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Data Processing and Precision Testing for TB 117-2013 Fire Test Response Standard

Prepared For:

California Department of Consumer Affairs
Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation (BEARHFTI)
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1. Study Purpose and Specifications:

As requested by the California Department of Consumer Affairs - Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation (BEARHFTI), the purpose of this study was to test a new flammability standard for upholstered furniture, TB 117-2013. The purpose of Omega Statistics was to validate standard TB 117-2013 and demonstrate its repeatability and reproducibility according to two ASTM standard guidelines for precision and bias studies:
1) ASTM E691 – 12: *Standard Practice for Conducting an Interlaboratory Study to Determine the Precision and Bias of a Test method.*
2) ASTM E1353 – 08a: *Standard Test Methods for Cigarette Ignition Resistance of Components of Upholstered Furniture.*
According to Dr. Said Nurbakhsh, Flammability Research Test Engineer at BEARHFTI:

> TB 117-2013 is based on ASTM E1353 and follows test methods and procedures with some modifications. One of the significant changes was adding a 45-minute time limit where the test shall be terminated. If a test is self-extinguished before 45 minutes AND the char length does not exceed what is permissible (e.g. 2 inches) the sample is determined as passing. If the char length exceeds the limit (within 45 mins.) it is determined as failing. If smoldering continues beyond 45 minutes, the sample will fail regardless of the char length. Therefore, a sample can fail the test either by exceeding the char length, by continued smoldering after 45 minutes has elapsed, or by both. Further, if within the 45 minutes time period a sample is heavily smoldering the test will be terminated by manually extinguishing it (e.g. with water) and that sample will be determined as failing.

Specifications included compilation of the data collected from 9 laboratories for 8 types of cover fabrics, 2 types of barrier materials, and 1 type of filling material.
Further specifications included performance of all statistical analyses as required by the ASTM guidance documentation to demonstrate repeatability and reproducibility of the new flammability standard. Two statistical evaluations were requested based on (1) actual char length measurements (*ref.* E1353-08a; 22.1.3), and (2) pass/fail standards (*ref.* E1353-08a; 22.1.4)

2. Data Collection and Preparation

Copies of round robin P&B study summary sheets as well as forms of each individual testing trial for a total of 9 laboratories were received via email by Omega Statistics. The laboratories included in the study were:
Labs A, B, C, D, E, F, G, H and L
The information was entered into an Excel spreadsheet upon receipt from BEARHFTI. Questions by Omega Statistics relating to any inconsistencies or discrepancies in the information received were addressed by Dr. Said Nurbakhsh, Flammability Research Test Engineer at BEARHFTI. The Excel file with the data as originally and entered as well as computations (*TB117_2013_Data.xlxs*) is attached separately for this reporting. Computations for the precision statement are located in the file under the tab labeled “Computations”.

Prior to analysis, diagnostic testing was performed to investigate the data for data entry errors, procedural errors or anomalies. A total of 16 trials were classified as manually extinguished but a char length was also reported. It was determined that a proper measurement of char length would be difficult to obtain upon manual extinguishing of the material due to smoldering or ignition and that these values should not be included in the precision testing based on the actual measurements of char length. However, the trials, all classified as failed trials, were included in the pass/fail precision analysis. Table 1 presents the manually extinguished trials and reported char lengths which were not included in the precision testing on char length.

Table 1. *Trials Manually Extinguished Due to Smoldering and/or Ignition with Reported Char Lengths Not Included in Precision Testing Based on Actual Measurements of Char Length Due to Failed Trial.*

Lab	Run ID	Reason	Char Length	Pass / Fail
B	F1-2	Heavily Smoldering	203	F
B	F1-12	Heavily Smoldering	203	F
B	F1-17	Heavily Smoldering	203	F
C	F1-3	Lightly Smoldering	53.3	F
C	F1-11	Heavily Smoldering	96.5	F
C	F1-20	Heavily Smoldering	132.1	F
C	C1-3	Lightly Smoldering	14.8	F
C	C1-11	Lightly Smoldering	14.7	F
H	C1-8	Lightly Smoldering	20	F
H	C1-16	Lightly Smoldering	30	F
H	C1-18	Lightly Smoldering	20	F
L	F1-10	Heavily Smoldering	90	F
L	F1-27	Heavily Smoldering	51	F
L	F1-30	Heavily Smoldering	60	F
L	B1-30	Medium Smoldering	36	F
L	C1-27	Medium Smoldering	50	F

