASTM D790)

0.2% offset strength, flexural strength and modulus tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW.

For the 0.2% offset strength dataset, the CTA condition has less than eighteen specimens, therefore only estimates were provided for that condition. The ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions and the normal method was used for CTA and RTA. Applying the modified CV, the ETA and ETW conditions failed the ADK test, therefore modified CV basis values are not available for these conditions. The normal method was used for CTA and RTA.

For the flexural strength dataset, the ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The CTA and RTA conditions met all the requirements for pooling. Applying the modified CV, the ETA condition failed the ADK test, therefore modified CV basis values are not available for that condition. The CTA and RTA conditions met all the requirements for pooling, and the normal method was used for ETW.

There were two statistical outliers. For 0.2% offset strength, the lowest value in batch four of the RTA condition was a condition outlier. For flexural strength, the lowest value in batch three of the RTA condition was a batch outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the FZ45 strength data in Table 4-21 and for the modulus data in Table 4-22. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-29 and Figure 4-30.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Flexural Z45 0.2% Offset Strength**

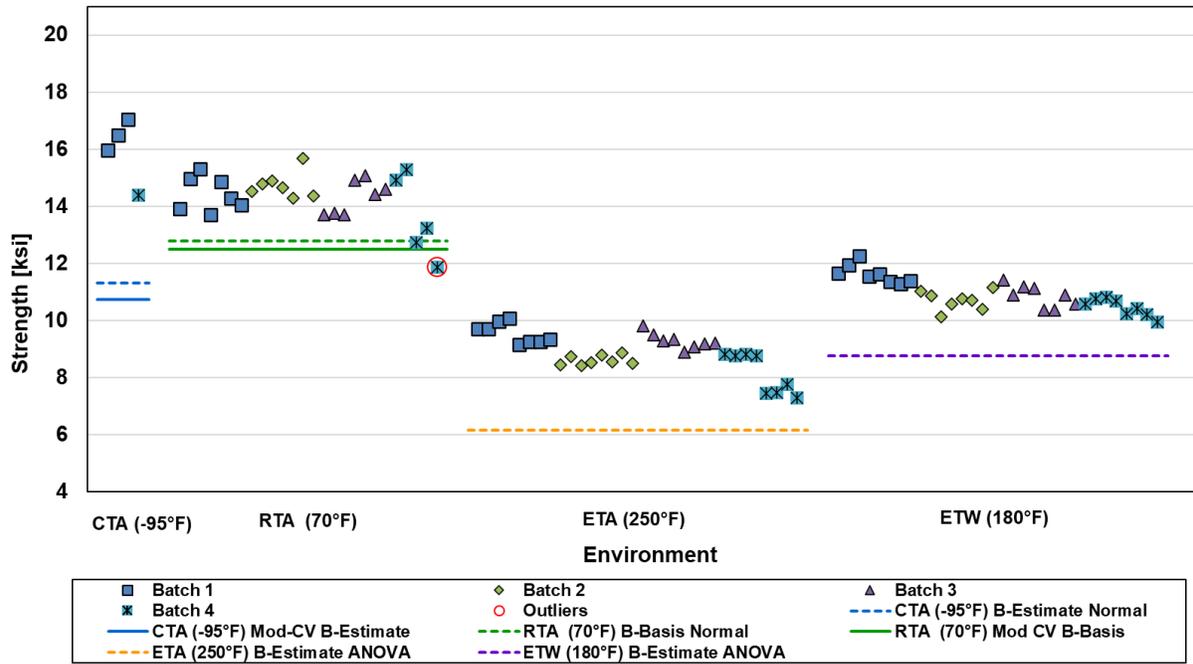


Figure 4-29: Batch Plot for Flexural Z45 0.2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Flexural Z45 Strength**

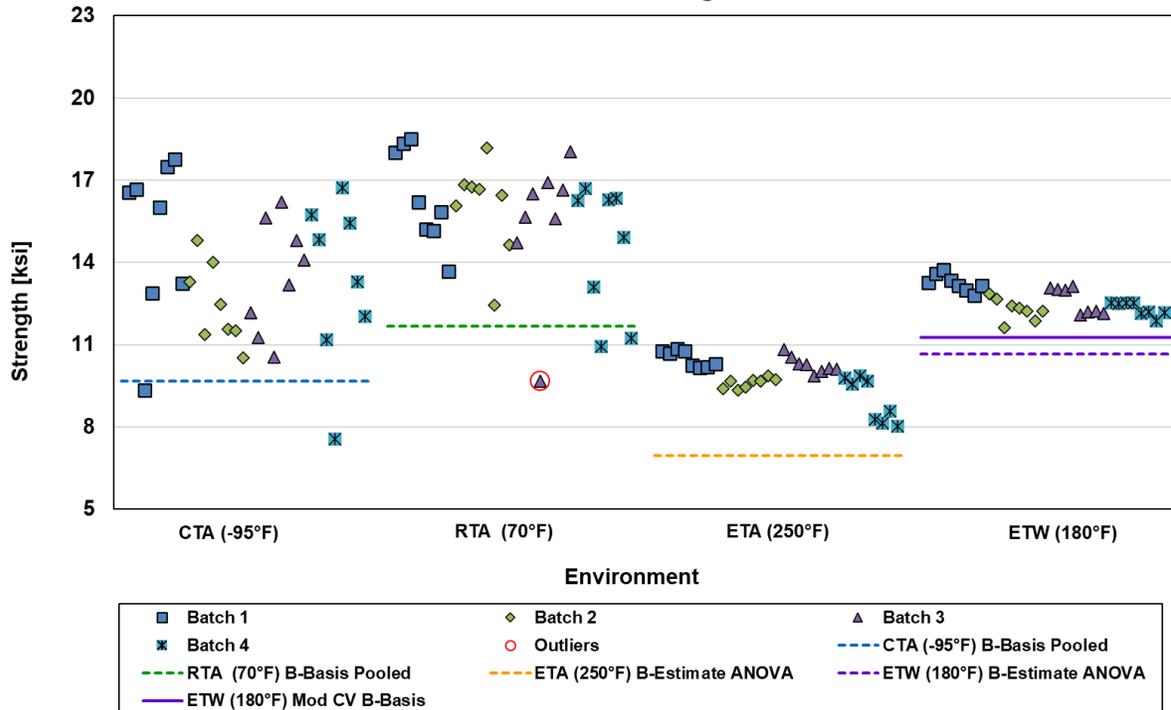


Figure 4-30: Batch Plot for Flexural Z45 Strength

FZ45 Strength (ksi) As-Measured Basis Values and Statistics								
Environment	0.2% Offset Strength				Flexural Strength			
	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	15.98	14.32	8.901	10.91	13.57	15.58	9.837	12.61
Std. Dev.	1.135	0.8449	0.6967	0.5521	2.507	2.159	0.7436	0.5313
CV	7.105	5.899	7.827	5.059	18.48	13.86	7.559	4.213
Modified CV	8.000	6.949	7.913	6.530	18.48	13.86	7.779	6.107
Min	14.40	11.87	7.292	9.951	7.555	9.657	8.012	11.62
Max	17.04	15.67	10.08	12.27	17.76	18.50	10.85	13.73
No. Batches	2	4	4	4	4	4	4	4
No. Specimens	4	26	32	32	32	32	32	32
Basis Values and Estimates								
B-Basis		12.78			9.671	11.68		
B-Estimate	11.33		6.171	8.754			6.949	10.66
A-Estimate	7.803	11.68	4.273	7.253	6.919	8.926	4.941	9.309
Method	Normal	Normal	ANOVA	ANOVA	Pooled	Pooled	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis		12.51			9.671	11.68		11.26
B-Estimate	10.74		NA	NA			NA	
A-Estimate	6.774	11.20			6.919	8.926		10.27
Method	Normal	Normal			Pooled	Pooled		Normal

Table 4-21: Statistics and Basis Values for Flexural Z45 Strength Data

FZ45 Modulus (Msi) Statistics				
Environment	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.4786	0.4359	0.3494	0.3799
Std. Dev.	0.02622	0.01739	0.02992	0.01716
CV	5.478	3.990	8.564	4.516
Min	0.4321	0.3979	0.2880	0.3520
Max	0.5309	0.4679	0.4113	0.4256
No. Batches	4	4	4	4
No. Specimens	32	32	32	32

Table 4-22: Statistics for Flexural Z45 Modulus Data

4.12 Flexural ZX Orientation (F Proc. B – ASTM D790)

0.2% offset strength, flexural strength and modulus tests were conducted in the following environmental conditions: CTA, RTA, ETA, and ETW.

For the 0.2% offset strength dataset, the CTA condition consists of a single batch of data with 2 specimens therefore basis values were not computed for that condition. The RTA condition has less than eighteen specimens, therefore only estimates were provided for that condition using the normal method. The ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. Applying the modified CV, the ETA condition failed the ADK test, therefore modified CV basis values are not available for that condition. The normal method was used for RTA and ETW.

For the flexural strength dataset, the CTA, ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for this conditions. The normal method was used for RTA. Applying the modified CV, the CTA and ETA conditions failed the ADK test, therefore modified CV basis values are not available for these conditions. The normal method was used for RTA and ETW. The RTA condition has an original CV greater than 8%, therefore the results are the same using the original and modified CV, and only the original CV line is visible in the graph.

There were three statistical outliers. For 0.2% offset strength, the highest value in batch two of the ETW condition was a batch and condition outlier. For flexural strength, the lowest value in batch three of the RTA condition was a condition outlier and the highest value in batch two of the ETW condition was a batch and condition outlier.

Statistics, basis values and estimates are given for the FZX strength data in Table 4-23 and for the modulus data in Table 4-24. The data, B-estimates and B-basis values are shown graphically in Figure 4-31 and Figure 4-32.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Flexural ZX 0.2% Offset Strength**

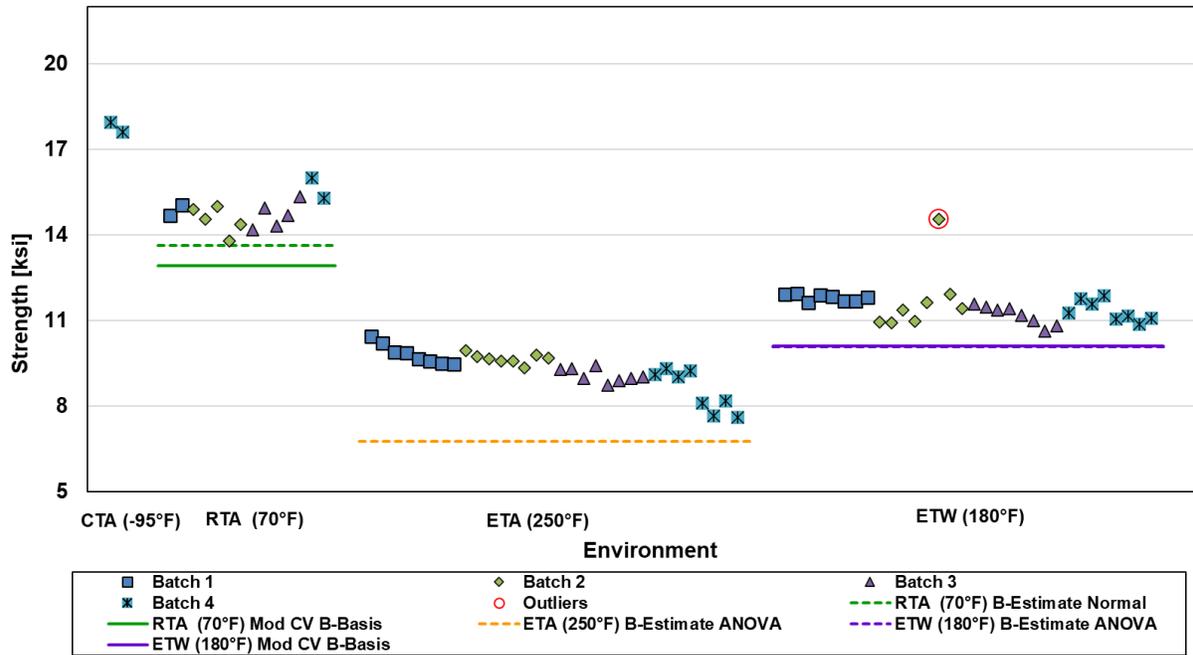


Figure 4-31: Batch Plot for Flexural ZX 0.2% Offset Strength

**Stratasy Inc. Additively Manufactured Antero(R) 840CN03
Flexural ZX Strength**

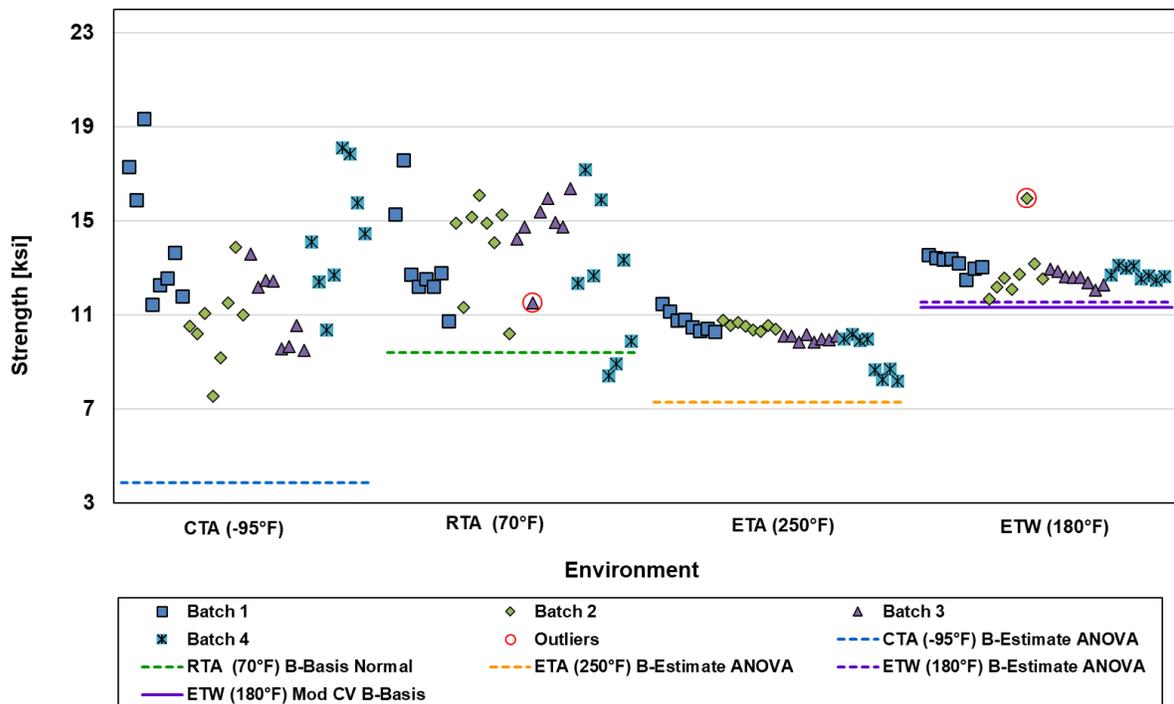


Figure 4-32: Batch Plot for Flexural ZX Strength

FZX Strength (ksi) As-Measured Basis Values and Statistics								
Environment	0.2% Offset Strength				Flexural Strength			
	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	17.78	14.79	9.279	11.51	12.65	13.58	10.11	12.84
Std. Dev.	0.2497	0.5516	0.6556	0.6748	2.833	2.372	0.7458	0.7154
CV	1.405	3.729	7.065	5.863	22.39	17.46	7.374	5.571
Modified CV	8.000	6.000	7.533	6.931	22.39	17.46	7.687	6.786
Min	17.60	13.80	7.623	10.63	7.556	8.402	8.180	11.67
Max	17.95	15.99	10.44	14.56	19.34	17.59	11.47	15.95
No. Batches	1	4	4	4	4	4	4	4
No. Specimens	2	14	32	32	32	32	32	32
Basis Values and Estimates								
B-Basis	NA					9.414		
B-Estimate		13.63	6.783	10.10	3.855		7.281	11.53
A-Estimate		12.81	5.047	9.082	0.000	6.390	5.309	10.58
Method		Normal	ANOVA	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis	NA			10.11		9.414		11.31
B-Estimate		12.92						
A-Estimate		11.60		9.091		6.390		10.20
Method		Normal		Normal		Normal		Normal

Table 4-23: Statistics and Basis Values for Flexural ZX Strength Data

FZX Modulus (Msi) Statistics				
Environment	CTA (-95 °F)	RTA (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.5111	0.4604	0.3779	0.4099
Std. Dev.	0.02494	0.01822	0.02790	0.01994
CV	4.880	3.957	7.383	4.865
Min	0.4575	0.4194	0.3166	0.3729
Max	0.5503	0.5044	0.4163	0.4901
No. Batches	4	4	4	4
No. Specimens	32	32	32	32

Table 4-24: Statistics for Flexural ZX Modulus Data

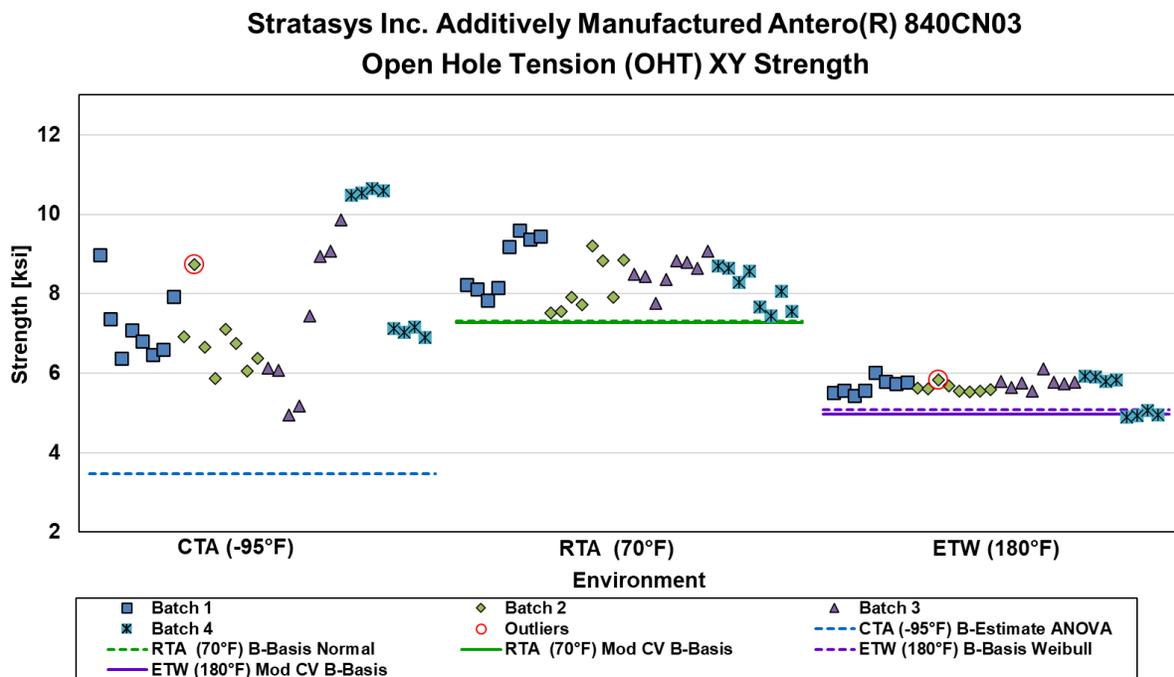
4.13 Open-Hole Tension XY Orientation (OHT – ASTM D5766)

Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The ETW failed the normality test, but the Weibull distribution was a good fit for the data, and the normal distribution was used for RTA. Applying the modified CV, the CTA condition failed the ADK test, therefore modified CV basis values are not available for this condition. The normal method was used for ETA and ETW.

