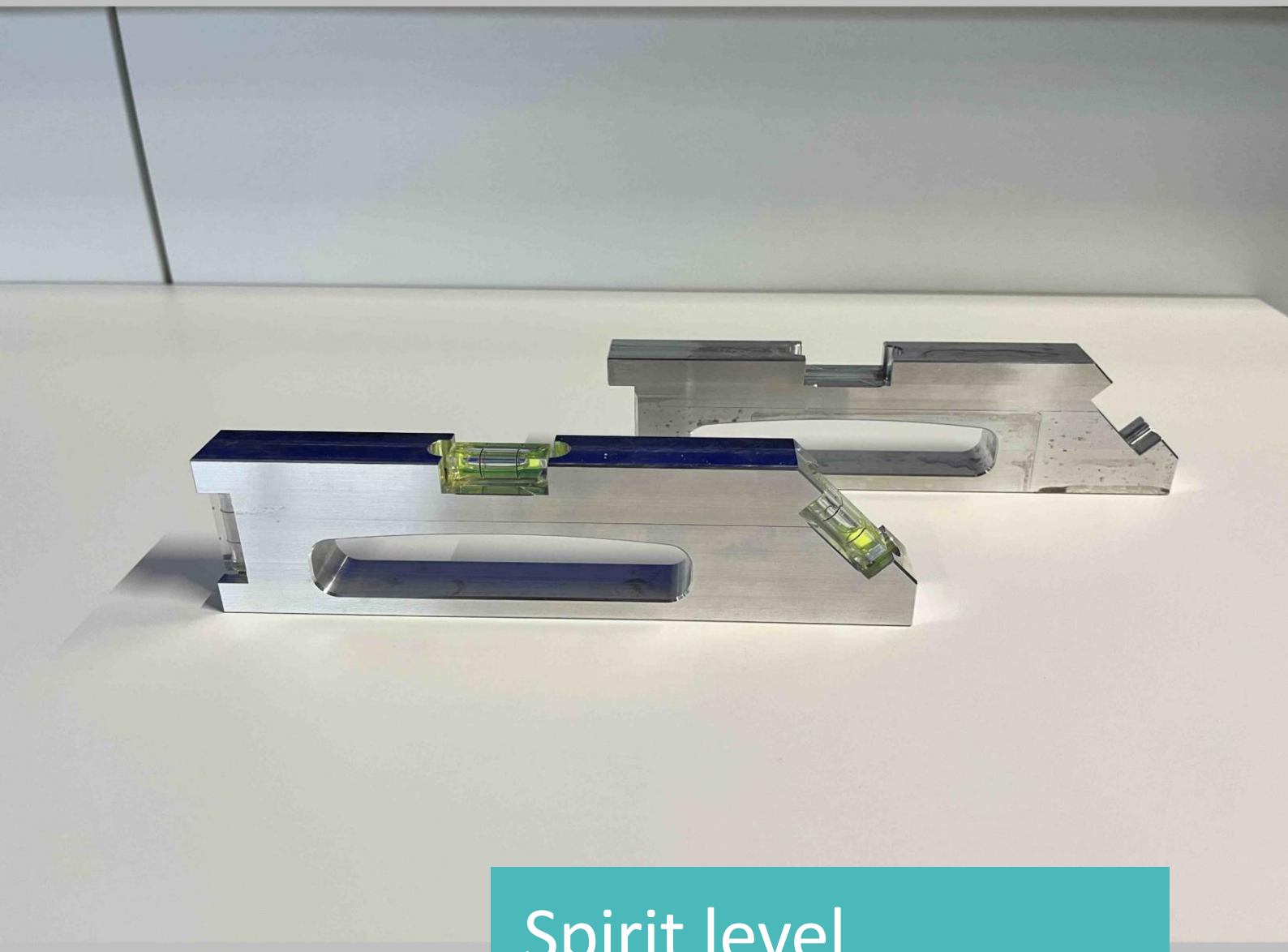
SIEMENS

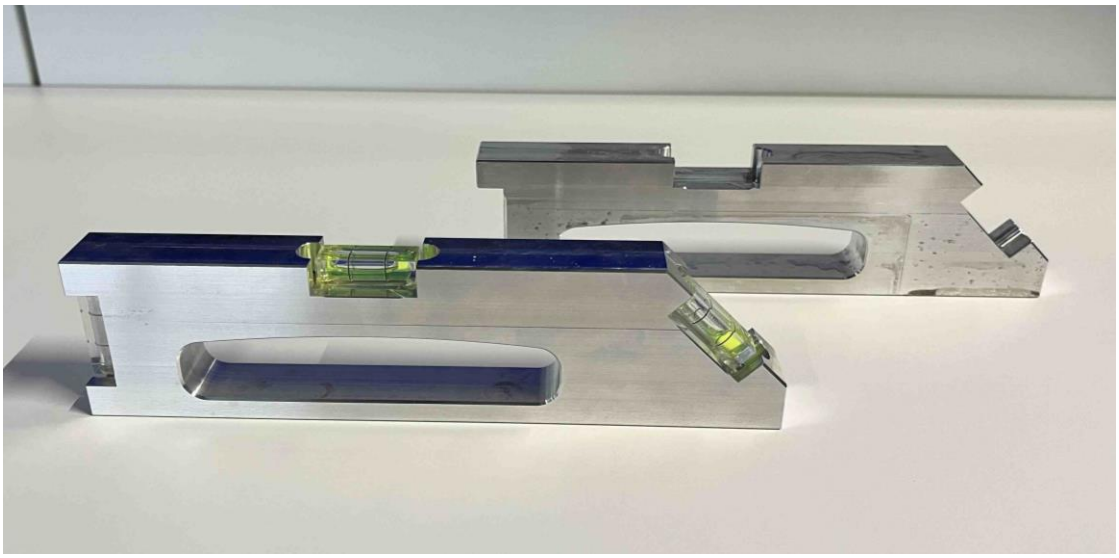


Spirit level

siemens.de/cnc4you

CNC4you "Spirit level" workpiece

The CNC4you "Spirit level" workpiece is a milled part that can be machined in multiple clamping operations or in several individual clamping operations, depending on the machine equipment.



Production scenario with multiple clamping operations

All the information required to machine the part is subsequently listed – such as tool data, machining plans and NC programs.

www.siemens.de/cnc4you

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1 Safety note

Handling machines involves dealing with a wide range of risks. This means that it is imperative that legal and the usual operational safety regulations are carefully complied with when fabricating the CNC4you spirit level.

2 Preliminary comments

The following description addresses technicians who are familiar with CNC machines and who have experience or know-how about SINUMERIK CNC control systems. All the technology data listed here correspond to the machines, tools, materials, machining plans and drawings used to craft this workpiece. When it comes to replication however, this only serves as an example because of the wide diversity of resources available in workshops. Having said that, in most cases, it should be possible to simply replicate this handy tool.

The program for the milled part was generated and tested on a 3+1-axis CNC milling machine. The machine was equipped with a SINUMERIK 828D with ShopMill. SINUMERIK Operate V4.95 was installed on the machine.

The workpiece was machined with multiple clamping operations: One clamping operation for machining the basic body, one clamping operation for machining the upper side and milling the recesses for the 3 mini bubble assemblies.

For working on 3-axis machines or the demonstration milling machine of the SinuTrain basic versions, the NC programs were modified to take into account several machining operations in six individual clamping operations. Here, a support body (with 45 degree inclination) is required, which users should fabricate themselves.

Generally, NC programs can be simply adapted to other SINUMERIK versions, for example, to other SINUMERIK Operate software releases. A simulation and necessary modifications should always be carried out – for example, the zero points rsp. workpiece offsets.

