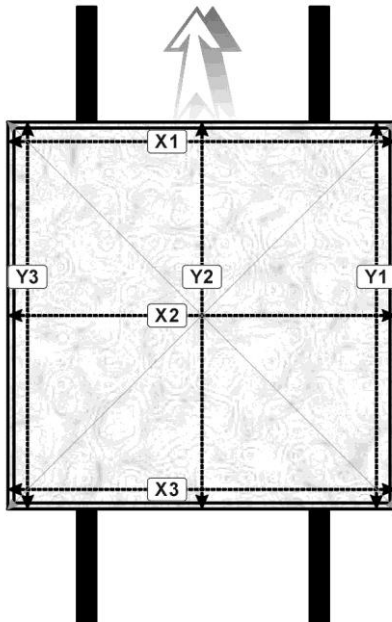# CALIPER SECTION OPERATING PRINCIPLE

Figure 1. -Measurements made by CALIPER section

Three measurements are made on each side:
- The side perpendicular to the tile movement: X1, X2 and X3.
- The side parallel to the tile movement: Y1, Y2 and Y3.

CALIPLAN D4 (CALIPER section) performs two types of checks on the tile:
- Shape defect detection.
- Dimensional check.

When the check has been completed, a class (based on the product quality) and a caliper (based on the product dimensions) is attributed to the product.
The number of classes into which a product can be classified varies from a minimum of 2 to a maximum of 4
The number of calipers into which the product can be divided varies from a minimum of 1 to a maximum of 10 for each class, except for the last class in which there is no caliper

Shape defect detection

CALIPLAN D4 detects a shape defect by making 5 different calculations on each tile.

Each of the 5 defects will be calculated as specified below. For each defect you can set the downgrading thresholds. CALIPLAN D4 will compare the defect found on the tile with the relative downgrading threshold values. If the value read exceeds the value set in the tile threshold, it will automatically be downgraded (higher class). The tile will be assigned to the worst class (higher class) with respect to all the checks performed.

Figure 2. - LUNETTE EFFECT reading
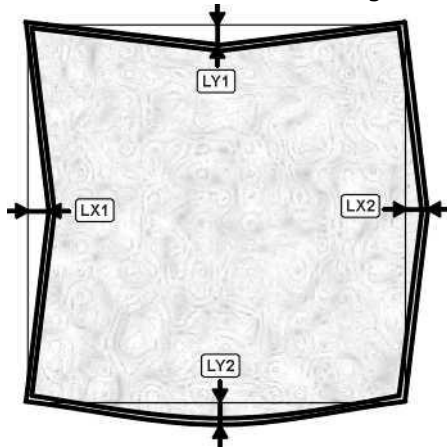
The differences of the central point of the side with respect to the two outer edges are measured for each of the four sides. These four values are the lunette effects of the four sides: LX1, LX2, LY1, LY2.

The lunette effect of side X is the worst of the two lunette effects read on the X sides: LX1 and LX2.

The lunette effect of side Y is the worst of the two lunette effects read on the opposite sides: LY1 and LY2.

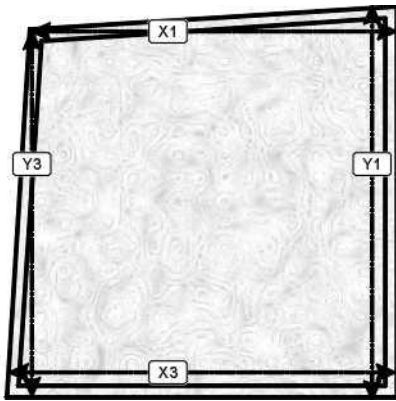Figure 3. - PILLOW EFFECT reading
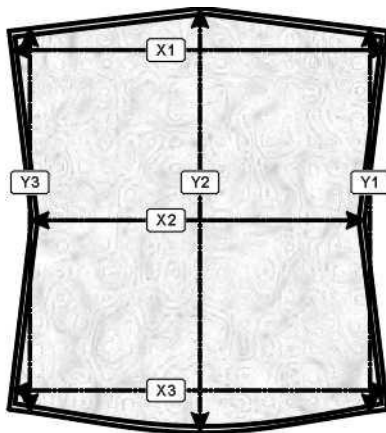
For side X and side Y the pillow effect is calculated by subtracting the central point reading from the mean value of the outer edge readings according to these formulas:

