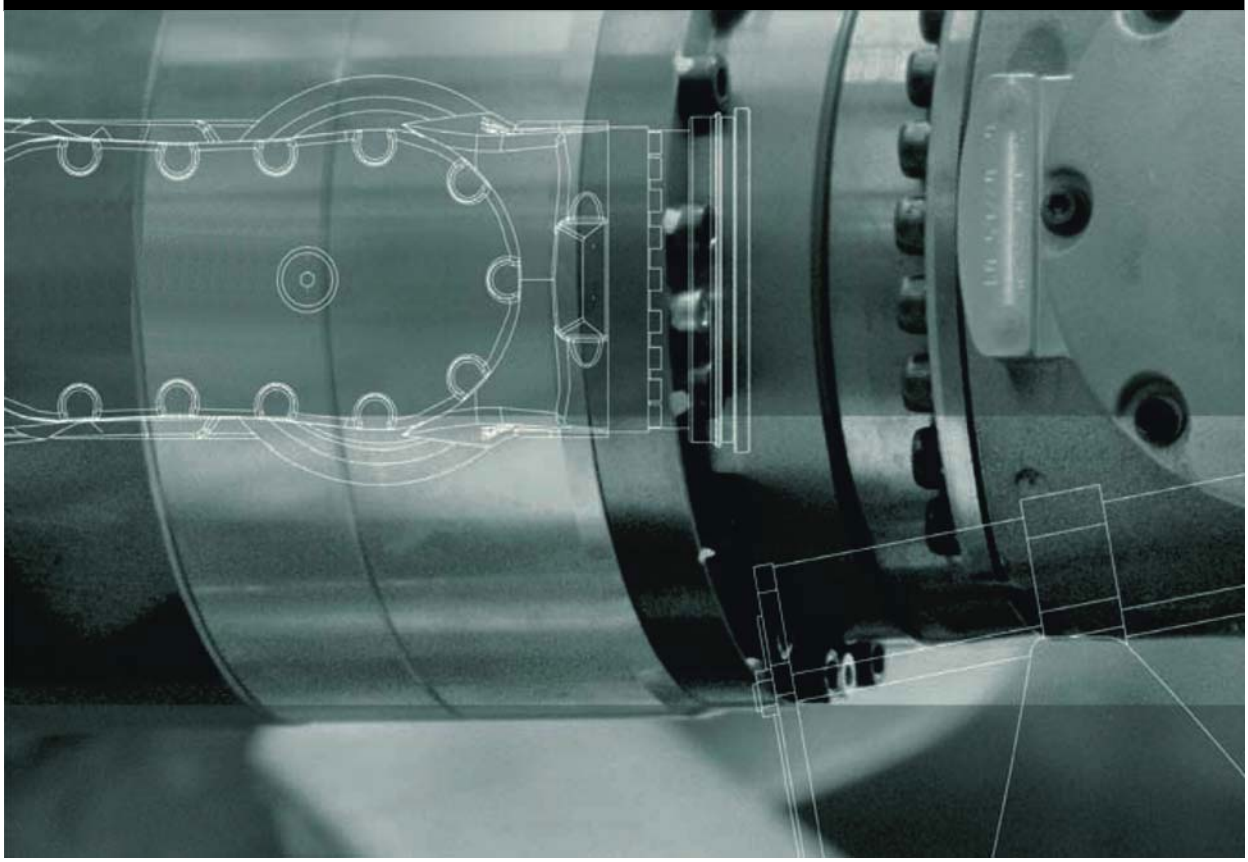
KUKA

KUKA System Technology

KUKA Roboter GmbH

KUKA.SeamTech Finding 2.0

For KUKA System Software 8.2



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Other functions not described in this documentation may be operable in the controller. The user has no claims to these functions, however, in the case of a replacement or service work.

We have checked the content of this documentation for conformity with the hardware and software described. Nevertheless, discrepancies cannot be precluded, for which reason we are not able to guarantee total conformity. The information in this documentation is checked on a regular basis, however, and necessary corrections will be incorporated in the subsequent edition.

Subject to technical alterations without an effect on the function.

Translation of the original documentation

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Contents

1 Introduction

1.1 Target group

This documentation is aimed at users with the following knowledge and skills:

- Advanced KRL programming skills
- Advanced knowledge of the robot controller system
- Advanced knowledge of the sensor controller system

1.2 Industrial robot documentation

The industrial robot documentation consists of the following parts:

- Documentation for the manipulator
- Documentation for the robot controller
- Operating and programming instructions for the control software
- Instructions for options and accessories
- Parts catalog on storage medium

Each of these sets of instructions is a separate document.

1.3 Representation of warnings and notes

Safety

These warnings are relevant to safety and **must** be observed.

DANGER	These warnings mean that it is certain or highly probable that death or severe injuries **will** occur, if no precautions are taken.
WARNING	These warnings mean that death or severe injuries **may** occur, if no precautions are taken.
CAUTION	These warnings mean that minor injuries **may** occur, if no precautions are taken.
NOTICE	These warnings mean that damage to property **may** occur, if no precautions are taken.
	These warnings contain references to safety-relevant information or general safety measures. These warnings do not refer to individual hazards or individual precautionary measures.

This warning draws attention to procedures which serve to prevent or remedy emergencies or malfunctions:

SAFETY INSTRUCTIONS	Procedures marked with this warning **must** be followed exactly.

Notes

These hints serve to make your work easier or contain references to further information.

	Tip to make your work easier or reference to further information.

1.4 Trademarks

WeldCom is a trademark of Servo-Robot.

1.5 Terms used

Term	Description
CD*x*	Information determined by the sensor during measurement of the workpiece position. The number of CD*x* data determined (maximum of 4) depends on the selected joint type. (>>> 9.1 "Overview of joint types" Page 75) The sensor determines the CD*x* data at defined positions and not at random points. The user needs to know these positions because in the correction instructions he has to select those CD*x* data that have measured the offset of the workpiece. (These are usually not all the CD*x* data of a measurement.) (>>> 2.3 "Principle of feature determination" Page 8) Name in the inline form: **CDa**, **CDb**, **CDc**, **CDd**
Dimension	Number of CD*x* data of a joint type
Feature	Set of all CD*x* data determined by the sensor during a measurement. The number of data (maximum of 4) depends on the selected joint type. Default name in the inline form: **ATTR***x*.
Joint type	Characteristic form (seam shape, sheet edge, punched hole, …) to be detected by the sensor on the workpiece. In this documentation, the characteristic form is generally referred to as the “joint type”. The joint type to be detected by the sensor is selected by the user in the measuring instruction. In WorkVisual, numerous joint types are available for configuration of the tasks.
Optical reference frame	A sensor-specific coordinate system. It is independent of the coordinate systems of the robot controller and cannot be modified by the user.
Reference workpiece	Workpiece for which the path was originally taught
Sensor coordinate system	The sensor is calibrated as a tool. It is assigned a coordinate system in the process. This is the sensor coordinate system. ■ If the sensor is installed on the mounting flange: The sensor coordinate system is a TOOL coordinate system. ■ If the sensor is a fixed tool: The sensor coordinate system is a BASE coordinate system.
Tracking point	Point to which the sensor refers during measurement of a joint type. It can be displayed and altered in the WeldCom software. The tracking point is not programmed or processed in a KRL program and is not addressed by the robot.

2 Product description

2.1 Overview of SeamTech Finding

Functional principle

With applications that require a high degree of precision, it is often necessary for the original path to be corrected in order to compensate for deviations in the shape or position of workpieces. SeamTech Finding offers this option.

For this purpose, a sensor measures the position of the reference workpiece. This is done by means of measuring instructions programmed by the user via inline forms.

The positions of the other workpieces are measured by the sensor in the same way. A search can also be performed before the measurement. This enables workpieces to be measured even if they are no longer located in the original field of view of the sensor.

The robot controller adapts the path to the position of the current workpiece. This is done by means of correction instructions likewise programmed by the user via inline forms.

Each measurement contains several items of information on the position of the workpiece. When programming the correction instructions, the user selects those items of information with which the robot controller can calculate the differences between the reference workpiece and the current workpiece. On the basis of this calculation, the robot controller adapts the path to the current workpiece.