All CAD drawings, programs and machining descriptions for the workpieces can be downloaded at no charge from **www.siemens.de/cnc4you**. You can find the following files and formats for this nifty workpiece here:

- NC programs for machining with multiple clamping operations (3+1-axis machine)
- NC programs for machining with several individual operations (3-axis machine)
- Workpiece drawings and 3D data (as PDF or STL file)

3 Workpiece, blanks/bill of materials

- For the workpiece:

  An aluminum cuboid with dimensions 210 x 60 x 26 mm (hard aluminum is best)

- As support body when machining with six individual clamping operations:

  A block with 45° inclination made out of a suitable material; the size depends on the clamping fixture

  Purchased parts: 3 mini bubble spirit levels

  - Type "Taskar 28 mm mini screw-on bubble spirit levels"
  - 28 mm (39 mm) x 10 mm x 11 mm
  - With a square frame
  - Matching screws (generally) included in the scope of delivery.

  Can be purchased, for example, through amazon.com or GOHardware.co.uk; large quantities can also be purchased directly from taskar.co.uk

4 Machines and NC programs

CNC milling machine:

- Type: Mazak VTC-530-C 3-axis milling machine
- CNC: SINUMERIK 840D with ShopMill V 4.95

NC programs:

A) For machining with multiple clamping operations (3+1-axis milling machine)

- 00_START_ALL.MPF – main program for multiple clamping, calls the following programs:
- SP01_WW.MPF – clamping 1: Machining the basic body with grip pocket
- SP02_WW.MPF – clamping 2: Machining the face sides with stock removal for the mini bubble spirit level pockets with slot, chamfers, holes and thread cuts

Note:

- The NC programs for multiple clamping can also be executed on the Sinu-Train machine model "Vertical milling machine with swivel table" with the appropriate license. To do this, the retract positions in the swivel data set TC1 must be adapted, otherwise contour violations will occur during swivelling. Tested values for the free travel positions on this machine model are Z = 200, X = -100, Y = 100. The operating path for changing the swivel data set is "Machine/Setup/NC/Transformations/TC1.
  Please refer to the operating and installation manuals for SINUMERIK Operate and SinuTrain to find out how to set the required access level (e.g. here, chapter "Access levels").
- An alternative to changing the swivel data set is to use tools with a particularly short shank for the tools marked with *) in the tool list.

B) For machining on a 3-axis milling machine in six individual clamping operations (or for a Sinu-Train demonstration milling machine, no license necessary):

- SP01_WW1.MPF – Milling the basic body
- SP01_WW2.MPF – Milling the pocket for the grip with chamfer on one side
- SP01_WW3.MPF – Chamfer for the other side of the grip
- SP02_WW1.MPF – Machining the upper side of the workpiece and remaining machining of the sides
- SP02_WW2.MPF – Machining the 45° face side
- SP02_WW3.MPF – Machining the 90° face side
- SUB01_SP02.SPF – Subroutine for milling pockets and grooves, chamfers, holes and thread cuts for the individual mini bubble spirit levels

4.1 Subroutine calls – preparation possibly required

Error message "Program not found"

The NC programs use subroutine calls. If the called programs are not found during the preparatory program simulation or when executing the NC programs, copy the complete directory from the USB stick, the local drive or the network folder into the NC memory. Alternatively, you can also adapt the subroutine calls (to the EXTCALL or EES function).

Error message "Program not tested by ShopMill"

If the control system rejects the simulation or the execution of an NC program that has been called as it was not tested by ShopMill, then first load the program involved directly via the program manager and start it in the simulation.

