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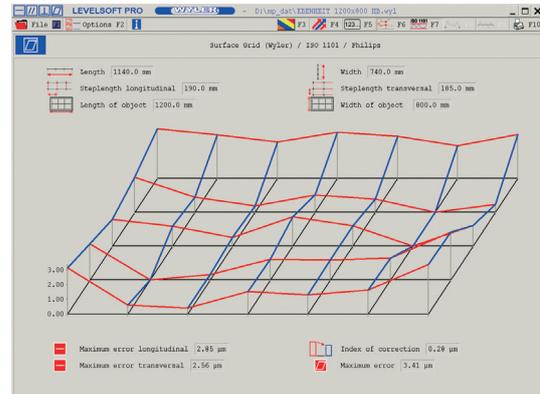
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**DETAILS TO THE
ALIGNMENT METHOD ACCORDING TO ISO1101
AND TO THE
CLOSURE ERROR CORRECTION
ACCORDING TO PHILIPS
WHEN USING THE
WYLER FLATNESS MEASUREMENT
SOFTWARE LEVELSOFT PRO**



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Änderungen / Modifications:

Datum / Date	Geändert durch Modified by	Beschreibung der Änderung Description of modifications
30.4.2003	HEH/MO	New document

1 INTRODUCTION to the closure error correction according to „PHILIPS“

The closure error correction according to “PHILIPS” is used in the WYLER grid flatness measuring method.

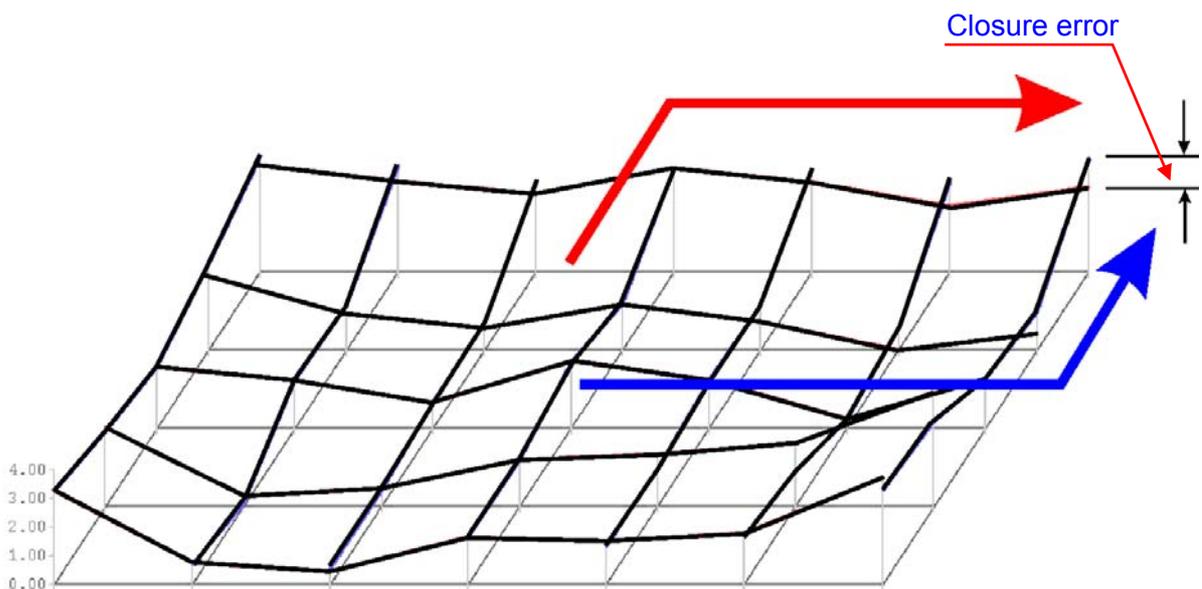
At the end of a measurement the result (flatness of a surface) can be displayed in two versions:

- without correction of the closure error
- with the correction of the closure error

When the version is used without the correction of the closure error all these error will be seen in numerical and graphical form. The so called closure error is an indication of the quality of the measurement.

