6 gsm 38% RC Material Allowables Statistical Analysis Report

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1. Introduction

This report contains statistical analysis of the Renegade RM-2014-LDk-Tk 4581 8HS Quartz satin fabric prepreg material property data published in NCAMP Test Report CAM-RP-2024-007 Rev N/C. The lamina and laminate material property data have been generated with NCAMP oversight through NCAMP Project Number NPN 032302 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 c Tm -792 re W* n BT /F2 112 77(e)-5(re)7( )-69(c

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Test Property	Symbol
Warp Compression Strength	F_1^{cu}
Warp Compression Modulus	E_1^{c}
Warp	$_{12}^{c}$
Warp Tension Strength	F_1^{tu}
Warp Tension Modulus	E_1^{t}
Warp	$_{12}^{t}$
Fill Compression Strength	F_2^{cu}
Fill Compression Modulus	E_2^{c}
Fill	$_{21}^{c}$
Fill Tension Strength	F_2^{tu}
Fill Tension Modulus	E_2^{t}
In Plane Shear Strength at 5% strain	$F_{12}^{s5\%}$
In Plane Shear Strength at 0.2% offse	$F_{12}^{s0.2\%}$
In Plane Shear Modulus	G_{12}^{s}

Table 1-2: Test Property Symbols

Environmental Condition	Abbreviation	Temperature
Cold Temperature Dry	CTD	
Room Temperature Dry	RTD	
Elevated Temperature Dry	ETD	212
Elevated Temperature We	ETW	212

Table 1-3: Environmental Conditions Abbreviations

Tests with a number immediately after the abbreviation indicate the layup.

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

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

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2024-007 Rev N/C.

1.2 Pooling Across Environments

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

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

1.3 Basis Value Computational Process

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

1.4 Modified Coefficient of Variation (CV) Method

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

The modified Coefficient of Variation (CV) used in this report is in accordance with section 8.4.4 of CMH-17-1G. It is a method of adjusting the original basis values downward in anticipation of the expected additional variation. Composite materials are expected to have a CV of at least 6%. The modified coefficient of variation (CV) method increases the measured coefficient of variation when it is below 8% prior to computing basis values. A higher CV will result in lower or more conservative basis values and lower specification limits. The use of the modified CV method is intended for a temporary period of time when there is minimal data available. When a sufficient number of production batches (approximately 8 to 15 n BT /F2 12 Tf

2. Background

Statistical computations are performed with CMH17 STATS. Pooling across environments will be used whenever it is permissible according to CMH-17-1G guidelines. If pooling is not permissible, the results of a single point analysis provided by CMH17STATS is included instead. If the data does not meet CMH-17-1G requirements for a single point analysis, estimates are created by a variety of methods depending on which is most appropriate for the dataset available. Specific procedures used are presented in the individual sections where the data is presented.

2.1 CMH17 STATS Statistical Formulas and Computations

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

2.1.1 Basic Descriptive Statistics

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

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

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

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

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

2.1.2 Statistics for Pooled Data

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

2.1.2.1 Pooled Standard Deviation

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

Pooled Std. Dev .: Equation 4

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

2.1.2.2 Pooled Coefficient of Variation

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

Pooled Coefficient of Variation 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

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where t is the $1-\frac{.05}{2n}$ quartile of a t distrib 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 proce is applied again. This process is repeated until no outliers are detected. Additional information on this procedure can be found in refe rences 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 $z_{(1)}$, $z_{(2)}$ « $z_{(L)}$, where L will be less than n if there are tied observations. These rankings are used to compute the test statistic.

The k-sample Anderson-Darling test statistic is:

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

Where

n_i = the number of test specimens in each batch

$n = n_1 + n_2$ « Q_k

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

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

F_{ij} = the number of values in the i^{th} group which are less than z

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 Test for Equality of Coefficient of Variation

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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

n	k	n	k	n	k
2	80.00380	38	1.79301	96	1.32324
3	16.91220	39	1.77546	98	

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 variance is used (see section 2.1.8) the values produced are likely to be conservative. Thus this method can still be used but the values should be listed as estimates.

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However, if the laminate CV is larger than the corresponding lamina CV, the larger laminate CV value is used.

The LVM B-basis value is then computed as:

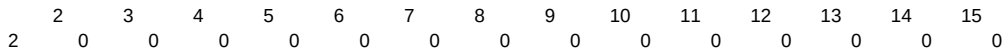

Table 2-4: B-Basis Factors for Small Datasets Using Variability of Corresponding Large Dataset

3. Summary of Results

Values are for normalized data unless noted

					0.2% Offset	5% Strain	
B-basis	111.1	72.21	NA: A	59.98	4.951	8.936	8.602
Mean	122.2	79.16	102.4	66.02	5.616	9.901	9.467
CV	6.000	6.728	7.550	6.000	6.000	6.000	6.000
B-basis	97.07	61.72	82.41	52.28	3.822	6.657	7.773
Mean	108.1	68.67	93.33	58.33	4.335	7.622	8.638
CV	6.000	6.037	6.000	6.000	6.000	6.000	6.000
B-basis	99.88	48.23	NA: A	38.32	2.468	NA: A	5.018
Mean	110.9	55.18	90.63	44.36	2.791	4.923	5.883
CV	6.000	6.982	8.318	6.597	6.000	6.939	6.000
B-basis	63.70	34.83	NA: A	24.85	1.428	2.139	3.017
Mean	74.75	41.57	63.12	30.73	1.653	2.527	3.447
CV	6.000	6.486	12.73	11.22	7.139	7.781	6.321

Notes:

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

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

Test data for fiber dominated properties was normalized according to nominal cured ply thickness. Both normalized and as-measured statistics were included in the tables, but only the normalzed

4.1 Warp Tension (WT)

Warp Tension data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: CTD,

4.2 Fill Tension (FT)

Fill Tension data is normalized by cured ply thickness. Both normalized and as-measured statistics are provided. Tests were conducted in the following environmental conditions: CTD, RTD, ETD, and ETW.

For the normalized dataset, all the environments failed the ADK test for batch equivalency. ANOVA was used to compute basis values, and with three batches of data available these are estimates. Applying the modified CV, only the RTD environment passed the ADK test for batch equivalency, therefore pooling is not acceptable.

For the as-measured dataset, the CTD, ETD and ETW environments failed the ADK test for batch equivalency. ANOVA was used to compute basis values, and with three batches of data available these are estimates. Applying the modified CV, CTD and ETD passed the ADK test for batch equivalency, but ETW failed and basis values were not computed. CTD, RTD, and ETD were acceptable for pooling.

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Figure 4-2: Batch Plot for FT Normalized S

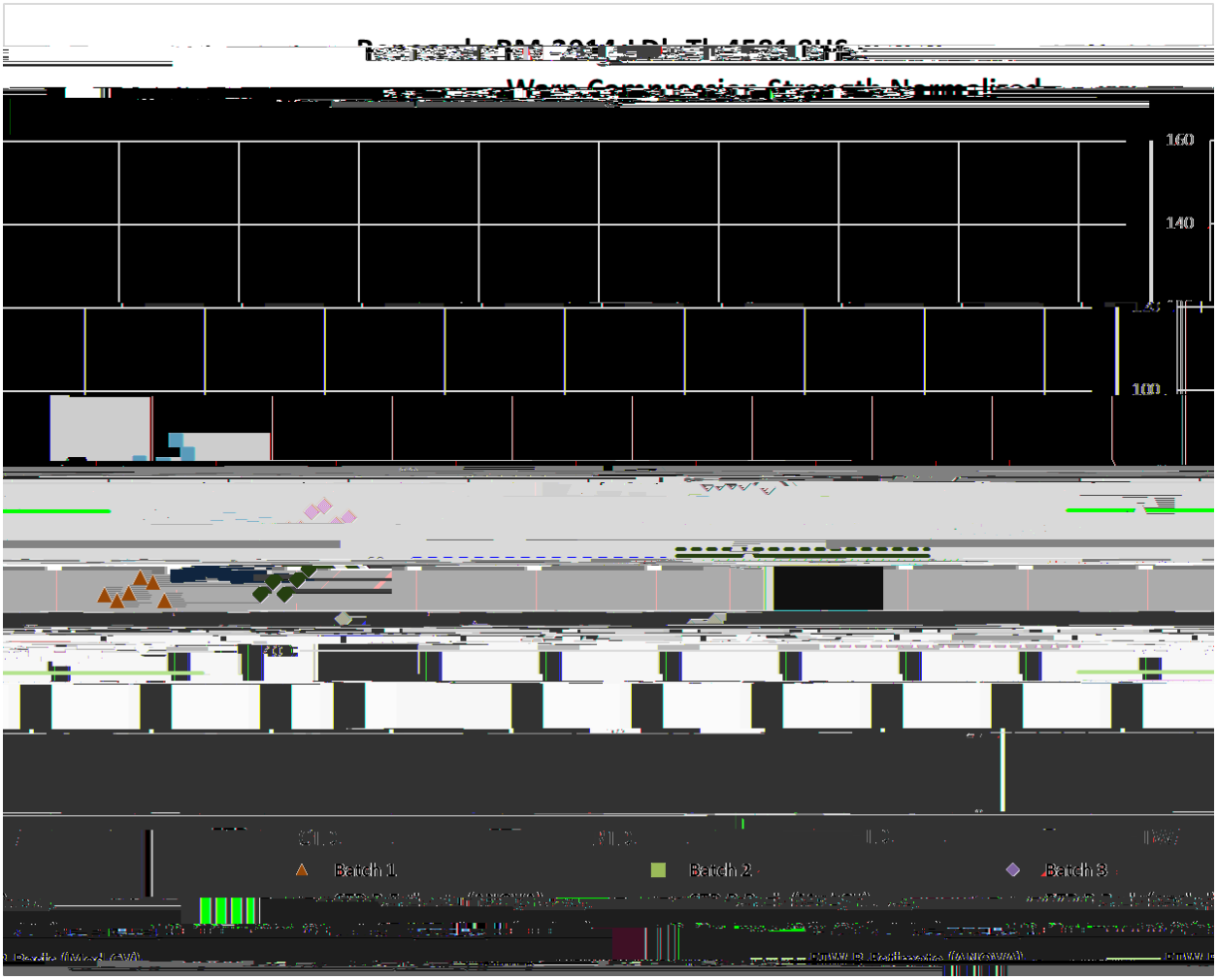

Figure 4-3: Batch Plot for W C Normalized Strength

Env	CTD	RTD	ETD	ETW	CTD	RTD	ETD	ETW

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

Warp Compression (WC) Modulus Statistics								
	Normalized				As-Measured			
Env	CTD	RTD	ETD	ETW	CTD	RTD	ETD	ETW
Mean	3.579	3.499	3.328	3.208	3.576	3.466	3.300	3.198
Stdev	0.03018	0.06806	0.1280	0.2087	0.03841	0.07717	0.1486	0.2250
CV	0.8432	1.945	3.846	6.503	1.074	2.227	4.504	7.033
Mod CV	6.000	6.000	6.000	7.252	6.000	6.000	6.252	7.517
Min	3.520	3.388	3.030	2.976	3.514	3.340	3.030	2.950
Max	3.617	3.610	3.550	3.938	3.651	3.610	3.550	4.010
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18

