

Length Compare Users Guide

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Introduction

The *Length Compare* utility calculates a series of En score values from two sets of overlapping length measurements as part of the interim testing process. The En score is one method to compare measurements by combining the deviation with the measurement uncertainty.

Overview

The *Length Compare* utility consists of two data editors for the length measurements and two graphs showing a representation of the deviation and uncertainty data along with the calculated En score values. Illustration 1 shows the main window of the *Length Compare* utility.

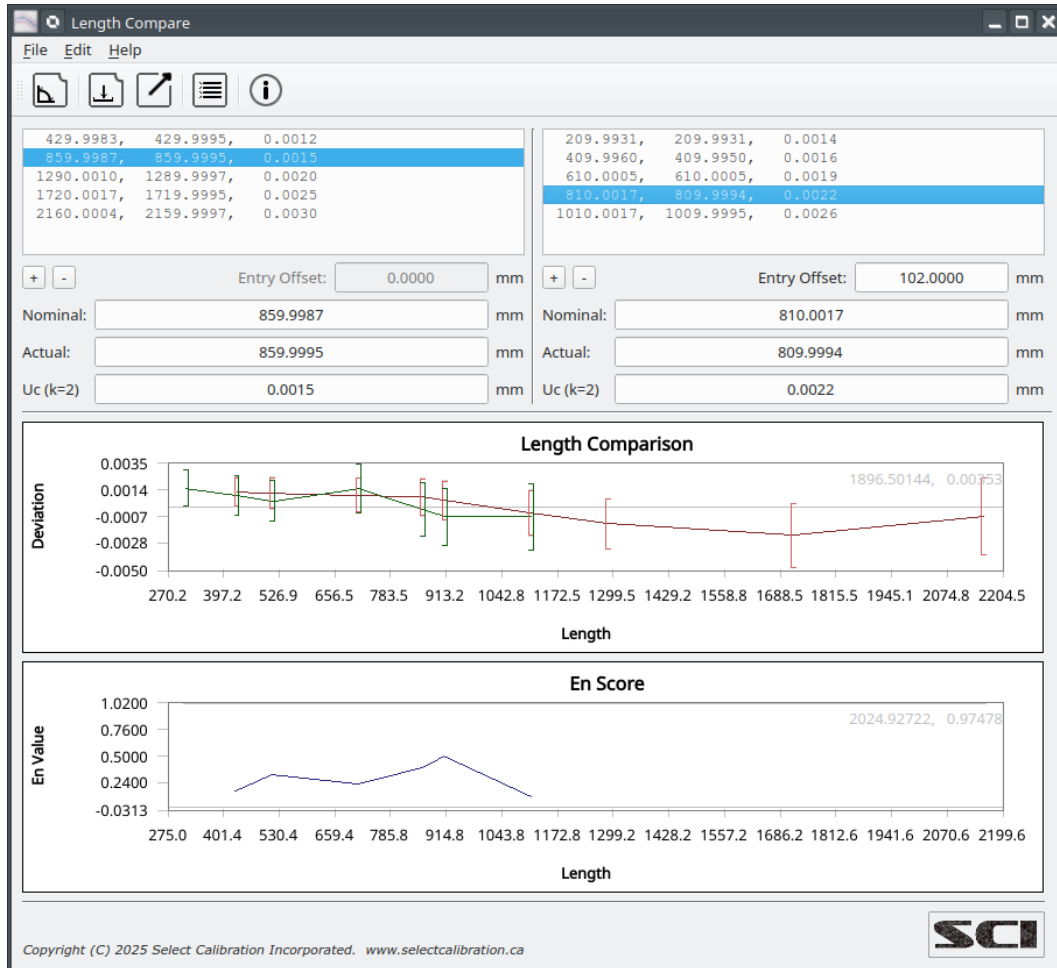


Illustration 1: Length Compare utility main window.

Table 1: Menu Options:

Menu Option	Description
File - Open	Load a length comparison file. The file extension used is '.lencomp'.

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Menu Option	Description
	<i>Drag and drop can be used to load a length comparison data file.</i>
File - Save	Save the current data to a length comparison file.
File - Export	Export the current data to a text file.
File - Close	Close the <i>Length Compare</i> utility.
Edit - Options	Options that affect how the <i>Length Compare</i> utility works.
Help - About	Information related to the version of the <i>Length Compare</i> utility.

