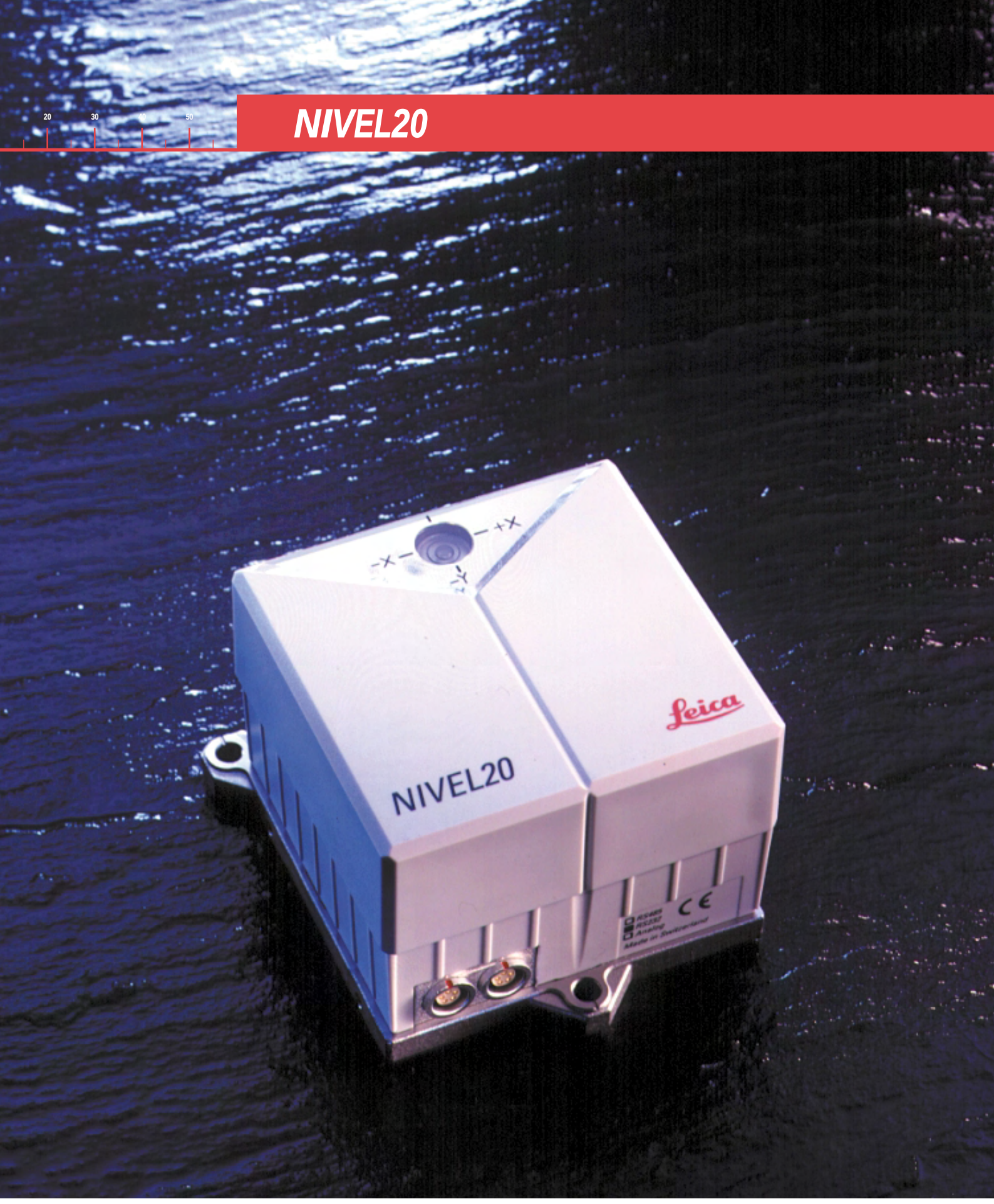
NIVEL20



Precision inclination sensor

Leica Geosystems

The Sensor meets your applications

NIVEL20 – the precision instrument for crucial measurements

The NIVEL20 is the first measuring sensor with which the degree and direction of inclinations and the temperature at the sensor can be determined simultaneously. Its compact construction and optoelectronic sensor unit ensures extremely accurate measurements and long-range stability.

Highest uptime rate
In contrast to conventional inductive or capacitive sensors, the NIVEL20 employs no mechanically driven moving parts. No mechanical parts also imply a maintenance-free sensor.

Measurement time cut by up to 80%
The 2-axis sensor does the job in significantly fewer steps because resetting and repositioning for both axes are no longer necessary. The NIVEL20 cuts flatness measurement times by up to 80%.

Your monitoring and set-up capabilities are expanded substantially because the NIVEL20 delivers real-time data on a continuous basis. Depending on the type of sensor, the measurements are output in digital RS232 or RS485 format or as an analogue signal.

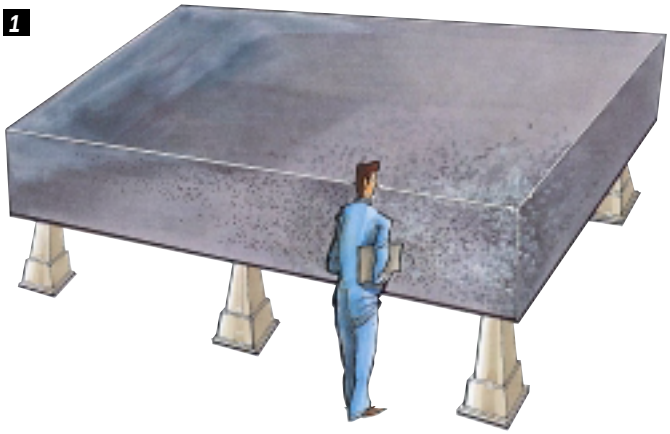
The NIVEL20 for quality assurance and engineering applications such as…

1. Determining flatness of plane tables and stone tables
2. Setting up measuring equipment and production lines
3. Gravity oriented 3D coordinate measurements and alignment in conjunction with a Leica Laser Tracker
4. Monitoring and inspection of bridges and dams

and furthermore:

- Automatic monitoring of changes in alignment of measuring equipment or production plant
- Monitoring of assembly facilities and stations
- Measurement and alignment of railbeds and surfaces
- Deformation measurements in construction applications
- Monitoring and inspection of structures

1



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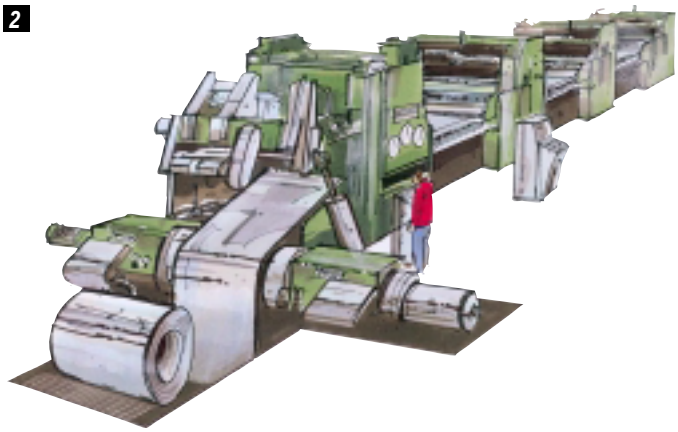

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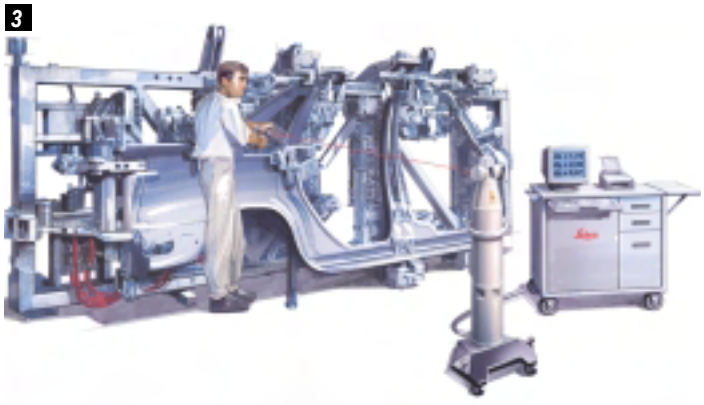