Table 4-6: Statistics from WC Modulus Data

Fill Compression (FC) Modulus Statistics								
	Normalized				As-Measured			
Env	CTD	RTD	ETD	ETW	CTD	RTD	ETD	ETW
Mean	3.408	3.346	3.180	2.906	3.451	3.360	3.194	2.937
Stdev	0.05918	0.1230	0.1193	0.1500	0.09116	0.1723	0.1498	0.1664
CV	1.736	3.675	3.753	5.163	2.641	5.128	4.690	5.667
Mod CV	6.000	6.000	6.000	6.582	6.000	6.564	6.345	6.833
Min	3.283	3.148	2.966	2.650	3.283	3.120	2.940	2.650
Max	3.482	3.591	3.410	3.163	3.603	3.690	3.410	3.250
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18

Table 4-8: Statistics from FC Modulus Data

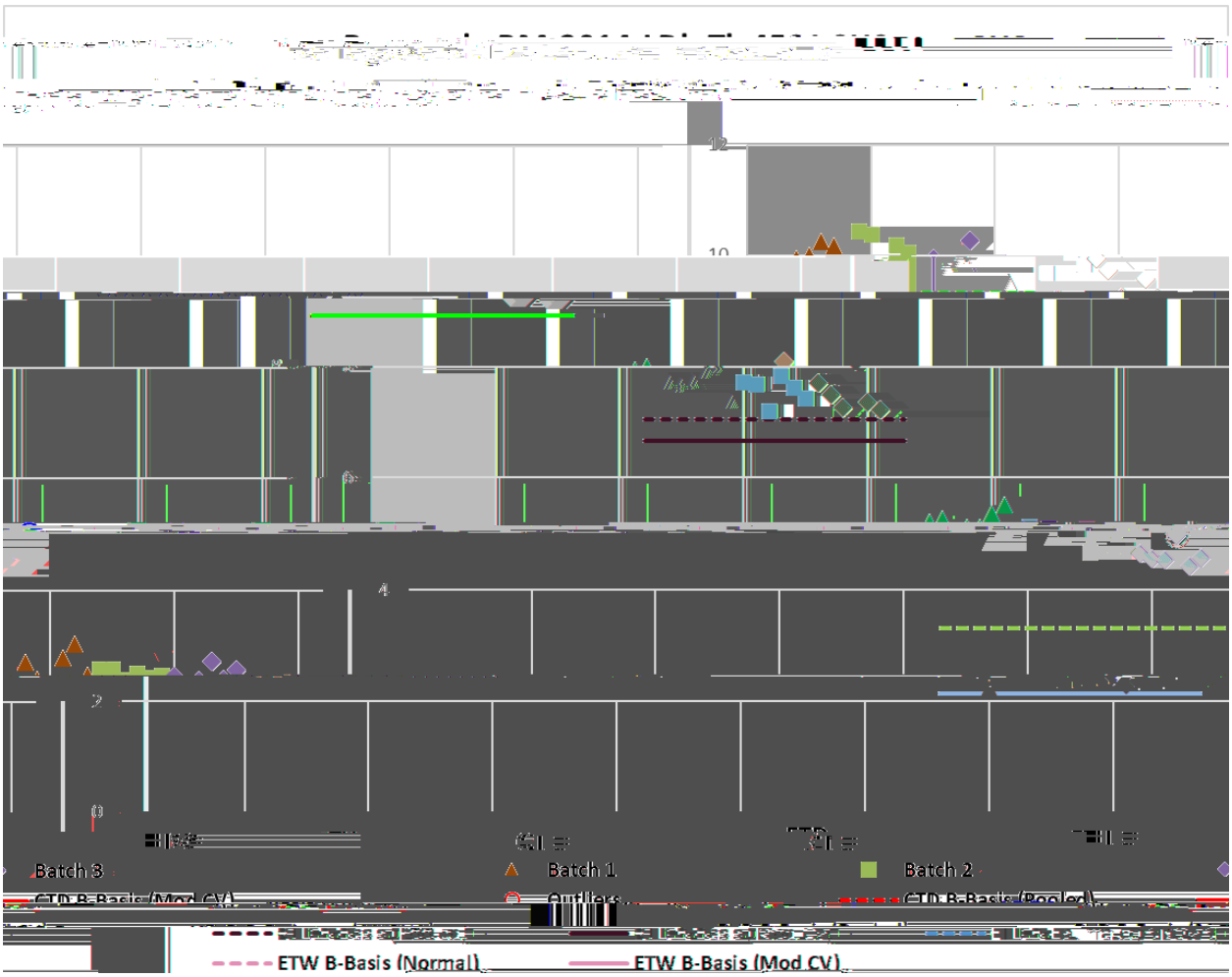

Figure 4-5: Batch Plot for IPS Maximum Strength and Strength at 5% Strain As-Measured

Env	CTD	RTD	ETD	ETW
Mean	0.7640	0.5988	0.4137	0.2470
Stdev	0.01668	0.01971	0.01454	0.02201
CV	2.183	3.291	3.516	8.913
Mod CV	6.000	6.000	6.000	8.913
Min	0.7336	0.5700	0.3900	0.2170
Max	0.7878	0.6440		

Table 4-10: Statistics from IPS Modulus Data

4.6 (UNT1)

The UNT1 data is normalized by cured ply thickness. Both normalized and as-measured statistics are provided. Tests were conducted in the following environmental conditions: CTD, RTD, an ETW.

For the normalized dataset, the ETW environment failed the ADK test for batch equivalency. ANOVA was used to compute its value, and with three batches of data available this is an estimate. The CTD and RTD environments were acceptable for pooling. Applying the modified CV, all pooling variations fail the Anderson Darling test for normality

For the as-measured dataset, the CTD and ETW environments fail the ADK test for batch equivalency. ANOVA was used to compute the basis values, and with three batches of data available, these are estimates. Applying the modified CV, there were no diagnostic test failures so pooling the three environments was acceptable.

There were no statistical outliers.

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

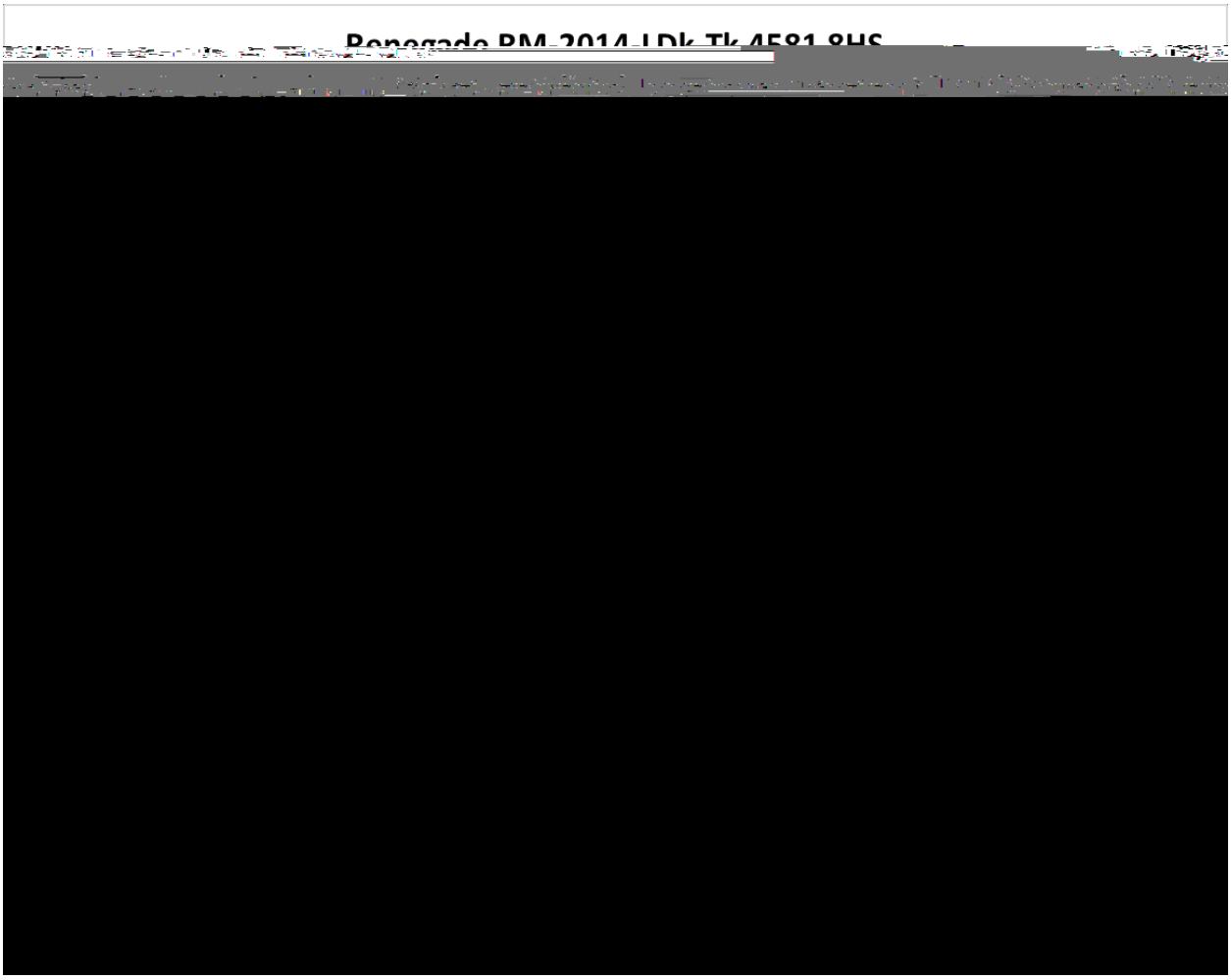

Figure 4-7: Batch Plot for UNT1 Normalized Strength

Unnotched Tension 1 (UNT1) Basis Values and Statistics						
	Normalized			As-Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	82.81	76.62	49.31	81.77	75.52	48.94
Stdev	2.830	2.262	2.007	2.772	2.267	1.604
CV	3.417	2.952	4.071	3.390	3.003	3.277
Mod CV	6.000	6.000	6.035	6.000	6.000	6.000
Min	78.50	73.27	44.69	77.03	71.20	45.50
Max	87.09	80.24	52.50	85.73	79.30	51.50
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	28	18	18	28
Basis Value Estimates						
B-Basis Value	78.14	71.96			71.04	
B-Estimate			40.36	68.21		40.60
A-Estimate	74.97	68.78	33.95	58.54	67.87	34.63
Method	Pooled	Pooled	ANOVA	ANOVA	Normal	ANOVA
Modified CV Basis Value Estimates						
B-Estimate	NA	67.55	43.96	NA	NA	43.66
A-Estimate		61.13	40.10			39.85
Method		Normal	Normal			Normal