Areas of application

SeamTech Finding supports the following systems:

- Sensor controllers supplied by SERVO-ROBOT

If systems from other manufacturers are to be used, please contact KUKA Roboter GmbH.
If SeamTech Finding is to be implemented together with the RoboTeam technology package, KUKA Roboter GmbH must likewise be consulted.
(>>> 10 "KUKA Service" Page 83)

WorkVisual

The following software is required for configuring sensors and joint types:

- WorkVisual 3.0

2.2 Principle of position measurement

Measuring instruction

The measuring instructions are programmed by the user via inline forms. For this purpose he selects a characteristic form on the workpiece (seam shape, sheet edge, punched hole, …) that is to be detected by the sensor. In this documentation, the characteristic form is generally referred to as the “joint type”.

A measuring instruction is also a motion instruction (PTP, LIN, CIRC, SLIN or SCIRC). At the end point of this motion, the sensor can measure the position of the workpiece, or a search can be performed from there first.

A search is necessary if the workpiece might possibly be displaced to the extent that it is no longer in the field of view of the sensor at the end point. The user specifies in the inline form whether a search is to be performed. If yes, he also defines the direction and maximum length of the search motion and additional properties of the search.

Sequence

Messages are additionally displayed during the sequence depending on the operating mode.

Sequence of a measurement without a search:

1. The robot moves to the end point.
2. The robot stops at the end point and the sensor performs a measurement.
   - If the sensor supplies measurements that match the selected joint type, the robot continues the program.
   - If the sensor does not supply measurements that match the selected joint type, the measurement is automatically repeated the number of times defined in the configuration (as long as errors still occur).

     When the automatic repetitions are completed, a dialog message is displayed in T1 and T2 modes, allowing the user to repeat the measurement. In AUT and AUT EXT modes, either a dialog message, a notification message or an acknowledgement message is displayed. (This depends on the response defined in the configuration.)

Sequence of a measurement with a search:

1. The robot moves to the end point. The end point cannot be approximated.
2. This is where the search is started: The robot moves in the defined direction.
   - If the sensor supplies measurements (within the defined search distance) that match the selected joint type, the robot stops. It then returns to the start point of the search, from where it continues the program.
   - If the sensor does not supply measurements that match the selected joint type, the robot stops after the defined search distance. It then returns to the start point of the search.

     The search is automatically repeated the number of times defined in the configuration (as long as errors still occur).

     When the automatic repetitions are completed, a dialog message is displayed in T1 and T2 modes, allowing the user to repeat the measurement. In AUT and AUT EXT modes, either a dialog message, a notification message or an acknowledgement message is displayed. (This depends on the response defined in the configuration.)

2.3 Principle of feature determination

Feature

The sensor determines a “feature” in each measurement. This contains up to 4 items of information on the position of the workpiece. The items of information are called “CDa”, “CDb”, “CDc” and “CDd”, or “CD*x*” in general. The actual number of CD*x* data depends on the joint type.

The CD*x* data refer to the sensor coordinate system and the tracking point.

Tracking point

The measurements of the sensor are referred to the so-called tracking point of the joint type. The position of the tracking point can be displayed and altered in the WeldCom software. (The tracking point is not programmed or processed in a KRL program and is not addressed by the robot.)

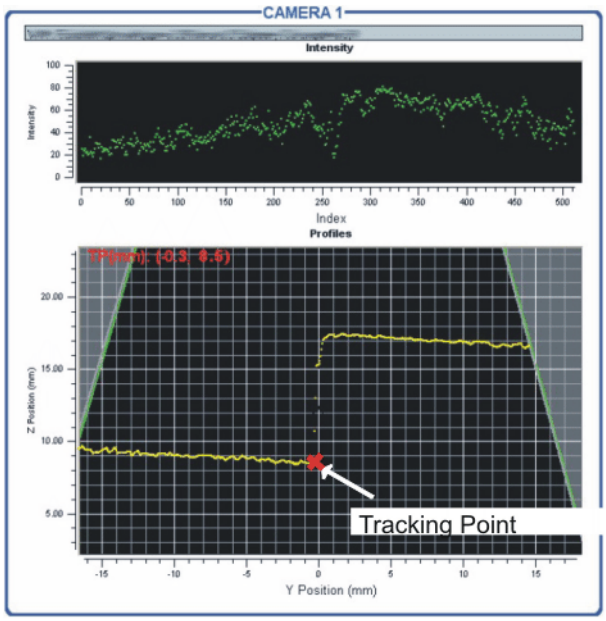

Fig. 2-1: Example: Representation of a lap joint in WeldCom

Overview of the joint types, with recommended positions for the tracking points: (>>> 9.1 "Overview of joint types" Page 75).

CD*x*

The user needs to know the CD*x* positions. The reason for this is that when programming the correction instructions he has to select those CD*x* data that are required for calculating the change in position of the workpiece. (These are usually not all the CD*x* data of a measurement.)

(>>> 9.4 "Sensor coordinate systems" Page 80)

CD*x*	Characteristics
CDa	■ Runs parallel to the Z axis of the sensor coordinate system. ■ Runs as far as the tracking point. CDa is always determined.
CDb	■ Runs parallel to the Z axis of the sensor coordinate system; on the positive side of the Y axis. ■ Runs as far as the extension of the more or less horizontal plane (from the point of view of the sensor) in which the tracking point is located. CDb is determined for joint types with 2 or more CD*x* data.
CDc	■ Runs parallel to the Y axis of the sensor coordinate system. ■ Runs as far as the tracking point. ■ CDc meets CDa at a 90° angle. CDc is determined for joint types with 3 or 4 CD*x* data.
CDd	■ Runs parallel to the Y axis of the sensor coordinate system; on the positive side of the Z axis. ■ Always runs below CDc. ■ Runs as far as the extension of the more or less vertical plane (from the point of view of the sensor) in which the tracking point is located. CDb is determined for joint types with 4 CD*x* data.

2.3.1 Example: lap joint

This example shows how the sensor detects the position of a lap joint. A lap joint is a joint type with CDa to CDc.

The red star represents the tracking point.

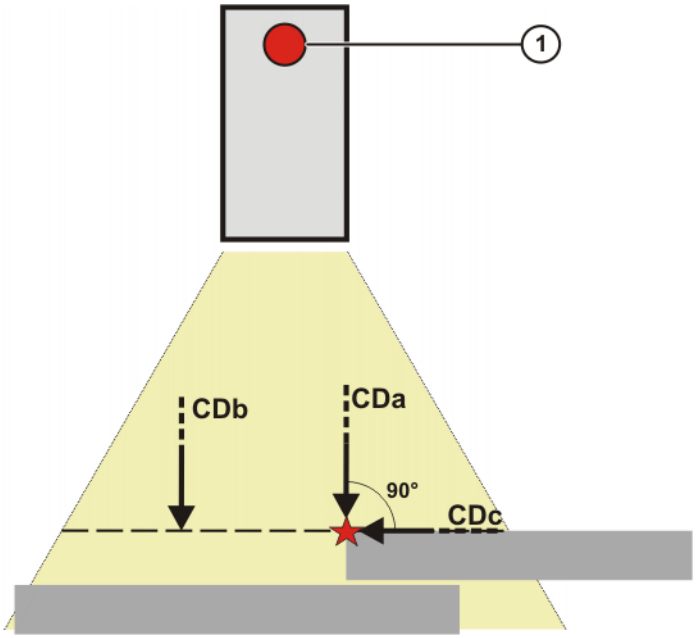

Fig. 2-2: Example A

1 Front view of the sensor with LED

In example A, CDc runs parallel not only to the Y axis of the sensor coordinate system but also to the plane in which the tracking point is located. (This is the case because this plane happens by chance also to be parallel to the Y axis.)