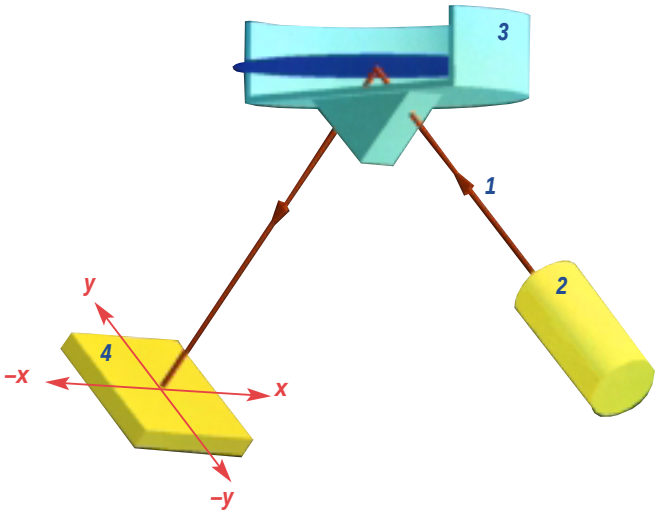
4

The leading edge operating principle

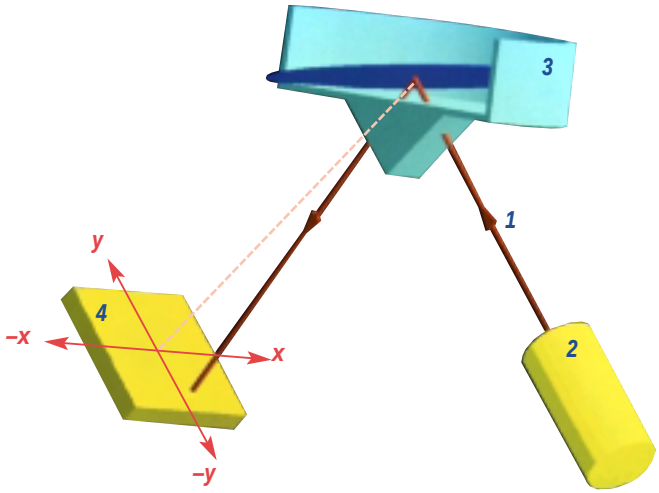
Compact optoelectronic sensor

The NIVEL20 inclination sensor exploits an optoelectronic principle that requires no moving parts. The reference plane is provided by a fluid horizontal that is absolutely perpendicular to the true vertical. The angle between the sensor and the absolute horizon changes with the inclination of the object being measured. These changes are detected and measured by the position-sensitive diode and translated into digital or analogue output signals.

The light beam (1) produced by the transmitter diode (2) is reflected by the fluid horizon (3) onto the position-sensitive diode (4). This zero-position measurement corresponds to a reading of X = 0.000, Y = 0.000.



When the sensor tilts, the position of the entire unit relative to the fluid horizon (3) is changed. The degree of inclination in this example corresponds to X = 0.050, Y = –0.200.

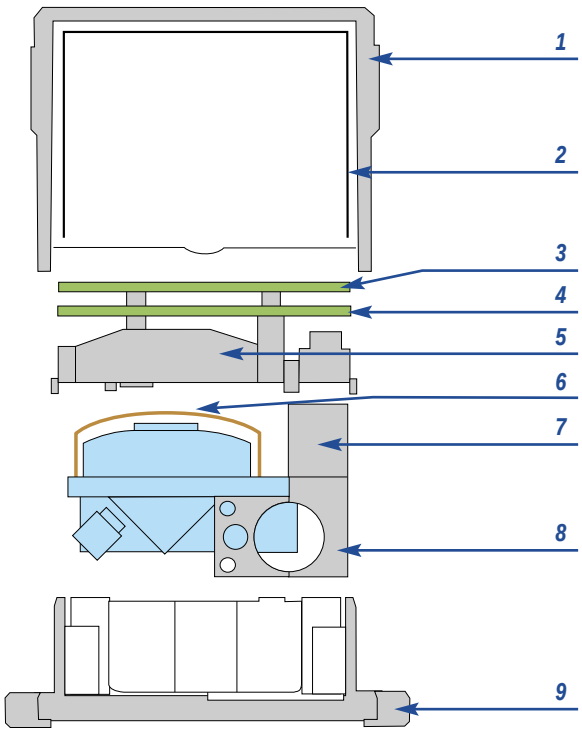


Sensor unit

- High insensitiveness to magnetic fields
- Rugged construction (CE marked)
- High temperature stability
- No mechanically driven moving parts
- Drift-free sensor provides a constant accuracy over the whole measurement cycle

All those features make the NIVEL20 ideal for industrial, research and construction applications.

1 *Synthetic cladding for thermal insulation*
2 *Electromagnetic and thermal shielding*
3 *Circuit board with CPU, sensor memory and temperature sensor*
4 *Synthetic cover with electromagnetic and thermal shielding*
5 *Circuit board with integrated analog-digital converter*
6 *Copper cover for sensor unit dissipates even minimal heat from electronic components*
7 *Two LEMO sockets for faultless data communication*
8 *Optoelectronic sensor device*
9 *Corrosion-resistant Invar alloy for base of sensor; lapped 3-point supports with toleranced mounting holes for attachment to baseplate or your individual installation*

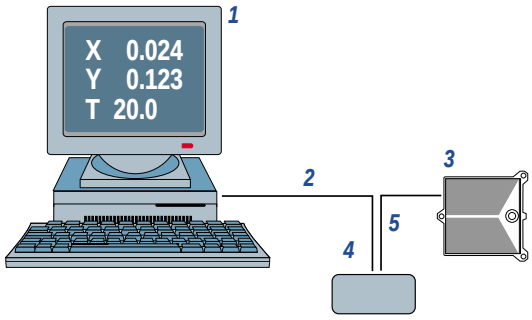


System configuration

The following standard configurations are possible, depending on the application:

Levelling, flatness and surface regularity measurements

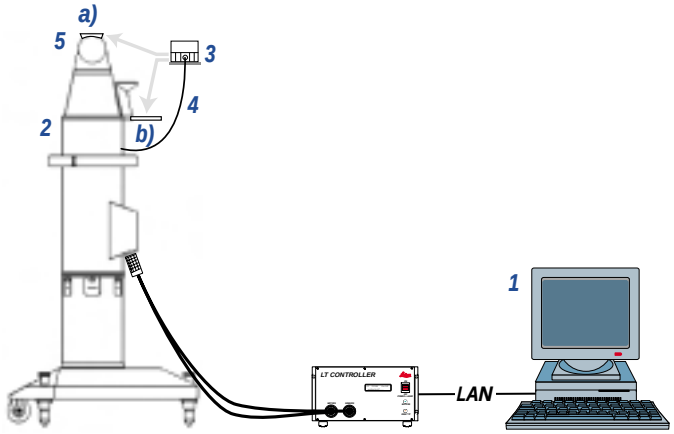
- Single NIVEL20 with RS232 data port
- NIVELplane software without reference sensor
- Real-time display of sensor readings to facilitate levelling of object measured.