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

Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	2.881	2.616	2.083	2.846	2.577	2.327
Stdev	0.03367	0.1081	0.06325	0.05972	0.08171	0.3807
CV	1.169	4.132	3.04	2.099	3.170	16.36
Mod CV	6.000	6.066	6.000	6.000	6.000	16.36
Min	2.796	2.452	1.945	2.724	2.439	1.950
Max	2.937	2.730	2.151	2.971	2.718	3.110
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	16	18	18	16

Table 4-12: Statistics from UNT1 Modulus Data

4.7 (UNT2)

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

For the normalized dataset, the RTD and ETW environments failed the ADK test for batch equivalency. ANOVA was used to compute

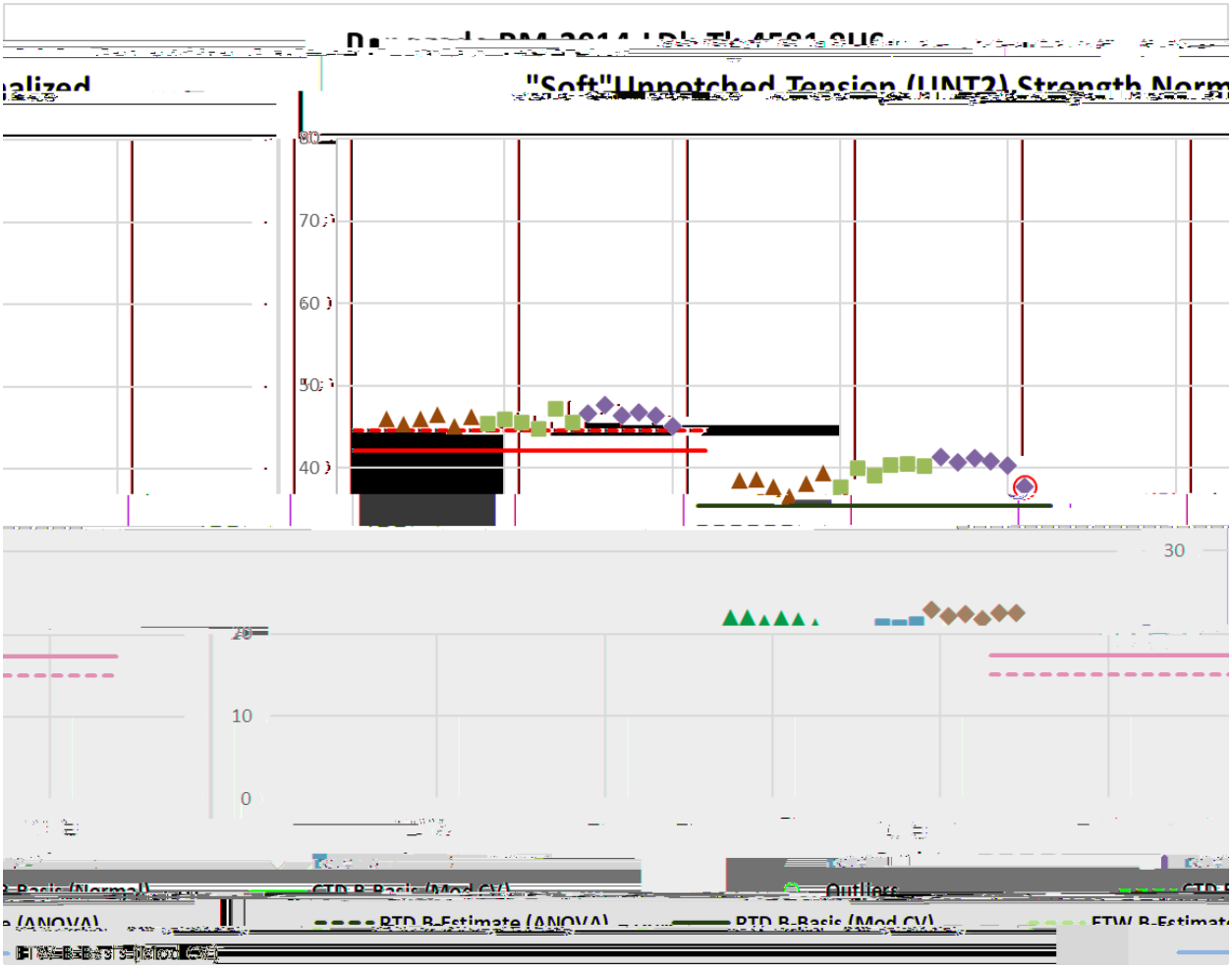

Figure 4-8: Batch Plot for UNT2 Normalized Strength

Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	46.05	39.42	21.43	46.11	39.40	21.54
Stdev	0.7691	1.424	1.054	1.075	1.702	1.124
CV	1.670	3.613	4.919	2.331	4.320	5.218
Mod CV	6.000	6.000	6.460	6.000	6.160	6.609
Min	44.82	36.62	19.25	44.01	36.30	19.40
Max	47.72	41.35	22.90	48.46	42.40	22.90
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
B-Basis Value	44.53					
B-Estimate		32.81	15.06	40.62	29.77	14.43
A-Estimate	43.46	28.10	10.51	36.70	22.90	9.356
Method	Normal	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
B-Value	42.07	35.44	17.45	40.65		
A-Estimate	39.42	32.79	14.80	36.79		
Env Method	Pooled	Pooled	Pooled	Normal		

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

Unnotched Tension 2 (UNT2) Modulus Statistics						
	Normalized			As-Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	2.450	2.087	1.549	2.453	2.085	1.556
Stdev	0.02747	0.08428	0.1614	0.04164	0.1015	0.1558
CV	1.121	4.037	10.42	1.698	4.867	10.01
Mod CV	6.000	6.019	10.42	6.000	6.433	10.01
Min	2.369	1.939	1.326	2.349	1.922	1.350
Max	2.484	2.175	1.917	2.507	2.228	1.900
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18

Table 4-14: Statistics from UNT2 Modulus Data

4.8 (UNT3)

The UNT3 data is normalized by cured ply thickness. Both normalized and as-measured statistics are provided. Tests were conducted in three environmental conditions.

For the normalized dataset, the three environments fail the ADK test for batch equivalency. ANOVA was used to compute their basis values, and with three batches of data available these are estimates. Applying the modified CV,
for equality of variances but the CTD and RTD environments were acceptable for pooling.

For the as-measured dataset, the RTD and ETW environments fail the ADK test for batch equivalency. ANOVA was used to compute their basis values, and with three batches of data available, these are estimates. Applying the modified CV, the RTD and ETW environments failed the ADK test for batch equivalency so basis values were not computed for those.

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

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

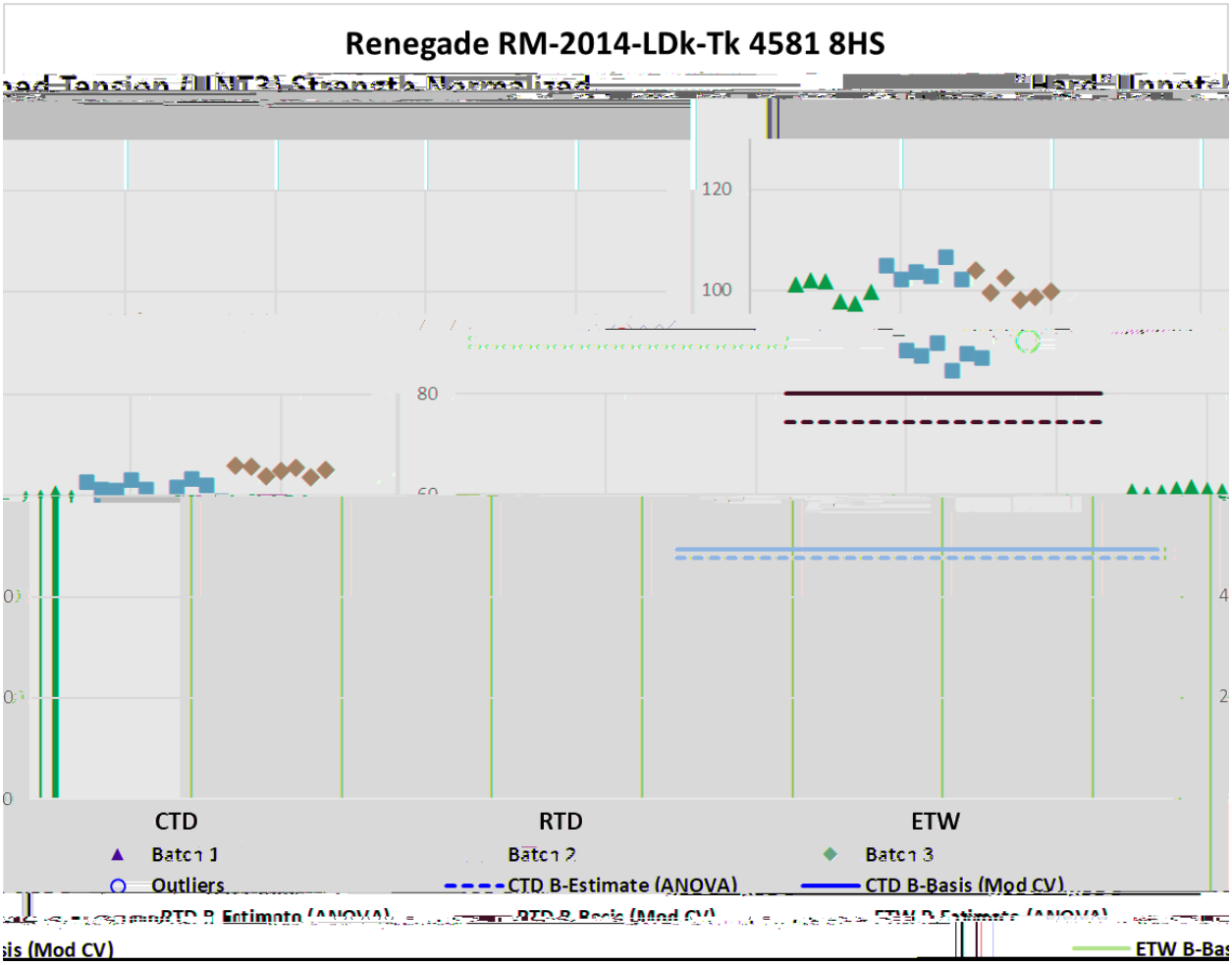

Figure 4-9: Batch Plot for UNT3 Normalized Strength

Unnotched Tension 3 (UNT3) Basis Values and Statistics						
	Normalized			As-Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	101.4	90.57	61.81	102.1	91.42	62.63
Stdev	2.615	2.725	2.221	2.511	4.294	2.903
CV	2.579	3.008	3.593	2.459	4.697	4.635
Mod CV	6.000	6.000	6.000	6.000	6.349	6.318
Min	97.38	84.65	58.20	97.13	83.90	58.20
Max	106.7	94.01	65.90	106.7	98.40	67.90
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	29	18	18	29
Basis Value Estimates						
B-Basis Value				97.15		
B-Estimate	89.19	74.26	47.66		62.82	42.90
A-Estimate	80.50	62.61	37.56	93.64	42.40	28.82
Method	ANOVA	ANOVA	ANOVA	Normal	ANOVA	ANOVA
Modified CV Basis Value Estimates						
B-Value	90.89	80.07	55.18	90.01	NA	NA
A-Estimate	83.74	72.92	50.39	81.46		
Method	Pooled	Pooled	Normal	Normal		

