



# A- & B-basis Analysis

User Manual

Ver. 1.1

Centre Composite  
August 2017

**ABBA, Ver. 1.1**  
**(A- & B-Basis Analysis)**  
**User Manual**

© "Centre Composite", 2016-2017 ([software@composite.lv](mailto:software@composite.lv))

## Table of Contents

Introduction.....	1
System requirements .....	1
Theoretical background.....	1
User interface .....	4
Random samples generation.....	7
ToDo .....	8
References.....	8
Appendix 1.....	9

## Introduction

The ABBA program (**A- & B-Basis Analysis**) performs statistical analysis of the composite material experimental strength data and estimates A- & B-basis values using methodology described in MIL-HDBK-17 1F [1].

## System requirements

Microsoft .Net Framework Ver. 4 or higher is required to run this software.

## Demo version

Limitations of demo version: no more than five specimens in each batch.

## Theoretical background

This manual describes the use of "ABBA" program to calculate A- & B-basis values from composite material strength data. A-basis and B-basis allowables are statistically based tolerance bounds of material strength data:

**A-basis or T99:** At least 99% of the population of material values is expected to equal or exceed this tolerance bound with 95% confidence.

**B-basis or T90:** At least 90% of the population of material values is expected to equal or exceed this tolerance bound with 95% confidence.

Composite materials typically exhibit considerable variability in many properties from batch to batch. Different approaches are used depending on whether the material data can be divided into several groups (for example, because of material batches or technological processes). Data sets which either cannot be grouped, or for which there are negligible differences among such groups, are called unstructured. Otherwise, the data are said to be structured.

For composite materials, experimental data from different panels can be treated as batches. k-sample Anderson-Darling test is used to determine whether the data should be treated as structured or unstructured.

Unstructured data are modeled using a Weibull, normal or lognormal distributions. Structured data are modeled using analysis of variance (ANOVA) method. Mean value, standard deviation, and coefficient of variation are also calculated.

The program detects the outliers and asks for user intervention. An outlier is an observation that is much lower or much higher than most other observations in a data set. The user can remove, keep or change the detected outliers.

The procedure used to determine a basis value depends on the characteristics of the data. The general analysis flowchart is presented in Figure 1. The main steps are:

**Step 1:** for structured data test each group/batch for outliers, for unstructured data go to step 4.

**Step 2:** use k-sample Anderson-Darling test to determine if the data can be pooled into single group (if Yes, go to step 4).

**Step 3:** use ANOVA method to estimate material tolerance bounds.

**Step 4:** for unstructured (or pooled) data test sample for outliers.

**Step 5:** use goodness-of-fit test to determine if the data have Weibull distribution. If test is positive, use Weibull distribution method to estimate material tolerance bounds, otherwise go to step 6.