There were two statistical outliers. The highest value in batch two of the CTA condition was a batch outlier. The highest value in batch two of the ETW condition was a batch outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the OHTXY strength data in Table 4-25. The data, B-estimates and B-basis values are shown graphically in Figure 4-33.



OHTXY Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-65 °F)	RTA (70 °F)	ETW (180 °F)
Mean	7.505	8.398	5.619
Std. Dev.	1.604	0.6160	0.2959
CV	21.37	7.335	5.266
Modified CV	21.37	7.667	6.633
Min	4.943	7.450	4.896
Max	10.64	9.606	6.108
No. Batches	4	4	4
No. Specimens	32	32	32
Basis Values and Estimates			
B-Basis		7.316	5.083
B-Estimate	3.477		
A-Estimate	0.6215	6.530	4.511
Method	ANOVA	Normal	Weibull
Modified CV Basis Values and Estimates			
B-Basis	NA	7.267	4.964
A-Estimate		6.446	4.489
Method		Normal	Normal

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

4.14 Open-Hole Tension XZ Orientation (OHT – ASTM D5766)

Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The CTA condition failed the normality test but the lognormal distribution was a good fit for the data. The RTA condition failed all the distributions tests, therefore the non-parametric method was used for that condition. The ETW condition failed the ADK test for batch equivalency, ANOVA was used to compute estimates for that condition. Applying the modified CV, the CTA and RTA conditions failed the normality test, therefore modified CV basis values are not available for these conditions and the normal method was used for ETW.

There were two statistical outliers. The lowest value in batch four of the RTA condition was a batch outlier. The lowest value in batch three of the ETW condition was a condition outlier. They were retained for this analysis

Statistics, basis values and estimates are given for the OHTXZ strength data in Table 4-26. The data, B-estimates and B-basis values are shown graphically in Figure 4-34.

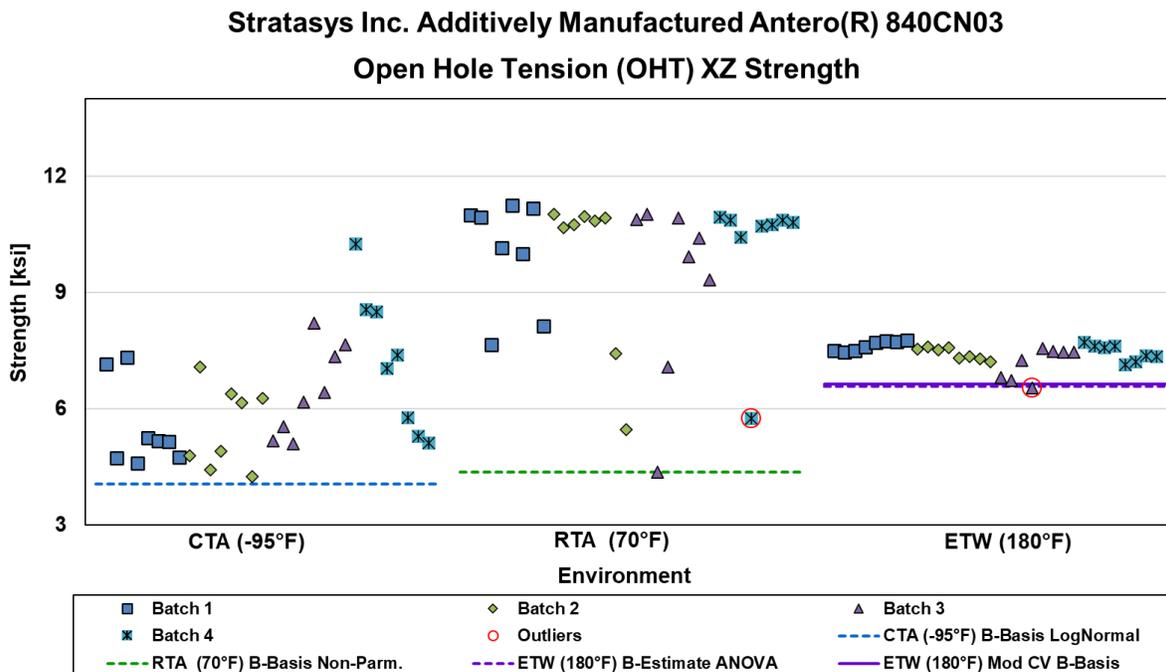


Figure 4-34: Batch Plot for OHT XZ Strength

OHTXZ Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-65 °F)	RTA (70 °F)	ETW (180 °F)
Mean	6.188	9.797	7.418
Std. Dev.	1.452	1.885	0.2891
CV	23.46	19.25	3.898
Modified CV	23.46	19.25	6.000
Min	4.247	4.362	6.541
Max	10.26	11.26	7.772
No. Batches	4	4	4
No. Specimens	32	32	32
Basis Values and Estimates			
B-Basis	4.071	4.362	
B-Estimate			6.579
A-Estimate	3.059	1.827	5.988
Method	Log Normal	Non-Parm.	ANOVA
Modified CV Basis Values and Estimates			
B-Basis	NA	NA	6.636
A-Estimate			6.069
Method			Normal

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

4.15 Open-Hole Tension Z45 Orientation (OHT – ASTM D5766)

Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The normal method was used for the CTA condition. The RTA condition failed the normality test, but the Weibull distribution was a good fit for the data. The ETW condition failed the ADK test for batch equivalency, ANOVA was used to compute estimates for that condition. Applying the modified CV, the normal method was used for CTA and ETW. The RTA condition failed the normality test, therefore modified CV basis values are not available for that condition. The CTA condition has an original CV greater than 8%, therefore, the results are the same using the original and modified CV, and only the original CV line is visible in the graph.

There were two statistical outliers. The lowest value in batch one of the RTA condition was a condition outlier. The lowest value in batch two of the RTA condition was a batch outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the OHTZ45 strength data in Table 4-27. The data, B-estimates and B-basis values are shown graphically in Figure 4-35.

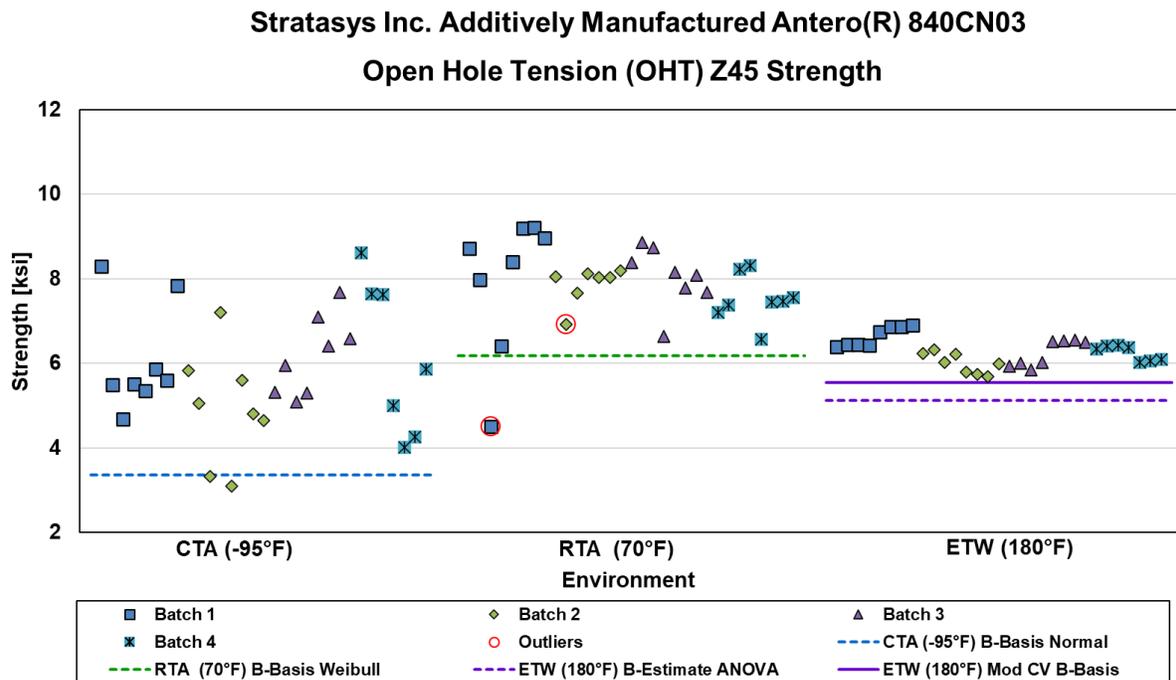


Figure 4-35: Batch Plot for OHT Z45 Strength

OHTZ45 Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-65 °F)	RTA (70 °F)	ETW (180 °F)
Mean	5.827	7.835	6.280
Std. Dev.	1.396	0.9502	0.3345
CV	23.96	12.13	5.326
Modified CV	23.96	12.13	6.663
Min	3.092	4.514	5.684
Max	8.610	9.207	6.908
No. Batches	4	4	4
No. Specimens	31	31	31
Basis Values and Estimates			
B-Basis	3.361	6.177	
B-Estimate			5.120
A-Estimate	1.574	4.676	4.310
Method	Normal	Weibull	ANOVA
Modified CV Basis Values and Estimates			
B-Basis	3.361	NA	5.541
A-Estimate	1.574		5.005
Method	Normal		Normal

Table 4-27: Statistics and Basis Values for OHT Z45 Strength Data

4.16 Open-Hole Tension ZX Orientation (OHT – ASTM D5766)

Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The CTA condition failed the normality test, but the Weibull distribution was a good fit for the data. The RTA and ETW conditions met all the requirements for pooling. Applying the modified CV, the CTA condition failed the normality test, therefore modified CV basis value are not available for that condition. The RTA and ETW conditions met all the requirements for pooling. The three conditions have original CVs greater than 8%, therefore the results using the original CV and modified CV are the same, for this reason only the original CV line is visible for all conditions in the graph.

There were two statistical outliers. The lowest value in batch two of the CTA condition was a batch outlier. The lowest value in batch two of the RTA condition was a batch outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the OHTZX strength data in Table 4-28. The data, B-estimates and B-basis values are shown graphically in Figure 4-36.

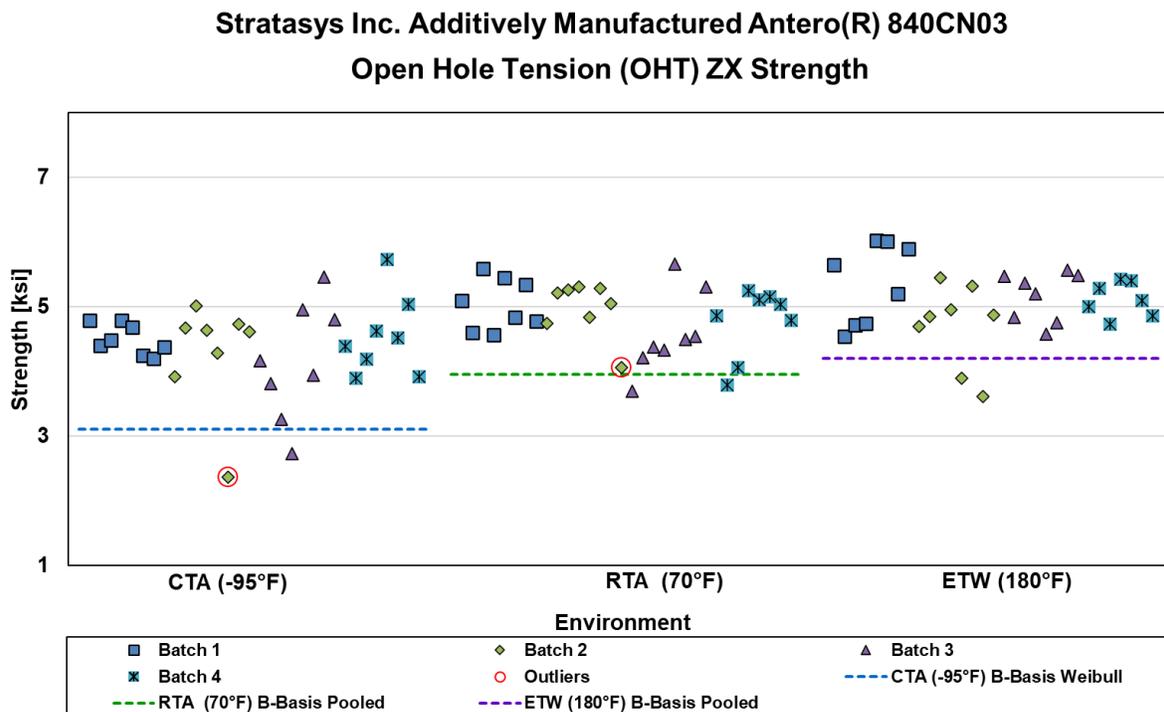


Figure 4-36: Batch Plot for OHT ZX Strength

OHTZX Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-65 °F)	RTA (70 °F)	ETW (180 °F)
Mean	4.364	4.834	5.079
Std. Dev.	0.6846	0.5120	0.5418
CV	15.69	10.59	10.67
Modified CV	15.69	10.59	10.67
Min	2.369	3.693	3.610
Max	5.735	5.657	6.019
No. Batches	4	4	4
No. Specimens	32	32	31
Basis Values and Estimates			
B-Basis	3.112	3.955	4.198
A-Estimate	2.106	3.335	3.578
Method	Weibull	Pooled	Pooled
Modified CV Basis Values and Estimates			
B-Basis	NA	3.955	4.198
A-Estimate		3.335	3.578
Method		Pooled	Pooled

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

4.17 Filled-Hole Tension XY Orientation (FHT – ASTM D6742)

Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The normal method was used for CTA and ETW. The RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, the CTA and RTA conditions met all the requirements for pooling and the normal method was used for ETW.

There was one statistical outlier. The highest value in batch three of the RTA condition was a batch outlier. It was retained for this analysis.

Statistics, basis values and estimates are given for the FHTXY strength data in Table 4-29. The data, B-estimates and B-basis values are shown graphically in Figure 4-37.