1 PC with RS232 interface
2 1 m RS232 data cable
3 NIVEL20 with RS232 data port
4 12 V power pack/battery
5 5 m RS232 data cable

Gravity oriented 3D coordinate measurements & alignments

- Single NIVEL20 with RS232 data port
- Axyz software with Laser Tracker Module (LTM)
- Level and monitor the Leica Laser Tracker LT500, LTD500 and LT300

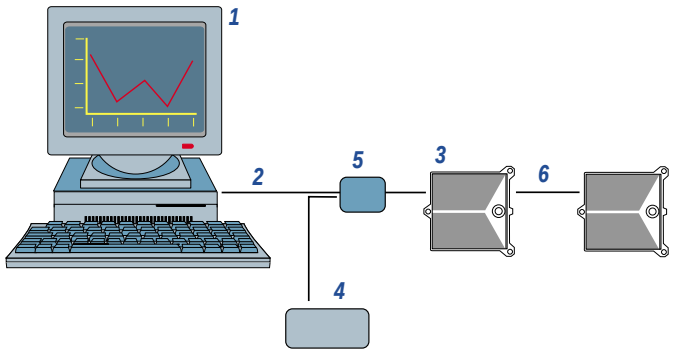


a) Levelling position
b) Monitoring position

1 PC
2 Laser LT/LTD500, LT300 with control unit
3 NIVEL20 with RS232 data port
4 1 m RS485 data cable
5 Mounting kit for levelling and monitoring

Flatness and surface regularity measurements

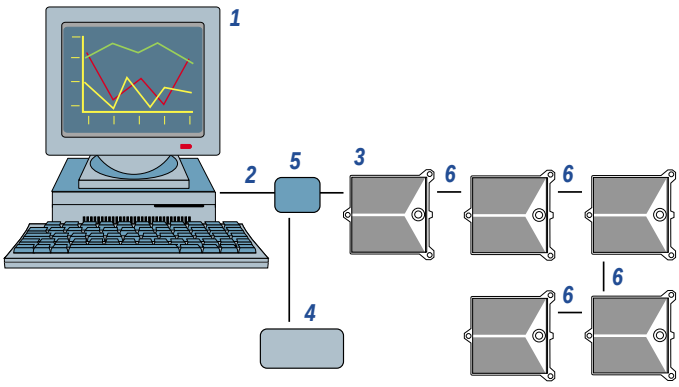
- 2 NIVEL20 with RS485 data port
- NIVELplane software by applying a second NIVEL20 as a reference sensor



1 PC with RS232 interface
2 1 m RS232 data cable
3 NIVEL20 with RS485 data port (measuring and reference sensor)
4 12 V power pack/battery with 1 m RS485 cable
5 RS232/RS485 converter
6 RS485 data cable (1 m, 5 m or 20 m lengths)

Monitoring

- Multiple NIVEL20 with RS485 data port
- NIVELtrack (or SOPOM) software by applying up to 32 NIVEL20



1 PC with RS232 interface
2 1 m RS232 data cable
3 NIVEL20 with RS485 data port
4 12 V power pack/battery with 1 m RS485 cable
5 RS232/RS485 converter
6 RS485 data cable (1 m, 5 m or 20 m lengths or customized cables)

Software and accessories

NIVELplane

Software for flatness measurements in production and quality-assurance operations.

- Windows 95, 98 or NT 4.0 operating systems
- Real-time readout of measured values
- On-screen coordinate system with continuous graphic display of sensor position during measuring sequence
- 4 different modes for plane and line measurements
- Deviations in height calculated according to DIN 1101
- 3D contour graph as error model
- 2D graphs of measured cross-sections
- Tabular presentation of calculated deviations in height
- Reports with graphics and numerical tabulation of results

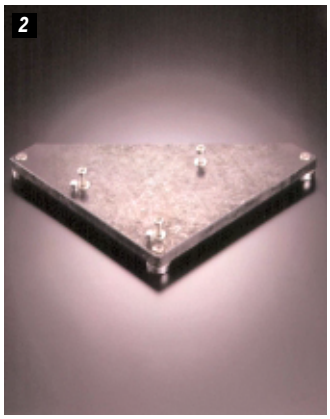
NIVELtrack

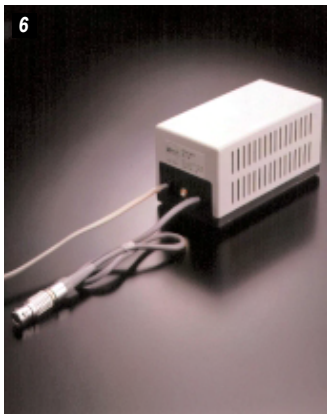
Software for mobile monitoring of machines, construction sites and structures.

- Windows 95, 98 or NT 4.0 operating systems
- User definable measurement times (start, interval)
- Numeric display of X, Y and temperature values in ASCII format
- Standard configuration supports up to 32 sensors

Running your own software package?

The NIVEL20 manual includes detailed parameters for sensor communication.





Accessories

1 ***Mounting kit***

for use of NIVEL20 with Laser Tracker (575 089) with cable (802 905)

2 ***Baseplate***

for flatness measurements 150 x 150 mm (803 365)

3 ***Infrared remote controls***

for NIVELplane (574 587)

4 ***12 V power supply***

(571 533)

5 ***4Ah battery***

for mobile applications (571 530)

6 ***Battery charger***

for 4 Ah battery (571 534)

7 ***Case for 1 NIVEL20***

with accessories (803 493)

8 ***Case for 2 NIVEL20s***

with accessories (803 494)

and furthermore:

- 1 m RS232 data cable – LEMO/DSUB9 (802 902)
- 5 m RS232 data cable – LEMO/LEMO (802 904)
- 1 m RS485 data cable – LEMO/LEMO (802 905)
- 5 m RS485 data cable – LEMO/LEMO (802 906)
- 20 m RS485 data cable – LEMO/LEMO (802 907)
- NIVEL20 user manual, German/French/English (803 592)
- Wall mount for monitoring applications (99 613)

Technical data

NIVEL20

Measuring range (deviation from vertical)	± 1.5 mrad or mm/m (± 5.2')
Working range	± 2.0 mrad or mm/m (± 6.9')
Display of + or –sign	over 2.0 mrad to max. 6.5 mrad (approx. 20.3')

Accuracy of sensor (linearity error)

Planimetric measurements	within 0.3 mrad ± 0.001 mrad (0.2")
Over entire measuring range	± 0.005 + 0.5% mrad (mm/m) ± (1" + 0.5% of measured value)
Resolution	0.001 mrad (mm/m)
Zero error	< 0.005 mrad/˚C < 1"/˚C
Operating temperature	– 20 to + 50 ˚C
Storage temperature	– 30 to + 60 ˚C
Relative humidity	10 to 95% (non-condensing)
Dimensions (L x W x H)	approx. 90 x 90 x 63 mm
Weight	850 g
Supply voltage	12 VDC ± 25%
Power consumption	15 mA analog 25 mA RS-232 50 mA RS-485
Sensor addressability	max. 32 different addresses can be stored in sensor (digital sensors only)
Averaging function	mean value can be calculated by sensor for up to 128 measurements (digital sensors only)

Measuring cycle

Digital	approx. 0.2 seconds
Analog	real time

Temperature sensor

Measuring range	– 30 to + 60 ˚C
Accuracy	± 2 ˚C
Accuracy at 20 ˚C	± 1 ˚C for digital sensors ± 2 ˚C for analog sensors

Interfaces

Analog sensors	Sensitivity of inclination measurement 1000 mV/mrad
Digital sensors	RS-232 or RS-485 serial port
Baud rates	1200, 2400, 9600, 19200

Battery

Output voltage	12 V DC ± 25%
Capacity	4 Ah
Charging current	0.7 A
Charging time	up to 8 hours
Operating temperature range	– 20 to + 50 ˚C
Weight	2200 g
Dimensions	230 x 90 x 85 mm

Power supply

Mains voltage	115/230 V (switch)
Line frequency	50/60 Hz
Output voltage	14 VDC ± 10%
Output current max.	250 mA
Operating temperature	0 to + 50 ˚C
Weight	540 g
Dimensions	111 x 68 x 51 mm

Leica Geosystems AG, Unterentfelden, Switzerland, has been certified as being equipped with a quality system which meets the International Standard of Quality Management and Quality Systems (ISO standard 9001) and Environmental Management Systems (ISO standard 14001).