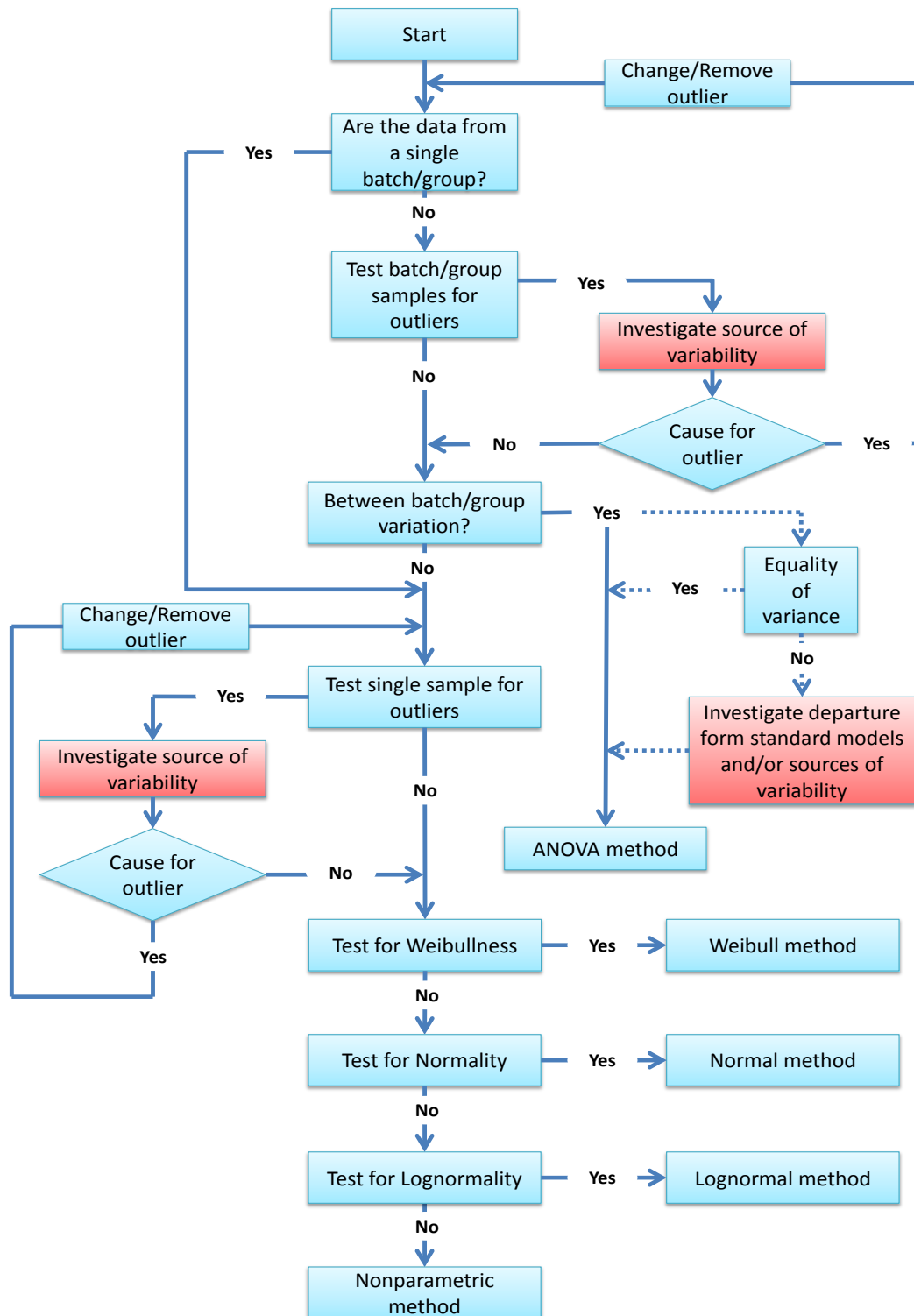
**Step 6:** use goodness-of-fit test to determine if the data have normal distribution. If test is positive, use normal distribution method to estimate material tolerance bounds, otherwise go to step 7.

**Step 7:** use goodness-of-fit test to determine if the data have lognormal distribution. If test is positive, use lognormal distribution method to estimate material tolerance bounds, otherwise go to step 8.

**Step 8:** use nonparametric method to estimate material tolerance bounds.

Note, that red-colored boxes in flowchart require user judgment for the next actions. User will be asked whether to keep, remove or change the value of outliers.

**Disclaimer:** generally the ABBA code follows the MIL-HDBK procedures. However, some errors and typos in MIL-HDBK were corrected and all efforts were made to check the formulas using different available sources. Also some statistical tables were recalculated using higher accuracy. Nevertheless, the software is distributed on an "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.