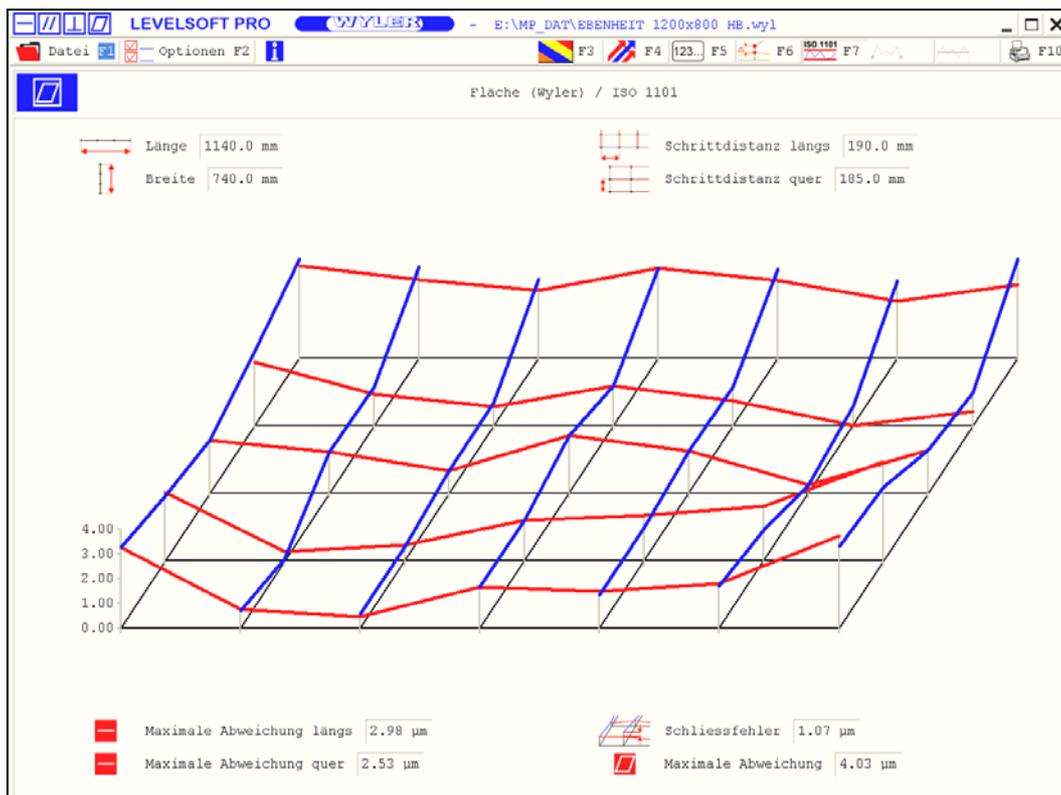
Explanation for the definition of the „CLOSURE ERROR“

The **CLOSURE ERROR** is the **LARGEST DEVIATION** of a measuring point in a overly defined grid when the calculation of such a height at this measuring point is done by using different paths. (see sketch below)



Reasons respectively the source of such closure errors are:

- Difference of temperature between the measuring object and the measuring base
- Changing of the position of the measuring object or vibrations
- The measurement is not done with the required care
- Dirt on the measuring object or on the instrument's base
- Settling time of the instrument disregarded before collecting the data
- Correct overlapping of the measuring steps disregarded (large closure errors will occur when the measuring points of the longitudinal and the transversal line measurements do not have a minimal correct overlapping)
- Inaccurate positioning of the instrument on the grid
- Worn or distorted measuring base
- Short-wave humpy surface error which can not correctly treated with the available measuring base, no correct positioning is possible (wobbling of the measuring base>>bad repetition)