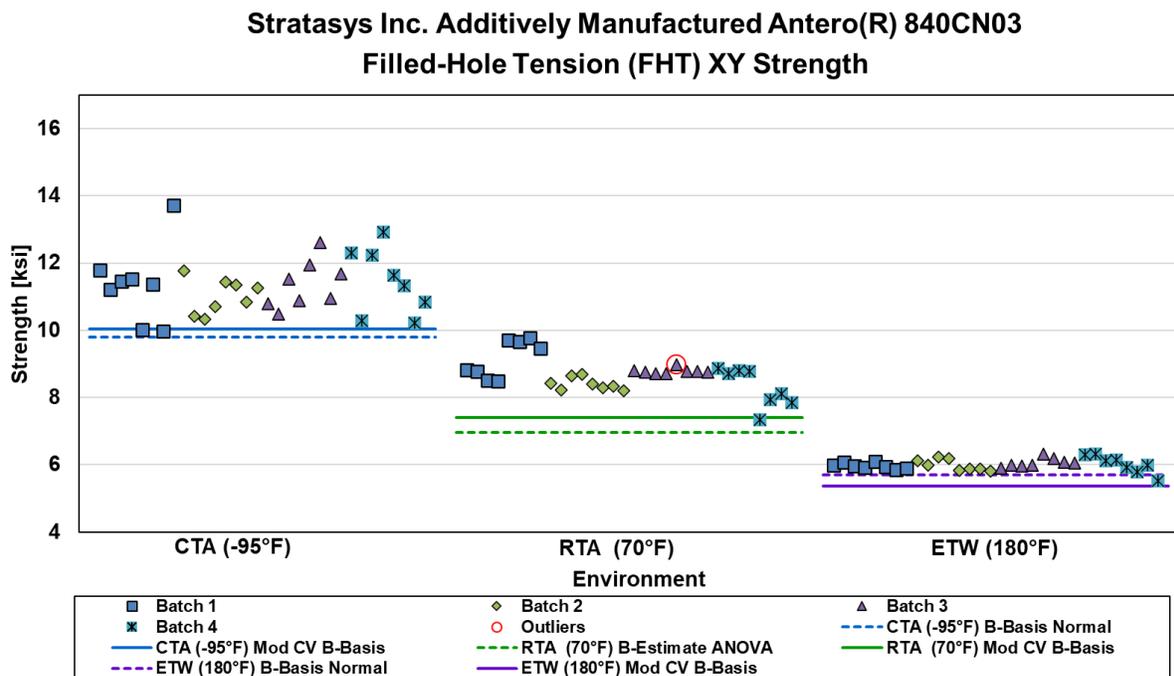


Figure 4-37: Batch Plot for FHT XY Strength

FHTXY Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-95 °F)	RTA (70 °F)	ETW (180 °F)
Mean	11.30	8.661	6.008
Std. Dev.	0.8544	0.5187	0.1708
CV	7.558	5.988	2.844
Modified CV	7.779	6.994	6.000
Min	9.970	7.342	5.531
Max	13.72	9.771	6.326
No. Batches	4	4	4
No. Specimens	32	32	32
Basis Values and Estimates			
B-Basis	9.803		5.708
B-Estimate		6.970	
A-Estimate	8.714	5.786	5.490
Method	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates			
B-Basis	10.05	7.402	5.375
A-Estimate	9.158	6.514	4.915
Method	Pooled	Pooled	Normal

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

4.18 Filled-Hole Tension XZ Orientation (FHT – ASTM D6742)

Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The CTA condition failed the normality test, but the lognormal distribution was a good fit for the data. The normal method was used for RTA. The ETW condition failed the ADK test for batch equivalency, ANOVA was used to compute estimates for that condition. Applying the modified CV, the CTA condition failed the normality test, therefore modified CV basis values are not available for that condition. The RTA and ETW conditions met all the requirements for pooling.

There were three statistical outliers. The lowest value in batch two of the RTA condition was a batch outlier. The lowest value in batch three of the ETW condition was a batch outlier. The lowest value in batch four of the ETW condition was a batch outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the FHTXZ strength data in Table 4-30. The data, B-estimates and B-basis values are shown graphically in Figure 4-38.

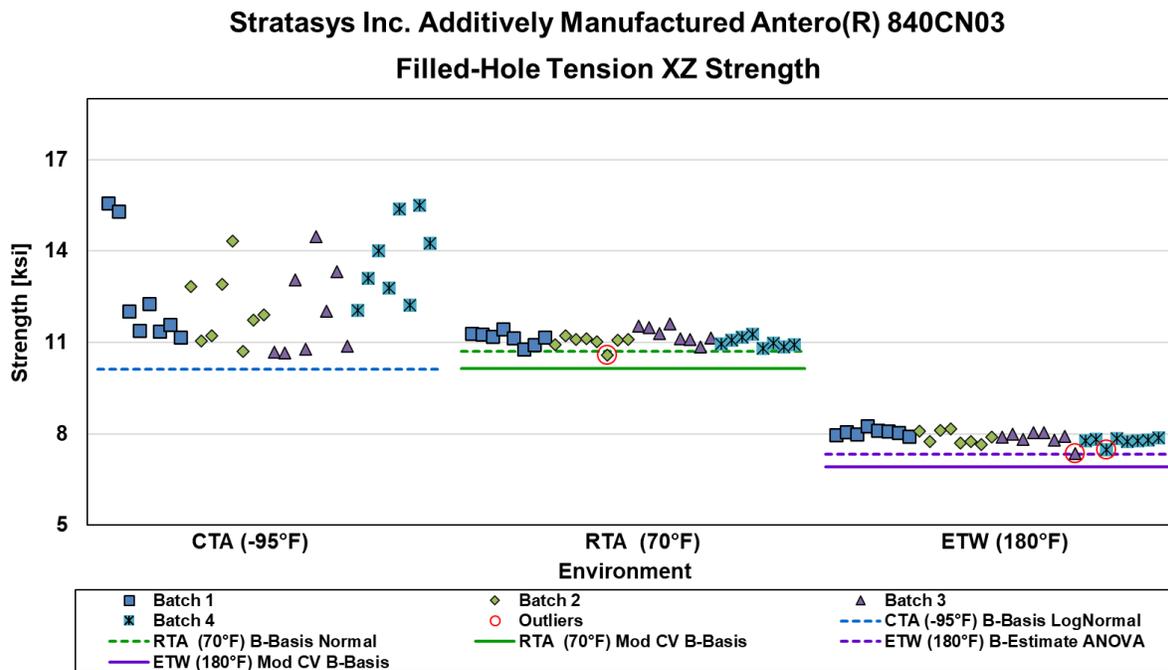


Figure 4-38: Batch Plot for FHT XZ Strength

FHTXZ Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-95 °F)	RTA (70 °F)	ETW (180 °F)
Mean	12.58	11.11	7.890
Std. Dev.	1.553	0.2267	0.1952
CV	12.35	2.041	2.474
Modified CV	12.35	6.000	6.000
Min	10.66	10.58	7.349
Max	15.57	11.61	8.257
No. Batches	4	4	4
No. Specimens	32	32	32
Basis Values and Estimates			
B-Basis	10.11	10.71	
B-Estimate			7.343
A-Estimate	8.671	10.42	6.957
Method	Log Normal	Normal	ANOVA
Modified CV Basis Values and Estimates			
B-Basis	NA	10.15	6.927
A-Estimate		9.466	6.247
Method		Pooled	Pooled

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

4.19 Filled-Hole Tension Z45 Orientation (FHT – ASTM D6742)

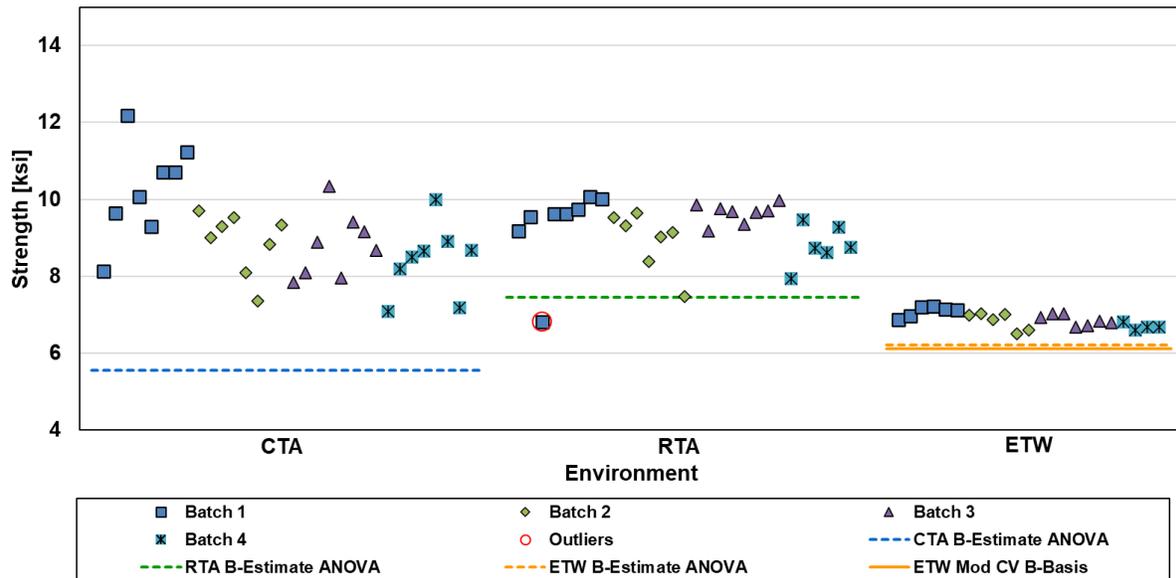
Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The three conditions failed the ADK test for batch equivalency, therefore ANOVA was used to compute estimates for all conditions. Applying the modified CV, the CTA and RTA conditions failed the ADK test, therefore, modified CV basis value are not available for these conditions. The normal method was used for ETW.

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

Statistics, basis values and estimates are given for the FHTZ45 strength data in Table 4-31. The data, B-estimates and B-basis values are shown graphically in Figure 4-39.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Filled-Hole Tension (FHT) Z45 Strength**



**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Filled-Hole Tension (FHT) Z45 Strength**

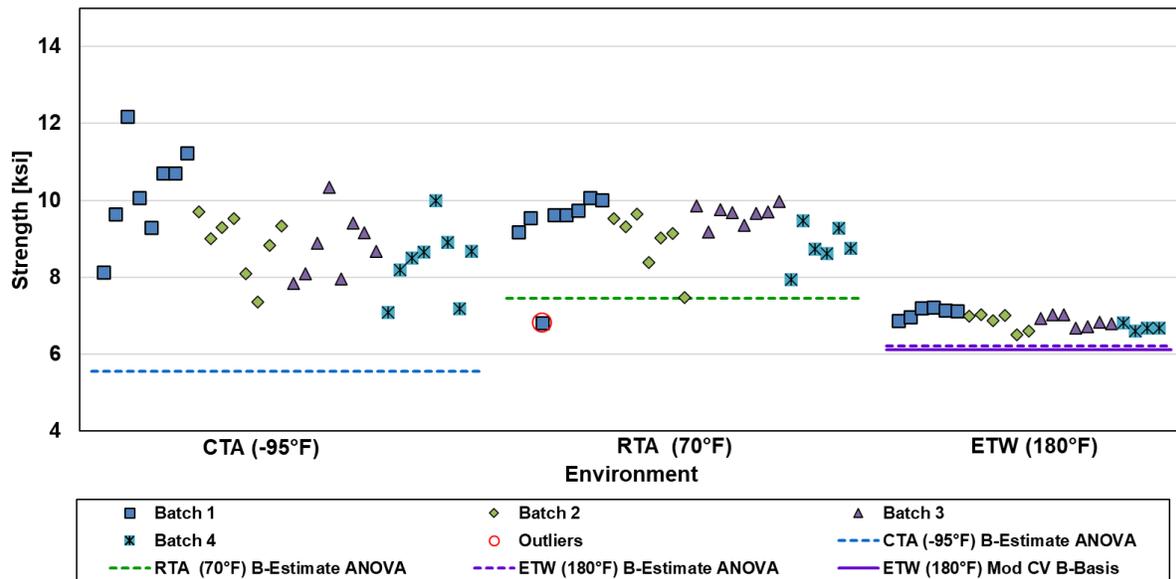


Figure 4-39: Batch Plot for FHT Z45 Strength

FHTZ45 Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-95 °F)	RTA (70 °F)	ETW (180 °F)
Mean	9.086	9.210	6.888
Std. Dev.	1.164	0.7649	0.2043
CV	12.81	8.305	2.966
Modified CV	12.81	8.305	6.000
Min	7.080	6.815	6.499
Max	12.17	10.08	7.227
No. Batches	4	4	4
No. Specimens	32	29	23
Basis Values and Estimates			
B-Estimate	5.554	7.458	6.222
A-Estimate	3.074	6.212	5.757
Method	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates			
B-Basis	NA	NA	6.116
A-Estimate			5.563
Method			Normal

Table 4-31: Statistics and Basis Values for FHT Z45 Strength Data

4.20 Filled-Hole Tension ZX Orientation (FHT – ASTM D6742)

Strength tests were conducted in the following environmental conditions: CTA, RTA, and ETW.

The normal method was used for the CTA condition. The RTA and ETW conditions failed the ADK test for batch equivalency, ANOVA was used to compute estimates for these conditions. Since the three conditions have CVs greater than 8%, the modified CV results are the same, therefore the normal method was used for CTA, and since the RTA and ETW conditions failed the ADK test, modified CV results are not available for these conditions. Only the original CV line is visible for RTA in the graph.

There were three statistical outliers. The lowest value in batch one of the RTA condition was a batch outlier. The lowest value in batch three of the ETW condition was a batch outlier. The lowest value in batch four of the ETW condition was a batch and condition outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the FHTZX strength data in Table 4-32. The data, B-estimates and B-basis values are shown graphically in Figure 4-40.

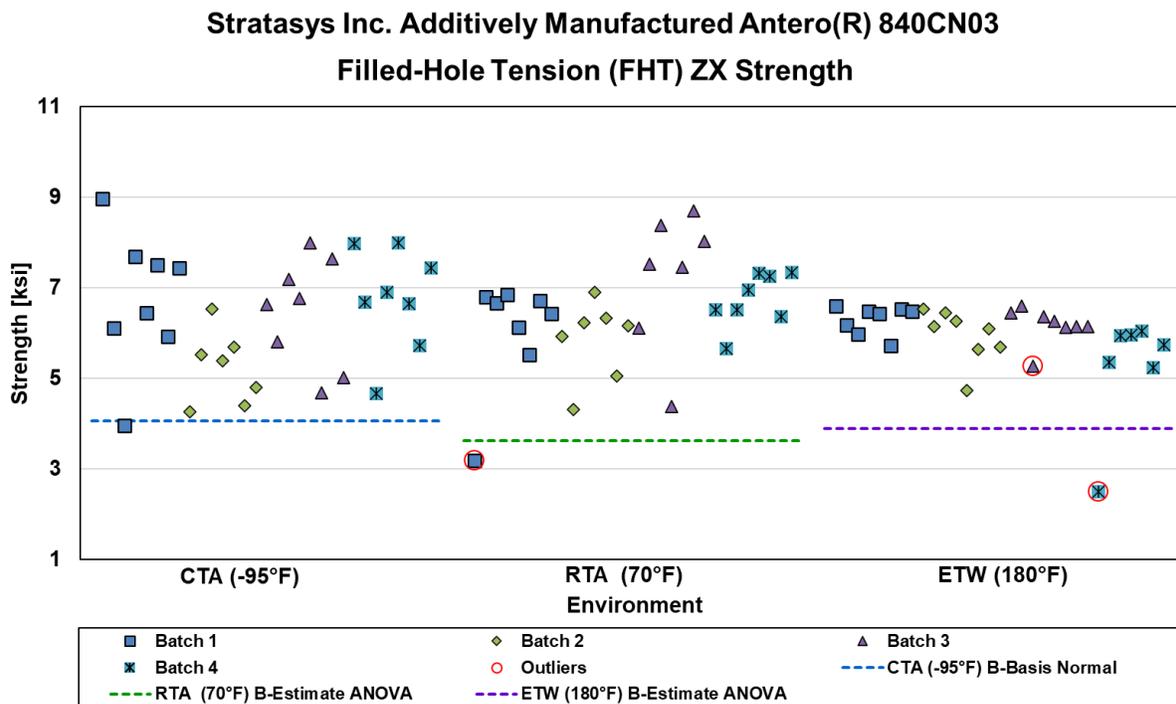


Figure 4-40: Batch Plot for FHT ZX Strength

FHTZX Strength (ksi) Basis Values and Statistics			
Environment	As-Measured		
	CTA (-95 °F)	RTA (70 °F)	ETW (180 °F)
Mean	6.336	6.456	5.936
Std. Dev.	1.292	1.175	0.7830
CV	20.39	18.20	13.19
Modified CV	20.39	18.20	13.19
Min	3.967	3.186	2.493
Max	8.958	8.695	6.599
No. Batches	4	4	4
No. Specimens	31	30	31
Basis Values and Estimates			
B-Basis	4.054		
B-Estimate		3.625	3.901
A-Estimate	2.401	1.616	2.461
Method	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates			
B-Basis	4.054	NA	NA
A-Estimate	2.401		
Method	Normal		

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

4.21 Single Shear Bearing XY Orientation (SSB Proc. C – ASTM D5961)

2% offset strength, ultimate strength and bearing stiffness tests were conducted in the following environmental conditions: RTA and ETW.

For the 2% offset strength dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The ETW condition failed the normality test, but the Weibull distribution was a good fit for the data. Applying the modified CV, both condition met all the requirements for pooling.

For the ultimate strength dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for ETW. Applying the modified CV, the normal method was used for RTA. The ETW condition failed the normality test, therefore modified CV basis values are not available for that condition.

There was one statistical outlier. For 2% offset strength, the lowest value in batch two of the ETW condition was a batch outlier. It was retained for this analysis.

Statistics, basis values and estimates are given for the SSBXY strength data in Table 4-33 and for the bearing stiffness data in Table 4-34. The data, B-basis values and B-estimates are shown graphically for 2% offset strength in Figure 4-41 and for ultimate strength in Figure 4-42.