(>>> 9.4 "Sensor coordinate systems" Page 80)

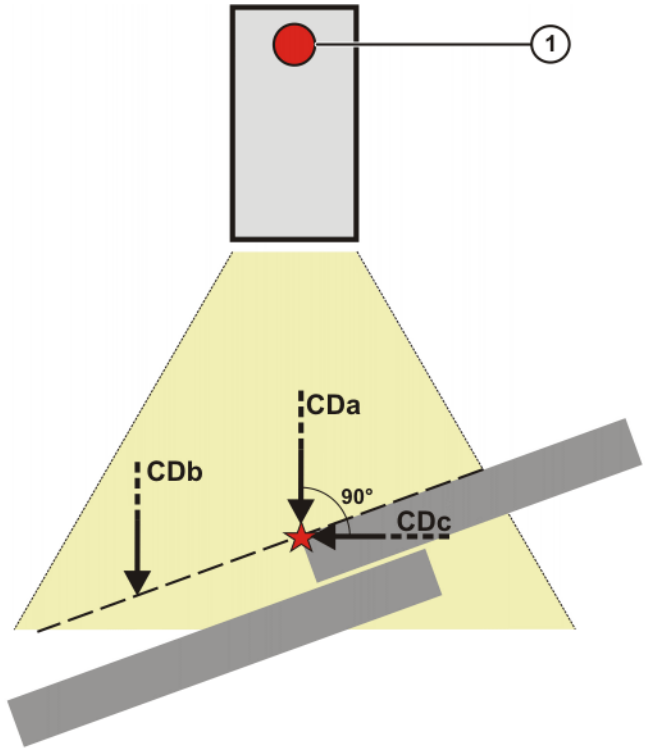

Fig. 2-3: Example B

1 Front view of the sensor with LED

2.3.2 Example: half V groove joint

This example shows how the sensor detects the position of a half V groove joint. A half V groove joint is a joint type with CDa to CDd.

The red star represents the tracking point.

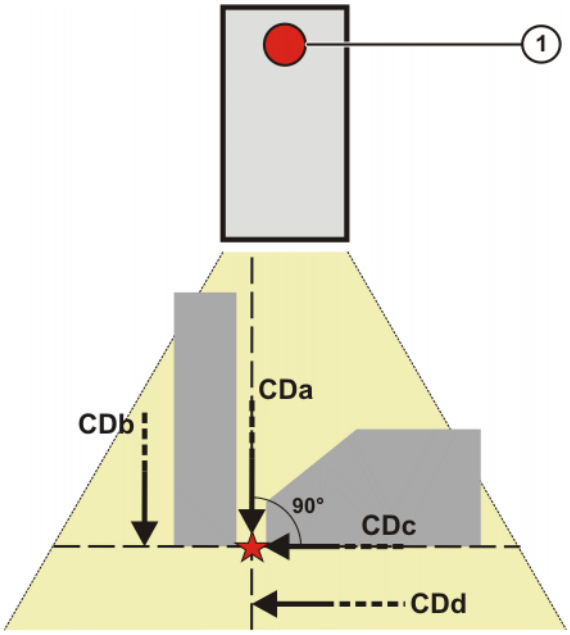

Fig. 2-4: Example A

1 Front view of the sensor with LED

In example A, CDc runs parallel not only to the Y axis of the sensor coordinate system but also to the plane in which the tracking point is located. (This is the case because this plane happens by chance also to be parallel to the Y axis.)

(>>> 9.4 "Sensor coordinate systems" Page 80)

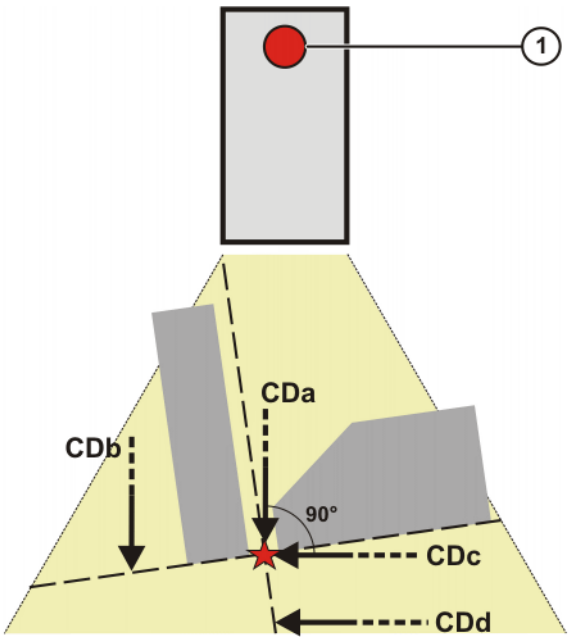

Fig. 2-5: Example B

1 Front view of the sensor with LED

2.4 Communication

2.4.1 SERVO-ROBOT sensors (types DIGI-I, PowerCam)

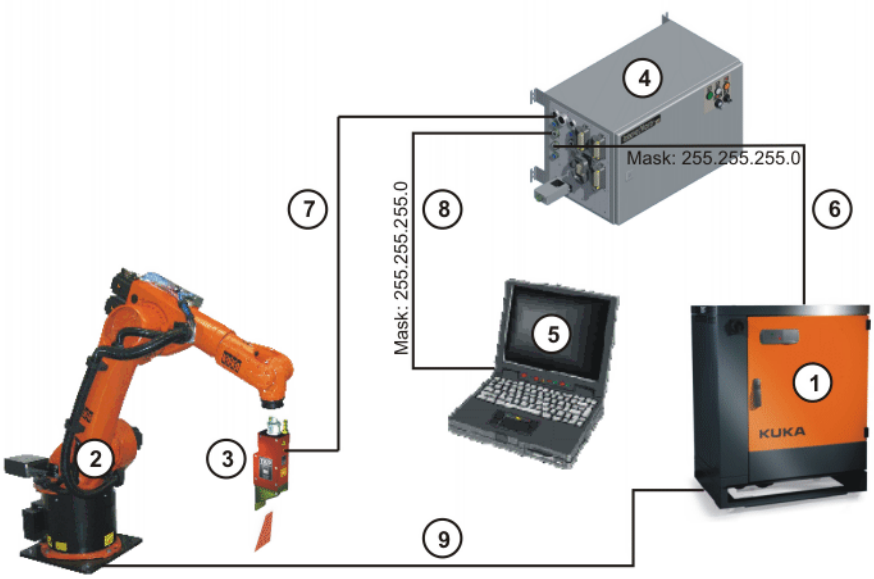

Fig. 2-6: Schematic overview

Item	Description
1	Robot controller; IP address: 192.168.2.x The IP address must be entered in the **Network configuration** window. Recommendation: enter 192.168.2.10. (Not allowed: 192.168.2.3, as this is already preassigned to the sensor controller.)
2	Robot
3	Sensor
4	Sensor controller; default IP address: 192.168.2.3 If a different IP address is required, it must be entered at the following locations: ■ In the SeamTechFinding Editor in WorkVisual ■ On the sensor itself. Information on this can be found in the documentation of the sensor manufacturer. Robot port: connector: CN6 User port: connector: CN5
5	External PC with WeldCom software; IP address: 192.168.3.x The IP address must be entered in the WeldCom software. (But no address that is already used may be entered.)
6	TCP/IP connection between the robot controller and the robot port of the sensor controller (TCP/IP-CAT5)
7	Connection between the sensor controller and the sensor; measuring cable, max. 40 m
8	TCP/IP connection between the external PC and the the user port of the sensor controller
9	Connection between the robot controller and the robot