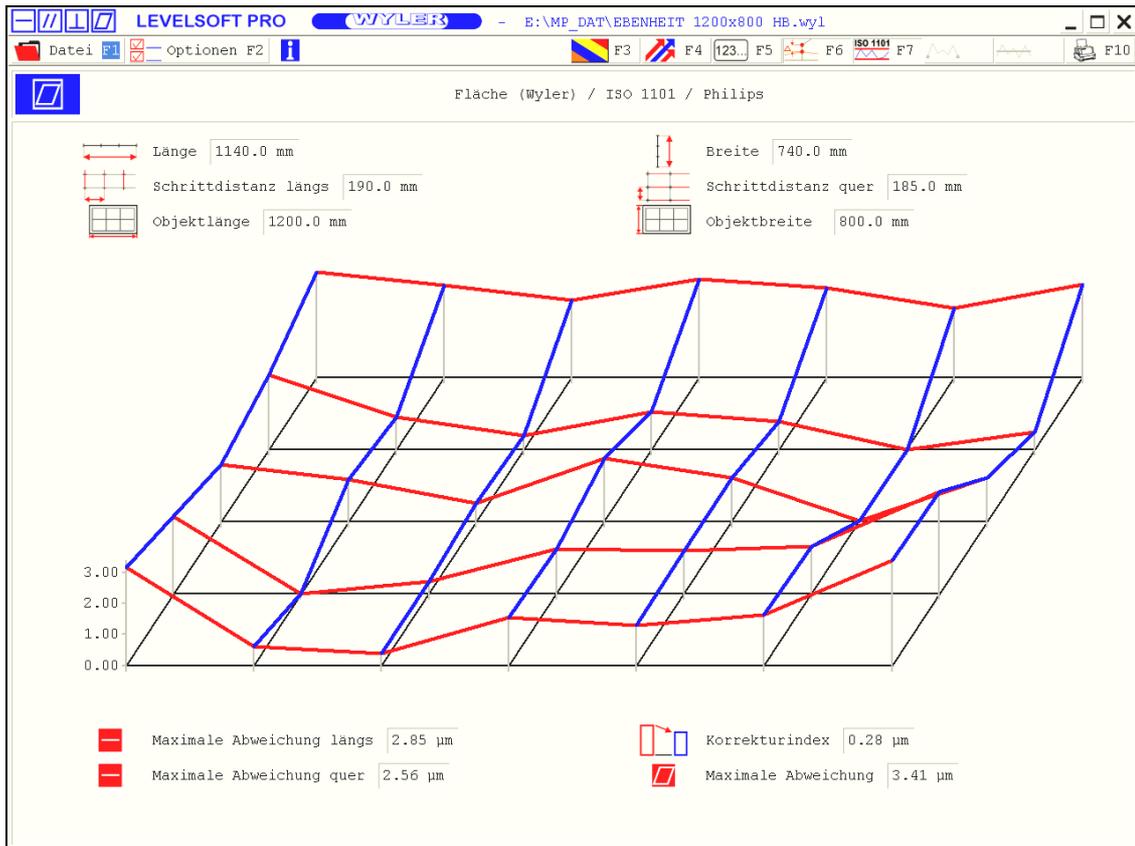


Display of a flatness measurement without correction of the closure error according to „PHILIPS“

The correction of the closure error according to „PHILIPS“ is a mathematical process with which a closure error of linearly spreading characteristic can be successfully corrected and the closure error eliminated

After the closure error correction a so called “Index of correction” is an indication of the “success” of the mathematical treatment. (the “Index of correction” is the result of the standard deviations of all the closure error corrections)

The larger the index of correction, the larger the measuring uncertainty!



Display of a flatness measurement with correction of the closure error according to „PHILIPS“

Remarks to the closure error correction:

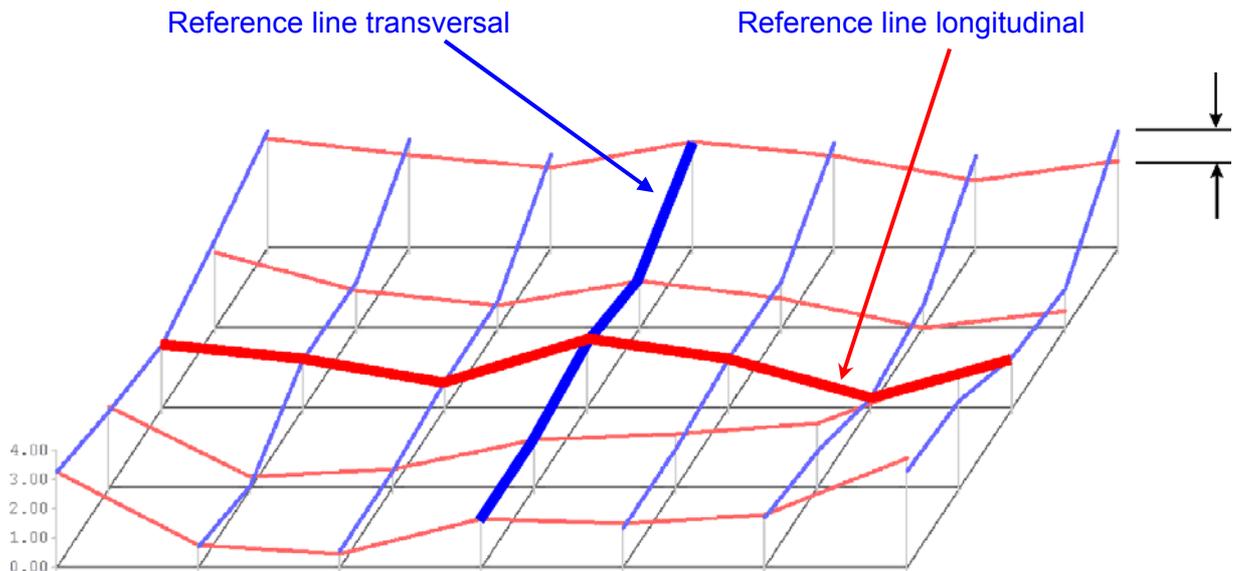
- After finishing of a measurement the display of the grid without correction of the closure error must be consulted. The closure error is an important hint to the quality of the measurement and the measuring uncertainty.
- Normally the closure error **should not exceed 20% to 25% of the maximum error**
Exception: When the maximum error is $< 4 \mu\text{m}$ the percentage of the closure error may be larger.
- In the previously shown example the closure error is 26% ($1.07 \mu\text{m}$ related to $4.03 \mu\text{m}$) is still acceptable because the maximum error is quite small $4.03 \mu\text{m}$.