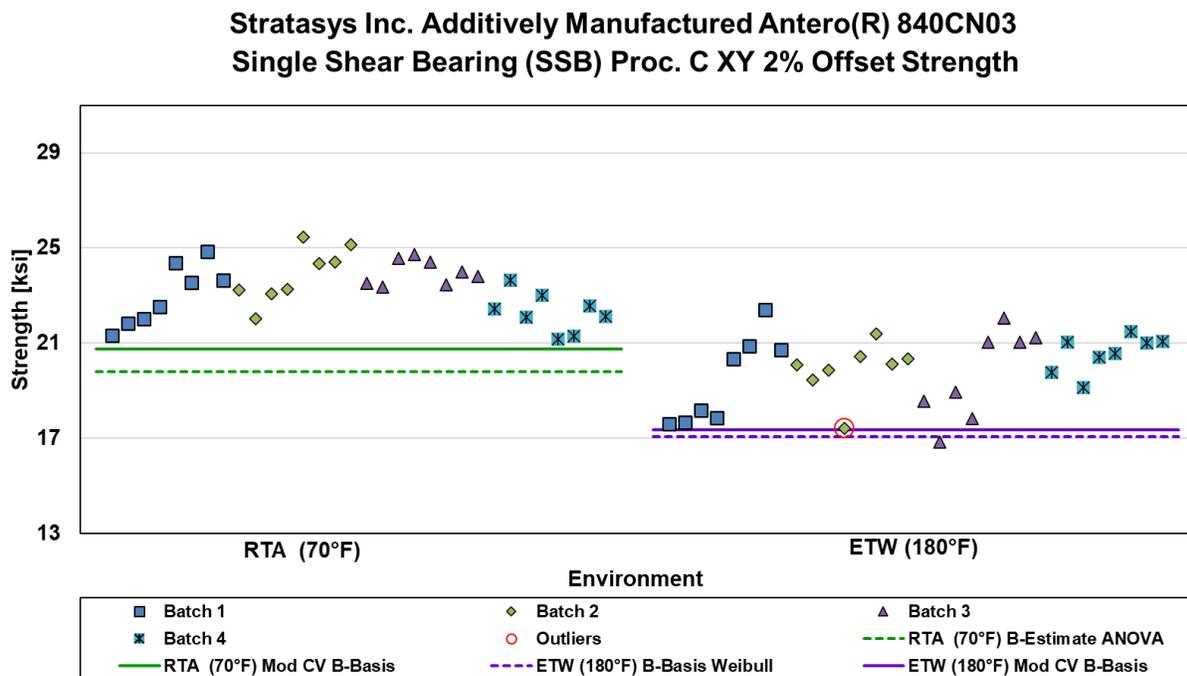


Figure 4-41: Batch Plot for SSB Proc. C XY 2% Offset Strength

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Single Shear Bearing (SSB) Proc. C XY Ultimate Strength**

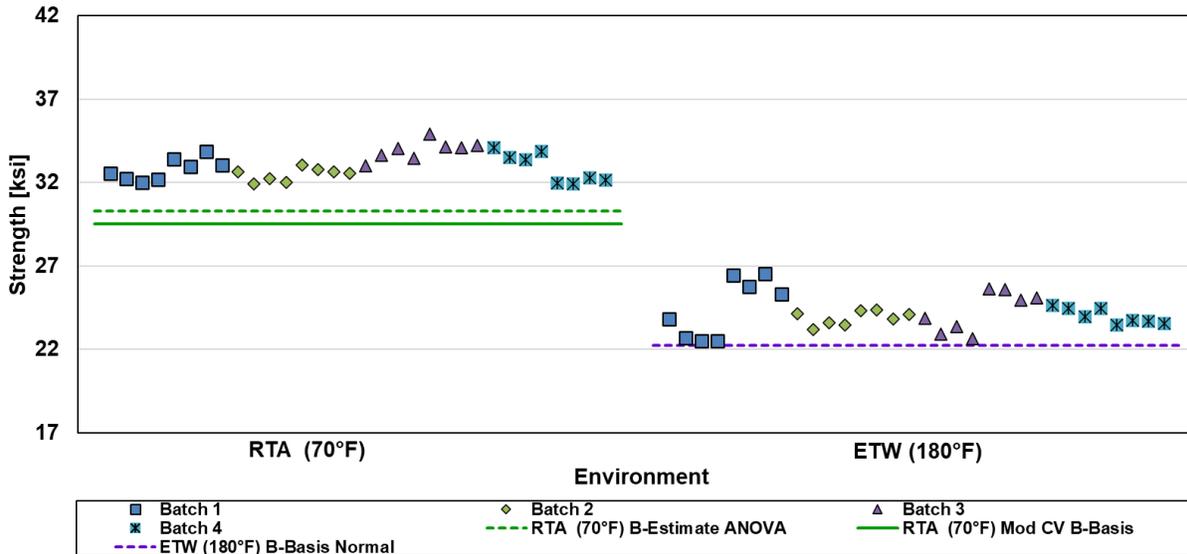


Figure 4-42: Batch Plot for SSB Proc. C XY Ultimate Strength

SSBXY Strength (ksi) As-Measured Basis Values and Statistics				
Environment	2% Offset Strength		Ultimate Strength	
	RTA (70 °F)	ETW (180 °F)	RTA (70 °F)	ETW (180 °F)
Mean	23.29	19.90	33.02	24.15
Std. Dev.	1.173	1.476	0.8331	1.082
CV	5.035	7.414	2.523	4.482
Modified CV	6.518	7.707	6.000	6.241
Min	21.18	16.86	31.90	22.50
Max	25.46	22.40	34.90	26.55
No. Batches	4	4	4	4
No. Specimens	32	32	32	32
Basis Values and Estimates				
B-Basis		17.08		22.24
B-Estimate	19.81		30.29	
A-Estimate	17.36	14.24	28.38	20.86
Method	ANOVA	Weibull	ANOVA	Normal
Modified CV Basis Values and Estimates				
B-Basis	20.75	17.36	29.54	NA
A-Estimate	18.95	15.57	27.02	
Method	Pooled	Pooled	Normal	

Table 4-33: Statistics and Basis Values for SSB Proc. C XY Strength Data

SSBXY Bearing Stiffness (Msi) Statistics		
Environment	RTA (70 °F)	ETW (180 °F)
Mean	0.1419	0.1551
Std. Dev.	0.006694	0.04618
CV	4.718	29.77
Min	0.1297	0.1158
Max	0.1552	0.2605
No. Batches	4	4
No. Specimens	32	32

Table 4-34: Statistics for SSB Proc. C XY Bearing Stiffness Data

4.22 Single Shear Bearing XZ Orientation (SSB Proc. C ASTM D5961)

2% offset strength, ultimate strength and bearing stiffness tests were conducted in the following environmental conditions: RTA and ETW.

For the 2% offset strength dataset, the normal method was used for the RTA condition. The ETW condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, both condition met all the requirements for pooling.

For the ultimate strength dataset, the RTA condition failed the normality test, but the Weibull distribution was a good fit for the data. The ETW condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, the normal method was used for both conditions.

There was one statistical outlier. For ultimate strength, the lowest value in batch three of the RTA condition was a condition outlier. It was retained for this analysis.

Statistics, basis values and estimates are given for the SSB XZ strength data in Table 4-35 and for the bearing stiffness data in Table 4-36. The data, B-basis values and B-estimates are shown graphically for 2% offset strength in Figure 4-43 and for ultimate strength in Figure 4-44

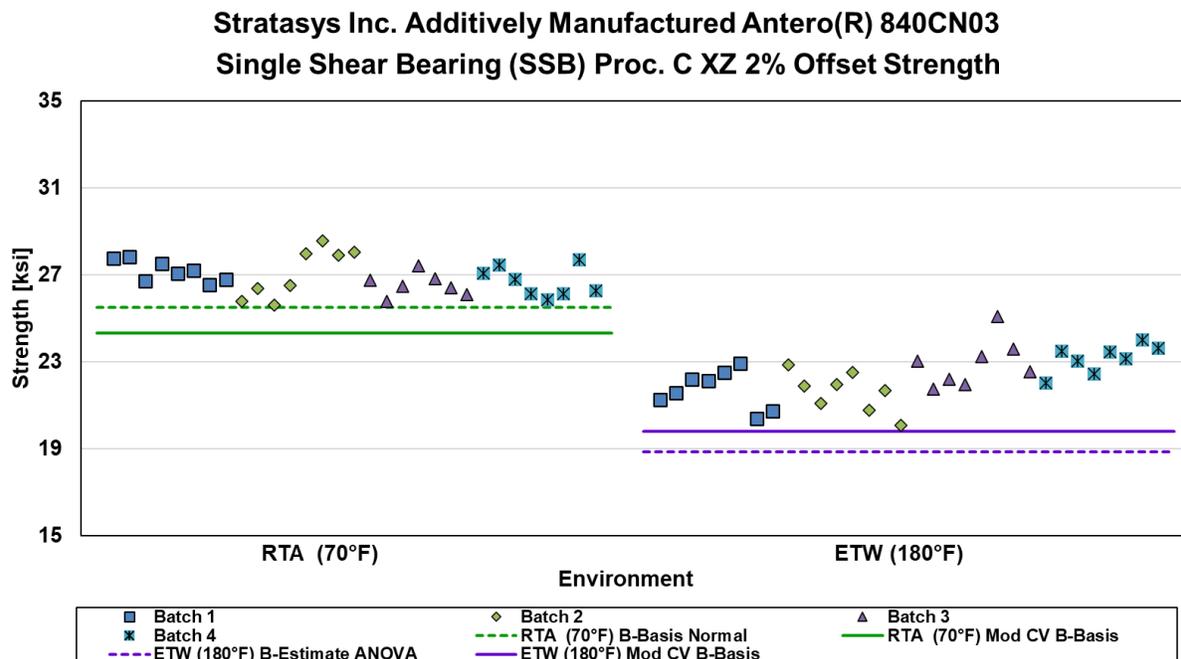


Figure 4-43: Batch Plot for SSB Proc C. XZ 2% Offset Strength

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Single Shear Bearing (SSB) Proc. C XZ Ultimate Strength**

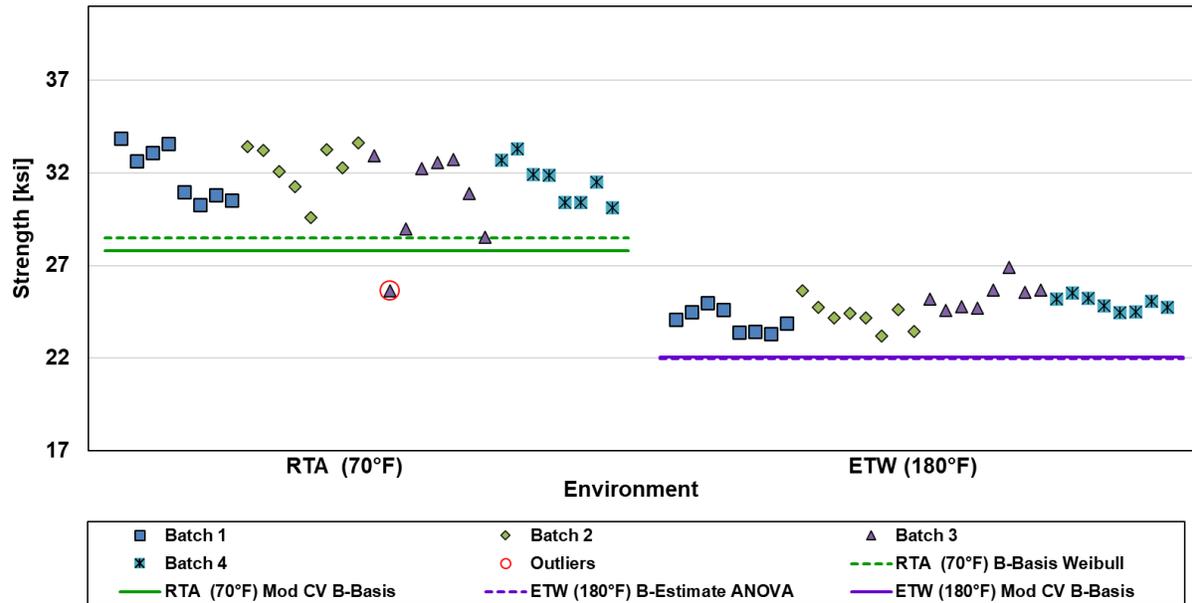


Figure 4-44: Batch Plot for SSB Proc C. XZ Ultimate Strength

SSBXZ Strength (ksi) As-Measured Basis Values and Statistics				
Environment	2% Offset Strength		Ultimate Strength	
	RTA (70 °F)	ETW (180 °F)	RTA (70 °F)	ETW (180 °F)
Mean	26.89	22.36	31.60	24.66
Std. Dev.	0.7762	1.105	1.798	0.8193
CV	2.886	4.944	5.690	3.322
Modified CV	6.000	6.472	6.845	6.000
Min	25.61	20.07	25.62	23.18
Max	28.57	25.10	33.87	26.88
No. Batches	4	4	4	4
No. Specimens	31	32	32	32
Basis Values and Estimates				
B-Basis	25.52		28.50	
B-Estimate		18.86		21.98
A-Estimate	24.53	16.41	25.16	20.11
Method	Normal	ANOVA	Weibull	ANOVA
Modified CV Basis Values and Estimates				
B-Basis	24.33	19.80	27.80	22.06
A-Estimate	22.53	18.00	25.05	20.17
Method	Pooled	Pooled	Normal	Normal

Table 4-35: Statistics and Basis Values for SSB Proc. C XZ Strength Data

SSBXZ Bearing Stiffness (Msi) Statistics		
Environment	RTA (70 °F)	ETW (180 °F)
Mean	0.1659	0.1740
Std. Dev.	0.005163	0.05472
CV	3.112	31.45
Min	0.1573	0.1381
Max	0.1809	0.3075
No. Batches	4	4
No. Specimens	32	32

Table 4-36: Statistics for SSB Proc. C XZ Bearing Stiffness Data

4.23 Single Shear Bearing Z45 Orientation (SSB Proc. C ASTM D5961)

2% offset strength, ultimate strength and bearing stiffness tests were conducted in the following environmental conditions: RTA and ETW.

For the 2% offset strength dataset, the RTA condition failed all the distributions tests, therefore the non-parametric method was used for that condition. The ETW condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, both condition met all the requirements for pooling.

For the ultimate strength dataset, the RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for ETW. Applying the modified CV, both conditions failed the normality test, therefore modified CV basis values are not available for both conditions.

There were two statistical outliers. For ultimate strength, the lowest value in batch two of the RTA condition was a batch and condition outlier. The lowest value in batch three of the RTA condition was a condition outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the SSBZ45 strength data in Table 4-37 and for the bearing stiffness data in Table 4-38. The data, B-basis values and B-estimates are shown graphically for 2% offset strength in Figure 4-45 and for ultimate strength in Figure 4-46.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Single Shear Bearing (SSB) Proc. C Z45 2% Offset Strength**

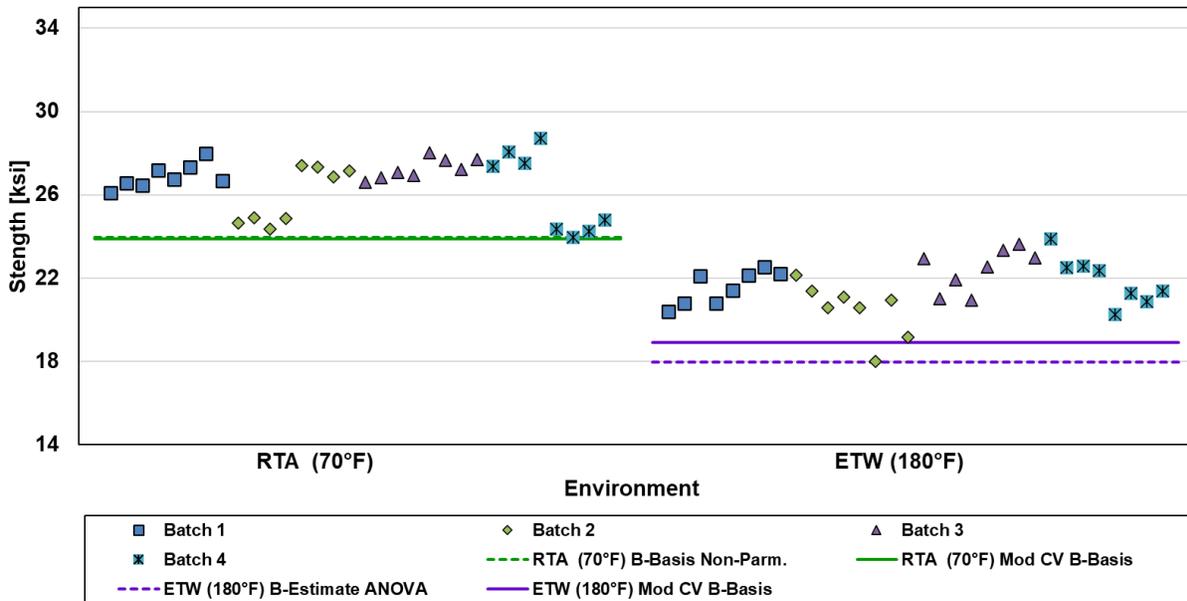


Figure 4-45: Batch Plot for SSB Proc. C Z45 2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Single Shear Bearing (SSB) Proc. C Z45 Ultimate Strength**