2.4.2 SERVO-ROBOT sensors (type SF/D)

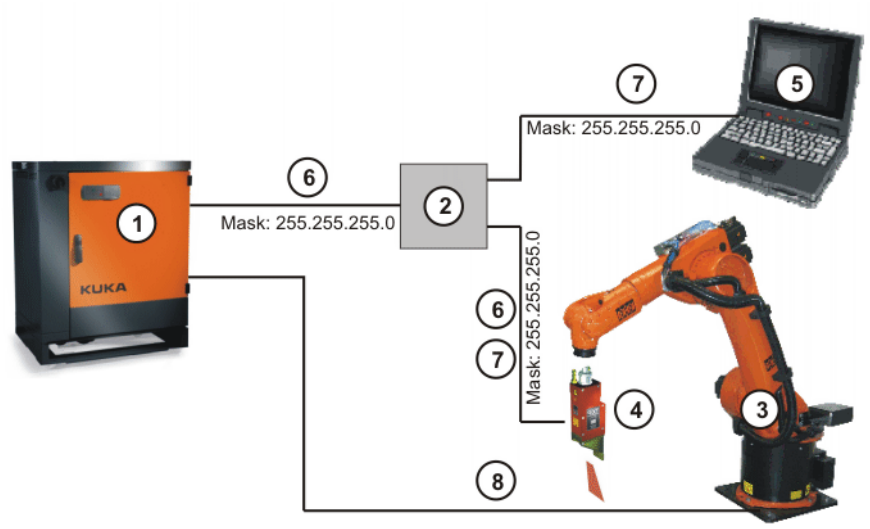

Fig. 2-7: Schematic overview

Item	Description
1	Robot controller; IP address: 192.168.5.x The IP address must be entered in the **Network configuration** window. Recommendation: enter 192.168.5.10. (Not allowed: 192.168.5.3, as this is already preassigned to the sensor.)
2	Switch The switch makes it possible to access the ports of the sensor from various devices (robot controller, external PC).
3	Robot
4	Sensor; default IP address: 192.168.5.3 If a different IP address is required, it must be entered at the following locations: ■ In the SeamTechFinding Editor in WorkVisual ■ On the sensor itself. Information on this can be found in the documentation of the sensor manufacturer. Ports on the sensor: ■ For connection to the external PC (see item 7): 10001 ■ For connection to the robot controller (see item 6): 10002
5	External PC with WeldCom software; IP address: 192.168.5.x The IP address must be entered in the WeldCom software. (But no address that is already used may be entered.)
6	TCP/IP connection between the robot controller and the sensor
7	TCP/IP connection between the sensor and the external PC
8	Connection between the robot controller and the robot

3 Safety

This documentation contains safety instructions which refer specifically to the software described here.

The fundamental safety information for the industrial robot can be found in the “Safety” chapter of the Operating and Programming Instructions for System Integrators or the Operating and Programming Instructions for End Users.

The “Safety” chapter in the operating and programming instructions of the KUKA System Software (KSS) must be observed. Death to persons, severe injuries or considerable damage to property may otherwise result.

The safety standards must be observed when working with the laser. Injuries may otherwise result. For further information and specification of the laser class, please refer to the documentation of the laser manufacturer.

Incorrect operation of the laser can cause injuries. The laser must be properly operated. Information on operator control can be found in the documentation of the laser manufacturer.

4 Installation

After initial installation, it is not yet possible to use the inline forms. To complete the installation of SeamTech Finding, a WorkVisual project with the configuration of the sensor must be transferred to the robot controller. (>>> 6.5 "Configure the sensor with WorkVisual" Page 28)

4.1 System requirements

Robot controller

Hardware:

- KR C4

Software:

- KUKA System Software 8.2
- KUKA.Ethernet KRL 2.1

Laptop/PC

Software:

- WorkVisual 3.0

  The requirements for installation of WorkVisual are contained in the WorkVisual documentation.

4.2 Installing or updating SeamTech Finding

It is advisable to archive all relevant data before updating a software package.

Preparation

- Copy software from CD to KUKA USB stick.

  The software must be copied onto the stick with the file Setup.exe at the highest level (i.e. not in a folder).

NOTICE Recommendation: Use a KUKA stick. Data may be lost if any other stick is used.

Precondition

- "Expert" user group

Procedure

1. Connect the USB stick to the robot controller or smartPAD.
2. In the main menu, select **Start-up** > **Additional software**.
3. Press **New software**. The entry **SeamTechFinding** must be displayed in the **Name** column and drive **E:** or **K:** in the **Path** column.

   If not, press **Refresh**.
4. If the specified entries are now displayed, continue with step 5.

   If not, the drive from which the software is being installed must be configured first:
   - Press the **Configuration** button. A new window opens.
   - Select a line in the **Installation paths for options** area.

     Note: If the line already contains a path, this path will be overwritten.
   - Press **Browse**. The available drives are displayed.
   - Select **E:**. (If stick connected to the robot controller.)

     Or select **K:**. (If stick connected to the smartPAD.)
   - Press **Save**. The window closes again.

   The drive only needs to be configured once and then remains saved for further installations.

5. Mark the entry **SeamTechFinding** and click on **Install**. Answer the request for confirmation with **Yes**.
6. Confirm the reboot prompt with **OK**.
7. Remove the stick.
8. Reboot the robot controller.

LOG file A LOG file is created under C:\KRC\ROBOTER\LOG.

4.3 Uninstalling SeamTech Finding

It is advisable to archive all relevant data before uninstalling a software package.

Precondition

- "Expert" user group

Procedure

1. In the main menu, select **Start-up** > **Additional software**. All additional programs installed are displayed.
2. Mark the entry **SeamTechFinding** and click on **Uninstall**. Reply to the request for confirmation with **Yes**. Uninstallation is prepared.
3. Reboot the robot controller. Uninstallation is resumed and completed.

LOG file A LOG file is created under C:\KRC\ROBOTER\LOG.

5 Operation

5.1 Menus

The following menus and commands are specific to this technology package:

Main menu:

- **Configuration** > **Status keys** > **SeamTech Finding**

Menu sequence **Commands** > **SeamTech Finding**

- Initialize sensor
- Measurement
- Correction in base system
- Correction in search direction
- Correction freely programmable
- Switch off correction
- Load and enable correction
- Reset sensor
- Calibration (check)
- Check position correction

5.2 Status keys

Procedure

Displaying the status keys:

- In the main menu, select **Configuration** > **Status keys** > **SeamTech Finding**.

Description

The status keys are only available if the following conditions are met:

- “Expert” user group
- Operating mode T1 or T2

Status key	Description
	The process is activated. Correction is not active. Pressing the status key deactivates the process. If the process is activated, the SeamTech Finding commands are passed through, but not executed. **Note**: Since no measurement or correction is performed, it is possible for the sensor to collide with the workpiece.
	The process is deactivated. Correction is not active. Pressing the status key activates the process.
	The process is activated. Correction is active. Pressing the status key deactivates the process.
	The process is deactivated. Correction is active. Pressing the status key activates the process.
	Pressing the status key activates or deactivates the sensor light. **Note**: It may take up to 5 seconds before the sensor light is activated.

Status key	Description
	No reference run is carried out. Pressing the status key activates the reference run. This is then performed for every measurement, starting from the next measurement. During a reference run, the reference coordinates are determined again and the previous reference coordinates are overwritten. **Note**: If the position of the reference piece is incorrect, subsequent corrections will be based on incorrect coordinates, which can result in collisions.
	A reference run is carried out. Pressing the status key deactivates the reference run.

6 Start-up and configuration

6.1 Overview

Step	Description
1	Install and configure the sensor controller. This includes in particular: ■ Load and optimize the XML file with the characteristics of the calibration plate in the WeldCom software. The XML file is located on the CD in the directory …DOC\ServoRobot. Instructions for loading are located in the same directory. For SERVO-ROBOT sensors; types DIGI-I, PowerCam: task no. 255 For SERVO-ROBOT sensors; type SF/D: task no. 39 **Note:** Not necessary if a sensor is used that cannot be calibrated semi-automatically (e.g. a fixed sensor). ■ Adapt the numbers of the joint types in the joint type tasks to those in SeamTech Finding. Numbers in SeamTech Finding: (>>> 6.5.3 "Creating a new joint type" Page 32) ■ If the joint type “Melt run” is to be used: For this type, the WeldCom software places the tracking point by default at the edge of the field of view of the sensor. This results in an error message. Therefore shift the tracking point in WeldCom into the center of the field of view. **Note:** Information on installing and configuring the sensor controller can be found in the documentation of the sensor manufacturer.
2	If required: Create new seam types. (>>> 6.5.3 "Creating a new joint type" Page 32)
3	Calibrate the tool (e.g. welding torch or adhesive nozzle).
4	Calibrate the base. Calibrate the workpiece as a base if possible.
5	Calibrate the calibration plate as a further base. (>>> 6.2 "Calibrating the calibration plate" Page 21) **Note:** Not necessary if a sensor is used that cannot be calibrated semi-automatically (e.g. a fixed sensor).
6	Calibrating the sensor (>>> 6.3 "Calibrating the sensor semi-automatically" Page 23)
7	If a sensor is used that could not be calibrated semi-automatically (e.g. a fixed sensor): Activate the parameter **Sensor calibrated**. (>>> 6.6.1 "“General settings” tab" Page 34)
8	Configure the sensor with WorkVisual (>>> 6.5 "Configure the sensor with WorkVisual" Page 28)
9	Configure SeamTech Finding (>>> 6.6 "Configuring SeamTech Finding" Page 33)

6.2 Calibrating the calibration plate

The calibration plate does not have to be calibrated if a sensor is used that cannot be calibrated semi-automatically (e.g. a fixed sensor).