5 Tools used

Tool/short name	Description
SHAFT_ALU_D6	End mill, 6 mm diameter *)
MILLING TOOL_D10	End mill, 10 mm diameter
ALU_D16	End mill, 16 mm diameter
VHM_D2.3	Drill bit, 2.3 mm diameter *)
STYLUS_D4	4 mm stylus or milling tool with 90 degree cutting edge angle *)
MILLING TOOL_10_VHM_4SN	10 mm milling tool, 4 cutting edges
THREAD_CUTTER_M2.5	Metric thread cutter, 2.5 mm *)
3D_PROBE	3D Measuring probe

*) See note on page 4

The tools are defined in the SPIRIT_LEVEL_TOOLS.INI file. After loading the tool list, the availability of all required tools can be checked using the TOOL_CHK.TTD program.

6 Fabricating the "Spirit level" workpiece

There are two NC program versions for this workpiece – a version for multiple clamping operations on a 3+1-axis milling machine and a version for 3-axis milling machines, which requires several individual clamping operations.

6.1 Machining on a 3+1-axis milling machine (multiple clamping operation)

6.1.1 Clamping situation

6.1.2 Machining sequence (3+1-axis milling machine)

- Preparation: Copy the NC programs to the NC memory of the machine (alternatively: adapt the subroutine calls)
  1. Approach the machine reference point.
  2. Read-in the machining plan: 00_START_ALL.MPF
  3. If you have not already done so: Read-in the tool list SPIRIT_LEVEL_TOOLS.INI
  4. If you have not already done so: Measure the tools, enter in the tool list.
  5. If you have not already done so: Insert the tools in the magazine.
  6. Attach the clamping fixtures.
  7. Using the clamping fixtures, clamp the blank for the first clamping operation.
  8. Set the workpiece zero by scratching, for example
  9. Check the work offsets programmed in the part program and if necessary appropriately adapt to the specific machine configuration.
  10. Perform the simulation. Watch out for collisions and check for contour violations. Make any necessary corrections until the simulation runs without errors.
  11. Start machining, execute the machining plan for the first run with air cuts over the empty 2nd clamping.
  12. Insert workpiece for machining the rear side in the 2nd clamping, clamp the new blank for the next workpiece in clamping 1.
  13. Repeat steps 11 and 12 until the required number of workpieces have been fabricated; for the last blank, with air cuts over the first clamping.

6.1.3 Sequence of NC program SP01_WW.MPF

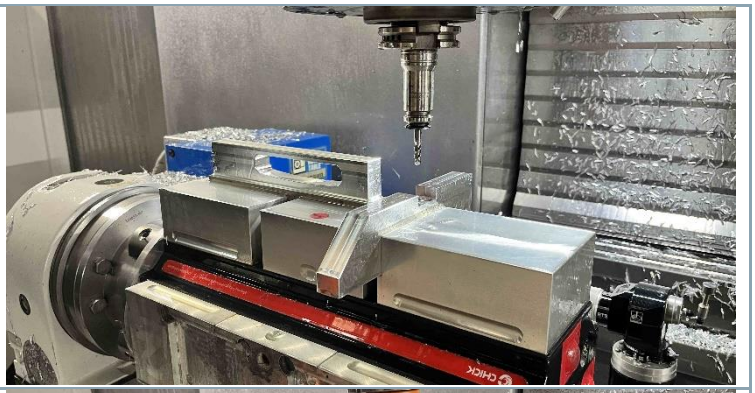
In clamping 1 of the multiple clamping, NC program SP01_WW.MPF machines the lower side of the workpiece and the part of the sides that can be accessed here (top surface, grip pocket). It is called from NC program 00_START_ALL.MPF.