2 Detailed explanations to the closure error correction according to „PHILIPS“

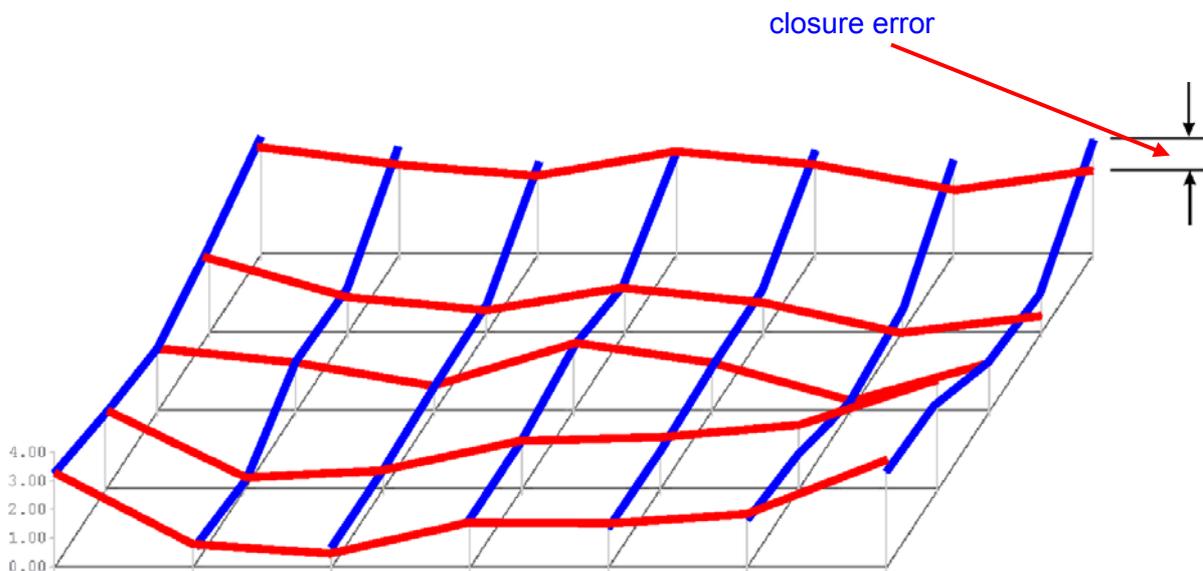
2.1 Closure error / alignment method according to ISO1101