Safety

NOTICE It must be ensured that the tool (e.g. welding torch) does not collide with the calibration plate. Damage to property may otherwise result.

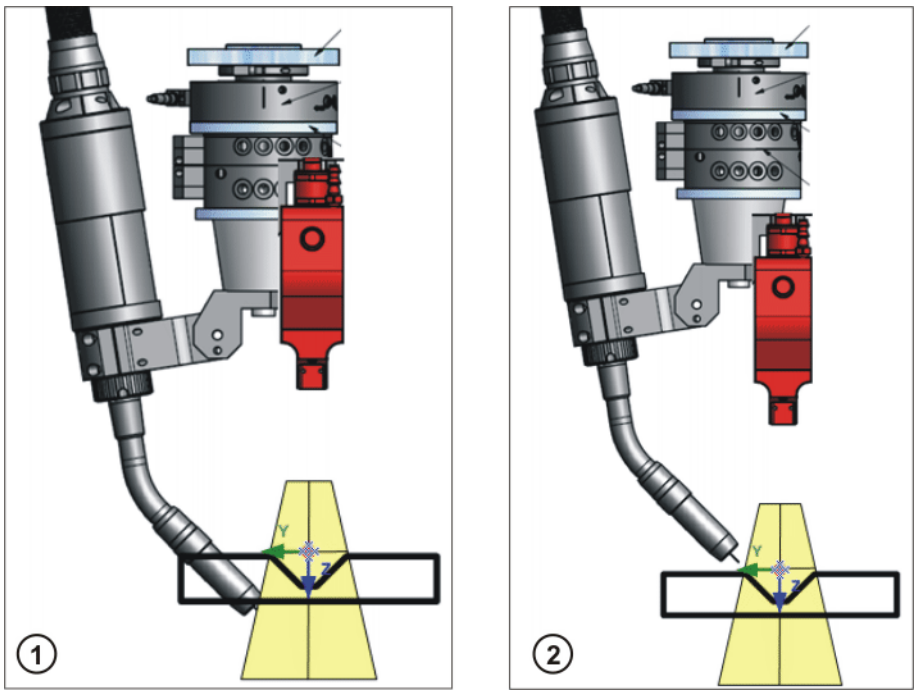

Fig. 6-1: Tool and calibration plate

Item	Description
1	WRONG – tool collides with calibration plate.
2	CORRECT – tool does not touch calibration plate.

Preparation

- Mount the calibration plate securely in the robot's work envelope. Recommendation: use dowel pins.
  (>>> 9.2 "Dimensions of the calibration plate" Page 77)
  Choose a place where the plate is protected from dust, dirt and strong light.

Precondition

- A previously calibrated tool is mounted on the mounting flange.
- Operating mode T1 or T2

Procedure

- Calibrate the calibration plate as a base using the 3-point method.
  - The origin of the coordinate system must be located at the predefined point.
  - The X axis runs along the long side.
  - The Y axis runs along the short side.

For calibration, the user selects a number under which the BASE coordinate system is to be saved. This number must be entered in WorkVisual under **Base number for calibration plate** on the **Calibration** tab.

Description

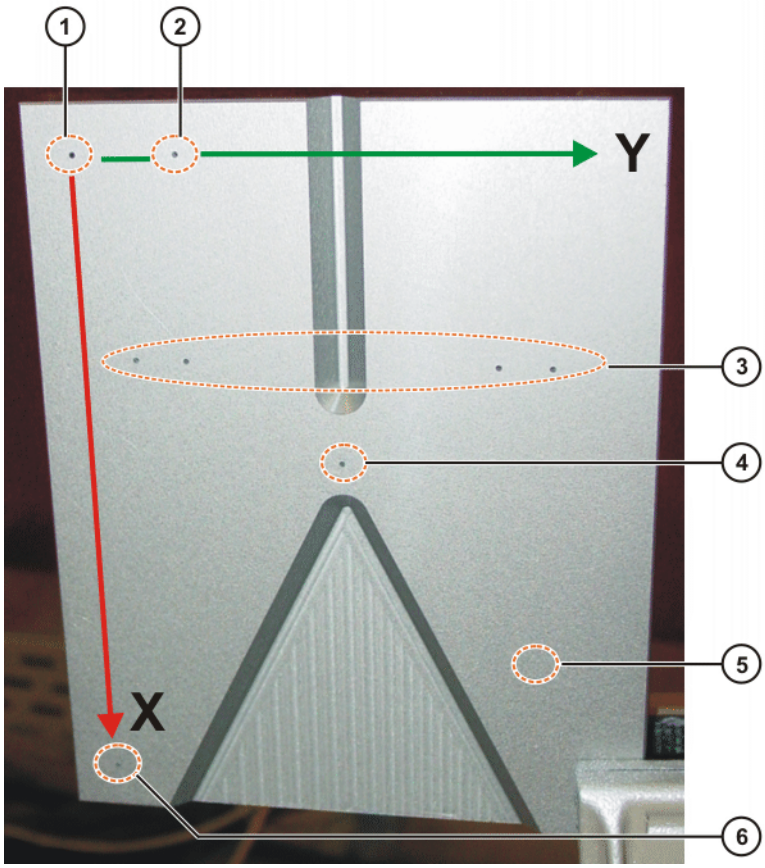

Fig. 6-2: Calibration plate

Item	Description
1	Origin of the BASE coordinate system
2	**Note:** Do not use this hole as a point for calibration.
3	Holes for sensor calibration These holes are not required for calibration of the calibration plate.
4	Origin of the triangle The triangle is not required for calibration of the calibration plate.
5	Example position for a point in the XY plane with a positive Y value. This point is not marked by a hole. The point must be addressed during calibration and can be selected itself (within the specifications for the 3-point method). The point must not lie on the Y axis but in the positive X and Y area. The point should be located as far as possible from the origin of the BASE coordinate system.
6	Hole on the positive X axis Marks the point to be addressed during calibration.

6.3 Calibrating the sensor semi-automatically

This procedure is used to assign a TOOL coordinate system to the sensor.

Fixed sensors cannot be calibrated using this procedure. They must be calibrated like conventional fixed tools. The TCP and the alignment of its coordinate system may not be freely selected but must be positioned as specified.
(>>> 9.4 "Sensor coordinate systems" Page 80)

Precondition

- The calibration plate has been calibrated as a base.
- The XML file with the characteristics of the calibration plate has been loaded and optimized in the WeldCom software:

  For SERVO-ROBOT sensors; types DIGI-I and PowerCam: task no. 255

  For SERVO-ROBOT sensors; type SF/D: task no. 39
- "Expert" user group
- Operating mode T1 or T2

  Precondition for T2: The configuration parameter **Allow operation mode T2** is TRUE.
- The configuration parameter **Tool number of sensor** is set.
- "Zero" is selected as the TOOL and BASE.

NOTICE During calibration, the robot moves the sensor to 5 different positions, with major reorientation. Therefore make sure that there are no potential obstacles present in the vicinity of the sensor. Furthermore, the robot must be observed during calibration in order to avoid collisions. Substantial damage to property may otherwise result.

NOTICE In T2 mode, the motions are executed at full speed. Semi-automatic sensor calibration may therefore be carried out in T2 in the following cases only:

- Program override is set to 10%.
- Or: The same calibration has already been performed several times in T1 in the system concerned.

Failure to observe this precaution may result in severe damage to property.

Procedure

1. In the configuration, activate the parameter **Sensor must be calibrated** on the **General settings** tab.
2. Create a new program.
3. Teach the motion to the start position.