Length Editor

The length editor allows entry for the nominal, actual, and measurement uncertainty for one for more samples. There are two identical length editors shown side by side with each representing a different measurement set. Illustration 2 shows an example of the length editor.

The screenshot shows a list of five data entries in a table. The second entry is highlighted in blue. Below the list are control elements: a '+' and '-' button, an 'Entry Offset' field with a value of 0.0000 and a unit of mm, and three input fields for 'Nominal', 'Actual', and 'Uc (k=2)', each with a value and a unit of mm.

429.9983,	429.9995,	0.0012
859.9987,	859.9995,	0.0015
1290.0010,	1289.9997,	0.0020
1720.0017,	1719.9995,	0.0025
2160.0004,	2159.9997,	0.0030

+ - Entry Offset: mm
 Nominal: mm
 Actual: mm
 Uc (k=2) mm

Illustration 2: Length editor.

Both length editors must have two or more unique entries before any meaningful results will be displayed.

Table 2: Length Editor Options:

Option	Description
+	Add a new entry. The nominal length, actual length, and uncertainty are assigned generic values.
-	Remove selected length entries.
Entry Offset	Relative starting position of the measurement. Although this entry exists for both input data sets the value is a relative offset from one data set to the other so only one is active.
Nominal	Nominal of the length entry.
Actual	Actual of the length entry.
Uc (k=2)	Expanded measurement uncertainty of the measurement length.

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There is no practical limit to the number of measurement samples that can be used.

Graphical Output

Two graphs are created based on the input data. The *Length Comparison* graph, as shown in illustration 3, shows the deviation between the two sets of input data along with the measurement uncertainty. Illustration 5 shows the calculated En value for all overlapping measurements in the graph titled *Deviation Comparison*.

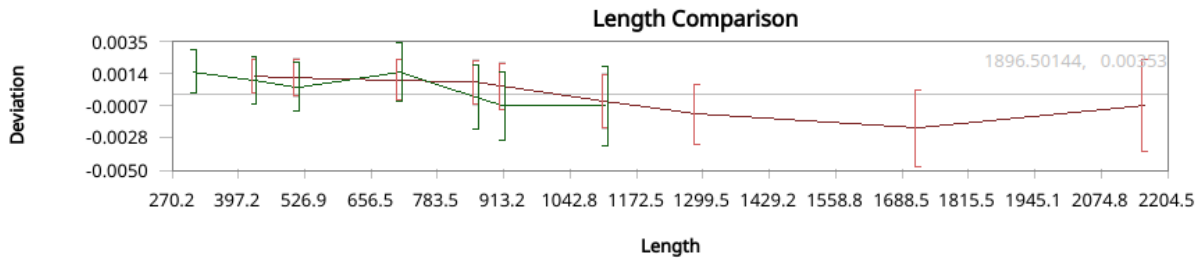


Illustration 3: Comparison of deviation and uncertainty between the two sets of input data.

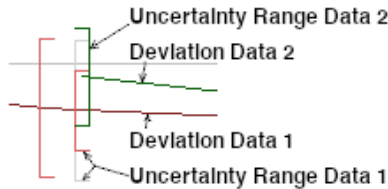


Illustration 4: Length Comparison legend

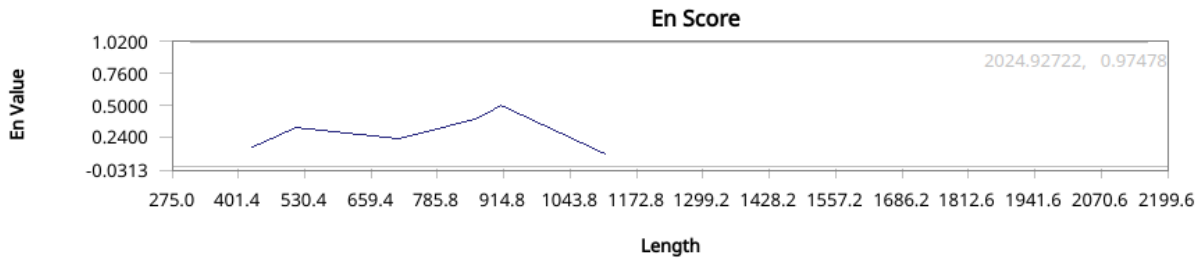


Illustration 5: Calculated En score for each data point.