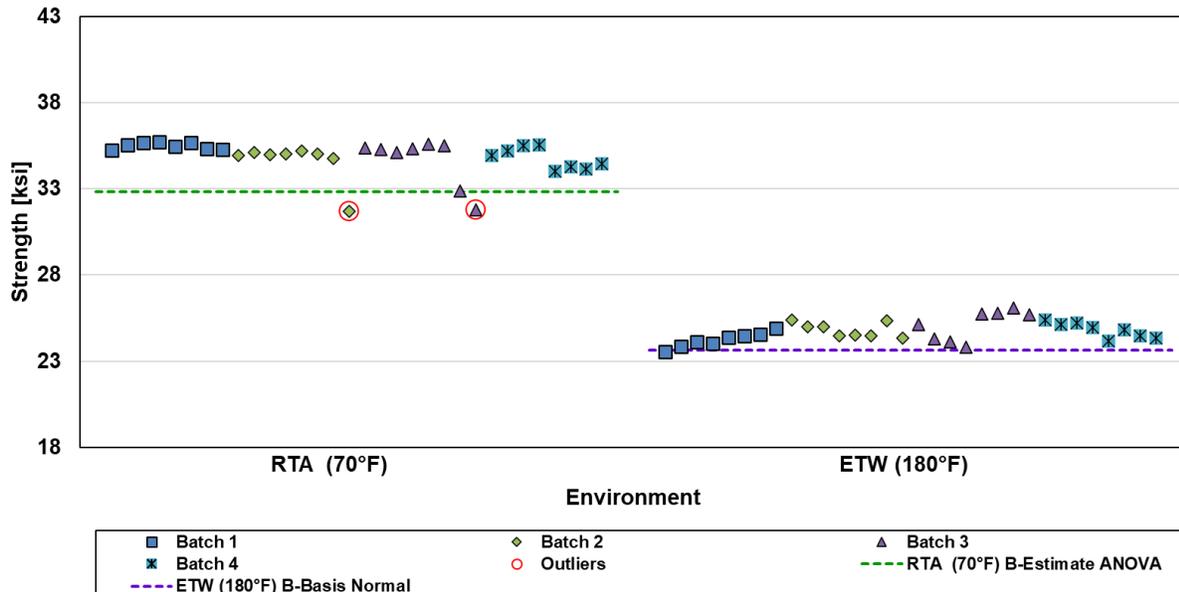


Figure 4-46: Batch Plot for SSB Proc. C Z45 Ultimate Strength

SSBZ45 Strength (ksi) As-Measured Basis Values and Statistics				
Environment	2% Offset Strength		Ultimate Strength	
	RTA (70 °F)	ETW (180 °F)	RTA (70 °F)	ETW (180 °F)
Mean	26.55	21.57	34.87	24.74
Std. Dev.	1.309	1.260	1.006	0.6349
CV	4.932	5.841	2.886	2.566
Modified CV	6.466	6.921	6.000	6.000
Min	23.95	17.99	31.70	23.55
Max	28.69	23.88	35.73	26.09
No. Batches	4	4	4	4
No. Specimens	32	32	32	32
Basis Values and Estimates				
B-Basis	23.95			23.63
B-Estimate		17.97	32.82	
A-Estimate	20.29	15.43	31.36	22.82
Method	Non-Parm.	ANOVA	ANOVA	Normal
Modified CV Basis Values and Estimates				
B-Basis	23.86	18.89	NA	NA
A-Estimate	21.97	17.00		
Method	Pooled	Pooled		

Table 4-37: Statistics and Basis Values for SSB Proc. C Z45 Strength Data

SSBZ45 Bearing Stiffness (Msi) Statistics		
Environment	RTA (70 °F)	ETW (180 °F)
Mean	0.1579	0.1406
Std. Dev.	0.005248	0.02417
CV	3.325	17.19
Min	0.1481	0.1208
Max	0.1688	0.2696
No. Batches	4	4
No. Specimens	32	32

Table 4-38: Statistics for SSB Proc. C Z45 Bearing Stiffness Data

4.24 Single Shear Bearing ZX Orientation (SSB Proc. C ASTM D5961)

2% offset strength, ultimate strength and bearing stiffness tests were conducted in the following environmental conditions: RTA and ETW.

For the 2% offset strength dataset, the RTA condition failed the normality test, but the Weibull distribution was a good fit for the data. The normal method was used for ETW. Applying the modified CV, the normal method was used for both conditions.

For the ultimate strength dataset, both condition failed all the distributions tests, therefore the non-parametric method was used for both conditions. Applying the modified CV, both conditions failed the normality test, therefore modified CV basis values are not available for both conditions.

There were four statistical outliers. For 2% offset strength, the lowest value in batch three of the RTA condition was a condition outlier. The highest value in batch four of the ETW condition was a batch and condition outlier. For ultimate strength, the lowest value in batch two of the ETW condition was a batch and condition outlier. The highest value in batch four of the ETW condition was a batch and condition outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the SSBZX strength data in Table 4-39 and for the bearing stiffness data in Table 4-40. The data, B-basis values and B-estimates are shown graphically for 2% offset strength in Figure 4-47 and for ultimate strength in Figure 4-48.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Single Shear Bearing (SSB) Proc. C ZX 2% Offset Strength**

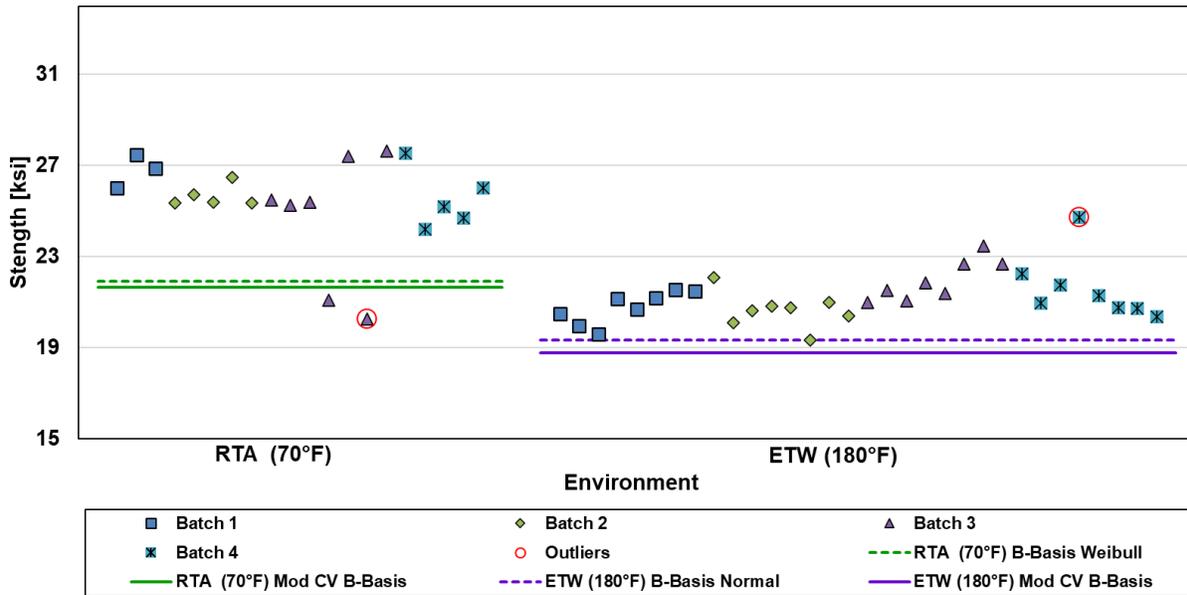


Figure 4-47: Batch Plot for SSB Proc. C ZX 2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Single Shear Bearing (SSB) Proc. C ZX Ultimate Strength**

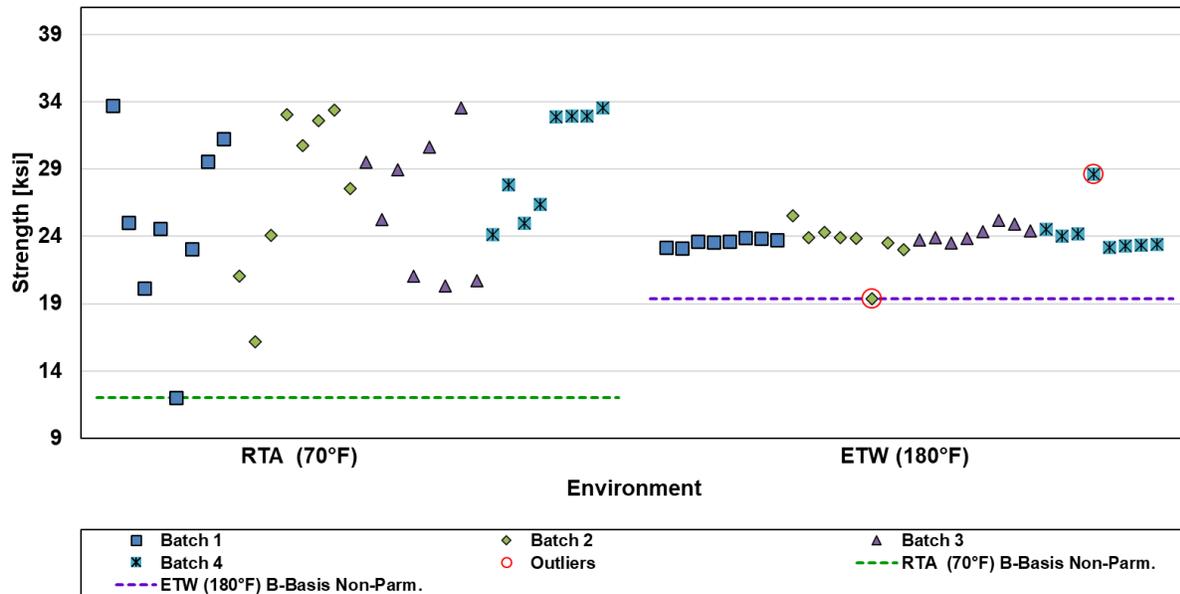


Figure 4-48: Batch Plot for SSB Proc. C ZX Ultimate Strength

SSBZX Strength (ksi) As-Measured Basis Values and Statistics				
Environment	2% Offset Strength		Ultimate Strength	
	RTA (70 °F)	ETW (180 °F)	RTA (70 °F)	ETW (180 °F)
Mean	25.44	21.24	26.98	23.89
Std. Dev.	1.911	1.094	5.681	1.311
CV	7.510	5.150	21.05	5.485
Modified CV	7.755	6.575	21.05	6.743
Min	20.26	19.33	12.02	19.37
Max	27.64	24.72	33.72	28.63
No. Batches	4	4	4	4
No. Specimens	20	32	32	32
Basis Values and Estimates				
B-Basis	21.91	19.31	12.02	19.37
A-Estimate	18.43	17.92	4.662	13.53
Method	Weibull	Normal	Non-Parm.	Non-Parm.
Modified CV Basis Values and Estimates				
B-Basis	21.64	18.78	NA	NA
A-Estimate	18.94	17.00		
Method	Normal	Normal		

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

SSBZX Bearing Stiffness (Msi) Statistics		
Environment	RTA (70 °F)	ETW (180 °F)
Mean	0.1528	0.1469
Std. Dev.	0.004551	0.04024
CV	2.979	27.39
Min	0.1451	0.1139
Max	0.1640	0.2856
No. Batches	4	4
No. Specimens	32	32

Table 4-40: Statistics for SSB Proc. C ZX Bearing Stiffness Data

4.25 Rail Shear XY Orientation (RS – ASTM D7078)

Maximum strength, 0.2% offset strength, strength at 5% strain and modulus tests were conducted in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition for all tests consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition.

For the maximum strength dataset, the normal method was used for the CTA and RTW conditions. The RTA, ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. Applying the modified CV, the normal method was used for CTA, RTW, and ETW. The RTA condition failed the ADK test and the ETA condition failed the normality test, therefore modified CV basis values are not available for these conditions. The CTA condition has an original CV greater than 8%, therefore the original CV and modified CV results are the same, and only the original CV result line is shown in the graph.

For the 0.2% offset strength dataset, the normal method was used for the CTA and RTW conditions. The RTA, ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. Applying the modified CV, the normal method was used for CTA, RTW, ETA, and ETW. The RTA condition failed the ADK test, therefore modified CV basis values are not available for that condition.

For the strength at 5% strain dataset, the ETW condition consists of a single batch of data with four specimens and the remaining conditions have less than eighteen specimens, therefore only basis value estimates are provided for this test. The normal method was used for CTA, RTW, ETA, and ETW. The RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, the normal method was used for the CTA, RTW, ETA, and ETW. The RTA condition failed the ADK test, therefore modified CV basis values are not available for that condition.

There were three statistical outliers. For maximum strength, the lowest value in batch two of the RTA condition was a batch outlier. The highest value in batch four of the ETA condition was a batch outlier. For 0.2% offset strength, the highest value in batch four of the ETW condition was a batch outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the RS XY strength data in Table 4-41 and for the modulus data in Table 4-42. The data, B-estimates and B-basis values are shown graphically in Figure 4-49 through Figure 4-51.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Rail Shear XY Maximum Strength**

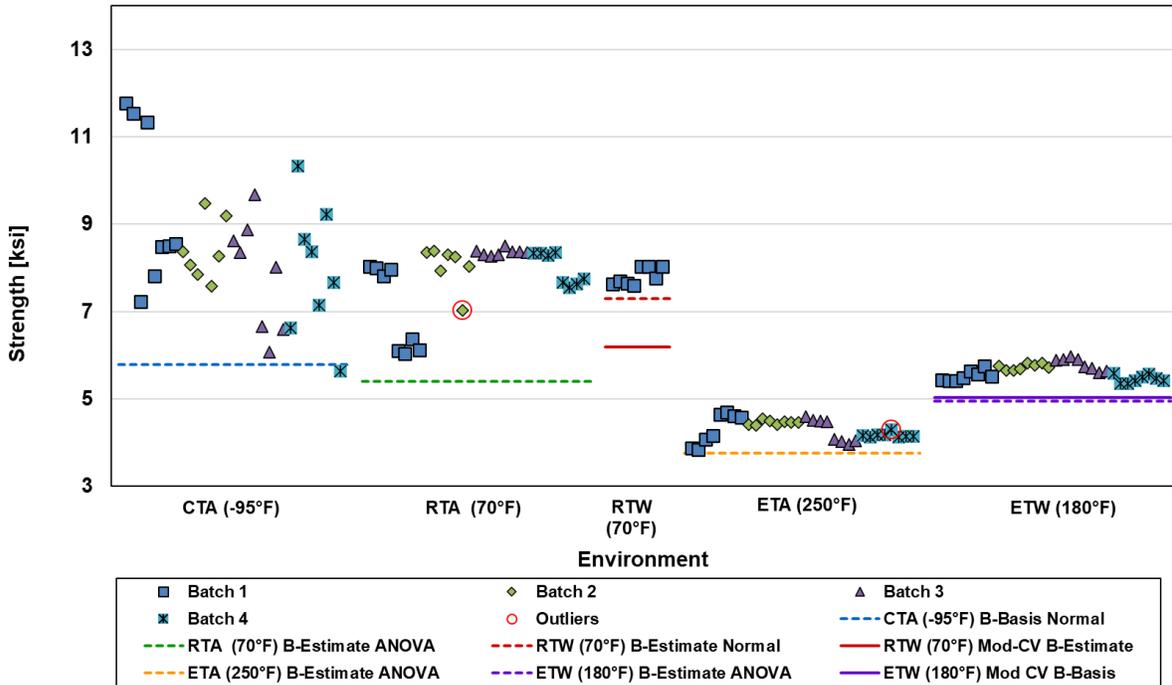


Figure 4-49: Batch Plot for RS XY Maximum Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Rail Shear XY 0.2% Offset Strength**

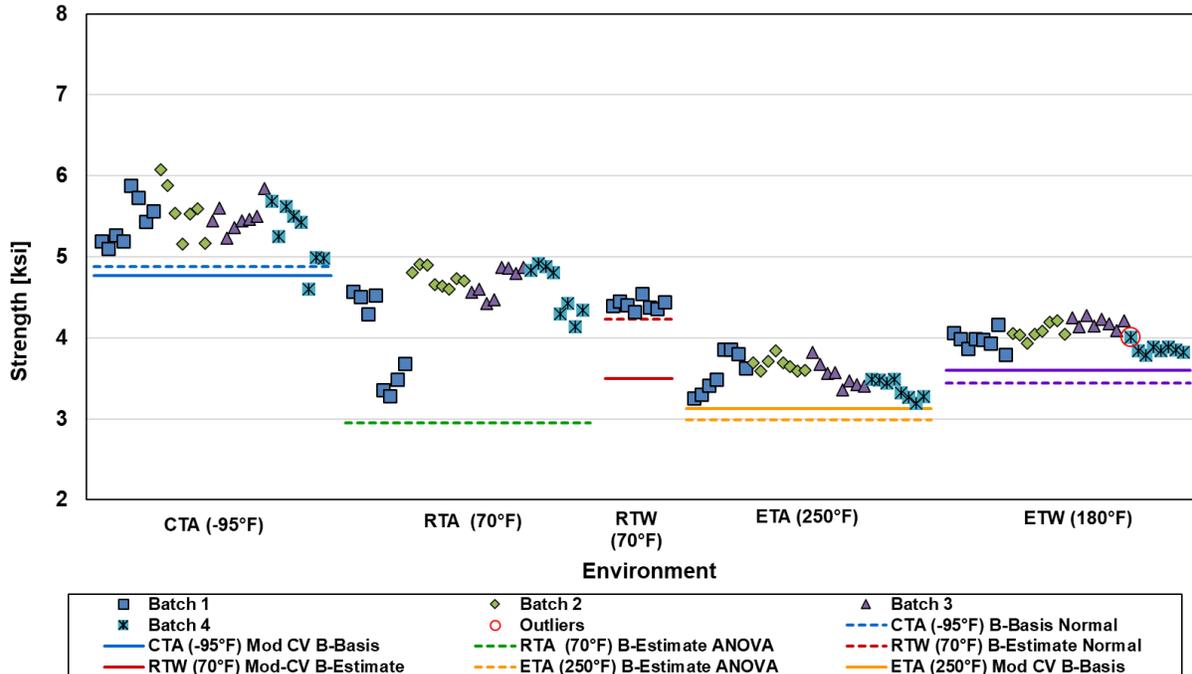


Figure 4-50: Batch Plot for RS XY 0.2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Rail Shear XY Strength at 5% Strain**