Machining step	Photograph
Machining starts with the lower side of the basic spirit level body in clamping 1 (shown in the photograph to the left)	
The lower side of the workpiece is machined and the accessible parts of the workpiece sides	
Workpiece is swiveled through 90 degrees, the grip pocket is then milled and one side of the grip pocket chamfered	
Workpiece is swiveled to the opposite side, the rear side of the grip pocket is chamfered (in the photograph on the rear side of the clamping fixture, workpiece is not visible)	
Workpiece is swiveled to the initial position	

6.1.4 Sequence of NC program SP02_WW.MPF

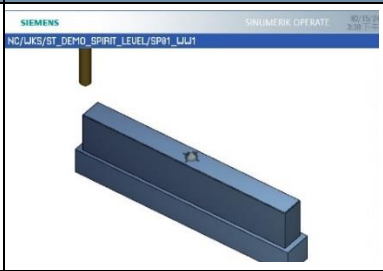
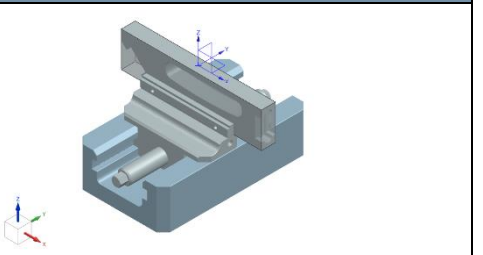
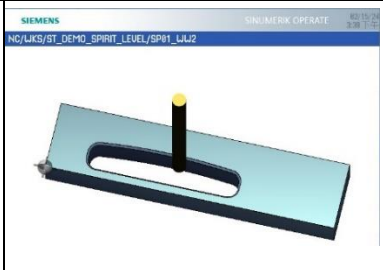
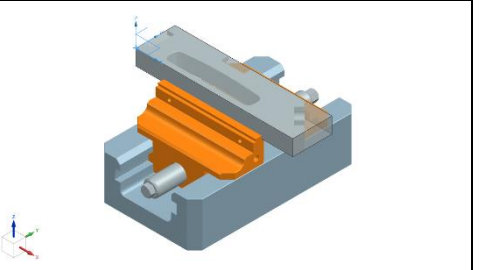
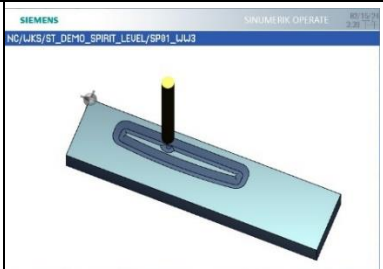
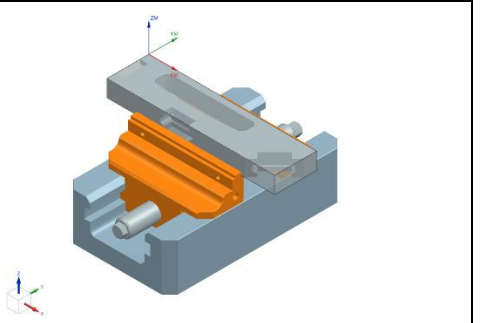
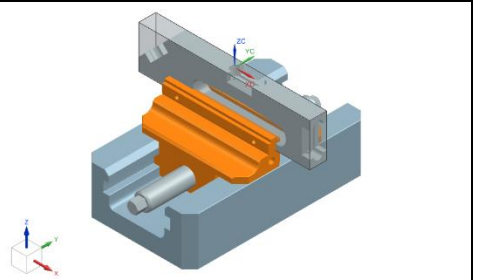
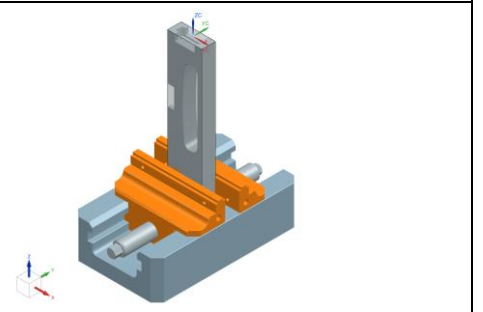
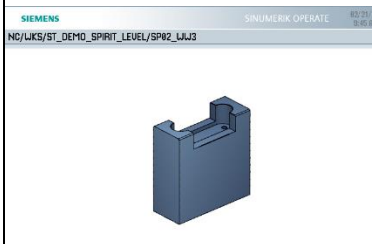
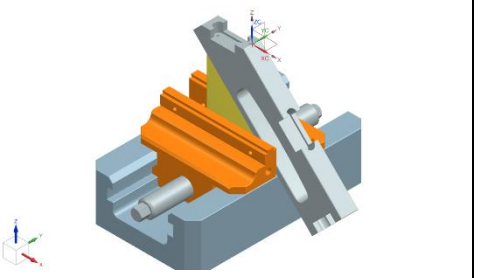
In clamping 2 of the multiple clamping, NC program SP02_WW.MPF machines the upper side of the workpiece and the face sides. The block with 45-degree inclination is milled and the recesses and fixing holes for the individual mini bubble spirit levels machined. The program is called from NC program 00_START_ALL.MPF.