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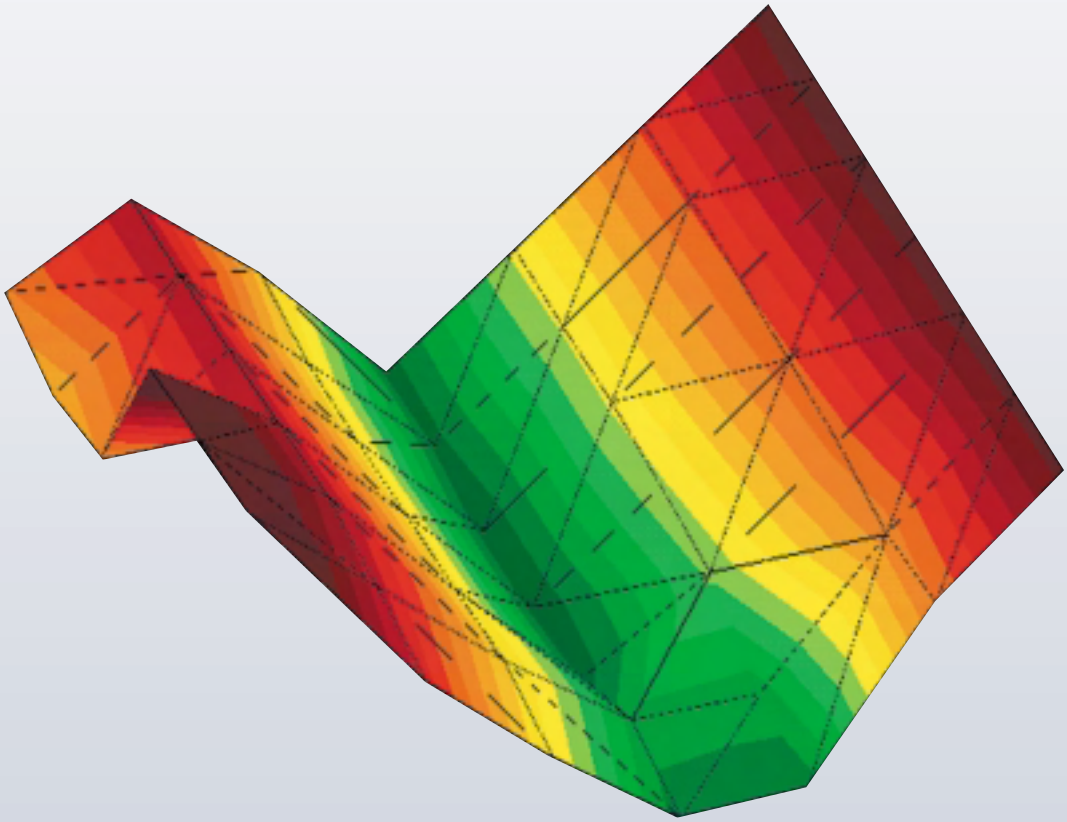
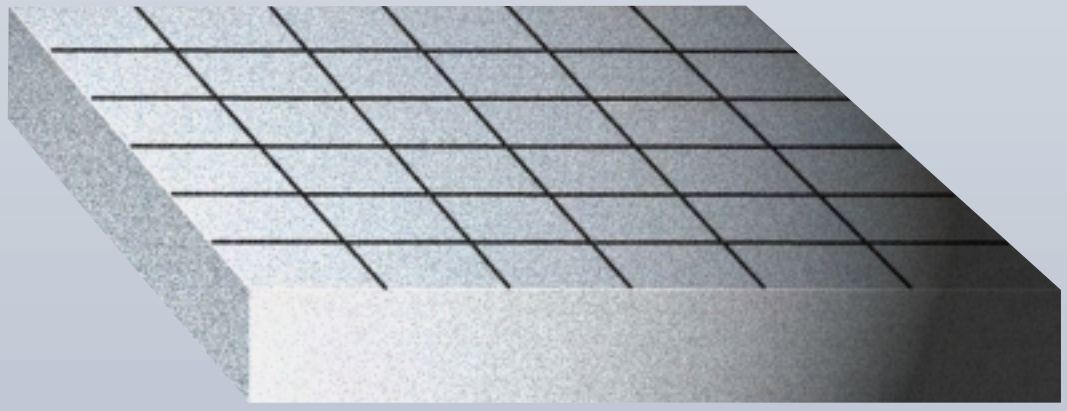
NIVELplane 2.0





Flatness measurement software

Leica Geosystems

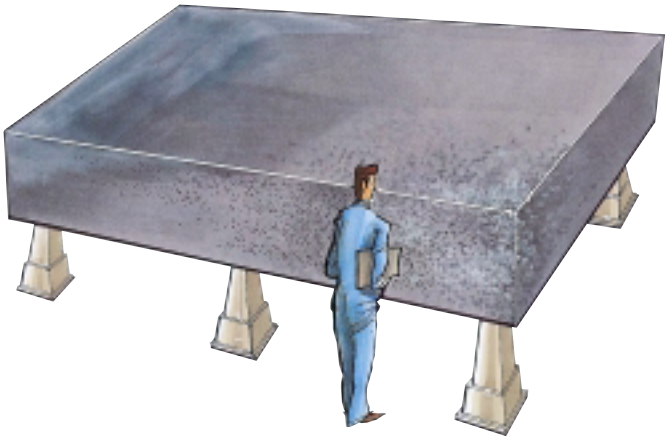
NIVELplane – setting the standard in level surfaces

What is NIVELplane?

- The NIVELplane program was developed for surface regularity and flatness measurements where precision is vital.
- Using this software in combination with the high-precision NIVEL20 inclination sensor enables you to record variations in height of just 0.001 mm/m.
- These height variations are calculated from measurements of the plane surface in accordance with DIN 1101 and the results are displayed graphically or as tables.
- The employment of an additional (reference) sensor makes it possible to compensate automatically for the slightest tilting of the object during measurement operations.

Where is NIVELplane used?

- Flatness measurements for the alignment of machines and surfaces
- Measurements for trueness of foundations for installations and structures
- Exact positioning relative to true vertical
- Determining sequence of motions in machines (static). Load analysis for machine troubleshooting
- Ultra-precise leveling of machine tools and component parts.

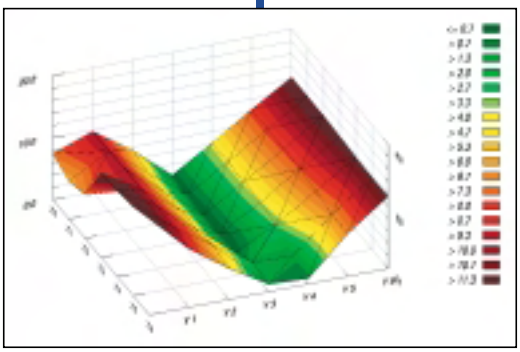


Procedure

The on-screen coordinate sequence are generated a mode, object size and base

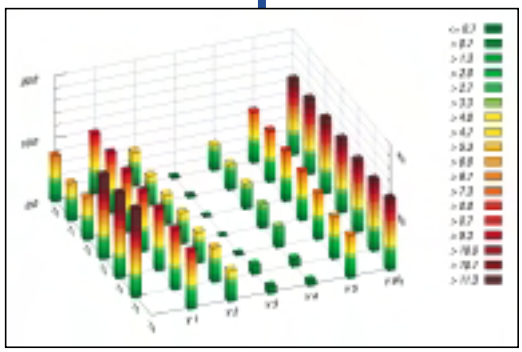
Interactive dialog for flatness measurement

The progress of the measurement operation is shown with visual representation of the sensor position. Measuring points can be skipped over or revisited by clicking on the "Backward" and "Forward" buttons.



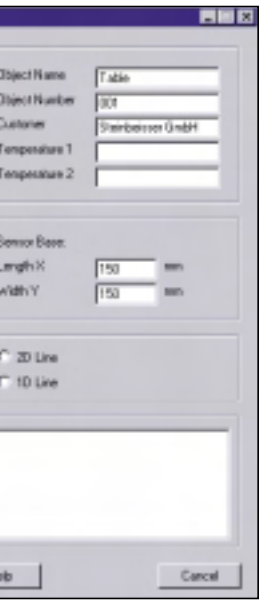
3D graphics

The deviation in height can be modeled as a shaded 3D and 2D contour graph. Various color schemes are available.