   The start position is reached when the laser line lies symmetrically between the 4 auxiliary points on the calibration plate. The two inner points should be covered by the line and the outer points uncovered.

   (>>> Fig. 6-3)

   Pay attention to the following:

   - Align the laser beam so that it is as perpendicular as possible to the calibration plate.
   - Align the sensor so that the LED on the sensor housing points in the direction running from the vertex of the triangle to its base. (Not the opposite way.)

     (>>> Fig. 6-4), (>>> Fig. 6-5)
4. Teach the start position.
5. Program the Check Calibration instruction.
6. Start the program. The sensor is automatically calibrated.

   If the calibration is completed successfully, the parameter **Sensor must be calibrated** is subsequently automatically deactivated.

Example

```
1  DEF mycalibration( )
2  INI
3
4  PTP HOME  Vel= 100% DEFAULT
5
6  PTP P1
7  PTP P2
8  PTP mycalibposition  Vel= 100 % PDAT2 Tool[0] Base[0]
9  SeamFind Check Calibration
10
11 PTP HOME  Vel= 100% DEFAULT
12
13 END
```

Line	Description
6, 7	Motion to start position
8	Start position for sensor calibration ■ Motion type: PTP, LIN, CIRC, SLIN or SCIRC ■ Exact positioning must be used. ■ TOOL and BASE must be “zero”.

Start position

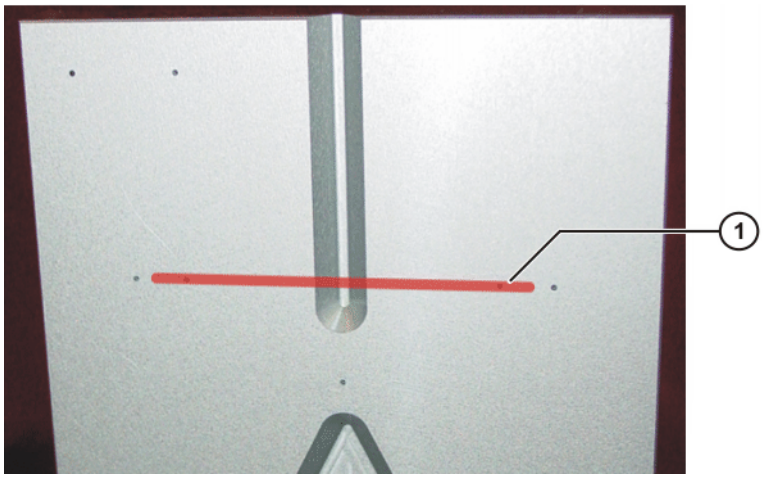

Fig. 6-3: Start position for sensor calibration

Item	Description
1	The laser line lies symmetrically between the 4 auxiliary points. The two inner points are covered by the line and the outer points uncovered.

Alignment of the sensor

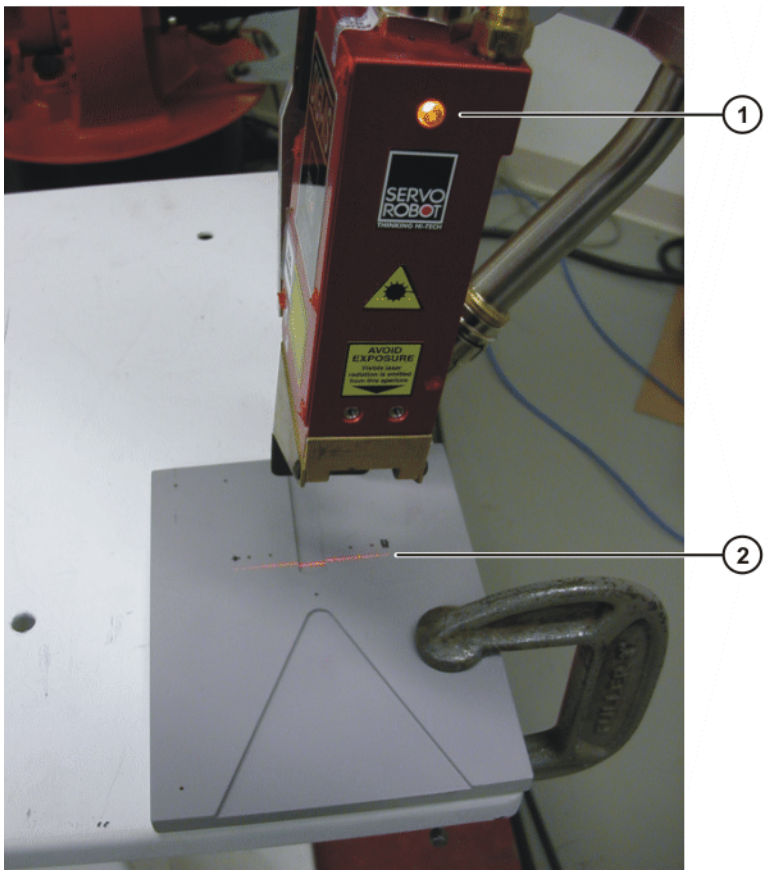

Fig. 6-4: Correct alignment of the sensor (except for SF/D-H)

Item	Description
1	The LED points in the direction running from the vertex of the triangle to its base.
2	The laser line is approaching the 4 auxiliary points.

Alignment of the sensor (SF/D-H)

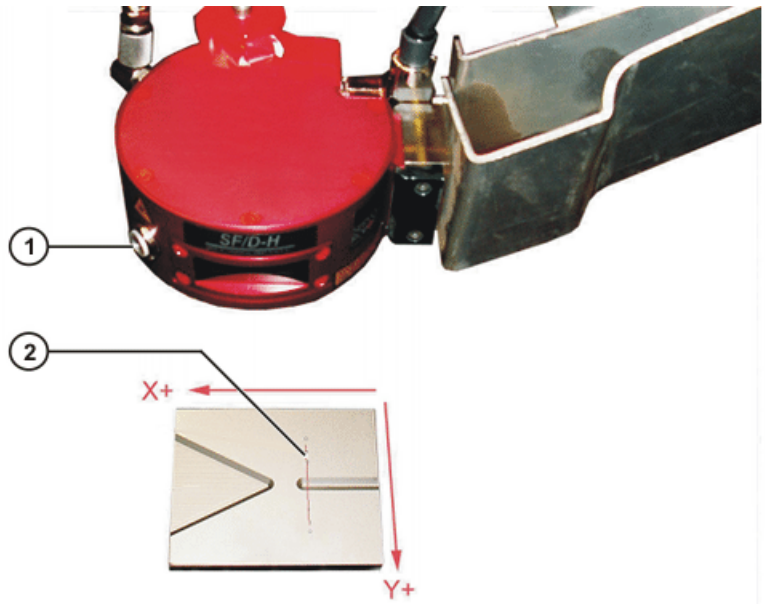

Fig. 6-5: Correct alignment of the SF/D-H sensor

Item	Description
1	The LED points in the direction running from the vertex of the triangle to its base.
2	Laser line

6.4 Calibrating the sensor semi-automatically – Optimization

Description

If the sensor was calibrated semi-automatically and it is discovered in the application that the accuracy is not yet sufficient, the calibration can be optimized.

Precondition

- Administrator user group
- The configuration parameter **Activate aut. gap adjustment** is active.
- The configuration parameter **Repeats for averaging** is set to a high value. (Recommendation: 5)
- Otherwise the same preconditions apply as for “Calibrating the sensor semi-automatically”.

Procedure

1. Carry out the Check Calibration instruction with the option **with Adjustment**.
   Or: Calibrate the sensor semi-automatically again.
2. Align the sensor so that the laser line on the calibration plate is located above the origin of the triangle. (>>> Fig. 6-6)

> Here it is important that the line is parallel to the narrow edges of the plate. This is generally the case as a result of having performed step 1. If not, move the line to the edge, manually align it with the edge as accurately as possible and then reposition it to the origin.

3. Move the sensor exactly 20 mm towards the base of the triangle. (By means of incremental jogging.)
4. In the WeldCom software read off the width measured by the sensor at this point. (>>> Fig. 6-6)
5. Enter the value under the configuration parameter **Actual width over "V" [mm]** and save.
6. Repeat step 1.