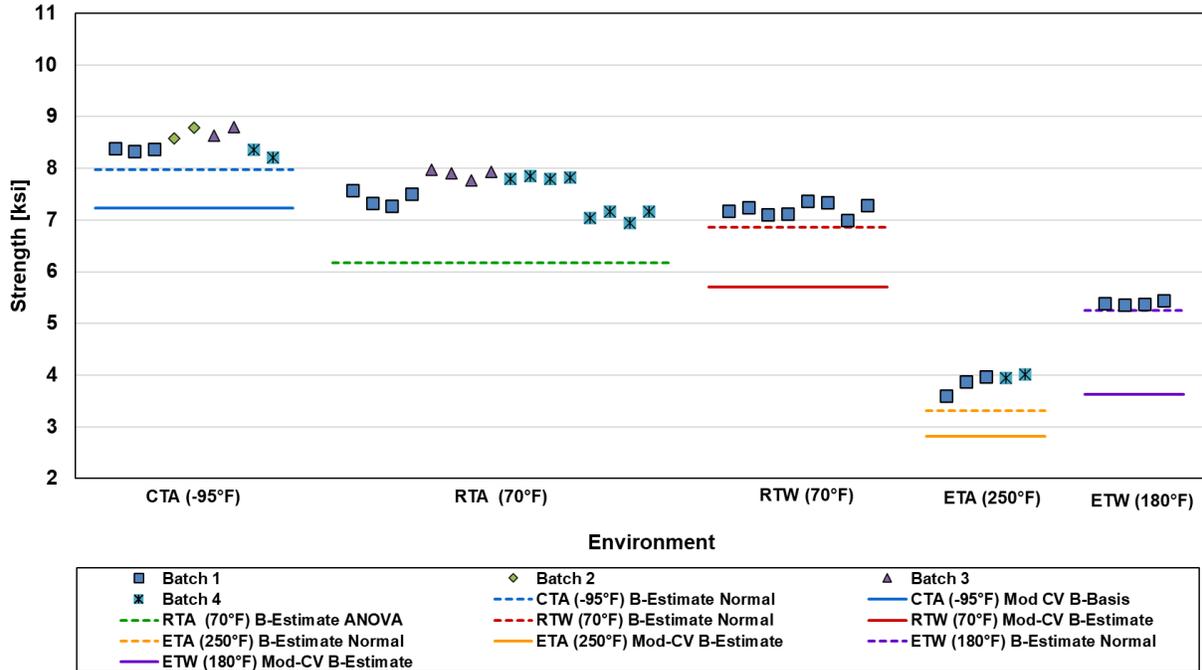


Figure 4-51: Batch Plot for RS XY Strength at 5% Strain

RSXY Strength (ksi) As-Measured Basis Values and Statistics															
Environment	Maximum Strength					0.2% Offset Strength					Strength at 5% Strain				
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	8.406	7.857	7.806	4.303	5.628	5.429	4.493	4.415	3.538	4.027	8.496	7.552	7.206	3.883	5.393
Std. Dev.	1.478	0.7392	0.1976	0.2409	0.1752	0.3083	0.4521	0.06985	0.1898	0.1468	0.2116	0.3496	0.1307	0.1652	0.03571
CV	17.59	9.409	2.531	5.598	3.113	5.680	10.06	1.582	5.363	3.645	2.491	4.630	1.814	4.254	0.6622
Modified CV	17.59	9.409	8.000	6.799	6.000	6.840	10.06	8.000	6.682	6.000	6.000	6.315	8.000	8.000	8.000
Min	5.640	6.031	7.601	3.841	5.344	4.599	3.281	4.319	3.191	3.785	8.209	6.948	6.995	3.601	5.357
Max	11.77	8.501	8.042	4.691	5.975	6.075	4.915	4.550	3.860	4.278	8.797	7.971	7.375	4.015	5.441
No. Batches	4	4	1	4	4	4	4	1	4	4	4	3	1	2	1
No. Specimens	31	31	8	32	32	31	32	8	32	32	9	16	8	5	4
Basis Values and Estimates															
B-Basis	5.794					4.884									
B-Estimate		5.402	7.293	3.754	4.945		2.948	4.234	2.985	3.439	7.974	6.170	6.867	3.318	5.247
A-Estimate	3.902	3.685	6.933	3.362	4.469	4.489	1.868	4.107	2.596	3.031	7.609	5.187	6.629	2.908	5.136
Method	Normal	ANOVA	Normal	ANOVA	ANOVA	Normal	ANOVA	Normal	ANOVA	ANOVA	Normal	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates															
B-Basis	5.794					5.035	4.773			3.123	3.602				
B-Estimate		NA	6.183	NA	5.035	4.773	NA	3.497			7.238	NA	5.708	2.821	3.626
A-Estimate	3.902		5.047		4.604	4.298		2.855	2.822	3.294	6.360		4.659	2.050	2.287
Method	Normal		Normal		Normal	Normal		Normal	Normal	Normal	Normal		Normal	Normal	Normal

Table 4-41: Statistics and Basis Values for Rail Shear XY Strength Data

RSXY Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.2135	0.1913	0.1891	0.1988	0.1885
Std. Dev.	0.01051	0.01768	0.002493	0.01084	0.005827
CV	4.923	9.243	1.318	5.452	3.091
Min	0.1984	0.1462	0.1858	0.1767	0.1797
Max	0.2357	0.2095	0.1928	0.2176	0.1992
No. Batches	4	4	1	4	4
No. Specimens	31	32	8	32	32

Table 4-42: Statistics for Rail Shear XY Modulus Data

4.26 Rail Shear XZ Orientation (RS – ASTM D7078)

Maximum strength, 0.2% offset strength, strength at 5% strain and modulus tests were conducted in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition for all tests consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition.

For the maximum strength dataset, the RTA condition has less than 18 specimens, therefore only basis value estimates were computed for that condition. The CTA and RTA conditions failed the normality test, but the Weibull distribution was a good fit for both datasets. The ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for RTW. Applying the modified CV, the CTA condition failed the normality test, therefore modified CV basis values are not available for these conditions. The normal method was used for the remaining conditions.

For the 0.2% offset strength dataset, the RTA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The ETA condition failed the normality test, but the Weibull distribution was a good fit for the data. The normal method was used for CTA and RTW. Applying the modified CV, the CTA and RTA conditions met all the requirements for pooling, and the normal method was used for the remaining conditions.

For strength at 5% strain dataset, all the conditions have less than eighteen specimens, therefore only estimates are provided for this property. The CTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTA condition failed the normality test, but the Weibull distribution was a good fit for the data. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for CTA, RTW, ETA, and ETW. The RTA condition failed the ADK test, therefore modified CV basis values are not available for that condition.

There were four statistical outliers. For maximum strength, the lowest value in batch three of the CTA condition was a batch outlier. The lowest value in batch two of the RTA condition was a condition outlier. For 0.2% offset strength, the lowest value in batch two of the CTA condition was a batch and condition outlier. For strength at 5% strain, the lowest value in batch two of the ETW condition was a condition outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the RS XZ strength data in Table 4-43 and for the modulus data in Table 4-44. The data, B-estimates and B-basis values are shown graphically in Figure 4-52 through Figure 4-54.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Rail Shear XZ Maximum Strength**

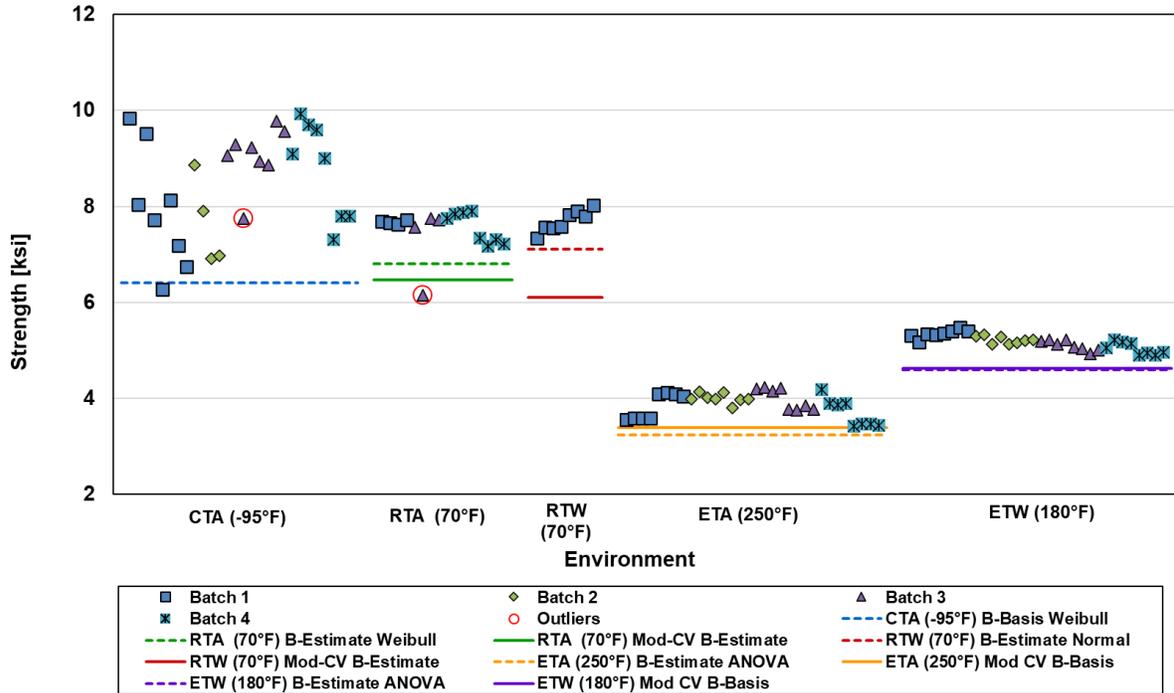


Figure 4-52: Batch Plot for Rail Shear XZ Maximum Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03

Rail Shear XZ 0.2% Offset Strength

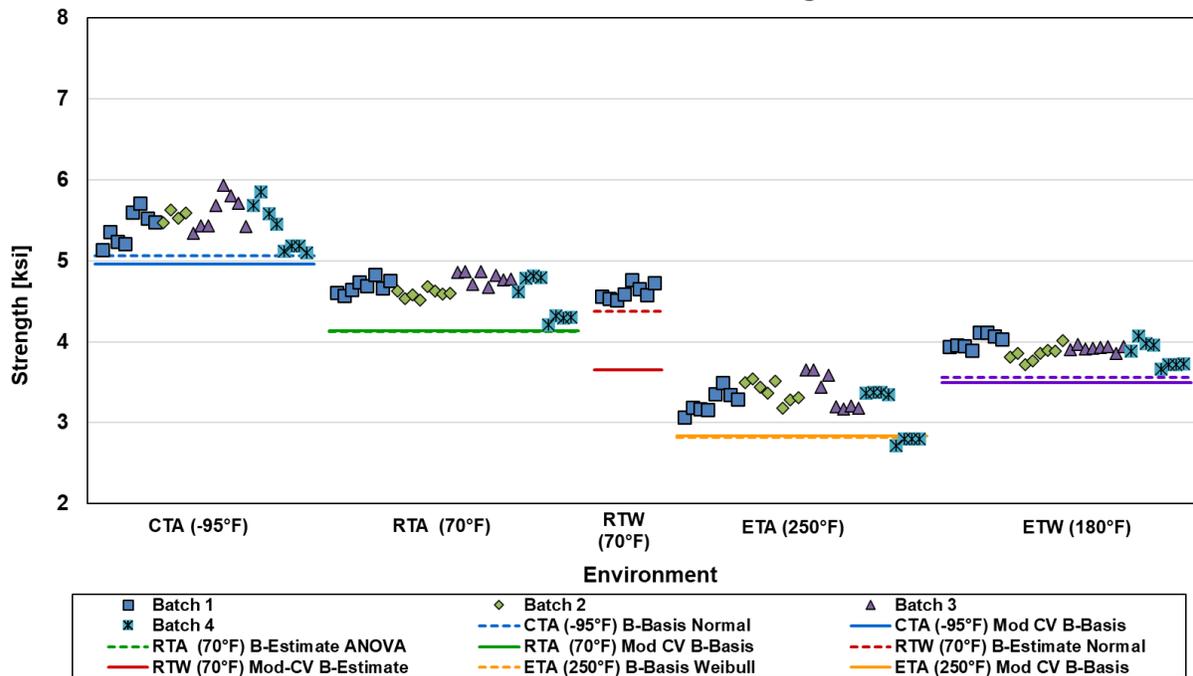


Figure 4-53: Batch Plot for Rail Shear XZ 0.2% Offset Strength

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Rail Shear XZ Strength at 5% Strain**

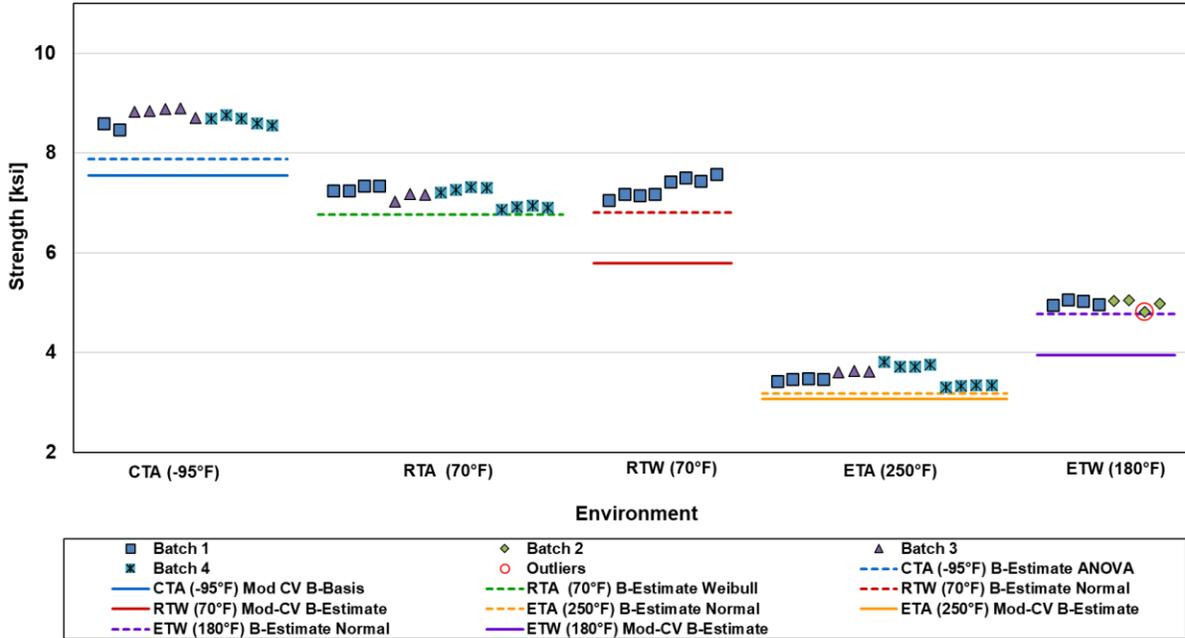


Figure 4-54: Batch Plot for Rail Shear XZ Strength at 5% Strain

RSXZ Strength (ksi) As-Measured Basis Values and Statistics															
Environment	Maximum Strength					0.2% Offset Strength					Strength at 5% Strain				
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	8.456	7.517	7.698	3.881	5.176	5.480	4.649	4.617	3.277	3.905	8.712	7.152	7.313	3.535	4.988
Std. Dev.	1.082	0.4322	0.2261	0.2560	0.1544	0.2317	0.1715	0.09272	0.2419	0.1175	0.1358	0.1724	0.1955	0.1693	0.08037
CV	12.80	5.750	2.937	6.596	2.983	4.227	3.690	2.008	7.382	3.010	1.559	2.410	2.674	4.789	1.611
Modified CV	12.80	6.875	8.000	7.298	6.000	6.114	6.000	8.000	7.691	6.000	6.000	6.000	8.000	6.394	8.000
Min	6.279	6.148	7.336	3.417	4.893	5.098	4.211	4.513	2.718	3.659	8.478	6.871	7.050	3.309	4.814
Max	9.925	7.900	8.026	4.226	5.474	5.935	4.870	4.769	3.652	4.116	8.902	7.349	7.574	3.812	5.059
No. Batches	4	3	1	4	4	4	4	1	4	4	3	3	1	3	2
No. Specimens	28	16	8	32	32	28	32	8	32	32	12	15	8	15	8
Basis Values and Estimates															
B-Basis	6.413					5.064			2.819						
B-Estimate		6.807	7.110	3.235	4.592		4.130	4.376		3.560	7.885	6.761	6.805	3.185	4.779
A-Estimate	4.648	6.066	6.699	2.778	4.185	4.763	3.766	4.207	2.358	3.316	7.296	6.339	6.449	2.938	4.633
Method	Weibull	Weibull	Normal	ANOVA	ANOVA	Normal	ANOVA	Normal	Weibull	ANOVA	ANOVA	Weibull	Normal	Normal	Normal
Modified CV Basis Values and Estimates															
B-Basis				3.383	4.630	4.962	4.136		2.835	3.494	7.554				
B-Estimate	NA	6.466	6.097					3.657				NA	5.792	3.067	3.951
A-Estimate		5.724	4.977	3.022	4.234	4.601	3.774	2.985	2.513	3.195	6.743		4.728	2.738	3.225
Method		Normal	Normal	Normal	Normal	Pooled	Pooled	Normal	Normal	Normal	Normal		Normal	Normal	Normal

Table 4-43: Statistics and Basis Values for Rail Shear XZ Strength Data

RSXZ Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.2142	0.1913	0.1964	0.1916	0.1882
Std. Dev.	0.006578	0.006053	0.003622	0.008456	0.002956
CV	3.070	3.164	1.844	4.413	1.570
Min	0.2033	0.1800	0.1924	0.1763	0.1833
Max	0.2300	0.2000	0.2009	0.2047	0.1956
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-44: Statistics for Rail Shear XZ Modulus Data

4.27 Rail Shear Z45 Orientation (RS – ASTM D7078)

Maximum strength, 0.2% offset strength, strength at 5% strain and modulus tests were conducted in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition for all tests consists of a single batch with eight specimens, therefore only basis value estimates are provided for that condition.