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

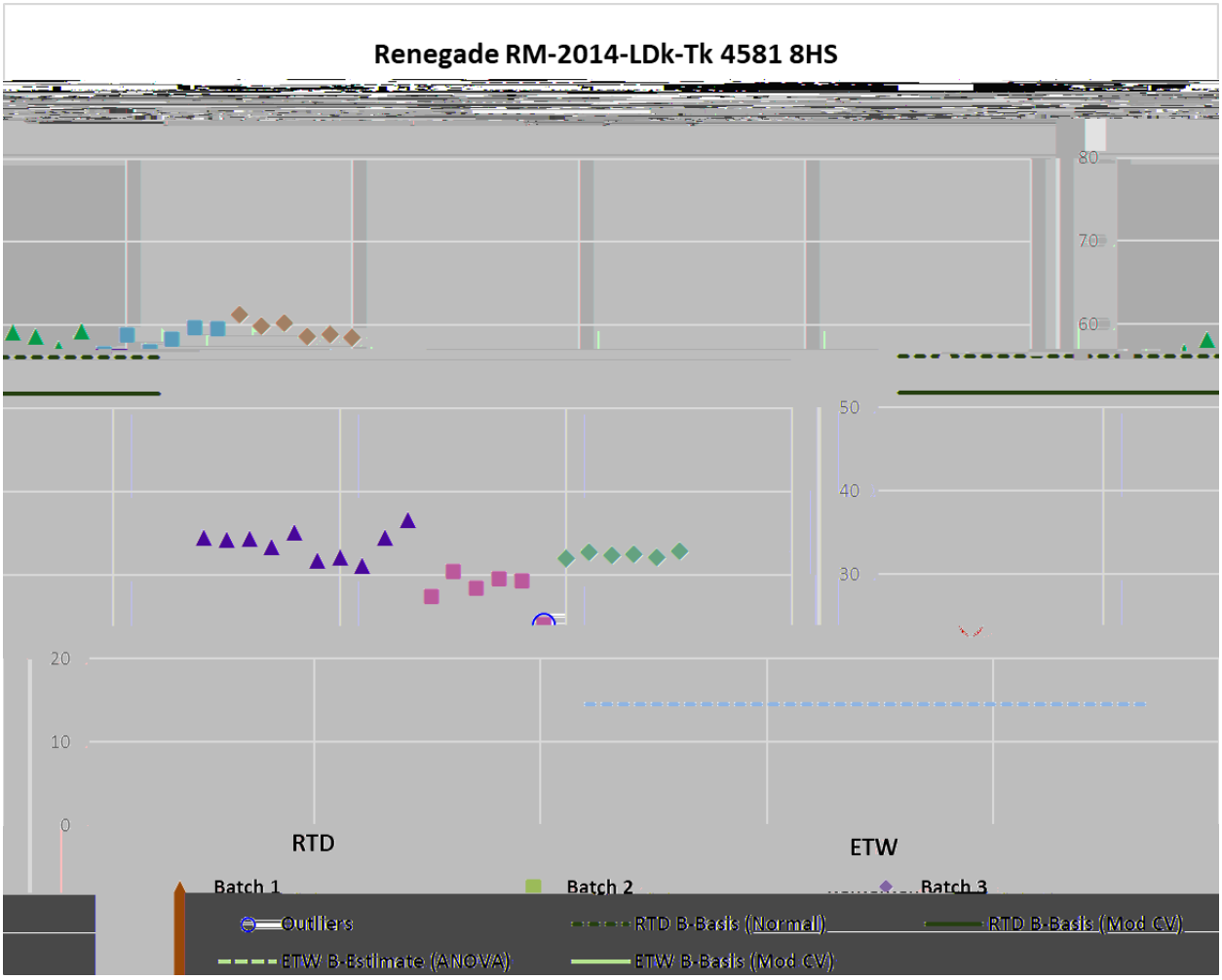

Figure 4-10: Batch Plot for UNC1 Normalized Strength

Unnotched Compression 1 (UNC1) Basis Values and Statistics				
			As-Measured	
Env	RTD	ETW	RTD	ETW
Mean	58.75	31.93	58.55	32.05
Stdev	1.285	2.835	1.717	3.091
CV	2.188	8.878	2.933	9.643
Mod CV	6.000	8.878	6.000	9.643
Min	56.63	24.11	55.20	24.00
Max	61.26	36.63	61.90	37.30
No. Batches	3	3	3	3
No. Spec.	18	22	18	22
		Basis Value Estimates		
B-Basis Value	56.21			
B-Estimate		14.57	50.65	12.08
A-Estimate	54.41	2.183	45.03	NA
Method	Normal	ANOVA	ANOVA	ANOVA
		Modified CV Basis Value Estimates		
B-Value	51.79		51.61	
A-Estimate	46.86	NA	46.71	NA
Method	Normal		Normal	

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

Unnotched Compression 1 (UNC1) Modulus Statistics				
	Normalized		As-Measured	
Env	RTD	ETW	RTD	ETW
Mean	2.799	2.232	2.789	2.232
Stdev	0.05678	0.06787	0.03848	0.05264
CV	2.029	3.041	1.380	2.358
Mod CV	6.000	6.000	6.000	6.000
Min	2.671	2.108	2.720	2.130
Max	2.854	2.344	2.850	2.300
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-18: Statistics from UNC1 Modulus Data

4.10 Unnotched Compression 2 (UNC2)

The UNC2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided.

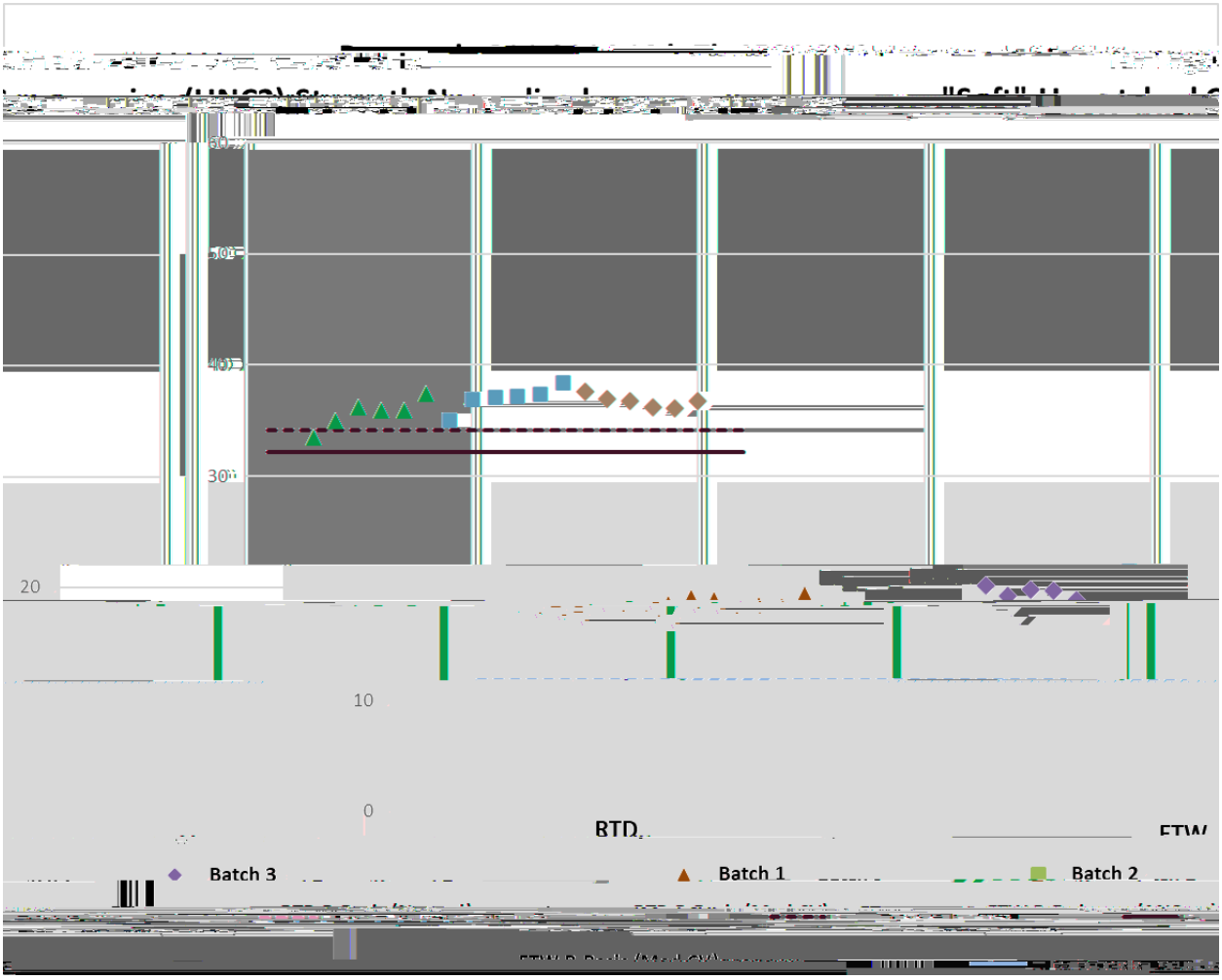

Figure 4-11: Batch Plot for UNC2 Normalized Strength

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4.11 Unnotched Compression 3 (UNC3)

The UNC3 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tare provided.