Pillow effect side X =
Absolute value $((X1+X3)/2)-X2)$

Pillow effect side Y =
Absolute value $((Y1+Y3)/2)-Y2)$
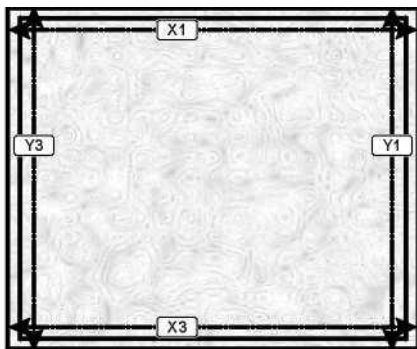
Figure 4. - TRAPEZIUM EFFECT reading

For side X and side Y the trapezium effect is calculated by subtracting the outer edge readings according to these formulas:

Trapezium effect side X = Absolute value (X1-X3)

Trapezium effect side Y = Absolute value (Y1-Y3)

Figure 5. - TOTAL TRAPEZIUM EFFECT reading

The total trapezium effect allows eliminating rectangular-shaped tiles; the following formula is used:
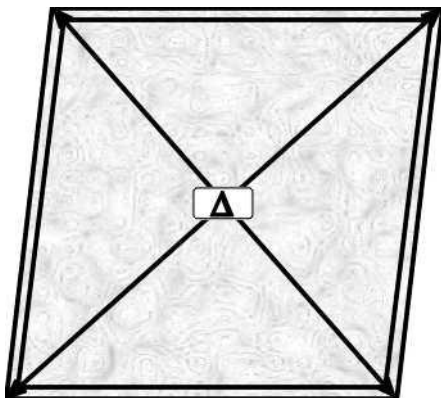
Total trapezium effect =
Maximum value between (X1, X3, Y1, Y3) –
Minimum value between (X1, X3, Y1, Y3)

WARNING!
This effect is NOT calculated if the tile to be checked is rectangular.

## Figure 6. - DIAGONAL DIFFERENCE reading

Diagonal difference is the value based on which tiles that have a difference between the lengths of the two diagonals can be identified. This calculation allows identifying all the tiles that do not have perfectly perpendicular X and Y sides.

PLANAR SECTION OPERATING PRINCIPLE

CALIPLAN D4 (PLANAR section) performs a series of checks on the tile and, when the check has been completed, attributes a class (based on the product quality). The number of classes into which the product can be classified varies from a minimum of 2 to a maximum of 4