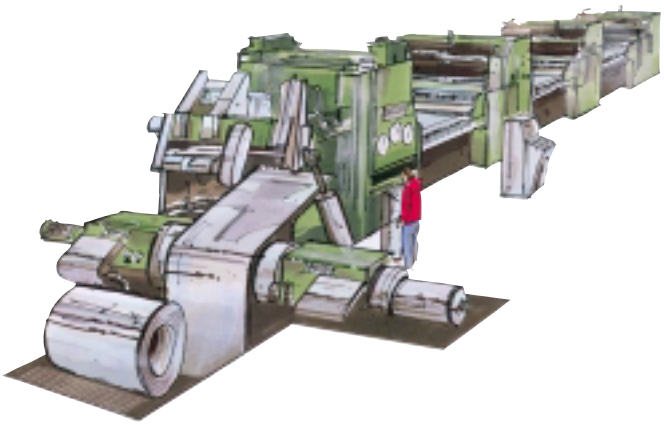


3D heights

The deviation in height are shown here as columns. The largest deviation is indicated graphically in the single column display.

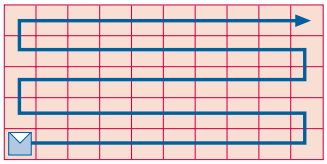


rid and the measurement
omatically when the
of the sensor are entered.

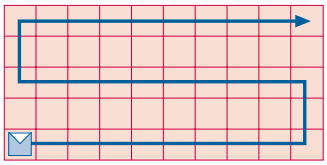


Measurement modes

Four different measurement modes are available to accommodate a wide range of applications. The dimensions of the coordinate system are determined by the base of the sensor.



Fine measurement for maximum precision and coordinate density.

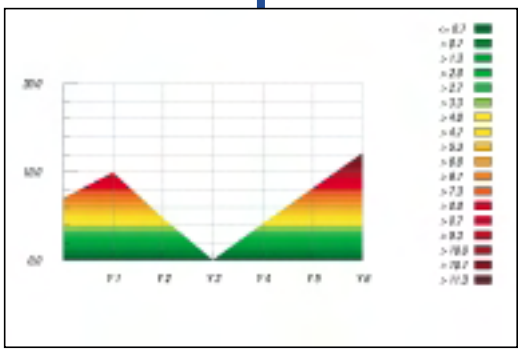


Coarse measurement where medium precision is specified at half the coordinate density.

2D or 1D linear measurement suitable for machinery alignment operations. In one-dimensional mode only the values in the direction of motion are recorded.

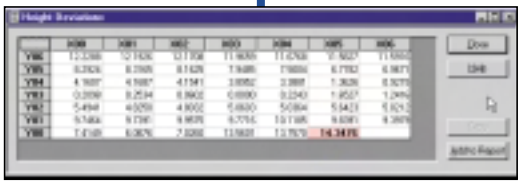
Real-time display for leveling work

For setting-up and leveling operations the sensor readings are displayed in real time.



2D view

All cross-sections along the X and Y axes can be viewed individually.



Tabular presentation

Calculated deviations in height can be displayed and printed as lists.

Program functions

☑ **NIVELplane 2.0**
- Windows 95, 98 or NT 4.0 operating systems
- English version
- Requires 1 RS232 serial port for communication with sensors
- Supports maximum of 2 NIVEL20 sensors

☑ **Administration**
Identification of object to be measured, definition of used sensor base and additional information

☑ **Measurement modes**
Fine, coarse, 2D line and 1D line

☑ **Graphics**
- 3 or 18 color mode for tolerances
- Translation, rotation and zoom functions for graphics manipulation

☑ **Units of measurement**
- Length: mm, in, m and ft
- Inclination: mrad, mm/m, mgon, min/ft. sec
- Height: mm, in, µm

☑ **Program settings**
- Spatial position of measured plane (2 vector relative to true vertical)
- Mathematically leveled position of plane
- Comparison of two measurements for degree of levelness (angle between the 2 plane vectors)
- Register tolerance (tolerance band)
- Repeat measurement (internal function)
- Reference sensor for automatic compensation of object tilt

☑ **Flatness measurement**
- Display coordinates
- Display sensor position
- Real-time readouts
- Forward/Backward
- Sensor stability display
- Optional angle mode for leveling

☑ **DIN 1101 calculation**

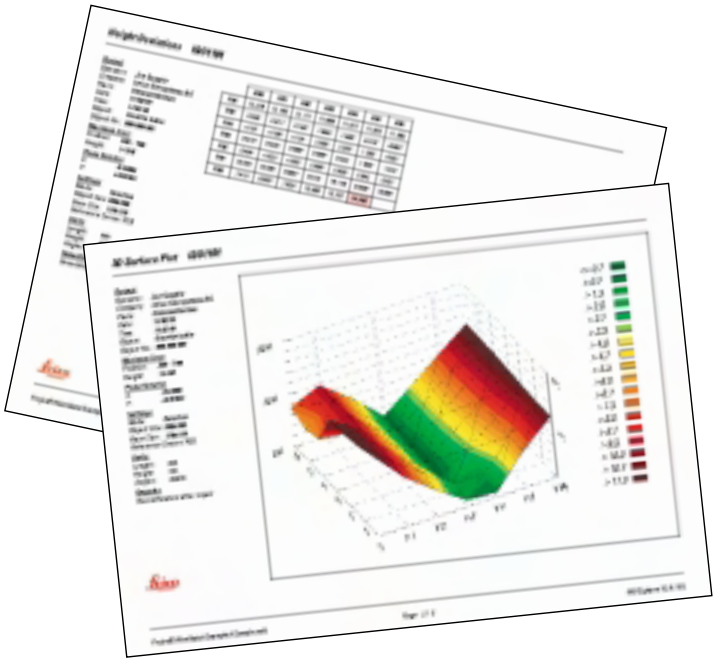
☑ **3D and 2D graph of measured surface**

☑ **3D heights as column graph**

☑ **2D cross-sectional views along X and Y axes**

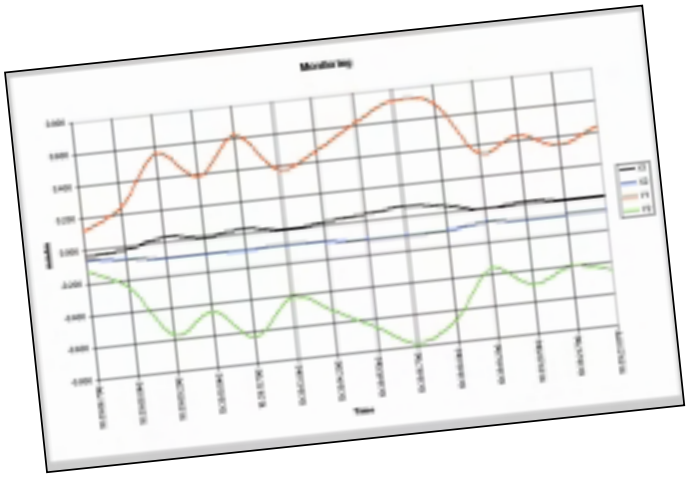
☑ **Measurement report**
- Printouts of profiles (cross-sections), 3D graphs and tables

☑ **Additional software utilities**
- NIVELtool for sensor settings and field check.
- NIVELtrack for real time monitoring measurement with up to 32 NIVEL20 sensors per serial port



NIVELplane reports

Reports can be generated quickly. You determine what additional information, measurements, cross-sectional views and graphics should be printed. The company logo can be included as a bitmap.



NIVELtrack

An MS-EXCEL printout for pitch and roll of a monitoring session using NIVELtrack and 2 NIVEL20 sensors.