Env	RTD	ETW	RTD	ETW
Mean	57.77	32.24	58.13	32.58
Stdev	1.573	2.335	1.731	2.413
CV	2.723	7.244	2.978	7.408
Mod CV	6.000	7.622	6.000	7.704
Min	54.80	27.50	54.80	27.50
Max	59.96	37.13	60.90	37.80
No. Batches	3	3	3	3
No. Spec.	18	22	18	22

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

Unnotched Compression 3 (UNC3) Modulus Statistics				
	Normalized		As-Measured	
Env	RTD	ETW	RTD	ETW
Mean	3.131	2.709	3.152	2.733
Stdev	0.1105	0.08700	0.1596	0.08568
CV	3.529	3.212	5.064	3.135
Mod CV	6.000	6.000	6.532	6.000
Min	2.931	2.495	2.880	2.540
Max	3.300	2.830	3.370	2.850
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

Table 4-22: Statistics from UNC3 Modulus Data

4.12 Lamina Short-Beam Strength (SBS)

The Short Beam Strength data is not normalized. Tests were conducted in the following environmental conditions: CTD, RTD, ETD, and ETW.

The datasets for the RTD and ETD environments failed the ADK test for batch equivalency. ANOVA was used to compute their basis values, and with three batches of data available these are estimates. Applying the modified CV, pooling the four environments was not acceptable because the pooled dataset
ETD environments were acceptable for pooling.

There were no statistical outliers.

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

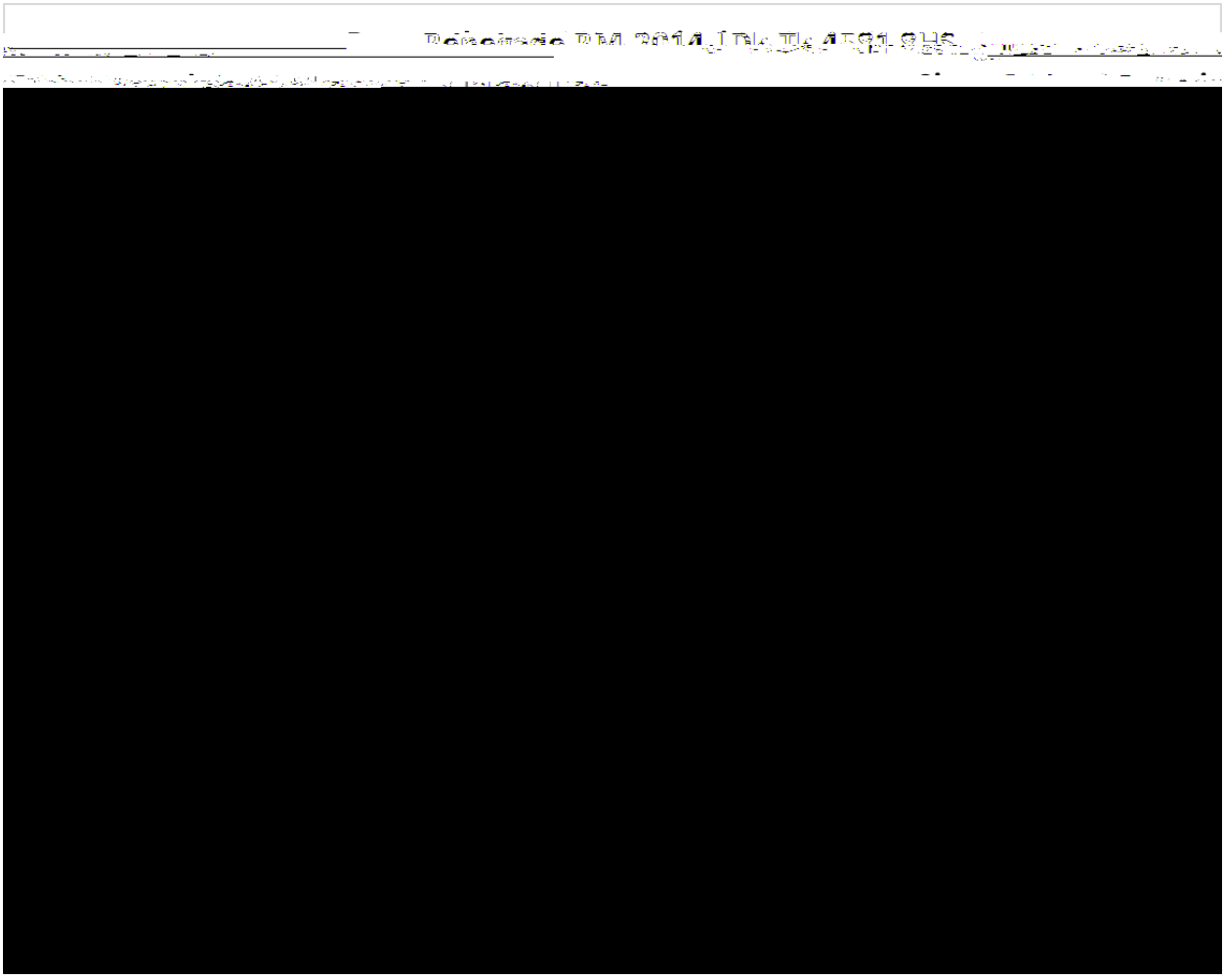

Figure 4-13: Batch Plot for SBS As-Measured

Short Beam Strength (SBS) As Measured Basis Values and Statistics				
Env	CTD	RTD	ETD	ETW
Mean	9.467	8.638	5.883	3.447
Stdev	0.1370	0.1602	0.09888	0.1600
CV	1.447	1.855	1.681	4.642
Mod CV	6.000	6.000	6.000	6.321
Min	9.275	8.380	5.690	3.180
Max	9.780	8.900	6.050	3.680
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
Basis Value Estimates				
B-Basis Value	9.201			3.131
B-Estimate		7.587	5.350	
A-Estimate	9.017	6.837	4.970	2.907
Method	LogNormal	ANOVA	ANOVA	Normal
Modified CV Basis Value Estimates				
B-Value	8.602	7.773	5.018	3.017
A-Estimate	8.025	7.196	4.441	2.712
Method	Pooled	Pooled	Pooled	Normal

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

4.13

4.14 Open-Hole Tension1 (OHT1)

The OHT1 data is normalized by cured ply thickness. Both normalized and as measured statistics

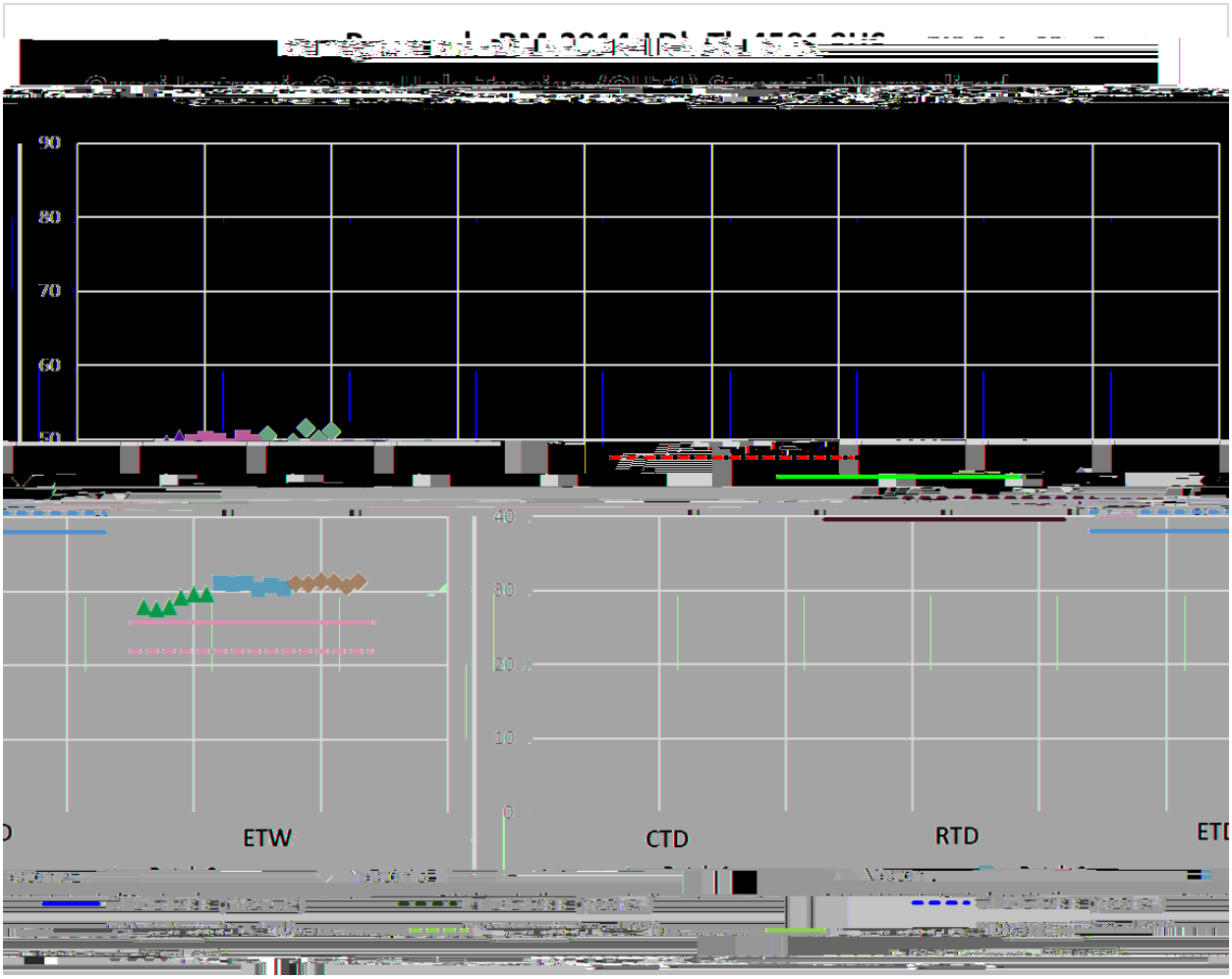

Figure 4-15: Batch Plot for OHT1 Normalized Strength

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

4.15 Open-Hole Tension 2(OHT2)

The OHT2 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted the following environmental conditions: CTD, RTD, and ETW.