Figure 7. - Measurements made by PLANAR section –standard configuration–

Standard configuration
5 sensors × 5 readings
Configuration to be used for square tiles.
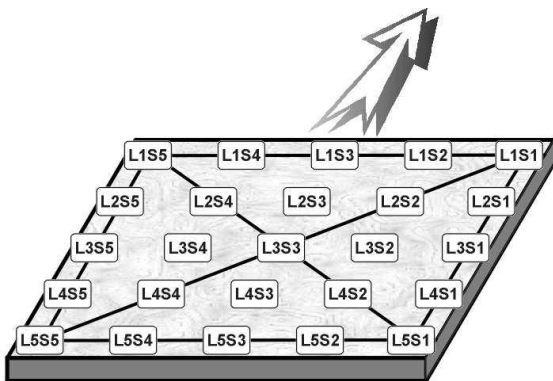
Standard configuration
5 sensors × 3 readings
Configuration to be used for rectangular tiles
(short side parallel to the belts)
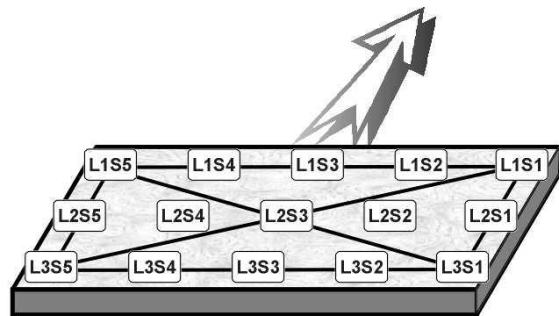
Standard configuration
5 sensors × 7 readings
Configuration to be used for rectangular tiles (long side parallel to the belts)
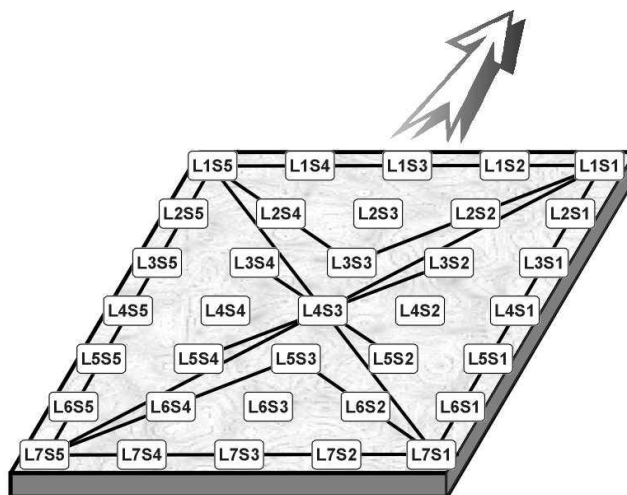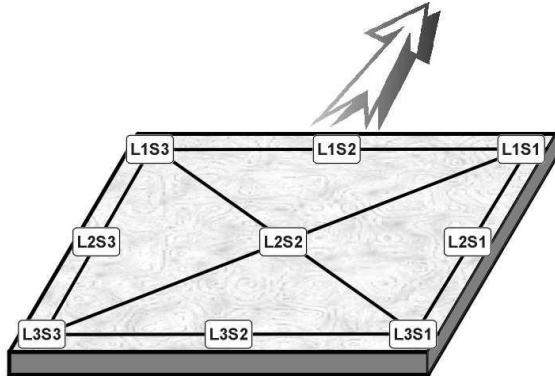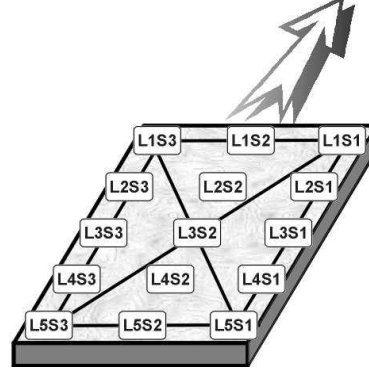
Figure 8. - Measurements made by PLANAR section –reduced configuration-

| Reduced configuration	Reduced configuration
3 sensors × 3 readings	**3 sensors × 5 readings**
Configuration to be used for square tiles.	Configuration to be used for rectangular tiles (long side parallel to the belts)

Each area represents a reading made by the sensors of the PLANAR section. Some symbols are shown within these areas: **L*n*S*m*** where ***n*** indicates the first, second, etc. reading made by the sensor number ***m*** (e.g. **L1S3** indicates the first reading of sensor 3, **L4S2** indicates the fourth reading of sensor 2 etc.).

The images show some lines that join some groups of readings: the so-called curvature defects are calculated on these lines. Three different curvatures are calculated on the lines that join 5 points: OVERALL CURVATURE, LATERAL CURVATURE and CENTRAL CURVATURE. Each curvature calculation uses 3 readings on the same line. The <u>curvature will have a positive value</u>, if the area corresponding to the central point reading is in a higher position than the outer edge readings; vice versa, the <u>curvature will have a negative value</u>, if the area corresponding to the central point reading is in a lower position than the outer edge readings.

For each of the curvatures calculated, you can set the two downgrading thresholds: positive threshold and negative threshold. CALIPLAN D4 will compare the curvatures read on the tile with the relative downgrading threshold values. If the value read exceeds the value set in the tile threshold, it will automatically be downgraded (higher class). The tile will be assigned to the worst class (higher class) with respect to all the checks performed.