Machining step	Photograph
Using the measuring probes, the precise position of the workpiece in the 2nd clamping (shown to the right in the photograph) is determined and the visible overhang from the first clamping operation removed (milled) until the final dimensions of the basic workpiece body are reached.	
The workpiece is swiveled through 45 degrees, the 45-degree inclination of the spirit level is chamfered.	
The mini bubble spirit level pocket is milled on this surface.	
The workpiece is swiveled into the 90-degree position and the mini bubble spirit level pocket milled on this surface.	

The workpiece is swiveled into the initial position and the upper mini bubble spirit level pocket milled.	
The workpiece is swiveled several times for drilling and cutting the threads for the fixing holes for the three mini bubble spirit levels of the complete spirit level.	
Machining has been completed with the workpiece clamping in the initial position. The finished workpiece is taken from the second clamping. The partially machined workpiece is then transferred from the first to the second clamping.	

6.2 Machining on a 3-axis milling machine (individual clamping, SinuTrain)

6.2.1 Overview of the NC programs and the clamping situation for 3-axis machines

NC program	Simulation	Clamping situation
SP01_WW1.MPF Machining the outer contour of the lower workpiece section		
SP01_WW2.MPF Milling the grip pocket and chamfering on one side		
SP01_WW3.MPF Milling the rear side of the grip pocket		
SP02_WW1.MPF Milling the upper side and top edges, machining the recess and the mounting holes for the 1st mini bubble spirit level (subroutine call)		
SP02_WW2.MPF Machining the 90-degree face side, the recess as well as the mounting points for the 2nd mini bubble spirit level (subroutine call)		
SP02_WW3.MPF Machining the 45-degree face side, recess as well as the mounting points for the 3rd mini bubble spirit level (subroutine call)		
SUB01_SP02.MPF	Subroutine to machine recesses and mounting holes for the mini bubble spirit levels (pocket milling, drilling, thread cuts, chamfers)	

6.2.2 Machining sequence (3-axis milling machine, SinuTrain)

- Preparation: Copy the NC programs to the NC memory of the machine (alternatively: adapt the subroutine calls)

1. Approach the machine reference point.
2. Read-in the machining plan: SP01_WW1.MPF
3. If you have not already done so: Read-in the tool list SPIRIT_LEVEL_TOOLS.INI
4. If you have not already done so: Measure the tools, enter in the tool list.
5. If you have not already done so: Insert the tools in the magazine.
6. Attach the clamping fixture.
7. Clamp the blank.
8. Set the workpiece zero by scratching.
9. Check the work offsets programmed in the part program and if necessary, appropriately adapt to the specific machine configuration.
10. Perform the simulation.
11. Start machining, execute the machining plan.
12. Prepare the workpiece for the next clamping (see Section 6.2.1), load the associated NC program.
13. Repeat steps 8 to 12 until all six clamping operations have been executed.