For the normalized dataset, the environment (fixed effect) was tested using the ETA-DK test to determine equivalency. W ANOVA was used to compute its basis value, and with three batches of data available this is an estimate. The CTD and RTD environments were pooled. Applying the m the (OHT2)

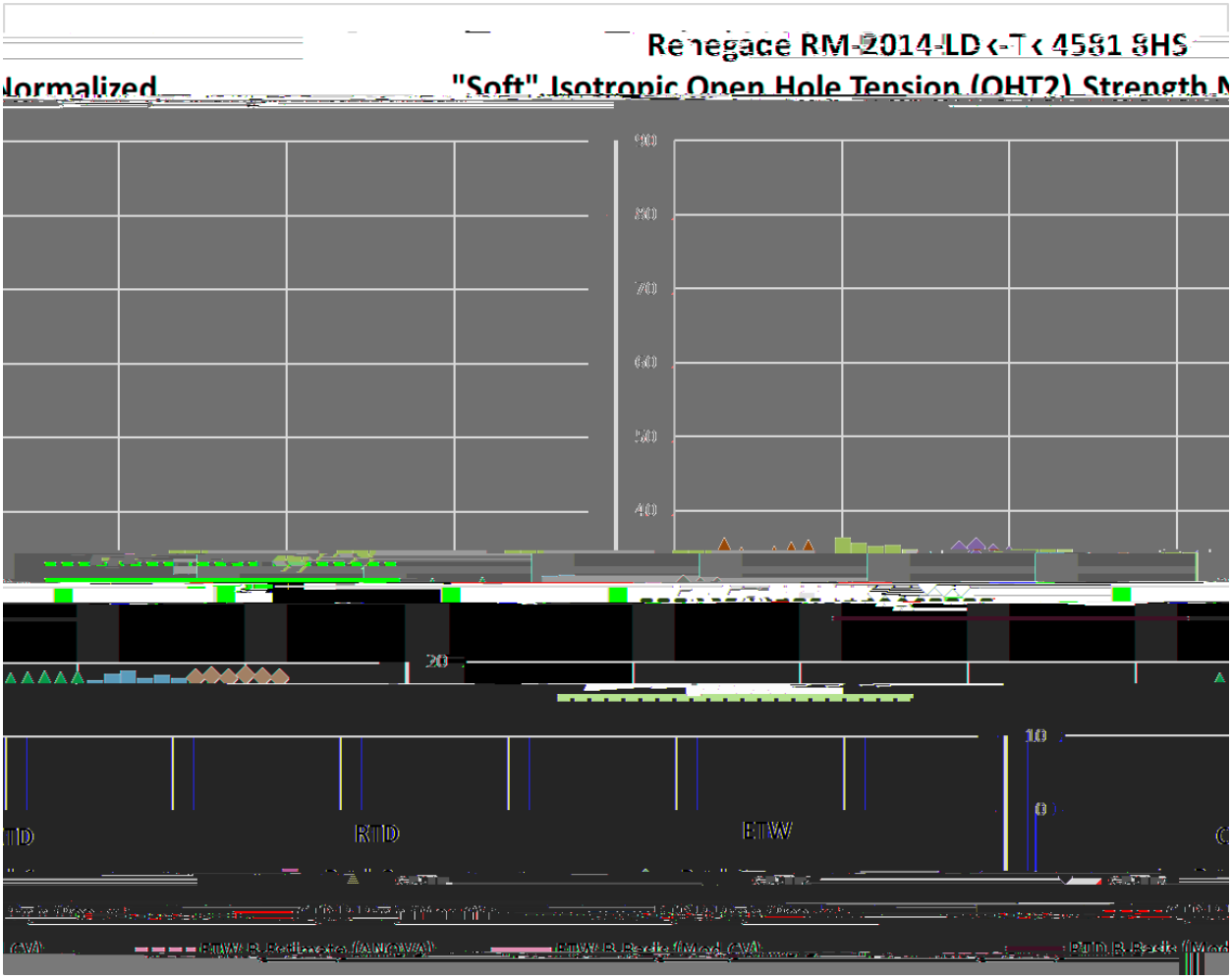

Figure 4-16: Batch Plot for OHT2 Normalized Strength

Env	CTD	RTD	ETD	CTD	RTD	ETD
Mean	34.20	29.43	17.67	34.39	29.56	17.72
Stdev	0.7424	0.6621	0.4564	0.6354	0.4767	0.7571
CV	2.171	2.250	2.583	1.847	1.613	4.274
Mod CV	6.000	6.000	6.000	6.000	6.000	6.137
Min	32.69	28.09	16.74	32.68	28.60	16.30

16.30

Table 4-26: Statistics and Basis Values for O HT2 Strength Data

4.16 Open-Hole Tension 3 (OHT3)

The OHT3 data is normalized by cured ply thickness. Both normalized and as-measured statistics are provided. Tests were conducted in the following environmental conditions: CTD, RTD, and ETD.

For both, the normalized and as-measured datasets, three environments failed the ADK test for batch equivalency. ANOVA was used to compute the basis values, and with three batches of data available these are estimates. Applying the modified CV, the RTD environment failed the ADK test for batch equivalency, therefore, basis values were not computed for this environment and pooling was not acceptable.

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

Statistics, basis values, and estimates are given for the

Figure 4-17: Batch Plot for OHT3 Normalized Strength

Env	CTD	RTD	ETW	CTD	RTD	ETD
Mean	71.37	58.00	38.52	71.52	58.06	38.72
Stdev	1.403	4.454	1.392	1.466	5.043	1.404
CV	1.966	7.679	3.613	2.050	8.686	3.626
Mod CV	6.000	7.840	6.000	6.000	8.686	6.000
Min	68.73	50.04	36.17	68.89	49.60	36.50
Max	73.35	62.17	40.05	73.95	63.30	40.00
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
B-Estimate	64.13	26.06	28.66	63.80	21.77	28.65
A-Estimate	58.97	3.261	21.61	58.29	NA	21.46
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
B-basis Value	62.91		33.96	63.05		
A-Estimate	56.93		30.73	57.05		
Method	Normal		Normal	Normal		

Table 4-27: Statistics and Basis Valalalalalsal and Bas4

4.17 Filled-Hole Tension1 (FHT1)

The FHT1 data is normalized by cured ply thickness. Both normalized and as-measured statistics are provided. Tests were conducted in the following environmental conditions: CTD, RTD, and ETW.

For both the normalized and as-measured datasets, the three environments failed the ADK test for batch equivalency. ANOVA was used to compute the basis

Filled-Hole Tension 1 (FHT1) Strength Basis Values and Statistics						
	Normalized			As-Measured		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	51.30	45.72	32.13	50.70	45.37	31.73
Stdev	1.736	1.064	1.295	1.739	1.055	1.068
CV	3.384	2.326	4.031	3.431	2.326	3.366
Mod CV	6.000	6.000	6.016	6.000	6.000	6.000
Min	47.92	43.71	29.73	47.32	43.20	29.60
Max	55.55	48.47	33.99	54.73	47.90	33.10
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Value Estimates						
B-Estimate	42.19	40.15	23.73	41.33	39.77	25.24
A-Estimate	35.69	36.17	17.74	34.65	35.77	20.61
Method	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
Modified CV Basis Value Estimates						
B-Basis Value	46.64	41.07	27.47	46.09	40.77	27.13
A-Estimate	43.54	37.96	24.37	43.02	37.70	24.06
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-28: Statistics and Basis Values for FHT 1 Strength Data

4.18 Filled-Hole Tension2 (FHT2)

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

For the normalized dataset, the RTD environment failed the ADK test for batch e]m 0 g12 0 61G8

4.20 Open-Hole Compression 1 (OHC1)

The OHC1 data is normalized by cured ply thickness. Both normalized and as measured statistics are provided. Tests were conducted in the following environmental conditions: RTD, ETD, and ETW.

Figure 4-21: Batch Plot for OHC1 Normalized Strength

Open Hole Compression 1 (OHC1) Strength Basis Values and Statistics						
	Normalized			As-Measured		
Env	RTD	ETD	ETW	RTD	ETD	ETW
Mean	32.05	24.91	21.69	31.79	24.74	21.58
Stdev	0.6480	0.8711	1.556	0.6194	0.7548	1.465
CV	2.022	3.497	7.171	1.948	3.050	6.788
Mod CV	6.000	6.000	7.586	6.000	6.000	7.394
Min	30.30	23.73	18.90	29.94	23.80	19.10
Max	33.27	26.50	26.31	32.90	26.00	26.00
No. Batches	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18
Basis Values and Estimates						
B-basis Value	30.77		18.86	30.53	23.49	18.26
B-Estimate		20.59				
A-Estimate	29.86	17.51	17.11	29.68	22.63	12.04
Method	Normal	ANOVA	LogNormal	Pooled	Pooled	Non-Parametric
Modified CV Basis Values and Estimates						
B-basis Value	29.04	21.90	18.69	28.83	21.78	18.62
A-Estimate	27.04	19.90	16.68	26.85	19.81	16.65
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4