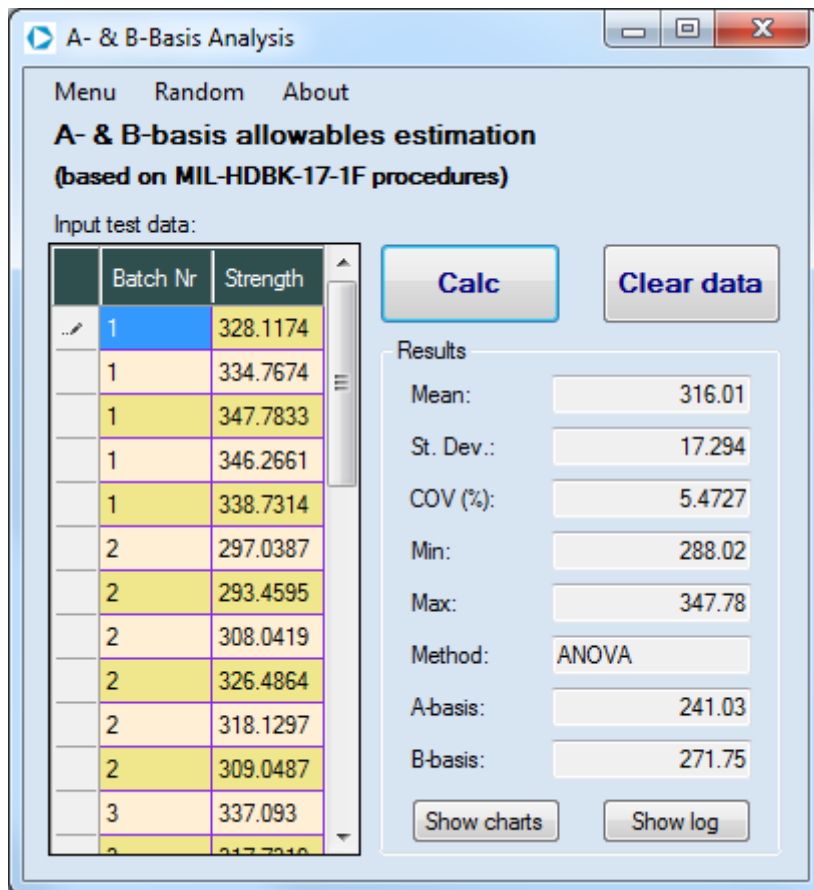
**Figure 1** Flowchart illustrating procedures for A- & B-basis estimation.

## User interface

Main window of the program is shown in Figure 2. The data has to be formatted in two columns: the batch/group in the first column and the corresponding strength values in second column, as shown in Figure 3. If the data is unstructured (comes from single batch/group), the first column can be left blank.

Empty lines in the input data will be ignored, however, if the batch field is not empty and data field is empty, warning will be issued. If only the batch field is empty, the default batch number "0" will be used for this data-point.

The batch/group's numbering does not necessarily need to be consecutive. You can delete one group of data and run analysis for the remaining groups.



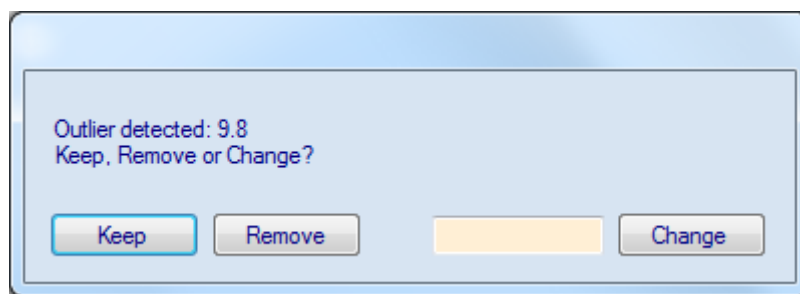
**Figure 2** Main window of the "ABBA" program.

The input data can be loaded from text file, with each data point on separate line and batch/strength values separated by spaces or comma (Figure 3).

1	136.64
1	125.91
1	1444.0
2	107.79
2	114.58
2	110.70
3	125.50
3	118.79
3	131.24
4	125.91
4	127.86
4	125.91
5	134.41
5	124.60
5	127.54
6	139.35
6	119.03
6	125.81

**Figure 3** Data input format example.

Press “Calc” button to start analysis. If outlier is detected in the data, dialog shown in Figure 4 will appear, asking user for next actions. Final results of the analysis will be shown in main window on the right (Figure 2).