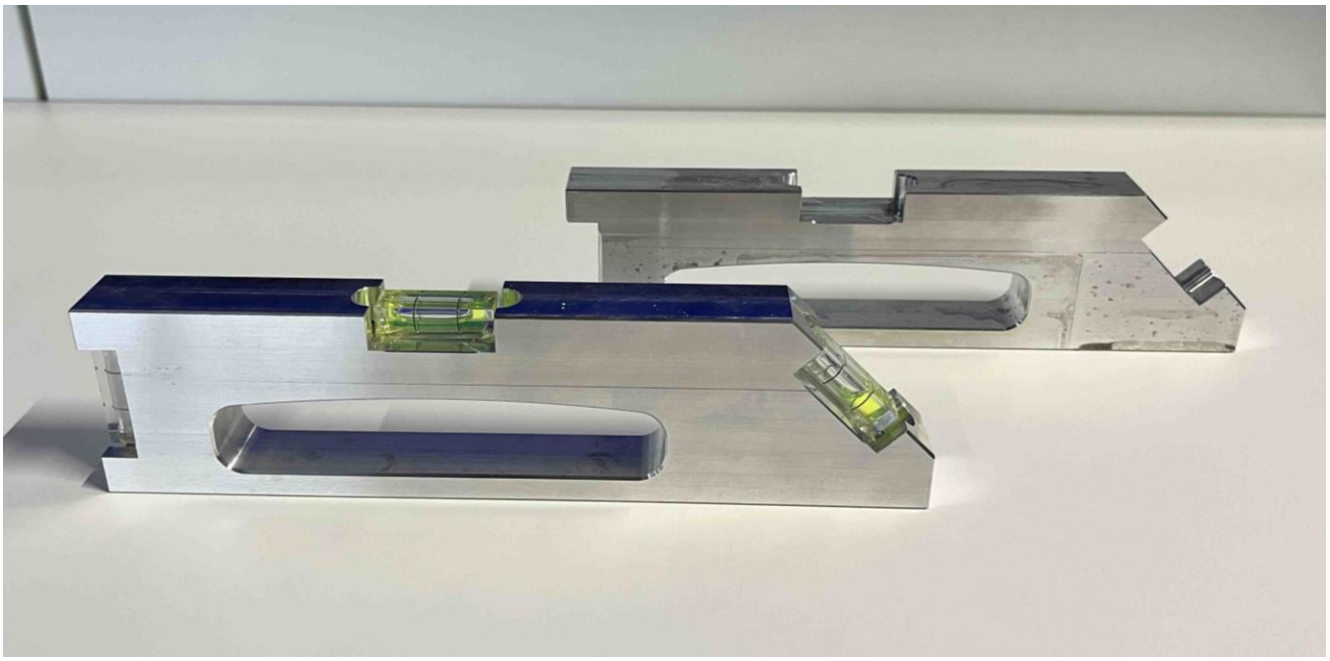
7 Notes relating to assembly and safety notes regarding the precision

- As specified by the manufacturer, install the purchased mini bubble spirit levels into the basic spirit level body that has been machined here.
- The precision that can be achieved with the fabricated spirit level depends on the quality and precision of the purchased mini bubble spirit levels, the accuracy with which they are mounted, the precision of the machine tool and measuring equipment used as well as precision and craftsmanship when clamping and measuring the workpiece zeros.
- As a consequence, the precision that can be achieved with the spirit level is the responsibility of the person that machines and assembles it.

7.1 Tip when it comes to testing the spirit level.

- Mark a point on a vertical surface.
- From this point, using the spirit level and the mini bubble spirit level draw a horizontal thin line on the vertical surface.
- Interchange the left and right sides of the spirit level and draw a thin horizontal line on the surface again from the same point (in the same direction).
- The precision of the spirit level is demonstrated if both lines precisely overlap one another. If the line drawn is thicker on one side, then the other side or if the two lines even form an identifiable acute angle, then this indicates a handling, machining or assembly fault.

To completely test your spirit level, repeat the test using vertical lines and 45-degree lines.



8 Information in the Internet

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Design of the parts, creation of the drawings,
Development of NC programs and the machining plans

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