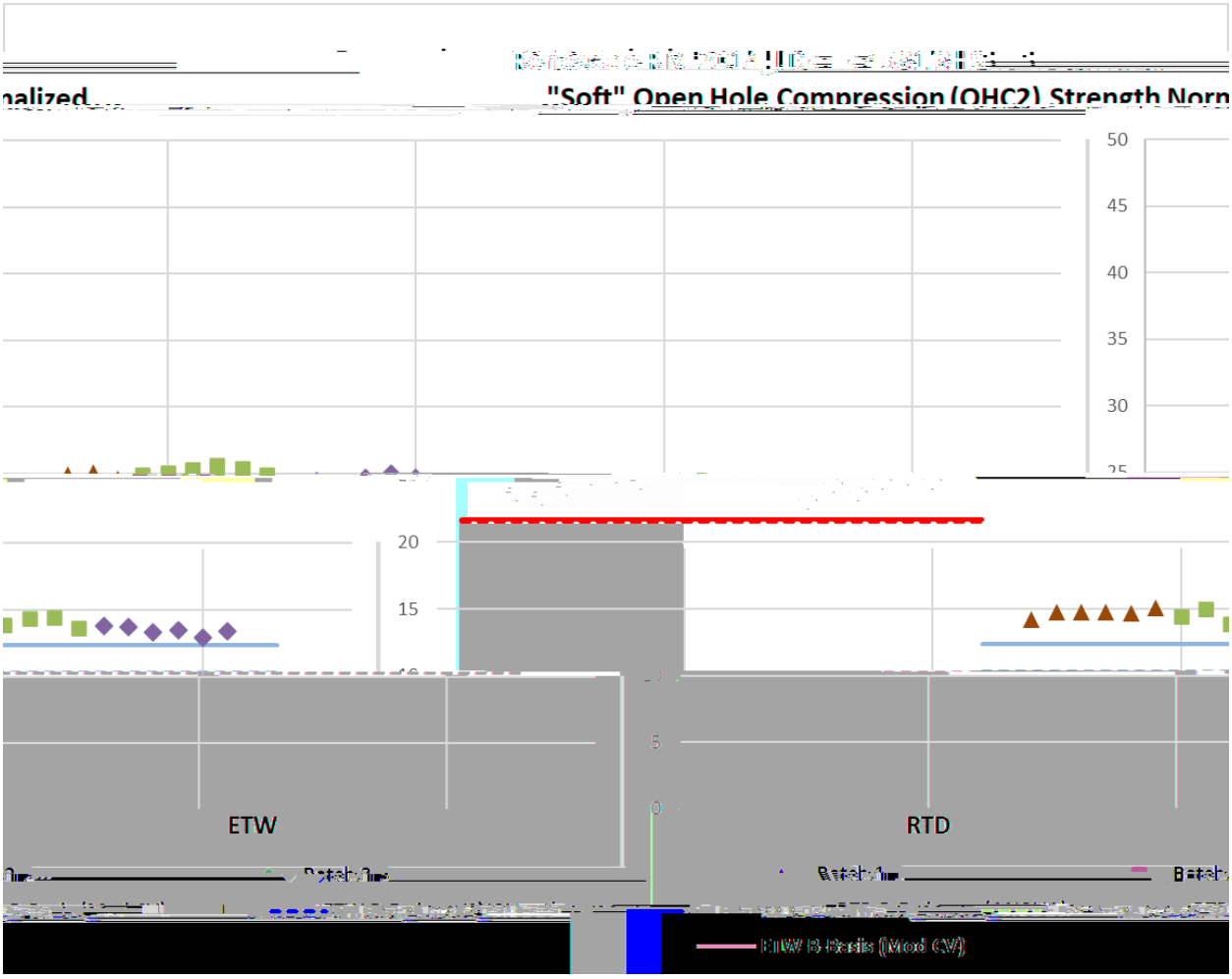

Figure 4-22: Batch Plot for OHC2 Normalized Strength

Env	RTD	ETW	RTD	ETW
Mean	24.60	14.14	24.77	14.26
Stdev	0.7019	0.6424	0.5881	0.7147
CV	2.854	4.542	2.375	5.011
Mod CV	6.000	6.271	6.000	6.506
Min	23.18	12.90	23.60	12.90
Max	25.60	15.06	25.60	15.30
No. Batches	3	3	3	3
No. Spec.	18	18	18	18
B-basis Value			23.53	
B-Estimate	21.53	10.27		9.862

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

4.22 -Hole Compression 3 (OHC3)

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

For both the normalized and as measured datasets, the ETW environment failed the ADK test for batch equivalency. ANOVA was used to compute basis values, and with three batches of data available these are estimates. Applying the modified CV, the ETW environment failed the ADK test for equivalency, therefore, basis values were not computed.

There were no statistical outliers.

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

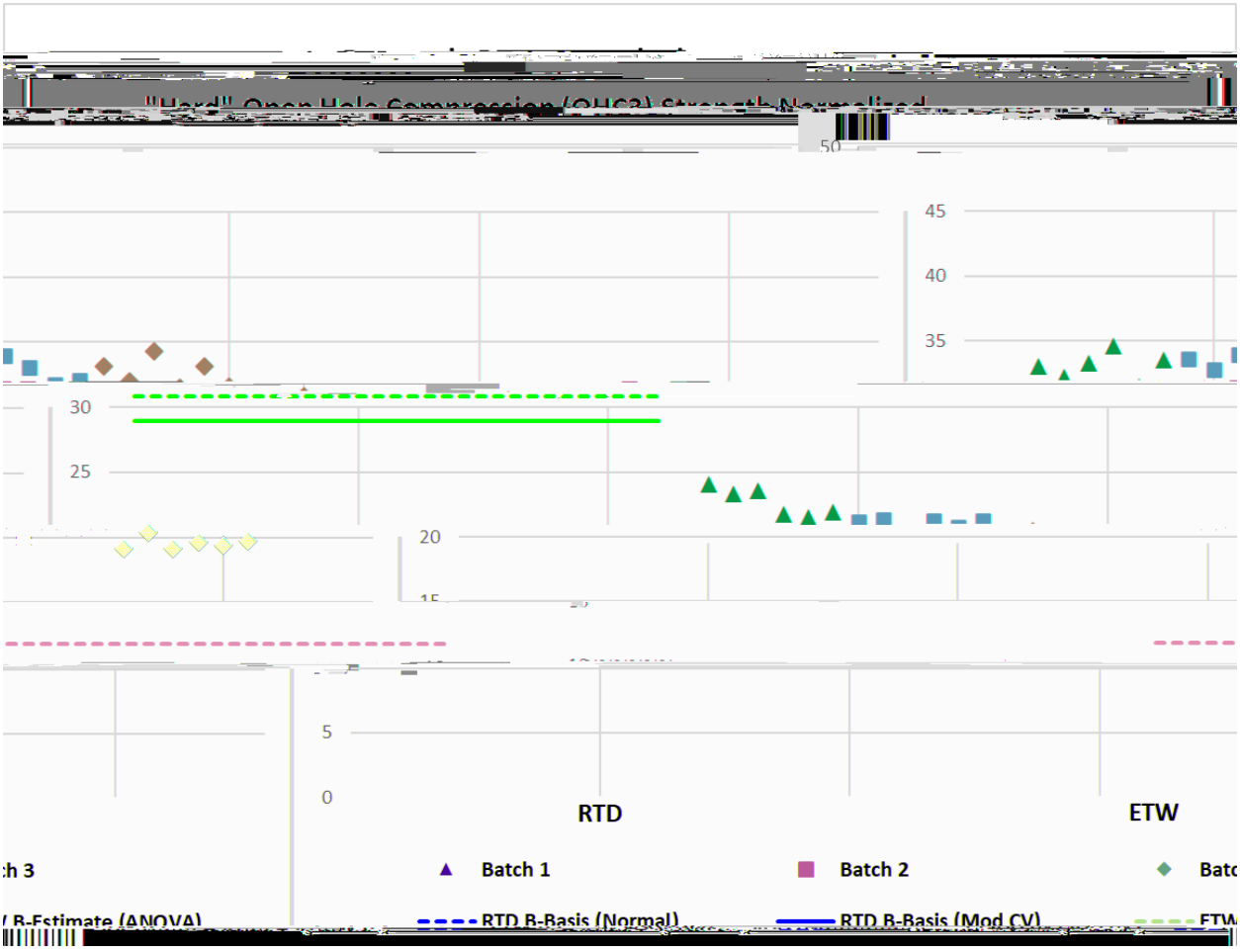

Figure 4-23: Batch Plot for OHC3 Normalized Strength

Env	RTD	ETW	RTD	ETW
Mean	32.80	21.08	33.20	21.41
Stdev	0.9885	1.463	0.9098	1.473
CV	3.014	6.939	2.741	6.884
Mod CV	6.000	7.470	6.000	7.442
Min	31.41	19.15	31.13	19.50
Max	34.61	24.04	34.61	24.70
No. Batches	3	3	3	3
No. Spec.	18	18	18	18

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

4.23 Filled-Hole Compression 1 (FHC1)

The FHC1 data is normalized by cured ply thickness. Both normalized and as-measured statistics are provided. Tests were conducted in the following environmental conditions: RTD and ETW.

For both normalized and as-measured datasets, the ETW environment failed the ADK test for batch equivalency. ANOVA was used to compute basis values, and with three batches of data available these are estimates. Applying the modified CV, the ETW environment failed the ADK test for equivalency, therefore, basis values were not computed.

There were no statistical outliers.

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

Figure 4-24: Batch plot for FHC1 Normalized Strength

Filled-Hole Compression 1 (FHC1) Strength Basis Values and Statistics				
	Normalized		As-Measured	
Env	RTD	ETW	RTD	ETW
Mean	57.77	29.83	57.65	29.70
Stdev	0.8143	1.737	0.8703	1.892
CV	1.409	5.822	1.510	6.370
Mod CV	6.000	6.911	6.000	7.185
Min	56.59	27.10	56.04	26.49
Max	59.35	33.31	59.12	33.69
No. Batches	3	3	3	3
No. Spec.	19	18	19	18
Basis Value Estimates				
B-Basis Value	56.19		55.95	
B-Estimate		19.39		17.99
A-Estimate	55.06	11.94	54.74	9.638
Method	Normal	ANOVA	Normal	ANOVA
Modified CV Basis Value Estimates				
B-Basis Value	51.02	NA	50.90	NA
A-Estimate	46.23		46.12	
Method	Normal		Normal	

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

Figure 4-25: Batch plot for FHC2 Normalized Strength

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4.26 Single-Shear Bearing 1 (SSB1)

The SSB1 data is normalized by cured ply thickness.

Figure 4-27: Batch Plot for SSB1 Normalized Strength

Single Shear Bearing 1 (SSB1) Strength Basis Values and Statistics								
	Normalized				As-Measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTD	ETW	RTD	ETW	RTD	ETW	RTD	ETW
Mean	87.73	69.32	103.6	71.77	86.45	68.35	102.1	70.80
Stdev	3.444	5.490	2.811	4.252	2.191	4.915	1.963	3.990
CV	3.926	7.920	2.713	5.924	2.535	7.192	1.922	5.636
Mod CV	6.000	7.960	6.000	6.962	6.000	7.596	6.000	6.818
Min	78.43	56.46	98.11	65.15	80.77	58.72	97.03	64.87
Max	92.74	76.67	106.9	79.86	90.16	75.02	105.1	77.38
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-basis Value	79.38	60.97		63.38	82.12	58.64	98.26	62.92
B-Estimate			89.50					
A-Estimate	73.70	55.29	79.42	57.43	79.06	51.77	95.52	57.34
Method	Pooled	Pooled	ANOVA	Normal	Normal	Normal	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	77.91	59.50	93.35	61.50	77.00	58.89	92.09	60.75
A-Estimate	71.23	52.82	86.36	54.51	70.57	52.46	85.26	53.91
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-37: Statistics and Bas is Values for SS B1 Strength Data

4.27 Single-Shear Bearing2 (SSB2)

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

Figure 4-28: Batch Plot for SSB2 Normalized Strength

Single Shear Bearing 2 (SSB2) Strength Basis Values and Statistics								
	Normalized				As-Measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTD	ETW	RTD	ETW	RTD	ETW	RTD	ETW
Mean	74.67	56.63	95.42	65.39	74.45	56.50	95.13	65.25
Stdev	2.214	4.247	3.408	2.512	2.087	4.140	2.942	2.570
CV	2.965	7.500	3.572	3.841	2.803	7.328	3.092	3.939
Mod CV	6.000	7.750	6.000	6.000	6.000	7.664	6.000	6.000
Min	71.22	45.68	90.86	59.42	71.45	46.16	90.52	60.05
Max	78.90	63.23	101.4	68.92	78.24	64.17	100.2	69.94
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	19	18	19	18	19	18	19
Basis Values and Estimates								
B-basis Value	70.30	48.35		60.36	70.33	48.43	90.12	60.27
B-Estimate			78.56					
A-Estimate	67.20	42.48	66.53	55.00	67.41	42.70	86.72	56.86
Method	Normal	Normal	ANOVA	Weibull	Normal	Normal	Pooled	Pooled
Modified CV Basis Values and Estimates								
B-basis Value	66.61	48.61	86.54	56.56	66.46	48.55	83.86	NA
A-Estimate	61.14	43.13	80.52	50.53	61.04	43.11	75.89	
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Normal	