For the maximum strength dataset, the CTA, RTA, ETA, and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for all conditions. The normal method was used for RTW. Applying the modified CV, the CTA condition failed the ADK test and the ETW condition failed the normality test, therefore modified CV basis values are not available for these conditions. The normal method was used for RTA, RTW, and ETA.

For the 0.2% offset strength dataset, the normal method was used for CTA and RTW. The RTA, ETA and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. Applying the modified CV, the normal method was used for CTA, RTA, RTW, and ETW. The ETA condition failed the ADK test, therefore modified CV basis values are not available for that condition.

For strength at 5% strain dataset, the ETA and ETW conditions consist of a single batch of data, therefore only basis value estimates are provided for these conditions. The normal method was used for CTA, RTW, ETA, and ETW. The RTA condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, the CTA and RTA conditions met all the requirements for pooling. The normal method was used for the remaining conditions.

There was one statistical outlier. The highest value in batch two of the ETA condition was a batch outlier. It was retained for this analysis.

Statistics, basis values and estimates are given for the RS Z45 strength data in Table 4-45 and for the modulus data in Table 4-46. The data, B-estimates and B-basis values are shown graphically in Figure 4-55 through Figure 4-57.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Rail Shear Z45 Maximum Strength**

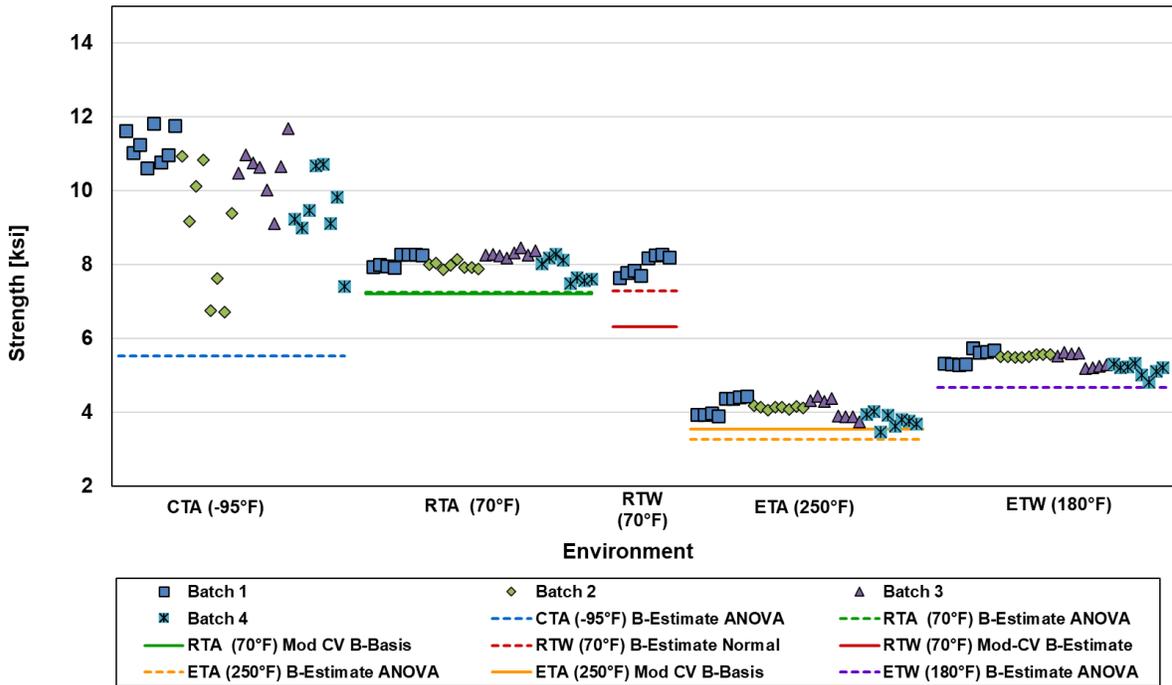


Figure 4-55: Batch Plot for Rail Shear Z45 Maximum Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Rail Shear Z45 0.2% Offset Strength

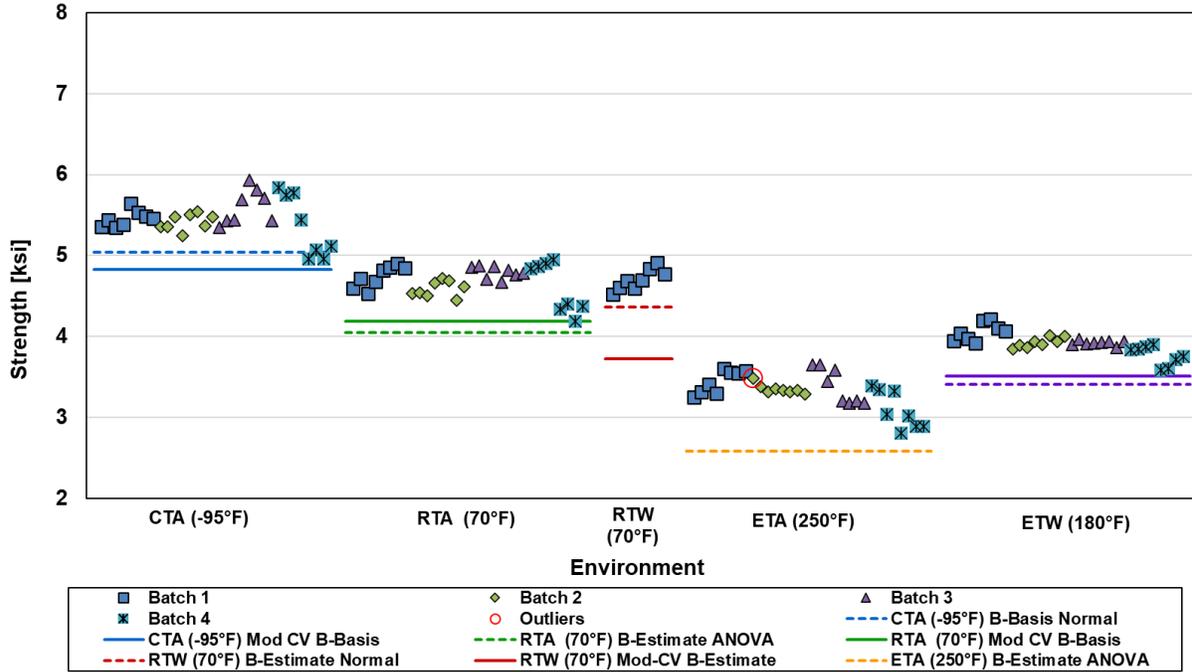


Figure 4-56: Batch Plot for Rail Shear Z45 0.2% Offset Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Rail Shear Z45 Strength at 5% Strain

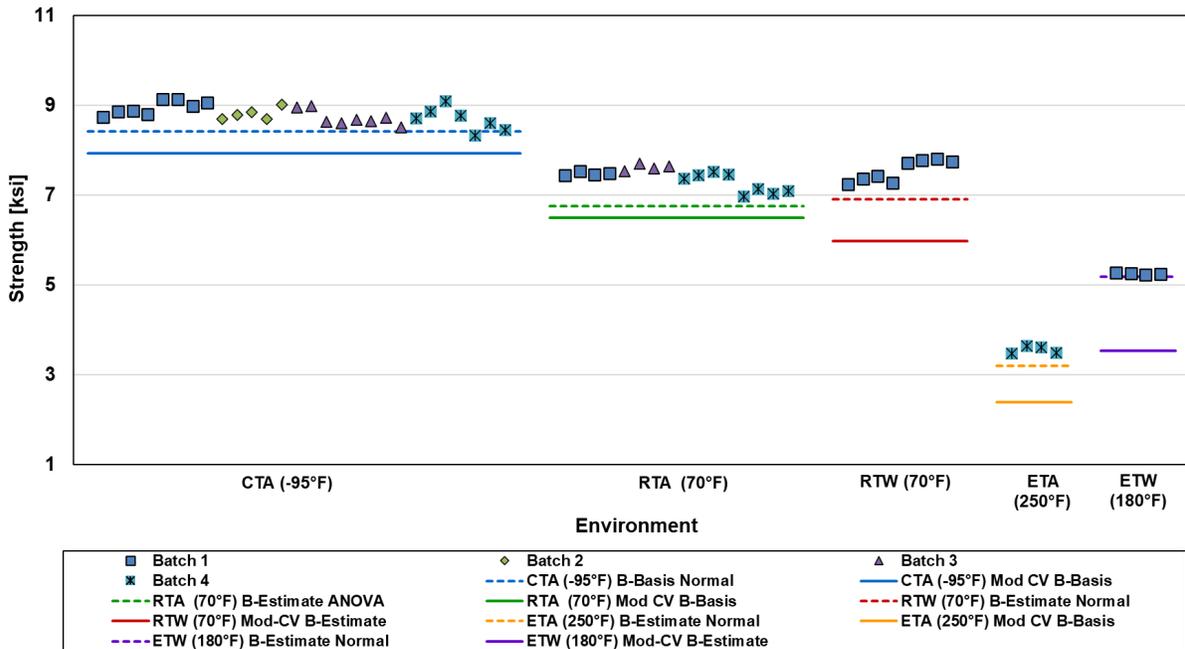


Figure 4-57: Batch Plot for Rail Shear Z45 Strength at 5% Strain

RSZ45 Strength (ksi) As-Measured Basis Values and Statistics																
Environment	Maximum Strength					0.2% Offset Strength					Strength at 5% Strain					
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	
Mean	10.03	8.060	7.984	4.042	5.391	5.400	4.713	4.704	3.335	3.926	8.795	7.405	7.545	3.551	5.252	
Std. Dev.	1.390	0.2462	0.2680	0.2530	0.2152	0.2059	0.2174	0.1301	0.2319	0.1460	0.2067	0.2228	0.2422	0.08485	0.01803	
CV	13.85	3.054	3.356	6.260	3.991	3.813	4.612	2.766	6.951	3.718	2.350	3.009	3.210	2.390	0.3433	
Modified CV	13.85	6.000	8.000	7.130	6.000	6.000	6.306	8.000	7.476	6.000	6.000	6.000	8.000	8.000	8.000	
Min	6.708	7.484	7.643	3.468	4.816	4.958	4.186	4.524	2.803	3.587	8.336	6.971	7.240	3.469	5.233	
Max	11.83	8.460	8.276	4.441	5.735	5.840	5.025	4.912	3.756	4.215	9.144	7.706	7.807	3.643	5.276	
No. Batches	4	4	1	4	4	4	4	1	4	4	4	3	1	1	1	
No. Specimens	32	32	8	32	32	32	32	8	32	32	28	16	8	4	4	
Basis Values and Estimates																
B-Basis						5.039					8.424					
B-Estimate	5.516	7.243	7.287	3.255	4.660		4.045	4.366	2.582	3.404		6.250	6.916	3.203	5.178	
A-Estimate	2.351	6.672	6.800	2.703	4.149	4.776	3.576	4.129	2.055	3.040	8.156	5.427	6.475	2.940	5.122	
Method	ANOVA	ANOVA	Normal	ANOVA	ANOVA	Normal	ANOVA	Normal	ANOVA	ANOVA	Normal	ANOVA	Normal	Normal	Normal	
Modified CV Basis Values and Estimates																
B-Basis	NA	7.210		3.535	NA	4.831	4.191		NA	3.513	7.933	6.499				
B-Estimate			6.324				3.726							5.977	2.387	3.531
A-Estimate		6.593	5.162	3.168		4.418	3.812	3.041		3.212	7.323	5.899	4.878	1.506	2.227	
Method		Normal	Normal	Normal		Normal	Normal	Normal		Normal	Normal	Pooled	Pooled	Normal	Normal	Normal

Table 4-45: Statistics and Basis Values for Rail Shear Z45 Strength Data

RSZ45 Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.2138	0.1945	0.2003	0.1950	0.1921
Std. Dev.	0.005239	0.004908	0.005496	0.008250	0.004165
CV	2.450	2.524	2.745	4.231	2.168
Min	0.2038	0.1856	0.1938	0.1755	0.1816
Max	0.2233	0.2026	0.2059	0.2079	0.2012
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-46: Statistics for Rail Shear Z45 Modulus Data

4.28 Rail Shear ZX Orientation (RS – ASTM D7078)

Maximum strength, 0.2% offset strength, strength at 5% strain and modulus tests were conducted in the following environmental conditions: CTA, RTA, RTW, ETA, and ETW. The RTW condition for all properties consists of a single batch with eight specimens, therefore only basis values estimates are provided for that condition.

For the maximum strength dataset, the CTA, RTA, and ETA conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The RTW condition failed all the distributions tests, therefore the non-parametric method was used for that condition. The normal method was used for ETW. Applying the modified CV, the CTA and ETA conditions failed the ADK test and the RTW condition failed the normality test, therefore modified CV basis values and estimates are not available for these conditions. The normal method was used for RTA and ETW.

For the 0.2% offset strength dataset, the RTA, ETA, and ETW conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for these conditions. The normal method was used for CTA and RTW. Applying the modified CV, the normal method was used for CTA, RTW, and ETW. The RTA condition failed the normality test and the ETA condition failed the ADK test, therefore modified CV basis values are not available for these conditions.

For strength at 5% strain dataset, due to insufficient data only estimates were computed for the ETA and ETW conditions. The CTA and RTA conditions met all the requirements for pooling. The RTW condition failed all the distribution tests, therefore the non-parametric method was used for that condition. The normal method was used for ETA and ETW. Applying the modified CV, the normal method was used for CTA, ETA, and ETW. The RTA and RTW conditions failed the normality test, therefore modified CV basis values are not available for those conditions.

There were two statistical outliers. For 0.2% offset strength, the highest value in batch three of the CTA condition was a batch outlier. The highest value in batch three of the RTA condition was a batch and condition outlier. They were retained for this analysis.

Statistics, basis values and estimates are given for the RS ZX strength data in Table 4-47 and for the modulus data in Table 4-48Table 4-44. The data, B-estimates and B-basis values are shown graphically in Figure 4-58 through Figure 4-60.

**Stratasys Inc. Additively Manufactured Antero(R) 840CN03
Rail Shear ZX Maximum Strength**

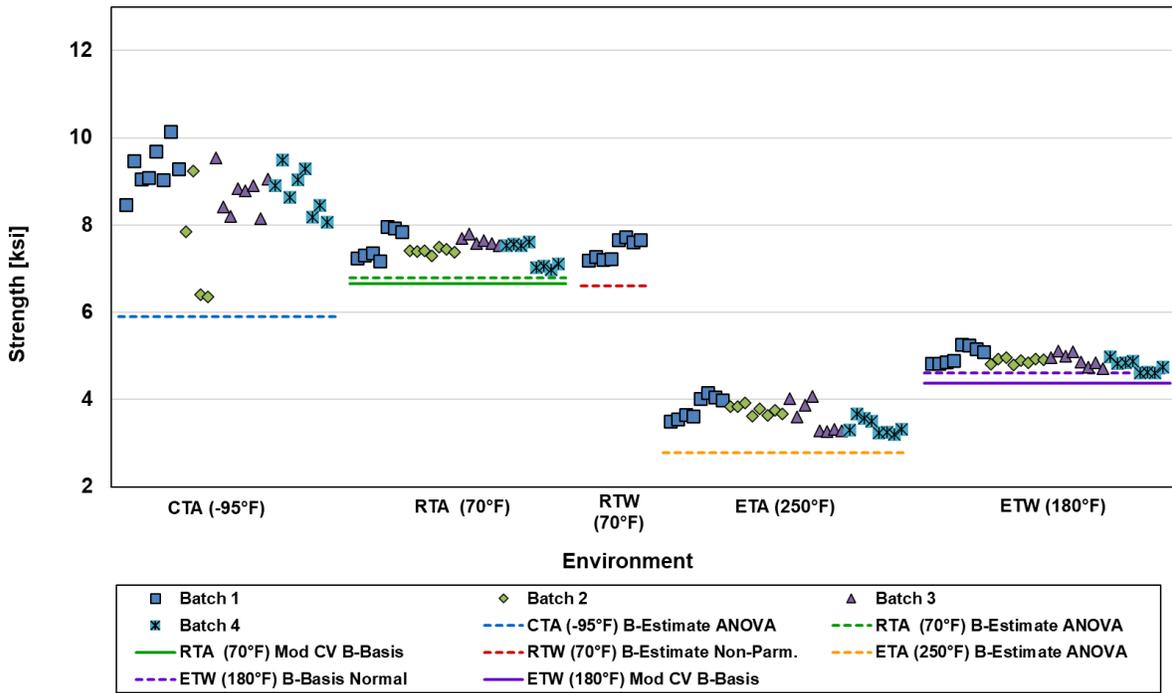


Figure 4-58: Batch Plot for Rail Shear ZX Maximum Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Rail Shear ZX 0.2% Offset Strength