Data Sample Positions

The individual sample positions are taken at lengths derived from both input data sets. If two sets of lengths are within 1 mm only one of the two input lengths are used for both sets of data.

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Illustration 3 shows examples of several input lengths that are similar enough where two sets of calculations appear side by side.

Entry Offset

When comparing two sets of length measurements that have different starting positions the difference in position can be taken into account using the entry offset. The left side length measurement data is considered to be the reference and has an offset of zero. The right side length measurement data allows the user to specify the location where the measurement begins relative to the left side data.

Using the example from illustration 1 the left side measurement is from a laser covering the full axis and the right side measurement is from a step gauge starting 102 mm relative to the starting position of the laser measurement. The laser data has small errors so, without taking this into account, this error would change the resulting En scores if the step gauge measurement starting point is not taken into account.

En Score Calculation

The En score is calculated by the following general formula:

$$En = \frac{|(A - B)|}{\sqrt{(AUc^2 + BUc^2)}}$$

where:

- En = En Score
- A = Length deviation A
- B = Length deviation B
- AUc = Measurement uncertainty for A
- BUc = Measurement uncertainty for B

Example:

$$\begin{aligned} A &= 0.0004, U_c(k=2) = 0.0031 \\ B &= 0.0002, U_c(k=2) = 0.0023 \\ \text{abs}[A-B] &= 0.0002 \\ En &= 0.0002 / \sqrt{(0.0031^2 + 0.0023^2)} \\ En &= 0.05 \end{aligned}$$

Deviation and Uc Adjustment

When comparing length measurement data, particularly when the starting position is not the same, it is necessary to remove any offset deviation between the data sets. Illustration 6 shows an example where the axis has a linear deviation that shows up identically for both test artifacts but since the two artifacts use unique starting positions a large offset exists. Illustration 7 shows the result of having the difference between the two sets of data automatically removed.

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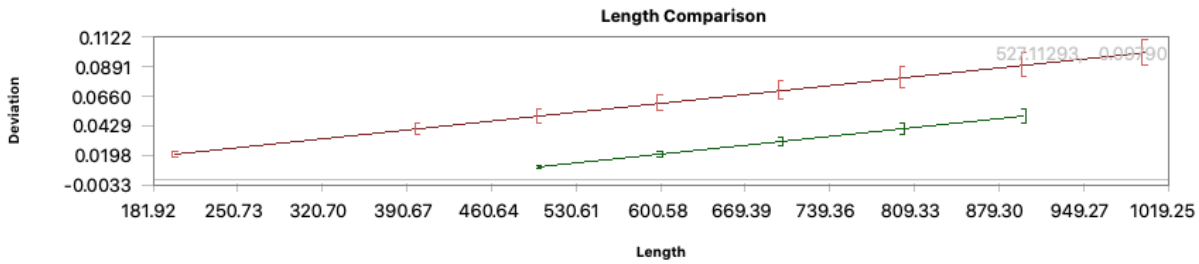


Illustration 6: Example where two artifacts show an identical error slope but offset due to unique starting positions.

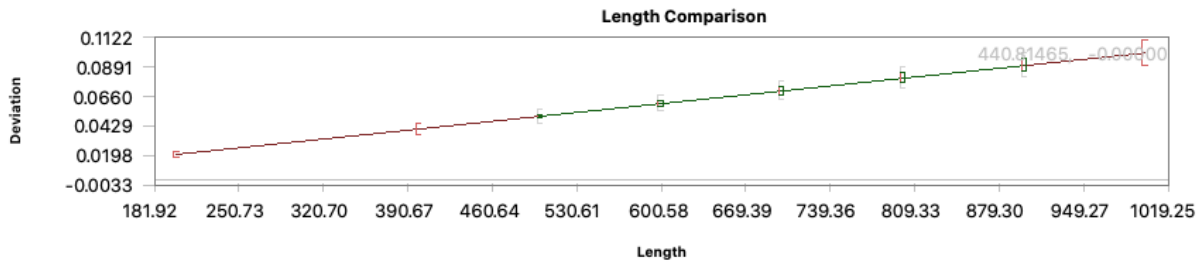


Illustration 7: Result when data sets with the deviation offset removed.