The three types of curvature are described below.

Overall Curvature

Figure 9. - OVERALL CURVATURE reading
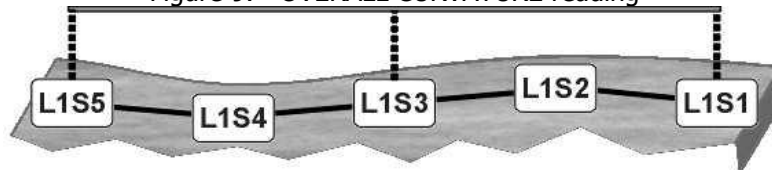
In each line of readings, the distance between the line going from the outermost readings to the central point is compared. In Figure 17 the line is L1S1 – L1S5 and the central point is L1S3.

Six overall curvatures are always calculated for each tile:
- 2 curvatures for side X (first and last row of sensor readings)
- 2 curvatures for side Y (columns of the readings of the first and last sensor)
- 2 diagonal curvatures (crossed readings of the four corners of the tile)

The values displayed are the worst out of those calculated. This defect is always calculated irrespective of the number of sensors and the number of readings configured in the PLANAR section.

Lateral Curvature

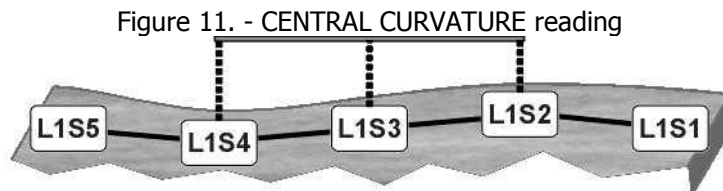Figure 10. - LATERAL CURVATURE reading
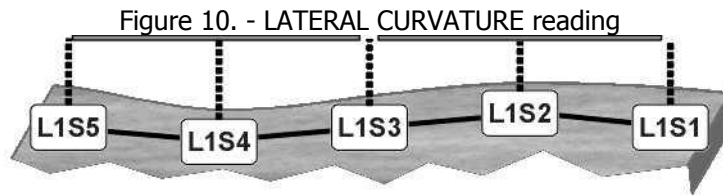
In each line made up of at least 5 readings, also 2 lateral curvatures are calculated; the 5 readings are split into 2 lines. The first line uses the first 3 readings; the second line uses the last three readings. In both lines the central points are compared with the outer edges. In Figure 18 the first line is L1S1 – L1S3 and its central point is L1S2; the second line is L1S3 – L1S5 and its central point is L1S4.

The lateral curvatures calculated on the tiles depend on the configuration of the PLANAR section:

- In the configurations with 5 sensors, irrespective of the number of readings, 4 lateral curvatures are always calculated for side X (first and last row of sensor readings)
- In the configurations with 5 or 7 readings, irrespective of the number of sensors, 4 lateral curvatures are always calculated for side Y (columns of the readings of the first and the last sensor)
- In the configurations with 5 sensors $\times$ and 5 readings, or 5 sensors $\times$ and 7 readings, 4 lateral diagonal curvatures are always calculated (crossed readings of the four corners of the tile)

The values displayed are the worst out of those calculated.

Central Curvature

Figure 11. - CENTRAL CURVATURE reading

In each line made up of at least 5 readings also the central curvature is calculated, by comparing the distance between the central point and the line going to the 2 adjacent readings. In Figure 19 the line is L1S2 – L1S4 and its central point is L1S3.

The central curvatures calculated on the tiles depend on the configuration of the PLANAR section:

- In the configurations with 5 sensors, irrespective of the number of readings, 2 central curvatures are always calculated for side X (first and last row of sensor readings)
- In the configurations with 5 or 7 readings, irrespective of the number of sensors, 2 central curvatures are always calculated for side Y (columns of the readings of the first and the last sensor)
- In the configurations with 5 sensors $\times$ and 5 readings, or 5 sensors $\times$ and 7 readings, 2 lateral diagonal curvatures are always calculated (crossed readings in the centre of the tile)

The values displayed are the worst out of those calculated.