Table 4-38

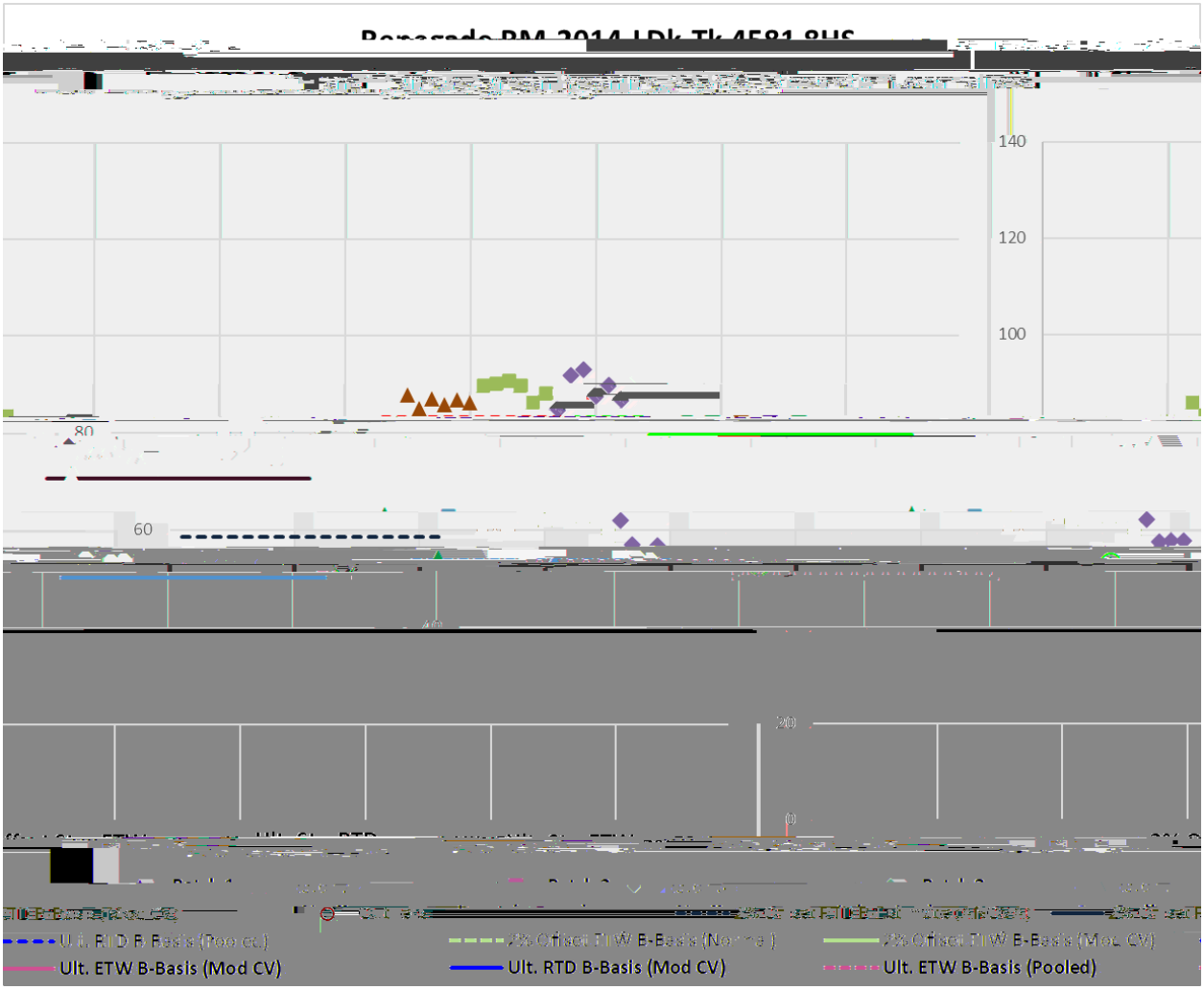

Figure 4-29: Batch Plot for SSB3 Normalized Strength

Single Shear Bearing 3 (SSB3) Strength Basis Values and Statistics								
	Normalized				As-Measured			
Property	2% Offset Strength		Ultimate Strength		2% Offset Strength		Ultimate Strength	
Env	RTD	ETW	RTD	ETW	RTD	ETW	RTD	ETW
Mean	78.97	58.26	88.06	59.04	78.56	57.85	87.60	58.63
Stdev	3.571	3.526	2.385	3.170	3.376	3.459	2.177	3.090
CV	4.522	6.051	2.709	5.370	4.297	5.979	2.485	5.270
Mod CV	6.261	7.026	6.000	6.685	6.149	6.989	6.000	6.635
Min	71.59	53.13	84.66	54.42	71.91	52.67	84.51	54.09
Max	85.95	63.22	92.87	63.40	85.07	62.52	92.34	62.70
No. Batches	3	3	3	3	3	3	3	3
No. Spec.	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-basis Value		51.30	82.95	53.93		51.02	83.31	52.53
B-Estimate	58.47				61.44			
A-Estimate	43.83	46.37	79.47	50.46	49.23	46.19	80.26	48.20
Method	ANOVA	Normal	Pooled	Pooled	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates								
B-basis Value	70.71	50.00	79.56	50.55	70.45	49.74	79.18	50.20
A-Estimate	65.08	44.37	73.78	44.77	64.93	44.22	73.45	44.47
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-39: Statistics and Basis Values for SSB3 Strength Data

4.29

Compression After Impact (CAI1) Strength		
	Normalized	As-Measured
Env	RTD	RTD
Mean	26.04	25.77
Stdev	0.4757	0.4724
CV	1.827	1.833
Mod CV	6.000	6.000
Min	25.23	24.94
Max	26.69	26.43
No. Batches	1	1
No. Spec.	7	7

Table 4-40: Statistics for Compression After Impact Strength Data

4.30 Interlaminar Tension Strength (ILT) and Curved Beam Strength (CBS)

The ILT data is not normalized. Data is reported on two properties: Interlaminar Tension Strength and Curved Beam Strength. Testing was done in the CTD, RTD and ETW conditions. Only one batch of material was tested. There was no statistical analysis. Basis values are not computed for these properties. Summary statistics are presented in Table 4-41 and the as-measured data are displayed graphically in Figure 4-31.

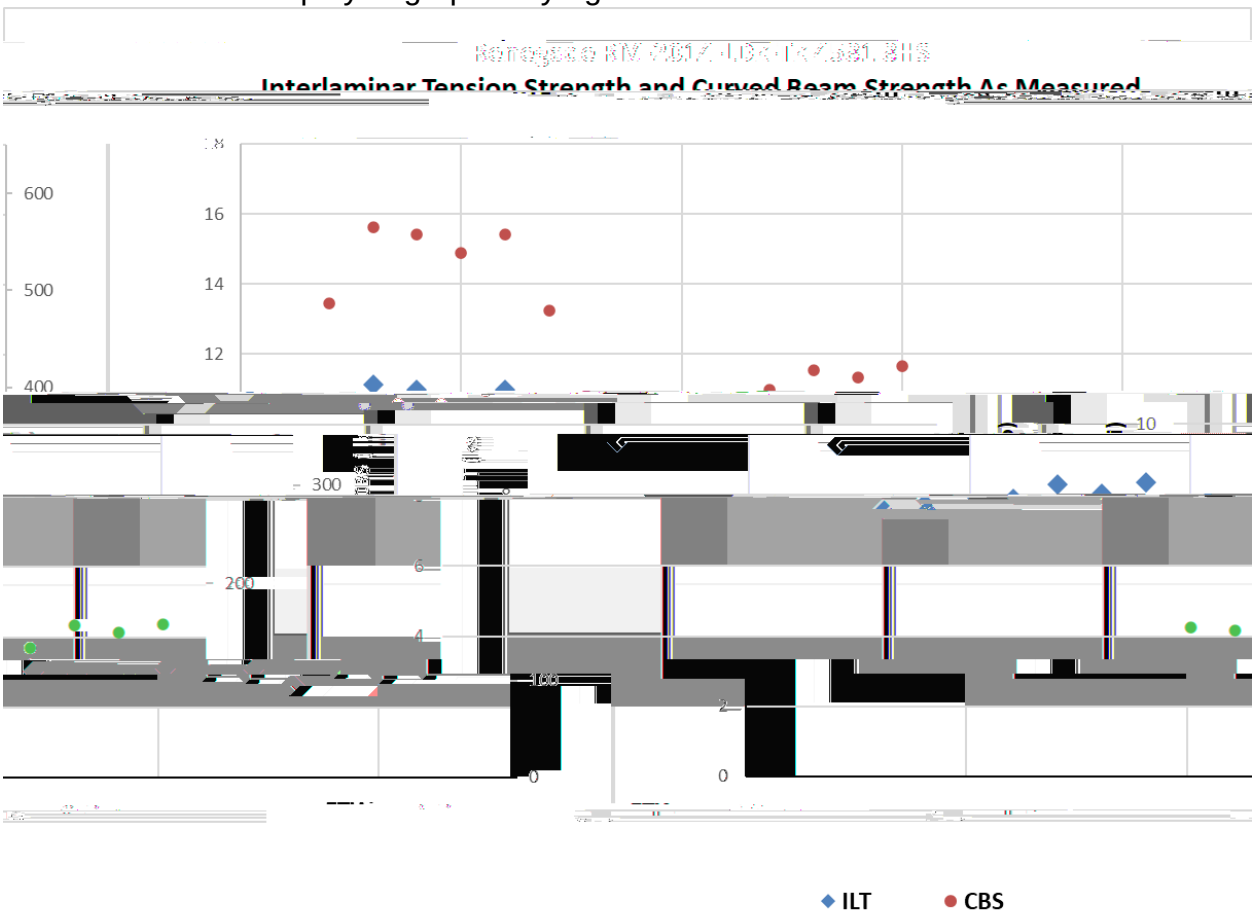

Figure 4-31: Plot for Interlaminar Tension and Curved Beam Strength

Interlaminar Tension (ILT) Strength Statistics						
	Interlaminar Tension Strength (ksi)			Curved Beam Strength (lb)		
Env	CTD	RTD	ETW	CTD	RTD	ETW
Mean	10.39	7.979	2.949	527.3	401.4	150.1
Stdev	0.7086	0.3139	0.1836	35.31	16.63	9.060
CV	6.823	3.935	6.227	6.696	4.143	6.035
Mod CV	7.411	6.000	7.114	7.348	6.072	7.018
Min	9.423	7.636	2.601	478.5	382.6	133.1
Max	11.11	8.364	3.116	564.3	420.9	158.2
No. Batches	1	1	1	1	1	1
No. Spec.	7	6	6	7	6	6

Table 4-41: Statistics for ILT and CBS Data

5. Outliers

Outliers were identified according to the standards documented in section 2.1.5