One trial for Laboratory H (cover fabric 1, trial 2, material specimen F1-18) was recorded as a "pass" result. However, the specimen was extinguished manually at 30 minutes because the two other specimens of cover fabric 1 (trials 1 and 3) started to "smolder extremely" and had to be manually extinguished. Therefore, this trial was reclassified as a "fail" because the time did not complete due to manual extinguishing of the specimen.

ASTM Guidance E1353-08a; 21.10 suggested classification of barrier materials that did not develop obvious ignition and exhibited a char length of less than 2.0 inches (51 mm) as Class A. Materials with a char length of more than 2.0 inches were to be classified as Class B. After removal of all char lengths of trials from Table 1, the remaining materials in this study with reported char lengths were all classified as Class A.

3. Precision and Bias

3.1. Precision

Statistical evaluation of the interlaboratory data was performed to obtain estimates of the precision of the test method. A total of 9 laboratories each tested 8 different cover fabrics, 2 different barriers, and 1 filling material. Each of the material types were tested in 3 replications at each of the laboratories.
Two sets of statistical analyses were performed to test repeatability and reproducibility of the test results; (1) based on measurements of char length (see section 3.1) and (2) based on pass/fail (See section 3.2).
The laboratory test data results were structured for analysis according to ATSM standard E691-12; *Standard Practice for Conducting an Interlaboratory Study to Determine the Precision and Bias of a Test method* (see Appendix A).
Results are reported according to ASTM E1353 – 08a: *Standard Test Methods for Cigarette Ignition Resistance of Components of Upholstered Furniture.* (see Appendix B).

3.1.1. Actual Char Length – Results

Table 2 presents the results of the statistical analyses for repeatability and reproducibility as relates to char length of the materials testing according to class of test (cover fabric, barrier material, filling material) and material type. Cover fabric #1 failed all 3 replications in all 9 laboratories and a valid char length was not measured for any of the trials in any of the laboratories. Therefore, cover fabric #1 was excluded from the scatterplots and overall tests of repeatability vs. reproducibility for char length.
Figures 1 and 2 present scatterplots of reproducibility vs. repeatability and reproducibility variance vs. repeatability variance, respectively, for the char length analysis.

Table 2. *Interlaboratory Study for TB 117-2013 Char Length (Results in mm)*

Class of Test	Material	Average	STD Repeat	STD Repro	*r*	*R*
Cover Fabric	1	**	**	**	**	**
	2	15.837	2.005	2.009	5.613	5.624
	3	13.719	1.975	3.765	5.530	10.542
	4	16.348	1.772	4.391	4.961	12.294
	5	14.885	1.339	2.931	3.748	8.207
	6	15.952	2.697	4.176	7.552	11.692
	7	13.404	1.603	3.849	4.489	10.778
	8	16.148	2.317	4.428	6.489	12.400
Barrier Material	1	14.750	1.697	1.962	4.751	5.492
	2	13.278	1.626	4.799	4.553	13.436
Filling Material	1	17.250	3.624	5.690	10.147	15.932

** Measurements of char length not tabled. All replications at all laboratories failed.
Note. STD Repeat = Standard Deviation of Repeatability; STD Repro – Standard Deviation of Reproducibility; *r* = System Repeatability; *R* = System Reproducibility.