TQM ISO 9001 / ISO 14001

Leica Geosystems AG, Unterentfelden, Switzerland, has been certified as being equipped with a quality system which meets the International Standard of Quality Management and Quality Systems (ISO standard 9001) and Environmental Management Systems (ISO standard 14001).

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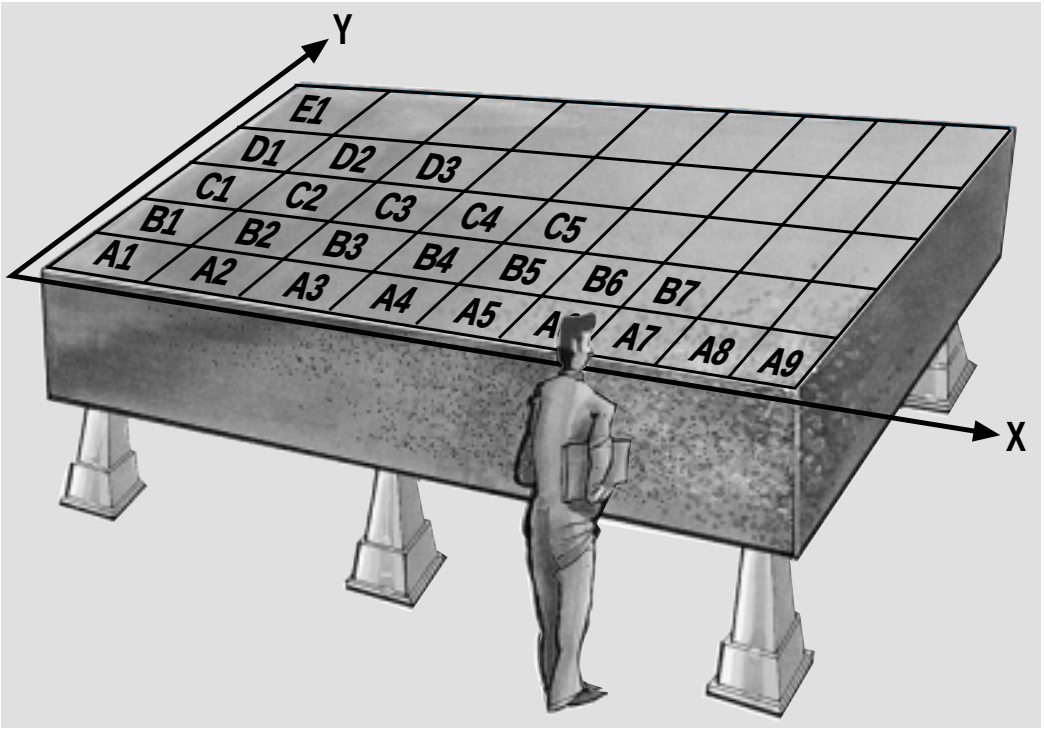
NIVELplane 2.0

Processing of measured inclinations

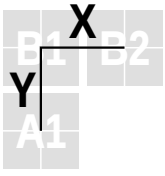
NIVELplane determines the height deviations of grid points measured with reference to the lower left-hand point (A1) of the surface being measured. The grid size is defined by the sensor base plate used during the measurement. Standard base plates supplied by Leica are 150 x 150 mm. The number is defined by the surface dimensions and the sensor base plate.



1.0 Measured inclinations

The inclination sensor NIVEL20 provides two values, one in the X and one in the Y axis. The program NIVELplane enables the inclination measurements to be saved either in mrad, In, mgon, cc or as differences of height in mm. Based on the known lengths of the grid (base plate) in X and Y, the measured inclinations (mrad) are converted to mm to obtain the differences of height to be saved (dhX and dhY).

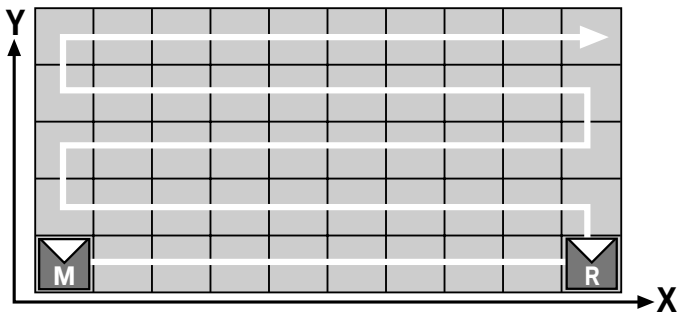
The signs are determined according to the following definition:



dhX = B2 – B1
dhY = B1 – A1

2.0 Calculating the heights of the grid points

The heights are calculated in 2 steps. First the unprocessed measurements are corrected. (2.1)
The heights of the points are then determined by an averaging compensation process. (2.3)



2.1 Reference sensor correction

Apart from the actual measurement sensor (M), a reference sensor (R) can be used for the flatness measurements.

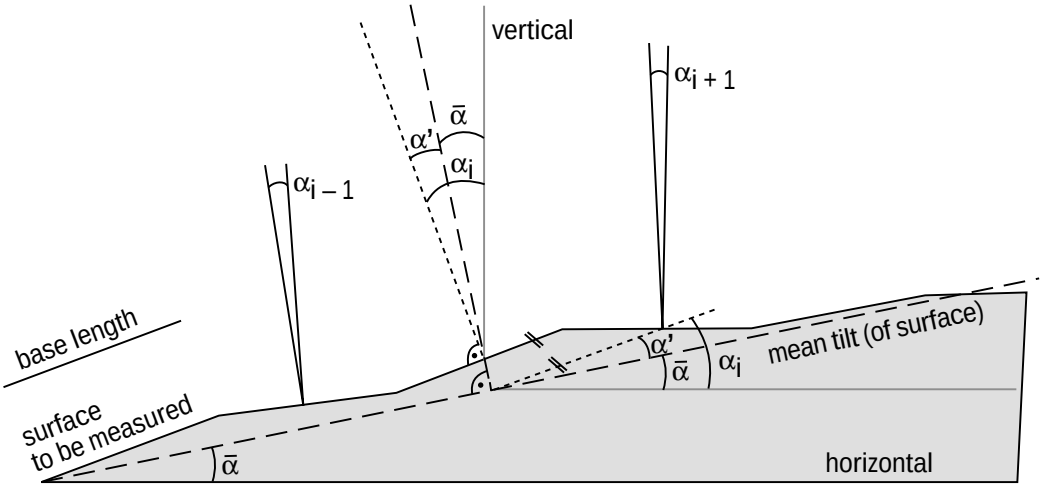
This technique detects changes of tilt of the total surface during the flatness measurement. They are then registered and corrected.

The reference sensor is positioned on the surface before the measurement commences and remains stationary. These reference values are recorded together with those from the measuring sensor.

Definitions:
- **dhX [i], dhY [i]**
  differences of inclination for measuring sensor in X and Y axes
- **dhXR [i], dhYR [i]**
  differences of inclination for reference sensor in X and Y axes
- **dhX* [i], dhY* [i]**
  corrected measurements for measuring sensor in X and Y axes
- **i**
  ordinal number of a recorded measurement
- **dhX* [i] = dhX [i] + (dhXR [1] – dhXR [i])**
- **dhY* [i] = dhY [i] + (dhYR [1] – dhYR [i])**

2.2 Reducing the differences of tilt to the horizon

Each measurement will contain an X and Y inclination of the surface being measured to the horizontal. This is taken into account by calculating the mean inclination in X and Y axis and applying them to the above measurements.