Basics

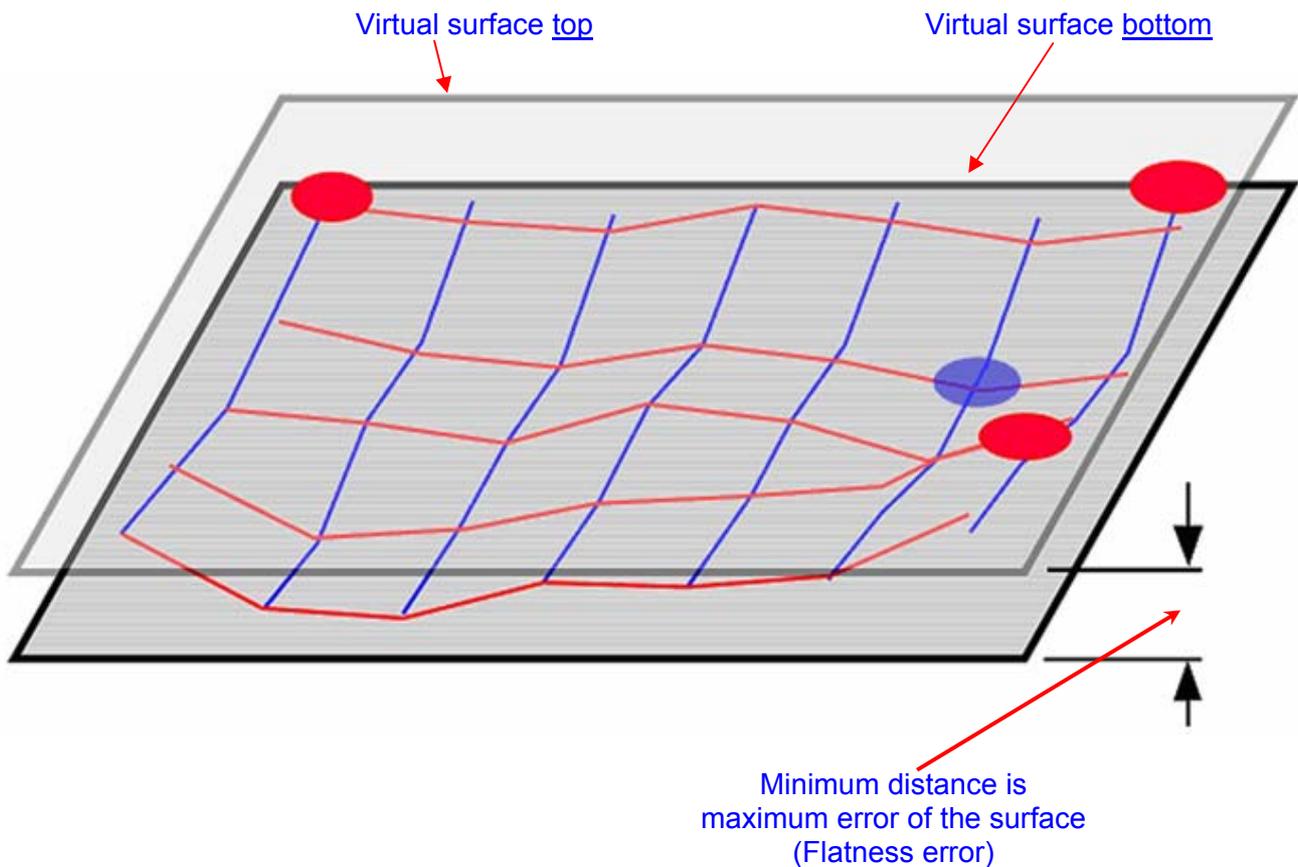
- The angular relationship of all measurements taken in the longitudinal and the transversal direction must remain unchanged.
- Both lines in the centre of the longitudinal and the transversal directions are used as reference lines. Should the number of lines in a direction be even, the one line closer to the first longitudinal respectively transversal line used as reference line.



- Both reference lines are adjusted to connect at an even elevation at their intersection. (same height)
- All other longitudinal and transversal lines are moved up or down until they cross the reference line at the even elevation.
- The largest deviation in height of two lines crossing is the closure error of the measurement.



- Two virtual flat parallel surfaces making contact with the measured grid surface at the highest and the lowest points will be turned freely in space until the distance between the two virtual surfaces is the minimum. This distance is the **FLATNESS ERROR ACCORDING TO ISO 1101**



Remarks:

Both parallel, virtual surfaces are making contact with the measured grid on the three highest and the one lowest point. Three options are possible:

- Option 1: Three contact points on top and one on the bottom side
(The one single point must lay within the triangular area created by the three other points)
- Option 2: Three contact points on the bottom side and one on top.
(The one single point must lay within the triangular area created by the three other points)
- Option 3: Two contact points on top and two contact points at the bottom side.
(Connecting line between the two top contact points and connecting line between the two bottom contact points must virtually cross each other)

Only when one of these three requirements are fulfilled is the alignment method correctly done according to ISO 1101

2.2 Correction of closure error according to „PHILIPS“

The goal of the correction of the closure error according to PHILIPS is the determination, respectively the correction of the deviation in height at all the intersections of all the lines other than the reference lines.