Measurement for optimization

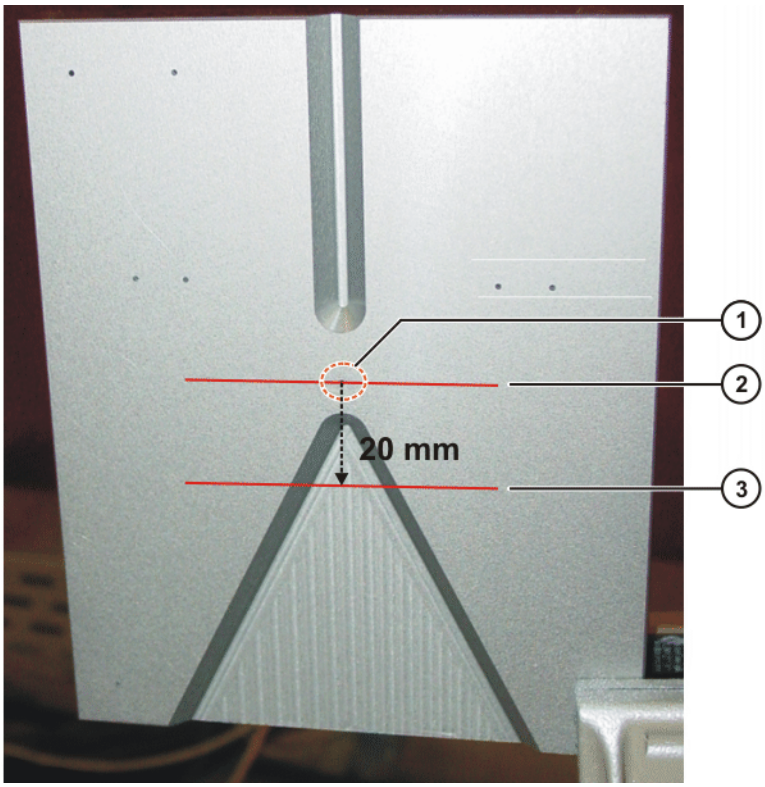

Fig. 6-6: Measurement for optimization

Item	Description
1	Origin of the triangle
2	Start position (laser line located above the origin)
3	Measurement position, 20 mm from the start position

6.5 Configure the sensor with WorkVisual

Step	Description
1	Install the **SeamTechFinding** option package in WorkVisual.
2	Transfer the project from the robot controller to WorkVisual. **Precondition**: SeamTech Finding is installed on the robot controller. **Note**: This project should be used for the configuration of SeamTech Finding in WorkVisual, otherwise the entries installed on the robot controller by SeamTech Finding could be lost when the project is transferred back to the robot controller (see step 6).
3	Insert the **SeamTechFinding** catalog in the currect project.
4	Insert the sensor in the project. (>>> 6.5.1 "Inserting a sensor in a project" Page 29)

Step	Description
5	Configure the sensor in the **SeamTechFinding Editor**: ■ Make the settings for the sensor. ■ Create and configure the joint types. (>>> 6.5.2 "Configuring the sensor" Page 29)
6	Transfer the project from WorkVisual to the robot controller. **Note**: During project transfer, the technology-specific files are copied to the robot controller and activated. If an earlier project has already been transferred, the files of this project are overwritten. It is therefore recommended to archive the files of the earlier project before transferring the new project.

Information about installing and managing option packages can be found in the **WorkVisual** documentation.

Information about bus configuration and project deployment can be found in the **WorkVisual** documentation.

6.5.1 Inserting a sensor in a project

Precondition
- The project is open.
- The **SeamTechFinding** catalog is inserted in the project.

Procedure
1. Select the **Hardware** tab in the **Project structure** window.
2. In the **Catalogs** window, select the **SeamTechFinding** catalog and mark the sensor.

   The sensor can now be renamed. To do this, enter a new name in the **Properties** window.
3. Drag the sensor into the **Project structure** window: into the **Hardware** tab, onto the robot controller there.

6.5.2 Configuring the sensor

Precondition
- The project is open.
- The sensor is inserted in the project.
- The robot controller has been set as the active controller.

Procedure
1. Select the sensor in the project (**Hardware** tab).
2. Open the **SeamTechFinding Editor**:
   - Select the menu sequence **Editors** > **Options packages** > **Open SeamTechFinding Editor**.
   - Alternatively: Click on the  button.
3. Define the sensor parameters on the tabs.
   - (>>> 6.5.2.1 "“Communication” tab" Page 30)
   - (>>> 6.5.2.2 "“Field of view” tab" Page 30)
   - (>>> 6.5.2.3 "“Calibration” tab" Page 31)
4. Activate the **Seam shapes** radio button to create and configure new joint types.
   (>>> 6.5.3 "Creating a new joint type" Page 32)

5. Save the project and answer the request for confirmation with **Yes**.

Description

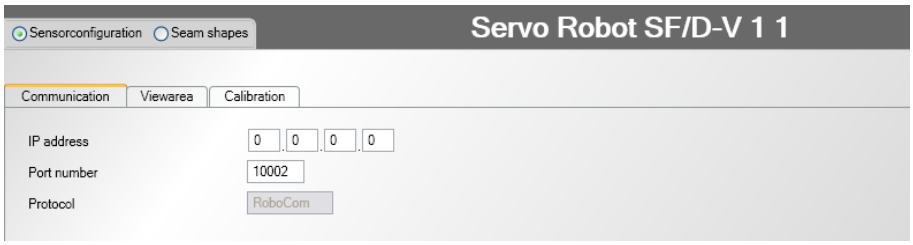

Fig. 6-7: SeamTechFinding Editor – Overview

The radio buttons can be used to switch to the available configuration pages.

Radio button	Description
Sensor configuration	The sensors can be configured.
Seam shapes	Seam shapes (joint types) can be created and configured.

6.5.2.1 "Communication" tab

Parameter	Description
IP address	The predefined IP address of the sensor can be changed here.
Port number	The predefined port number of the sensor can be changed here.
Protocol	Name of the protocol used for communication with the sensor. This parameter depends on the sensor and cannot be edited.

6.5.2.2 "Field of view" tab

Depending on whether the sensor uses the CoRob or RoboCom protocol, different parameters are displayed on this tab:

- **CoRob** protocol: Only the parameter **Offset (Z value)** is displayed and can be changed. The values of the other parameters are already preconfigured.
- **RoboCom** protocol: All parameters except **Offset (Z value)** are displayed and can be changed.

Parameter	Description
Optimal position <Y>	Y value of the optimal view point, referred to the optical reference frame **Note:** If this value is altered, the sensor must then be recalibrated.
Optimal position <Z>	Z value of the optimal view point, referred to the optical reference frame **For SERVO-ROBOT sensors (types SF/D):** This value should be selected so that the point is as close as possible to $+Z_{near}$, i.e. at the upper limit of the field of view. It must be placed at least in the upper third of the field of view. **Note:** If this value is altered, the sensor must then be recalibrated.
Near range <-Y> from	Half the upper width of the field of view in -Y direction of the optical reference frame In the diagram: $-Y_{near}$

Parameter	Description
Near range <+Y> to	Half the upper width of the field of view in +Y direction of the optical reference frame In the diagram: $+Y_{near}$
Far range <-Y> from	Half the lower width of the field of view in -Y direction of the optical reference frame In the diagram: $-Y_{far}$
Far range <+Y> to	Half the lower width of the field of view in +Y direction of the optical reference frame In the diagram: $+Y_{far}$
Height of field of view from <+Z near>	Upper limit of the field of view, referred to the Z axis of the optical reference frame In the diagram: $+Z_{near}$
Height of field of view to <+Z far>	Lower limit of the field of view of the sensor, referred to the Z axis of the optical reference frame In the diagram: $+Z_{far}$ The height of the field of view (in its largest size) is derived from $+Z_{near}$ and $+Z_{far}$.
Offset (Z value)	Offset of the optimal position