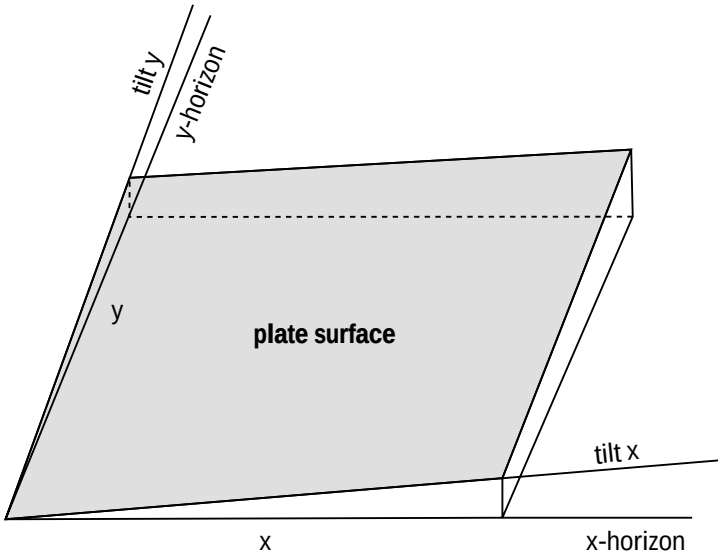
$\bar{\alpha}$ = mean tilt of the surface
α_i = i th. tilt measured
$\alpha' = \alpha_i - \bar{\alpha}$ = tilt referred to the surface being measured

2.3 Determining height (average compensation)

From the corrected measurements (according to 2.1) it is now possible to determine the heights of the grid points by averaging compensation. In the following paragraphs, a point is referred to as a measured point, if a difference of height has been determined. It follows from this that there are points on the surface, which do not exhibit a difference of height and therefore are not measured. (e.g. the point at the right-hand bottom corner of a surface A9.)

Calculation:
For the purpose of calculation, a reference height of 0 (zero) is assigned to the point at the left-hand bottom corner. In a second step, all heights are translated in negative direction (max. | Hneg |) by assigning the height zero (0) to the point with the lowest height value. The heights themselves are calculated by averaging compensation according to the principle of least squares error (DIN 1101). The heights of the measured points are inserted in the calculation as unknowns.

Correcting the tilt of the surface to be measured



U1-355-0EN – II.2000

Leica Geosystems

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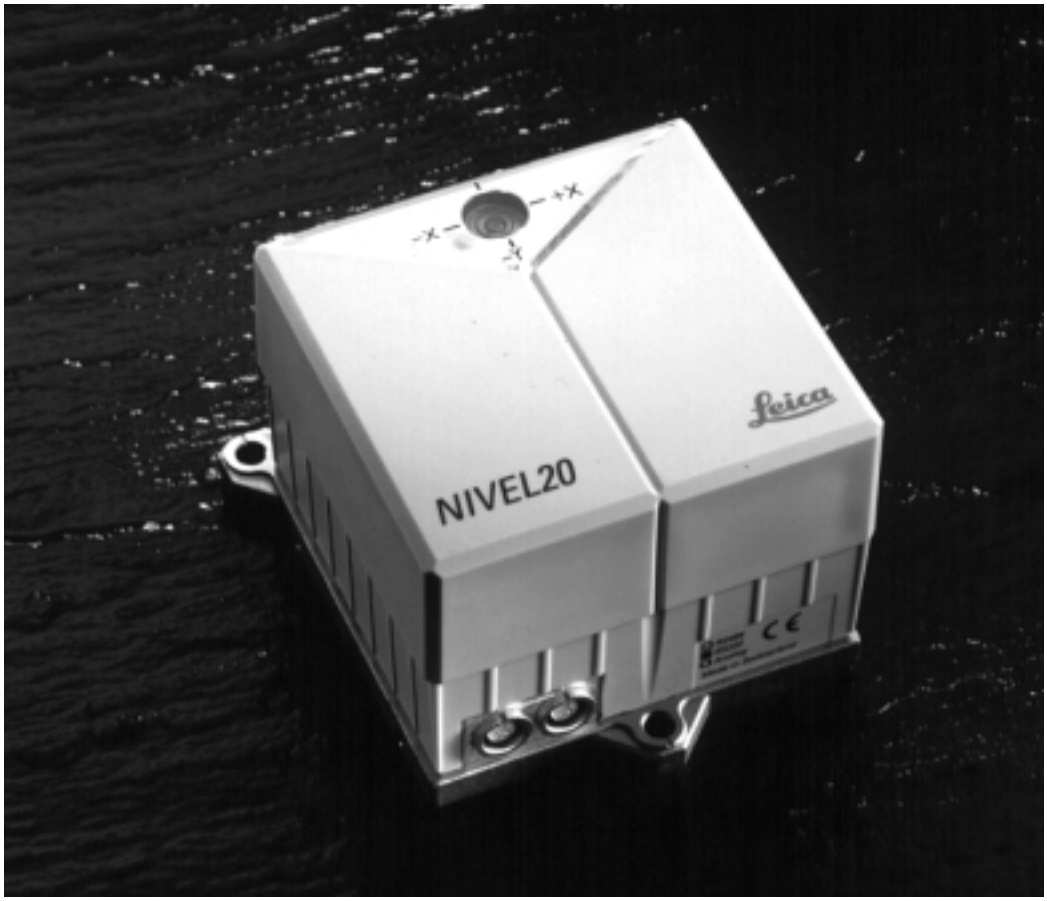
Application Report

Measuring even surfaces on high precision components

The Oelze Präzisions-Messzeugfabrik GmbH in Aschaffenburg, Germany, is an accredited German Calibration Service (DKD) centre that measures the quantities of straightness, flatness and perpendicularity. When measurements for straightness and flatness are needed the Leica NIVEL20 is used. It is approved by the German Federal Physical Technical Institute (PTB).



The Leica NIVEL20 in the production of measuring machines and machine tools

Apart from its standard products, the innovative Oelze company, now into its third generation, also manufactures basic modules for high precision measuring machines and machine tools. For some time the company has been working with the NIVEL20 inclination sensor from Leica and have gained a lot of useful experience with it.

The base frame or bed of such a machine is a load-bearing component. Attached to it are feeding elements, guides, drives etc. This places direct forces upon the bed and deformations occur as a result.

In order to measure and produce products in the µm range, the base frame of such a machine must be constructed to be statically, dynamically and thermally stable. Here, the designer with a suitable choice in raw materials and a construction which takes those materials into account, can provide the basis for a successful machine. The Oelze products which are specifically designed for customers, use primarily granite as the material.

Dr. T. Barth from Oelze explains the procedure as follows: “In order to manufacture the component part of a precision machine from a natural product like stone, the functional surfaces are accurately ground in our factory in the µm range. They are then lapped by hand. Apart from the right personnel and stable climatic conditions, a further pre-condition is the use of a suitable means of measuring.”

Leica Geosystems

Exacting straightness and flatness measuring

For the actual measuring of straightness and flatness, the surface to be measured is provided with a grid. Along this network the NIVEL20 is moved in short stages. In doing this the inclination of the sensor is registered at each measuring point. From this data, changes in height are calculated. The individual changes in height are linked by the software and the straightness and flatness profile is calculated.

During measurement for straightness, the inclination is registered in one direction, while during measuring for flatness the inclinations are registered in two mutually perpendicular directions.