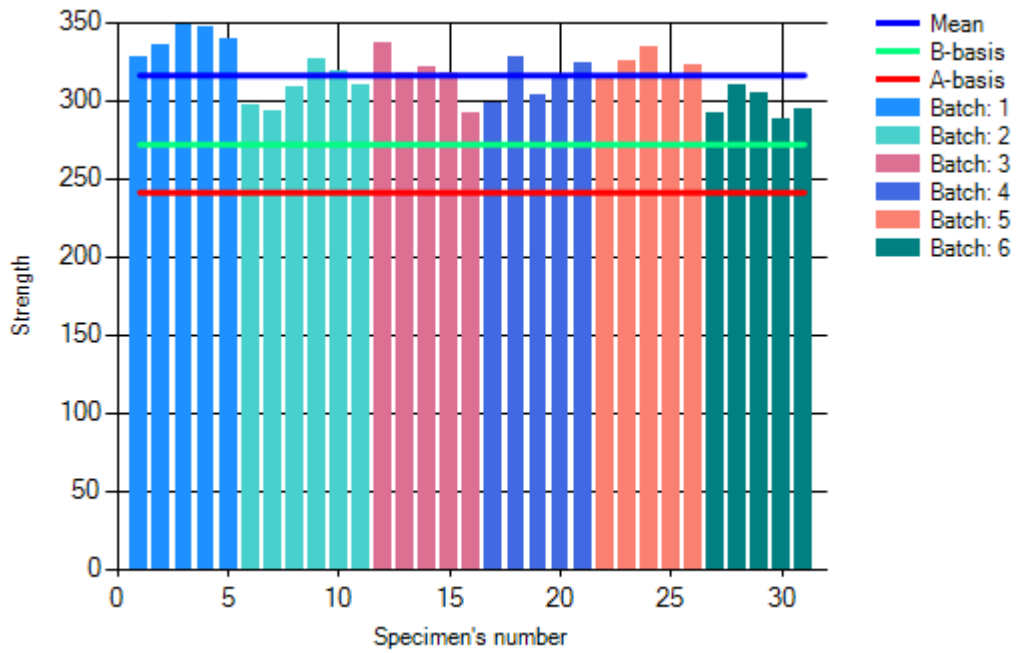


**Figure 4** Dialog showing available options for the outlier.

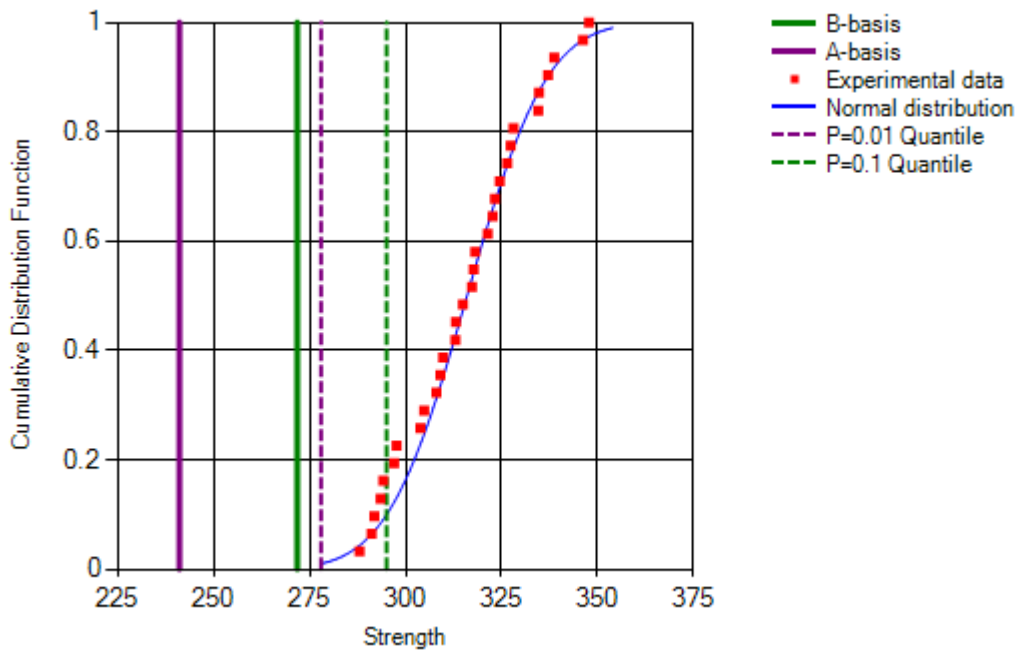
Press “Show charts” button for graphical representation of the input data and analysis results. The first chart (Figure 5) shows the strength values of each individual sample together with population mean, A-basis and B-basis.