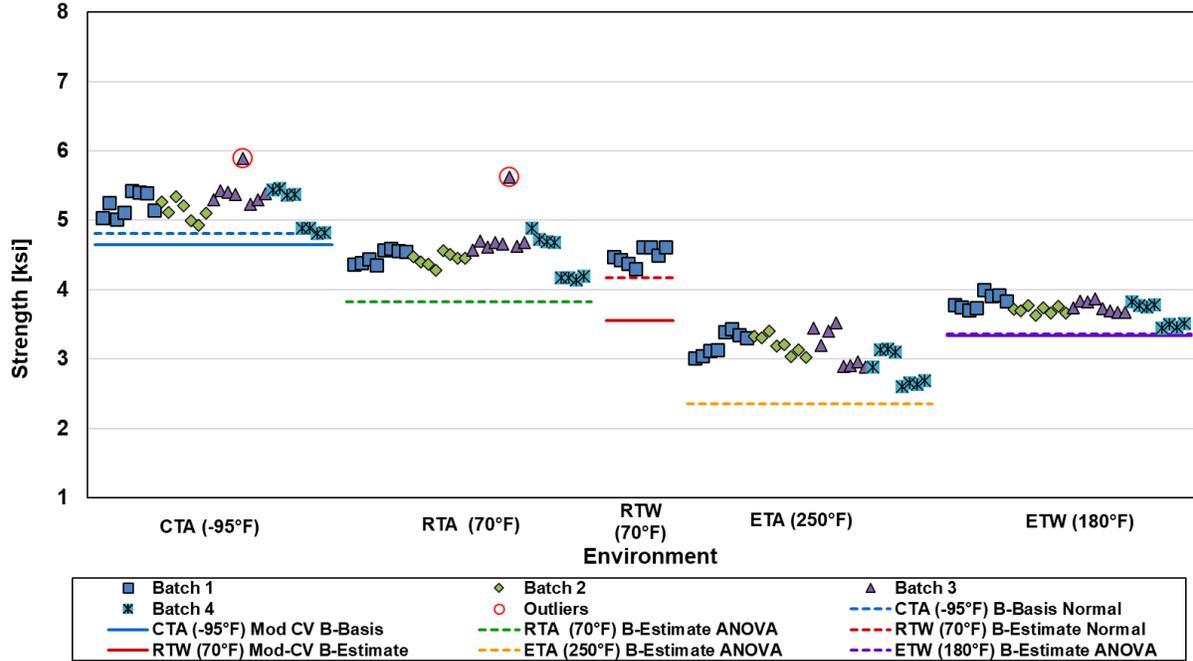


Figure 4-59: Batch Plot for Rail Shear ZX 0.2% Offset Strength

Stratasys Inc. Additively Manufactured Antero(R) 840CN03
 Rail Shear ZX Strength at 5% Strain

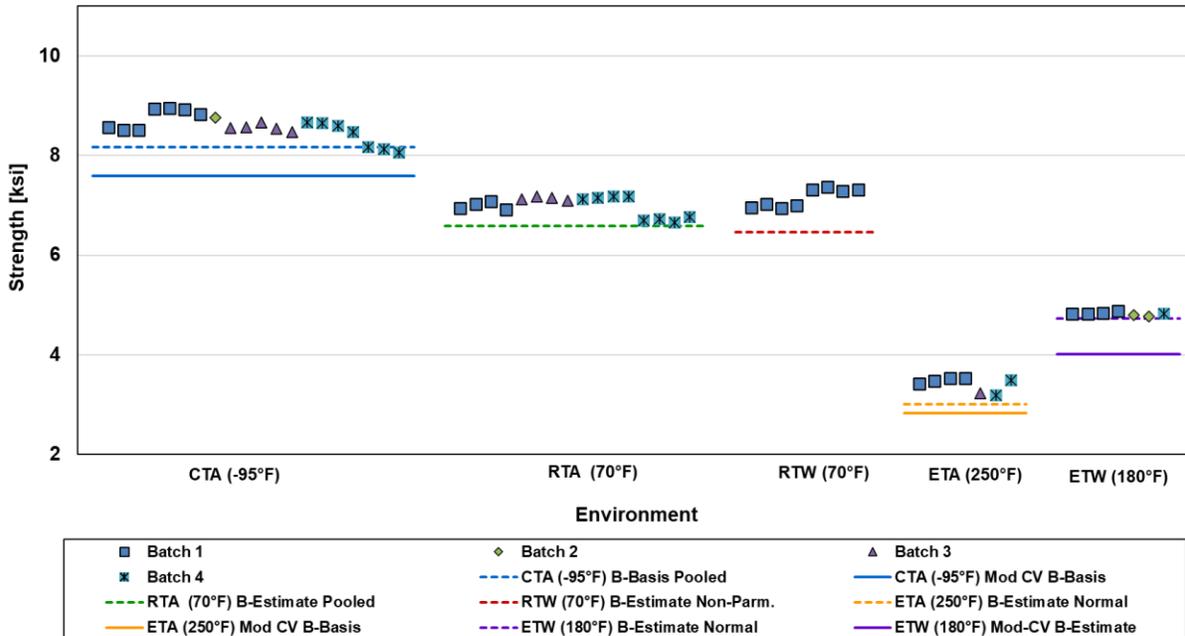


Figure 4-60: Batch Plot for Rail Shear ZX Strength at 5% Strain

RSZX Strength As-Measured (ksi) Basis Values and Statistics															
Environment	Maximum Strength					0.2% Offset Strength					Strength at 5% Strain				
	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	8.715	7.458	7.445	3.636	4.894	5.229	4.535	4.489	3.109	3.731	8.576	6.999	7.149	3.410	4.820
Std. Dev.	0.8545	0.2586	0.2386	0.2882	0.1646	0.2356	0.2698	0.1202	0.2517	0.1266	0.2497	0.1868	0.1847	0.1426	0.03265
CV	9.804	3.467	3.205	7.928	3.363	4.506	5.950	2.679	8.096	3.393	2.912	2.669	2.583	4.181	0.6774
Modified CV	9.804	6.000	8.000	7.964	6.000	6.253	6.975	8.000	8.096	6.000	6.000	6.000	8.000	6.091	6.000
Min	6.350	6.976	7.193	3.191	4.605	4.815	4.145	4.298	2.601	3.450	8.058	6.660	6.941	3.191	4.769
Max	10.14	7.959	7.732	4.148	5.256	5.887	5.624	4.618	3.521	4.001	8.955	7.180	7.367	3.538	4.875
No. Batches	4	4	1	4	4	4	4	1	4	4	4	3	1	3	3
No. Specimens	28	28	8	32	32	31	32	8	32	32	20	16	8	7	7
Basis Values and Estimates															
B-Basis					4.605	4.813					8.172	6.586			
B-Estimate	5.894	6.796	6.596	2.773			3.829	4.176	2.352	3.360			6.460	3.014	4.730
A-Estimate	3.921	6.328	5.687	2.166	4.395	4.511	3.329	3.957	1.821	3.099	7.893	6.309	5.719	2.736	4.666
Method	ANOVA	ANOVA	Non-Param.	ANOVA	Normal	Normal	ANOVA	Normal	ANOVA	ANOVA	Pooled	Pooled	Non-Param.	Normal	Normal
Modified CV Basis Values and Estimates															
B-Basis		6.653			4.378	4.652				3.337	7.585				
B-Estimate	NA		NA	NA			NA	3.555	NA			NA	NA	2.833	4.017
A-Estimate		6.073			4.004	4.233		2.902		3.052	6.880			2.428	3.452
Method		Normal			Normal	Normal		Normal		Normal	Normal			Normal	Normal

Table 4-47: Statistics and Basis Values for Rail Shear ZX Strength Data

RSZX Modulus (Msi) Statistics					
Environment	CTA (-95 °F)	RTA (70 °F)	RTW (70 °F)	ETA (250 °F)	ETW (180 °F)
Mean	0.2089	0.1869	0.1934	0.1842	0.1832
Std. Dev.	0.005360	0.005659	0.002963	0.009501	0.003928
CV	2.566	3.028	1.532	5.156	2.144
Min	0.1998	0.1711	0.1883	0.1678	0.1738
Max	0.2183	0.1954	0.1968	0.2004	0.1910
No. Batches	4	4	1	4	4
No. Specimens	32	32	8	32	32

Table 4-48: Statistics for Rail Shear ZX Modulus Data

5. Outliers

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

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

All outliers identified were investigated to determine if a cause could be found. Outliers with causes were removed from the dataset and the remaining specimens were analyzed for this report. Information about specimens that were removed from the dataset along with the cause for removal is documented in the material property data report, NCAMP Test Report CAM-RP-2025-031 Rev - . Outliers for which no causes could be identified are listed in Table 5-1. These outliers were included in the analysis for their respective test properties.

Test	Property	Condition	Batch	Specimen No.	Value	Type	Outlier		
							High/Low	Batch	Outlier
TXY	Strength	CTA	4	NTPAM8400Q1-STR-840CN-BLU-D-M6-XY-T-11-CTA-1	13.33	As-Measured	Low	Yes	No
TXY	Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XY-T-14-RTA-3	8.998	As-Measured	Low	Yes	Yes
TXZ	Strength	CTA	1	NTPAM8400Q1-STR-840CN-NGC-A-M1-XZ-T-12-CTA-2	15.96	As-Measured	Low	Yes	No
TXZ	Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-XZ-T-14-RTA-3	11.21	As-Measured	Low	No	Yes
TXZ	0.2% Offset Strength	ETW	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-XZ-T-12-ETW-2	6.908	As-Measured	Low	No	Yes
TZ45	Strength	RTA	4	NTPAM8400Q1-STR-840CN-BLU-D-M6-Z45-T-13-RTA-2	8.377	As-Measured	Low	No	Yes
TZ45	0.2% Offset Strength	CTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-Z45-T-14-CTA-3	7.726	As-Measured	Low	Yes	No
TZX	0.2% Offset Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XZ-T-14-RTA-3	7.971	As-Measured	High	Yes	No
CXY	0.2% Offset Strength	CTA	1	NTPAM8400Q1-STR-840CN-NGC-A-M1-XY-C-15-CTA-4	9.816	As-Measured	Low	Yes	No
CXY	0.2% Offset Strength	CTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-XY-C-12-CTA-2	15.66	As-Measured	High	Yes	No
CXY	1% Offset Strength	CTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-XY-C-12-CTA-2	21.76	As-Measured	High	Yes	No
CXZ	1% Offset Strength	CTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XZ-C-11-CTA-1	20.98	As-Measured	High	Yes	No
CXZ	2% Offset Strength	RTW	1	NTPAM8400Q1-STR-840CN-RAY-A-M2-XZ-C-11-RTW-1	14.91	As-Measured	High	Yes	Yes
CXZ	Compressive Strength	ETA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XZ-C-11-ETA-1	8.421	As-Measured	High	Yes	No
CXZ	Compressive Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-XZ-C-11-ETW-1	10.80	As-Measured	High	Yes	No
CZ45	0.2% Offset Strength	CTA	4	NTPAM8400Q1-STR-840CN-SDM-D-M4-Z45-C-12-CTA-2	17.95	As-Measured	High	No	Yes
CZX	0.2% Offset Strength	ETW	3	NTPAM8400Q1-STR-840CN-SDM-C-M5-ZX-C-14-ETW-3	6.912	As-Measured	Low	No	Yes
CZX	1% Offset Strength	ETW	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-ZX-C-14-ETW-3	8.824	As-Measured	Low	No	Yes
FHTXY	Strength	RTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-XY-FHT-11-RTA-1	8.969	As-Measured	High	Yes	No
FHTXZ	Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-XZ-FHT-13-RTA-2	10.58	As-Measured	Low	Yes	No
FHTXZ	Strength	ETW	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-XZ-FHT-15-ETW-4	7.349	As-Measured	Low	Yes	No
FHTXZ	Strength	ETW	4	NTPAM8400Q1-STR-840CN-SDM-D-M4-XZ-FHT-14-ETW-3	7.484	As-Measured	Low	Yes	No
FHTZ45	Strength	RTA	1	NTPAM8400Q1-STR-840CN-NGC-A-M1-Z45-FHT-14-RTA-3	6.815	As-Measured	Low	Yes	Yes
FHTZX	Strength	RTA	1	NTPAM8400Q1-STR-840CN-NGC-A-M1-ZX-FHT-11-RTA-1	3.186	As-Measured	Low	Yes	No
FHTZX	Strength	ETW	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-ZX-FHT-14-ETW-3	5.266	As-Measured	Low	Yes	No
FHTZX	Strength	ETW	4	NTPAM8400Q1-STR-840CN-SDM-D-M4-ZX-FHT-12-ETW-2	2.493	As-Measured	Low	Yes	Yes
FXY	0.2% Offset Strength	ETW	1	NTPAM8400Q1-STR-840CN-RAY-A-M2-XY-F-12-ETW-2	10.05	As-Measured	Low	No	Yes
FXY	Flexural Strength	CTA	1	NTPAM8400Q1-STR-840CN-RAY-A-M2-XY-F-13-CTA-2	23.60	As-Measured	Low	Yes	No
FXY	Flexural Strength	CTA	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-XY-F-11-CTA-1	22.88	As-Measured	Low	Yes	No
FXY	Flexural Strength	CTA	4	NTPAM8400Q1-STR-840CN-BLU-D-M6-XY-F-11-CTA-1	17.66	As-Measured	Low	Yes	Yes
FXZ	0.2% Offset Strength	CTA	1	NTPAM8400Q1-STR-840CN-RAY-A-M2-XZ-F-15-CTA-4	22.67	As-Measured	High	Yes	No
FXZ	0.2% Offset Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-XZ-F-13-ETW-2	11.28	As-Measured	Low	Yes	Yes
FXZ	Flexural Strength	CTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XZ-F-15-CTA-4	29.21	As-Measured	Low	Yes	No
FXZ	Flexural Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-XZ-F-13-ETW-2	12.75	As-Measured	Low	Yes	Yes
FZ45	0.2% Offset Strength	RTA	4	NTPAM8400Q1-STR-840CN-NGC-A-M1-Z45-OHT-14-RTA-3	11.87	As-Measured	Low	No	Yes
FZ45	Flexural Strength	RTA	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-Z45-F-15-RTA-4	9.657	As-Measured	Low	Yes	No
FZX	0.2% Offset Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-ZX-F-13-ETW-2	14.56	As-Measured	High	Yes	Yes
FZX	Flexural Strength	RTA	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-ZX-F-14-RTA-3	11.52	As-Measured	Low	Yes	No
FZX	Flexural Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-ZX-F-13-ETW-2	15.95	As-Measured	High	Yes	Yes
OHTXY	Strength	CTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XY-OHT-12-CTA-2	8.729	As-Measured	High	Yes	No
OHTXY	Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XY-OHT-14-ETW-3	5.827	As-Measured	High	Yes	No
OHTXZ	Strength	RTA	4	NTPAM8400Q1-STR-840CN-SDM-D-M4-XZ-OHT-15-RTA-4	5.747	As-Measured	Low	Yes	No
OHTXZ	Strength	ETW	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-XZ-OHT-15-ETW-4	6.541	As-Measured	Low	No	Yes
OHTZ45	Strength	RTA	1	NTPAM8400Q1-STR-840CN-NGC-A-M1-Z45-OHT-14-RTA-3	4.514	As-Measured	Low	No	Yes
OHTZ45	Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-Z45-OHT-12-RTA-2	6.928	As-Measured	Low	Yes	No
OHTZX	Strength	CTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-ZX-OHT-13-CTA-2	2.369	As-Measured	Low	Yes	No
OHTZX	Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-ZX-OHT-15-RTA-4	4.066	As-Measured	Low	Yes	No
SSBXY	2% Offset Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XY-SSB-15-ETW-4	17.43	As-Measured	Low	Yes	No
SSBZX	Ultimate Strength	RTA	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-XZ-SSB-12-RTA-2	25.62	As-Measured	Low	No	Yes
SSBZ45	Ultimate Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-Z45-SSB-15-RTA-4	31.70	As-Measured	Low	Yes	Yes
SSBZ45	Ultimate Strength	RTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-Z45-SSB-15-RTA-4	31.81	As-Measured	Low	No	Yes
SSBZX	2% Offset Strength	RTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-ZX-SSB-12-RTA-2	20.26	As-Measured	Low	No	Yes
SSBZX	2% Offset Strength	ETW	4	NTPAM8400Q1-STR-840CN-SDM-D-M4-ZX-SSB-15-ETW-4	24.72	As-Measured	High	Yes	Yes
SSBZX	Ultimate Strength	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-ZX-SSB-13-ETW-2	19.37	As-Measured	Low	Yes	Yes
SSBZX	Ultimate Strength	ETW	4	NTPAM8400Q1-STR-840CN-SDM-D-M4-ZX-SSB-15-ETW-4	28.63	As-Measured	High	Yes	Yes
RSXY	0.2% Offset Strength	ETW	4	NTPAM8400Q1-STR-840CN-SDM-D-M4-XY-RS-11-ETW-1	4.011	As-Measured	High	Yes	No
RSXY	Maximum Strength	RTA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R2-XY-RS-14-RTA-3	7.022	As-Measured	Low	Yes	No
RSXY	Maximum Strength	ETA	4	NTPAM8400Q1-STR-840CN-BLU-D-M6-XY-RS-11-ETA-1	4.295	As-Measured	High	Yes	No
RSXZ	Maximum Strength	CTA	3	NTPAM8400Q1-STR-840CN-NAV-C-M5-XZ-RS-14-CTA-3	7.744	As-Measured	Low	Yes	No
RSXZ	Maximum Strength	RTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-XZ-RS-12-RTA-2	6.148	As-Measured	Low	Yes	Yes
RSXZ	Strength at 5% Strain	ETW	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-XZ-RS-14-ETW-3	4.814	As-Measured	Low	No	Yes
RSZ45	0.2% Offset Strength	ETA	2	NTPAM8400Q1-STR-840CN-NIA-B-M3R1-Z45-RS-11-ETA-1	3.484	As-Measured	High	Yes	No
RSZX	0.2% Offset Strength	CTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-ZX-RS-11-CTA-1	5.887	As-Measured	High	Yes	No
RSZX	0.2% Offset Strength	RTA	3	NTPAM8400Q1-STR-840CN-SDM-C-M4-ZX-RS-12-RTA-2	5.624	As-Measured	High	Yes	Yes

Table 5-1: List of Outliers

6. References

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