The means of measuring employed by Oelze must have the following characteristics:

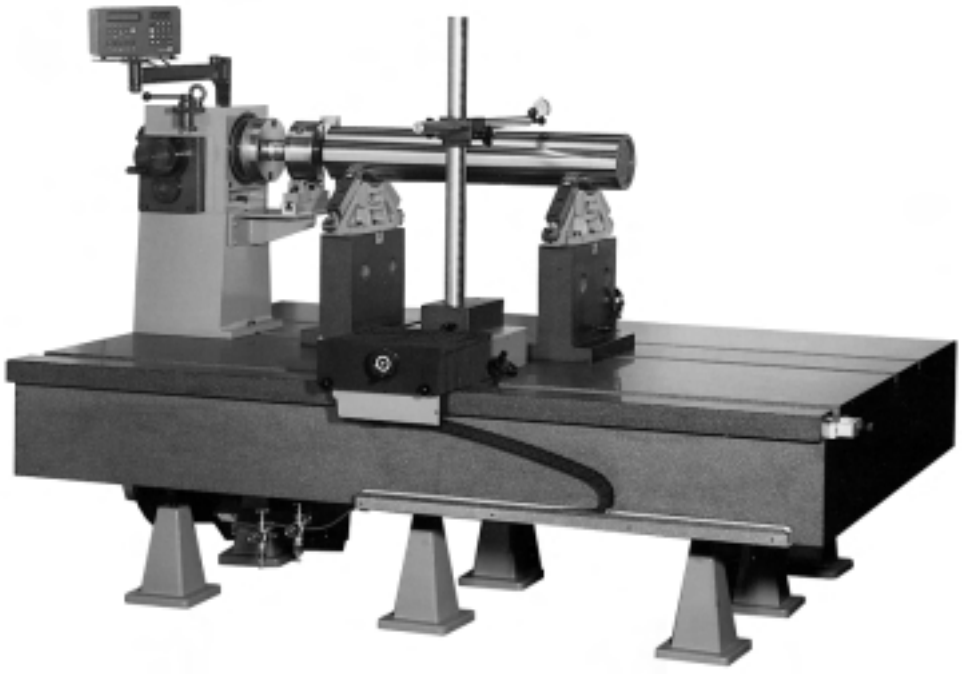
- simple and reliable operation of both the sensor and the software,
- reproducibility of the results of measuring, that is, long term stability, operator independence,
- suitable resolution,
- low dead weight,
- rigid, low-vibration construction,
- good price/performance ratio.

As Dr. T. Bart from Oelze said: “From our point of view the NIVEL20 measuring instrument offered by Leica fulfilled these requirements as compared with previous measuring methods. The system stands out particularly in the simultaneous registering of inclinations in two mutually perpendicular (bi-directional) directions. Apart from the slight possibility of making a mistake (each movement of a measuring sensor brings about a possibility for making an error) the time for measuring is minimized. The saving in time, with more than 100 measuring points, can amount to a quarter of an hour. Taking into account that the manufacture of precision surfaces is an iterative process, that is, repetition of measuring – processing – measuring etc., the cost-effectiveness of the system can be proved fairly quickly”.

Software now runs under Windows 95/98 and NT 4.0

Unlike original versions, the NIVEL20 software has been upgraded to run under Windows 95/98 and NT 4.0. This gives the user the advantage of the Microsoft Windows environment. NIVEL20 data can be copied to other programs (spreadsheets, databases, word processing, etc.) and further analyzed or reported.

Assembly equipment for printing machines. Required evenness <0.008 mm over a surface area of 2700 mm x 2100 mm



Measuring machine for measuring rotationally symmetrical components. Required evenness for the guide surface is 0.005 mm

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U1-368-0EN – II.2000

Certificate

Producer inspection certificate M

in accordance with DIN 55350-18-4.2.2

Product:	Inclination Sensor NIVEL20 RS485
Article no:	801 453
Serial no:	379918
Inspection date:	March, 17, 2001
Ordered by:	test order 1 test order 2
Your order number:	test order number
Customer:	test customer 1 test customer 2

1. Specifications:

a) Directional error:	< ±0.017	rad =	< ±1 °
b) Orthogonal error:	< ±0.034	rad =	< ±2 °
c) Linearity error:	< 0.005 mrad + 0.5% of measured value = < 1 “ + 0.5% of measured value		
d) Zero-point error on X-Axis and Y-Axis:	< 0.025	mrad =	< 5 “

2. Test results:

The inclination sensor was checked by measurements against the tilting stand with calibrated dial gauge which has a standard deviation of 1σ = 0.0002 mm (Calibration date of the dial gauge is January 16, 2001)

a) Directional error:	**0.000**	rad
b) Orthogonal error:	**0.025**	rad
c) Linearity error X-Axis:	**ok**	
d) Zero-point error X-Axis:	**0.020**	mrad
Zero-point error Y-Axis:	**-0.002**	mrad

3. Certificate:

We hereby certify that the product described has been tested and complies with the specifications and test results as stated above.
The test equipment used is traceable to national standards or to recognized procedures. This is established by our Quality Management System, audited to ISO 9001 by an independent national accredited body.

Leica Geosystems AG
Business Area IMS
CH-9435 Heerbrugg (Switzerland) March 21, 2001

TQM ISO 9001 / ISO 14001

Harald Traxler
Assembly Manager

Heinrich Graf
Quality Management

Leica Geosystems

Prüfprotokoll Nivel20

Digital RS 485

Artikel-Nummer: **801453**

Formular	725036	Index -

Datum: 21.03.2001

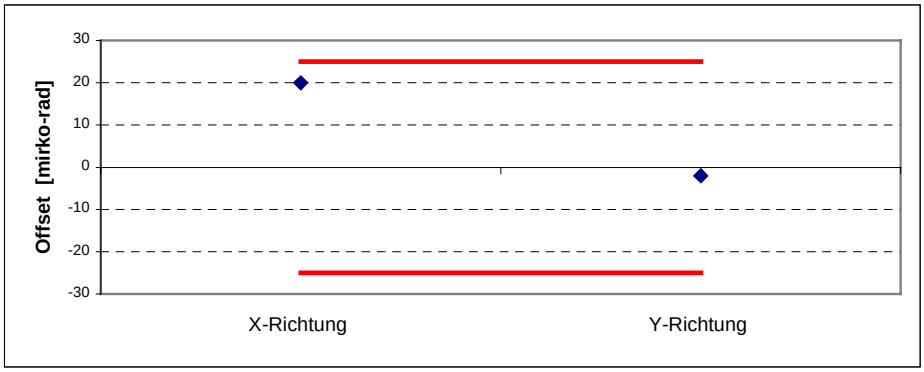
Serie Nr: **379918**

Bemerkungen:

Offset Nullpunkt

Operateur: HBRU

			Toleranzen:
X-Richtung	20	[mikro-rad]	± 25 [mikro-rad]
Y-Richtung	-2	[mikro-rad]	± 25 [mikro-rad]



Datum: 16.03.2001

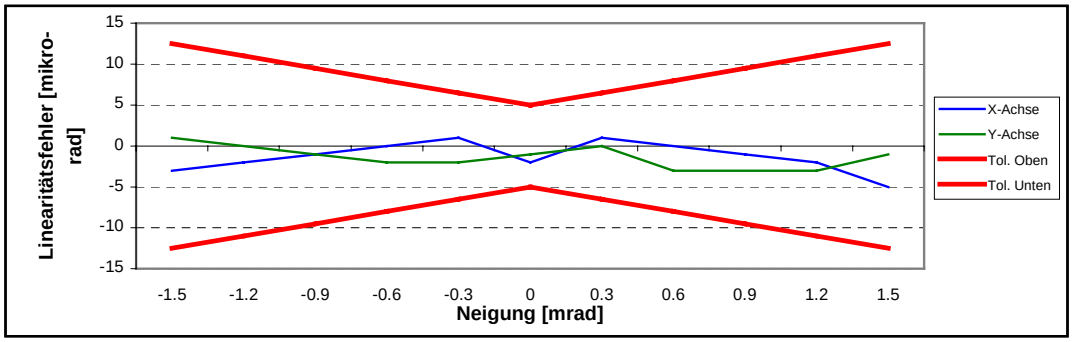
Linearitätsfehler

Operateur: HBRU

Toleranzen:

± (0.005 mrad + 0.5% des Messwertes)

Neigung	-1.5	-1.2	-0.9	-0.6	-0.3	0	0.3	0.6	0.9	1.2	1.5	[mrad]
X-Achse	-3	-2	-1	0	1	-2	1	0	-1	-2	-5	[mikro-rad]
Y-Achse	1	0	-1	-2	-2	-1	0	-3	-3	-3	-1	[mikro-rad]



Datum: 17.03.2001

Richtungsfehler

Operateur: HBRU

Richtungsfehler	0.000	[rad]

Toleranzen:

± 0.002 rad

Datum: 17.03.2001

Orthogonalitätsfehler

Operateur: HBRU

Orthogonalitätsfehler	0.025	[rad]

Toleranzen:

± 0.035 rad

Datum: 17.03.2001