In addition to the deviation offset of data set B the uncertainty of data set A is adjusted so that it is comparable to what it was at the start of data A. Illustration 8 shows an example of the uncertainty reduction that would be comparable to having both measurements start at the identical position.



Illustration 8: Highlighted section showing reduction of U_c at start of measurement.

The grey uncertainty band is the original uncertainty at this target position.

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Options

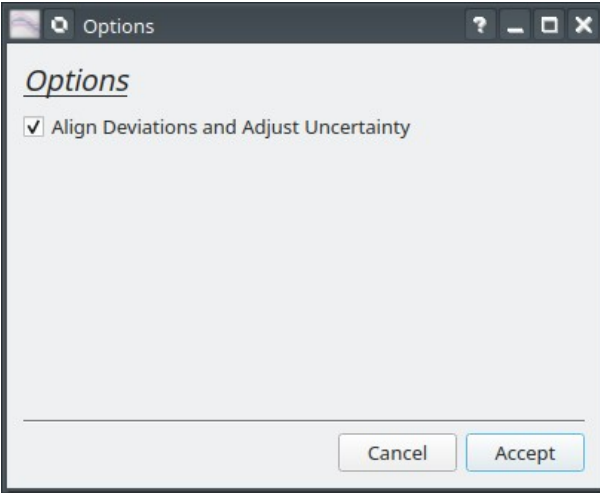


Illustration 9: Options dialog.

The options dialog has only one option at present. The current option allows the user to turn on or off the *Deviation and Uc Adjustment* feature.

Table 3: Options

Option	Description
Align Deviations and Adjust Uncertainty	Align deviations between the input data sets and update the measurement uncertainty as though it was the starting point of the measurement.

Exported File

The exported file contains the input data and calculated En scores where there is overlap. Data that is extrapolated beyond the range of either input is shown with a placeholder (-----).

Comparison Data

Position	Dev. A	Dev. B	Uc A	Uc A Adj	Uc B	En
311.9931	-----	0.0015	-----	-----	0.0014	-----
429.9983	0.0012	0.0009	0.0012	0.0011	0.0015	0.1506
511.9960	0.0011	0.0005	0.0013	0.0012	0.0016	0.3106
712.0005	0.0009	0.0015	0.0014	0.0013	0.0019	0.2277
859.9987	0.0008	-0.0002	0.0015	0.0014	0.0021	0.3822
912.0017	0.0005	-0.0008	0.0016	0.0015	0.0022	0.4897
1112.0017	-0.0004	-0.0007	0.0018	0.0017	0.0026	0.0975
1290.0010	-0.0013	-----	0.0020	0.0020	-----	-----
1720.0017	-0.0022	-----	0.0025	0.0025	-----	-----
2160.0004	-0.0007	-----	0.0030	0.0030	-----	-----

Data B Pos Offset: 102.0000
 Data B Dev Offset: 0.0015
 En Avg: 0.2764
 En Max: 0.4897

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In the above example data A is from a laser where data B is a step gauge measured at a relative position of 102 mm with respect to A. The calculated deviation offset is 0.0015 mm which has been removed automatically. The Uc A and Uc A Adj columns show the input and adjusted uncertainty when the two data sets overlap each other.

A deviation offset of 0.0015 may not seem that much but it is comparable to the uncertainty and would therefore make the calculated En score roughly twice as high.

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Revision History

<i>Date</i>	<i>Version</i>	<i>Changes</i>
Jan 28, 2021	1.0	New Program
Oct 6, 2024	1.1	Added entry offset.
Oct 14, 2025	2.0	Redesign of user interface. Added option to remove deviation difference between sets of data that have different starting points. Recalculate U_c when starting points are different.
Mar 8, 2026	2.1	Method to find common starting point uses data best fit. Previously this was extrapolated and could lead to an offset if data noise or error shapes exists.