The second chart values (Figure 6) presents cumulative distribution function of raw data points (red dots) with best-fit approximation (blue line) and corresponding A- & B-basis values. The dotted lines show 0.01 and 0.1 quantiles of the best-fit distribution. The distribution for the best-fit approximation is chosen based on the method used for the allowables estimation (in case of the ANOVA or nonparametric method normal distribution fit is used).

Please note, that when randomly generated samples are analyzed (as will be discussed later), instead of best-fit approximation actual distribution parameters (as entered by the user) will be used to present analytic cumulative distribution function and quantiles. If the button “Calc” is pressed for the same data, the chart will be redrawn with the best-fit approximation (as if the data came from unknown source with unknown distribution parameters).



**Figure 5** Chart illustrating raw data points with corresponding mean and A- & B-basis values.



**Figure 6** Chart illustrating cumulative distribution function of raw data points with best-fit distribution approximation and corresponding A- & B-basis values.

The charts can be copied to clipboard or saved to file in PNG format using right mouse click on the chart area.

For experienced user, the log data with some intermediate results of the analysis is available (Figure 7).

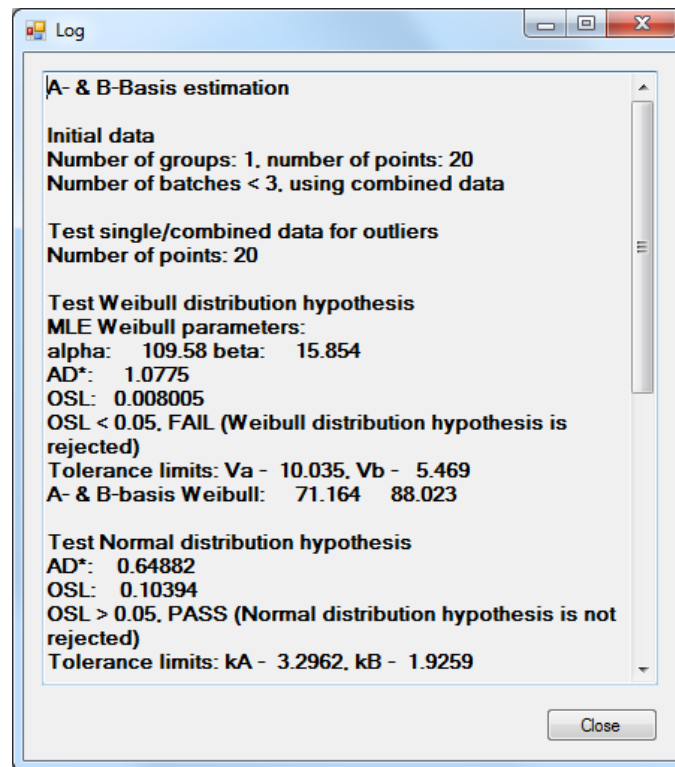


Figure 7 Log window with some intermediate calculations results.

### Random samples generation

Random samples with given parameters can be generated automatically for testing or research purposes using one of three distributions: normal, Weibull or lognormal. User can define number of batches, number of points in batch and distribution parameters: mean and standard deviation for normal and lognormal distribution (or scale and shape parameters for Weibull distribution).