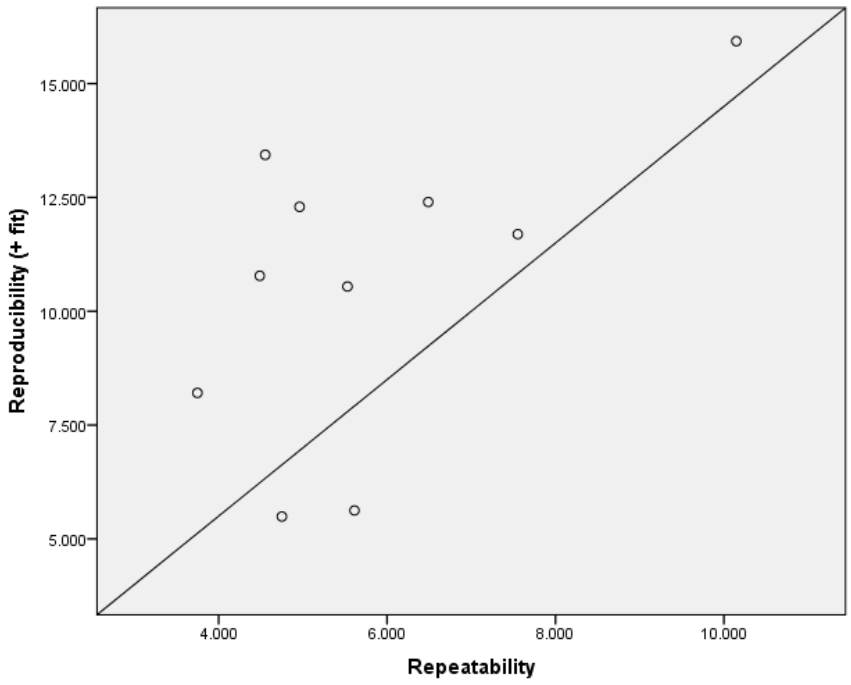

Figure 1. Scatterplot of Data on TB 117-2013 – Repeatability vs. Reproducibility (mm)

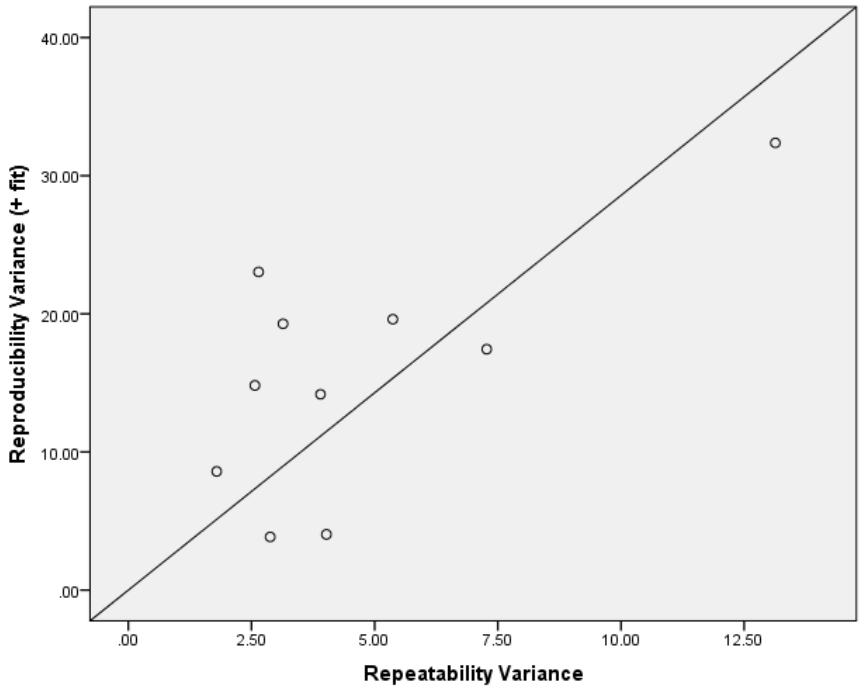

Figure 2. Scatterplot of Variance of Data for TB 117-2013 – Repeatability vs. Reproducibility (mm)

3.1.2. Pass/Fail – Results

Table 3 presents the results of the statistical analyses for repeatability and reproducibility as relates to pass/fail testing according to class of test (cover fabric, barrier material, filling material) and material type. Fail was taken to be any of (a) a char length over 51 mm within the 45 minute test limit, (b) smoldering continues beyond 45 minute test limit, (c) manually extinguishing of a material sample before or at the 45 minute test limit due to smoldering or ignition. Results were coded as Pass = 1, Fail = 0.
Figures 3 and 4 present scatterplots of reproducibility vs. repeatability and reproducibility variance vs. repeatability variance, respectively, for the pass/fail analysis.