Procedure:

The starting point for the corrective actions is the intersection of the two reference lines and working its way out to the borders.

At every intersection the height difference between the longitudinal and the transversal line will be eliminated by lowering the upper line and lifting the lower line by the same value. The outbound portion of the same lines will be subject by the same change in elevation at each cross section. In this way the relation at the outbound cross sections will remain unchanged.

Order of treatment of the various rectangulars starting at A ... D (centre >> outbound)

D	C	B	B	C	D
C	B	A	A	B	C
C	B	A	A	B	C
D	C	B	B	C	D

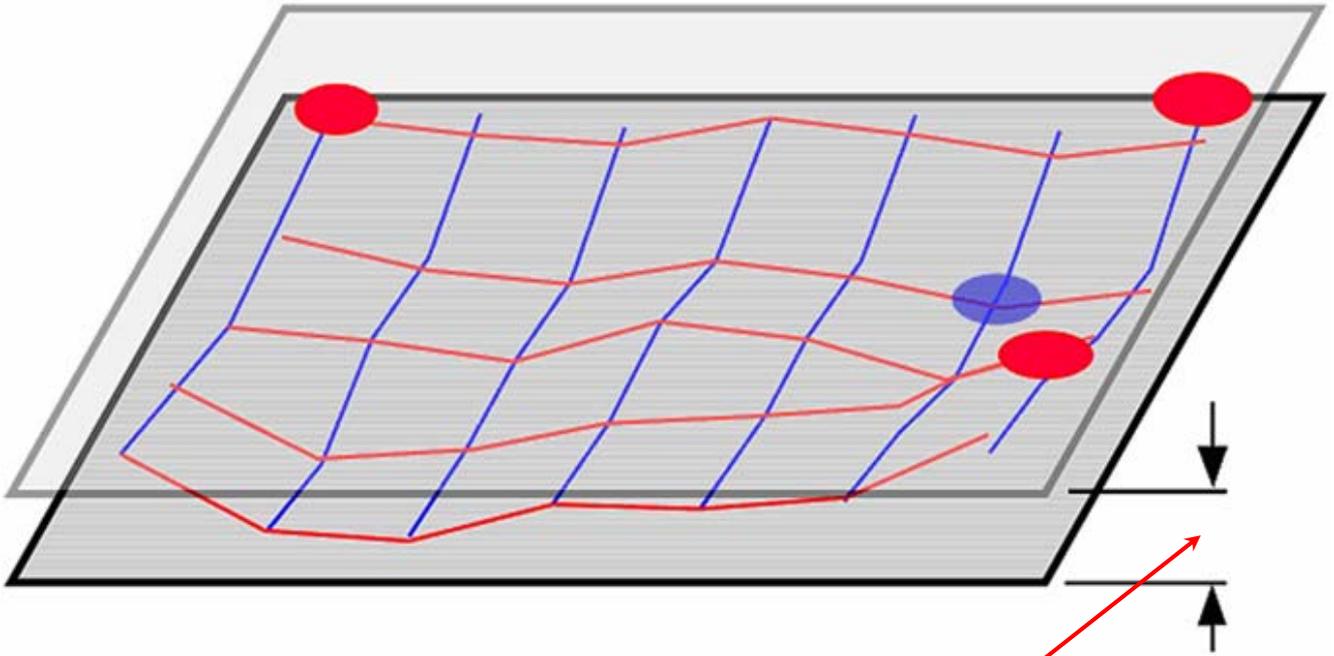
For all corrected values the standard deviation is calculated and displayed as the index of correction.

Remarks:

- Measurements not done with the required care will lead to excessive corrections and the index of correction will be high.
- Careful taken measurements will lead to even and minimal corrections and the index of correction will be quite low.

If the measurement has undergone a correction according to PHILIPS this can be seen when the **“Index of correction”** is displayed in the graph.

The definition of the flatness error is calculated in the same manner as described before. Two virtual flat parallel surfaces making contact with the measured grid surface at the highest and the lowest points will be turned freely in space until the distance between the two virtual surfaces is the minimum. This distance is the **FLATNESS ERROR ACCORDING TO ISO 1101**



Minimum distance is
maximum error of the surface
(Flatness error)

Remarks:

The maximum deviation from a completely flat surface (flatness error) is smaller now. It is also quite possible that due to the correction of the closure error a new distribution of the contact points with the virtual surfaces has taken place. In the example above there are now two points on top and two points on the bottom.