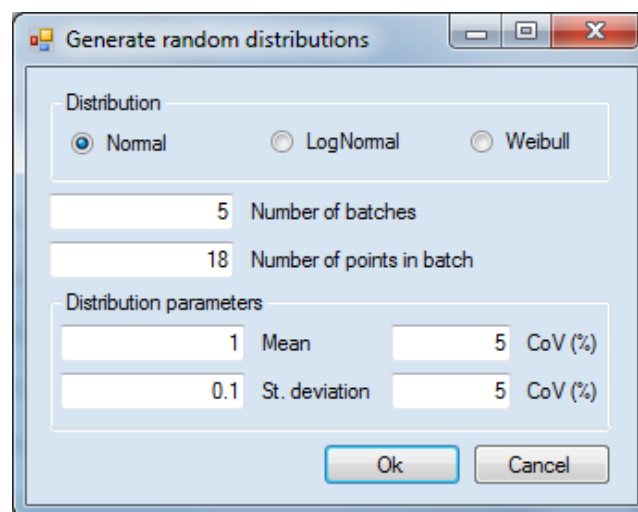


Figure 8 Dialog window for random distributions generation.



If non-zero values of coefficients of variations (CoV) are used, each batch will be generated using different set of parameters. In this case mean and standard deviation (or scale and shape parameters) are random numbers itself with normal distribution and given coefficient of variation.

## ToDo

1. Add AGATE methodology (DOT/FAA/AR-03/19) for allowables estimation.
2. More chart options.
3. Report generation.

## References

1. MIL-HDBK-17-1F: Military Handbook - Composite Materials Handbook, Volume 1 - Polymer Matrix Composites Guidelines for Characterization of Structural Materials.

# Appendix 1

Example data sets (from MIL-HDBK-17)

Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
Mean	124.49	106.45		97.202		129.86		316.01	
St.Dev.	8.3695	6.4357		7.2723		8.3796		17.294	
COV(%)	6.723	6.0458		7.4817		6.4528		5.4727	
Min	107.8	98		85.39		114.56		288.02	
Max	144.4	121		114.32		140.39		347.78	
Method	Weibull	Normal		LogNormal		Nonparametric		ANOVA	
A-basis	85.316	85.243		77.419		80.151		241.03	
B-basis	104.43	94.055		85.087		105.5		271.75	
1	136.6	1	99	1	85.39	1	118.58	1	328.1174
1	125.9	1	100	1	97.12	1	121.77	1	334.7674
1	144.4	1	106	1	92.66	1	137.54	1	347.7833
2	107.8	1	107	1	96.43	1	140.39	1	346.2661
2	114.6	1	110	1	90.72	1	134.03	1	338.7314
2	110.7	1	98	1	95.84	2	133.44	2	297.0387
3	125.5	1	103	2	97.3	2	114.56	2	293.4595
3	118.8	1	111	2	109.47	2	123.28	2	308.0419
3	131.2	1	119	2	101.35	2	130.33	2	326.4864
4	125.9	1	121	2	98.01	2	138	2	318.1297
4	127.9	1	100	2	86.18	3	122.69	2	309.0487
4	125.9	1	100	2	100.91	3	137.1	3	337.093
5	134.4	1	104	3	96.05	3	137.49	3	317.7319
5	124.6	1	108	3	92.2	3	122.87	3	321.4292
5	127.5	1	116	3	90.86	3	135.82	3	317.2652
6	139.4	1	103	3	101.27			3	291.8881
6	119.0	1	104	3	101.23			4	297.6943
6	125.8	1	106	3	93.15			4	327.3973
7	120.0	1	106	4	114.32			4	303.8629
7	121.9	1	108	4	100.14			4	313.0984
7	132.6			4	91.24			4	323.2769
8	119.3			4	86.11			5	312.9743
8	118.3			4	93.42			5	324.5192
8	126.1			4	92.65			5	334.5965
9	109.5			5	97.58			5	314.9458
9	121.2			5	97.75			5	322.7194
9	130.0			5	97.95			6	291.1215
10	118.7			5	112.49			6	309.7852
10	126.6			5	95.75			6	304.8499
10	124.6			5	110.53			6	288.0184
								6	294.1995