Table 3. *Interlaboratory Study for TB 117-2013 (Results as Pass = 1, Fail = 0)*

Class of Test	Material	Average	STD Repeat	STD Repro	*r*	*R*
Cover Fabric	1	0.000	0.000	0.000	0.000	0.000
	2	1.000	0.000	0.000	0.000	0.000
	3	1.000	0.000	0.000	0.000	0.000
	4	1.000	0.000	0.000	0.000	0.000
	5	1.000	0.000	0.000	0.000	0.000
	6	1.000	0.000	0.000	0.000	0.000
	7	1.000	0.000	0.000	0.000	0.000
	8	1.000	0.000	0.000	0.000	0.000
Barrier Material	1	0.852	0.192	0.373	0.538	1.044
	2	1.000	0.000	0.000	0.000	0.000
Filling Material	1	0.519	0.333	0.521	0.932	1.459

Note. STD Repeat = Standard Deviation of Repeatability; STD Repro – Standard Deviation of Reproducibility; *r* = System Repeatability; *R* = System Reproducibility.

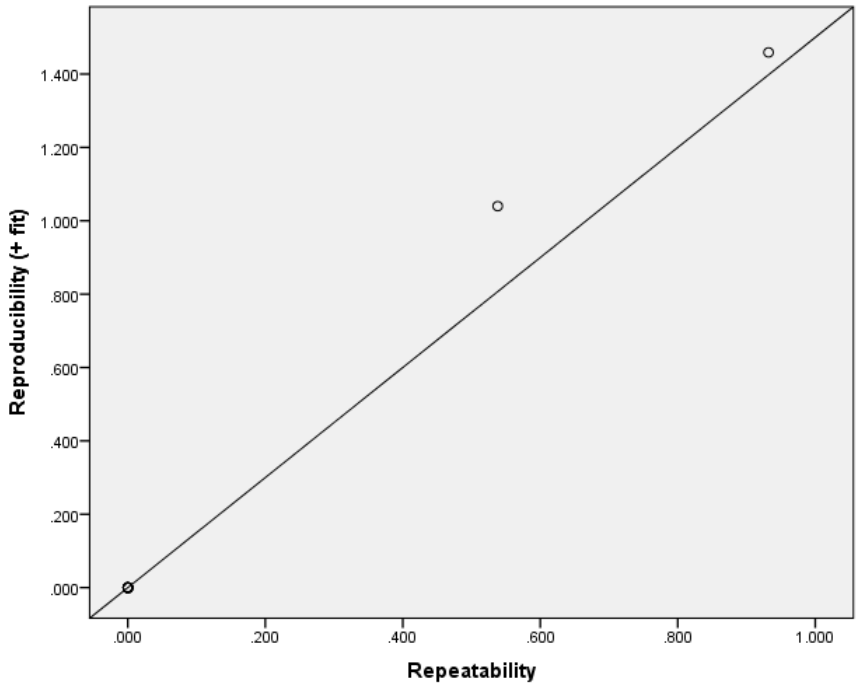

Figure 3. Scatterplot of Data on TB 117-2013 – Repeatability vs. Reproducibility (Pass/Fail)

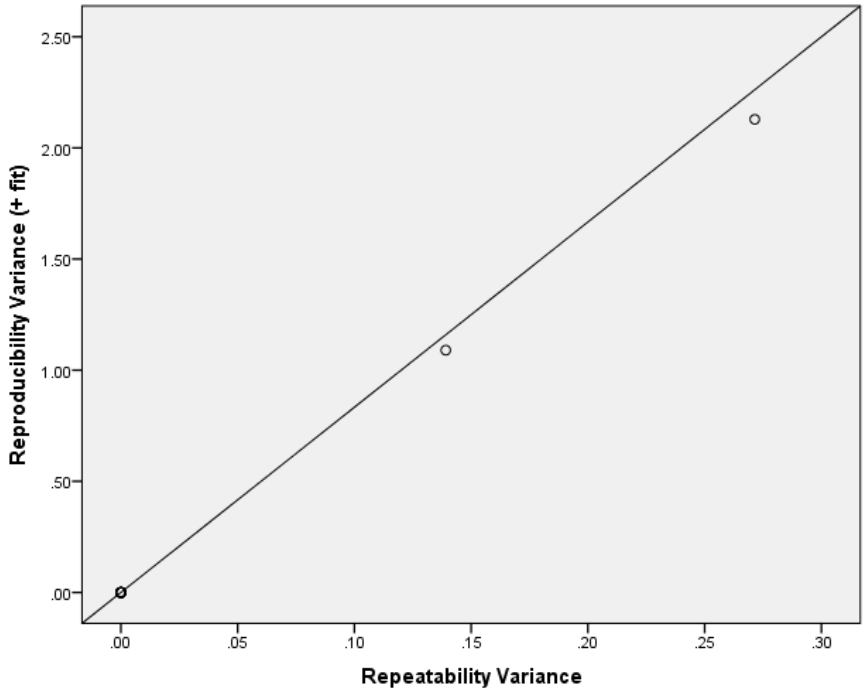

Figure 4. Scatterplot of Variance of Data on TB 117-2013 – Repeatability vs. Reproducibility (Pass/Fail)

3.1.3. Overall Results for Precision

Table 4 presents the overall repeatability and reproducibility of the test for both the char length and pass/fail measures. The precision of the pass/fail data is better than that of the char length data.

Table 4. *Repeatability and Reproducibility of Test Method – Overall Results for Precision*

Statistic	Char Length Data	Pass/Fail Data
Average	15.11	0.85
r	5.78	0.13
R	10.63	0.23
Coeff STD fit	1.77	1.66
Coeff Variance fit	2.85	7.84
RSQ STD fit	0.93	0.99
RSQ Variance fit	0.83	1.00

Note. Avg = Average; *r* = Overall Repeatability; *R* = Overall Reproducibility; Coeff STD fit = Multiplicative coefficient of the linear regression analysis of reproducibility vs. repeatability; Coeff Variance fit = Multiplicative coefficient of the linear regression analysis of reproducibility variance vs. repeatability variance; RSQ STD fit = Linear least square correlation coefficient of the fit between reproducibility and repeatability; RSQ Variance fit = Linear least squares correlation coefficient of the fit between reproducibility variance and repeatability variance.

3.2. Bias

The true value of cigarette ignition resistance of upholstered furniture components can only be estimated in terms of a test method. Within the limitation of the test methods used for this study, these methods have no known bias and can be generally accepted as a referee method based on ASTM guidance E1353-08a.

END OF REPORT

APPENDIX A

TESTING MATERIALS FOR PRECISION TESTING FOR TB 117-2013

Section 1: Eight different cover fabrics were used in Section 1 as follows:

Fabric	**Content**	**Weight (Oz/yd^2)**	**Color/Description**	**Backcoating**
1	Cotton 100%	13.19	Mustard, woven fabric	No
2	Polyester 40%/Cotton 60%	10.06	Blue/beige/brown, oven fabric	No
3	Polyester 41%/Rayon 59%	13.46	Lt brown/beige, woven fabric	No
4	Polyester 42%/Rayon 23%/ 35% Acrylic	8.56	Plum, woven fabric	No
5	Polyester 53%/Rayon 47%	12.91	Multicolor (green/beige/brown), woven fabric	No
6	Polyester 64%/Cotton36%	7.62	Black, woven fabric	No
7	Polyester81%/Cotton19%	12.46	Black woven, fabric with back coating	Yes
8	Polyester 100%	8.06	Green, woven fabric	No

Section 2. Two barriers were used in Section 2 as follows:

a) A ½ inch thick polyester fiber batting.
b) A 1 inch thick polyester fiber batting.

Section 3. One type of filling material was used in Section 3. It consisted of multi-layers of a fire resistant synthetic batting material 10.27 (Oz/yd^2).