6.5.2.3 “Calibration” tab

Parameter	Description
Calibration task number	Task number in the sensor controller with which the semi-automatic sensor calibration is carried out. Not editable
Base number for calibration plate	For calibration of the calibration plate, the user selects a number under which the BASE coordinate system is to be saved. This must be entered here. ■ **1 … 32**
Tool number of sensor	In semi-automatic sensor calibration the robot controller saves the TOOL coordinate system under a number. This number must be predefined here. ■ **1 … 32**
Measurement repeats	Number of measurements at a single position during sensor calibration. The higher the value, the more accurate the measurement. Recommended value: 5 ■ **1 … 5**

Parameter	Description
Number of repetitions of calibration procedure	The overall sensor calibration consists of *x* individual runs. The number of these can be configured here. The higher the value, the more accurate the measurement. Each individual run is based on the result of the preceding individual run. (Each individual run in turn consists of several sub-runs. (>>> Fig. 6-12)) Recommended value: 3 ■ **1 … 5**
Allow operation mode T2	**FALSE**: Semi-automatic sensor calibration can only be carried out in T1 mode. **TRUE**: Semi-automatic sensor calibration can be carried out in T1 or T2 mode. **Note:** In T2 mode, the motions are executed at full speed. Semi-automatic sensor calibration may therefore be carried out in T2 in the following cases only: ■ Program override is set to 10%. ■ Or: The same calibration has already been performed several times in T1 in the system concerned. Failure to observe this precaution may result in severe damage to property.

6.5.3 Creating a new joint type

New joint types can be created in WorkVisual if required.

New joint types must be be created both in WorkVisual and in the sensor controller. They must have the same task numbers.
Information on the creation procedure in the sensor controller can be found in the documentation of the sensor manufacturer.

Precondition

- The sensor is selected in the **Project structure** window.

Procedure

1. Open the **SeamTechFinding Editor**:
   - Select the menu sequence **Editors** > **Options packages** > **Open SeamTechFinding Editor**.
   - Alternatively: Click on the  button.
2. Activate the **Seam shapes** radio button.
3. Click on the  button to create a new joint type.
4. Select a joint type in the **Seam type** box.
5. Enter a seam name and a task number.
6. Save the project to accept the changes made.

Description

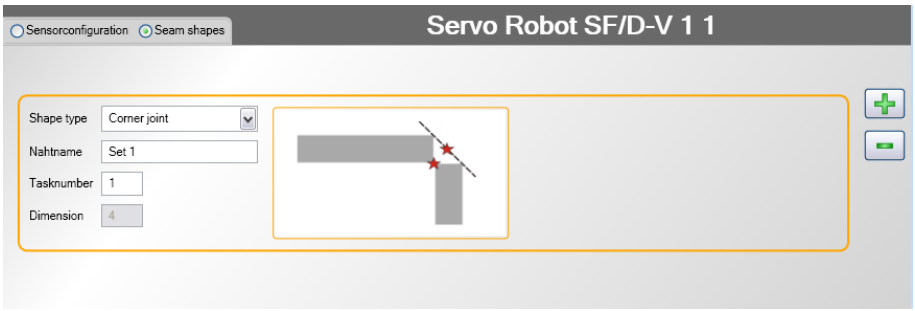

Fig. 6-8: Creating joint types

Parameter	Description
Seam type	Select a joint type. The following joint types are available: ■ Butt joint ■ Corner joint ■ User-defined seam ■ Dot ■ Fillet joint ■ Half V groove joint ■ J groove joint ■ Lap joint ■ Melt run ■ TWB joint ■ V groove joint
Seam name	Name of the joint type. This name is displayed in the **Search profile** option window. The name can be changed. (The change becomes visible in the **Search profile** option window after the user interface has been reinitialized.) ■ Maximum 24 characters Names of the joint types: (>>> 9.1 "Overview of joint types" Page 75)
Task number	Number of the task to which the joint is assigned. Each task number may only be assigned once.
Dimension	Number of CD*x* data of this joint type ■ **1 … 4** Only editable if **User-defined seam** was selected as the joint type.

Buttons

Button	Name / description
	**Add Set** Inserts a new joint type in the editor.
	**Remove Set** Removes the open joint type from the editor.

6.6 Configuring SeamTech Finding

Precondition

- "Expert" user group

Procedure

1. In the main menu, select **Configuration** > **SeamTechFinding**.
2. Set the parameters on the tabs as required.
   (>>> 6.6.1 ""General settings" tab" Page 34)

(>>> 6.6.2 "“Search dynamic” tab" Page 36)
(>>> 6.6.3 "“Sensor tool check” tab" Page 36)
(>>> 6.6.4 "“Sensor tool optimization” tab" Page 37)

3. Close the window. Respond to the request for confirmation asking whether the changes should be saved by pressing **Yes**.

6.6.1 “General settings” tab

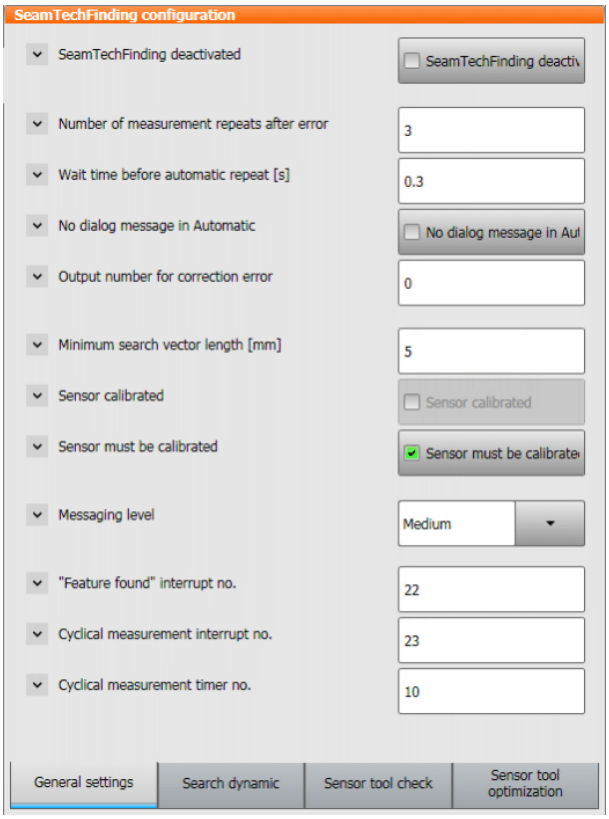

Fig. 6-9: “General settings” tab

Parameter	Description
SeamTechFinding deactivated	■ **Activated**: SeamTechFinding is deactivated. ■ **Deactivated**: SeamTechFinding is activated. **Note**: The parameter has the same function as the status key for the process.
Number of measurement repeats after error	For measurements on the workpiece: If an error occurs during a measurement, the robot controller automatically repeats the measurement up to the specified number of retries (as long as errors still occur). After the last repetition, the robot stops and the robot controller generates a message. In the case of a measurement with a search, the entire search is repeated. ■ **0 … 5**
Wait time before automatic repeat [s]	Before the repetitions configured under **Number of measurement repeats after error**, the robot controller waits for the time specified here. ■ **0.3 … 2.00 s**

Parameter	Description
No dialog message in Automatic	This parameter defines how the robot reacts to a failed measurement. ■ **Activated**: In AUT and EXT modes, a dialog message is displayed in the event of an error. ■ **Deactivated**: In the event of an error, an acknowledgement message is displayed in AUT and EXT modes, which can be acknowledged by the PLC.
Output number for correction error	Only relevant if **No dialog message in Automatic** is deactivated: This parameter determines whether an output is set in the event of a correction error, in order to signal the error to the PLC. ■ **0**: No output is set. ■ **≠0**: The output with the specified number is set.
Minimum search vector length [mm]	The minimum length required for the search vector. With shorter search vectors, the search direction would not be defined accurately enough. The search vector is derived from the end point of the preceding motion and the via point. ■ **2.0 … 20.0 mm**
Sensor calibrated	■ **Activated**: The sensor is calibrated. ■ **Deactivated**: The sensor is not calibrated. The parameter is automatically activated after successful semi-automatic calibration. Only editable in the case of sensors that cannot be calibrated semi-automatically. **Note:** If a sensor is used that cannot be calibrated semi-automatically (e.g. a fixed sensor): The sensor must be calibrated by the conventional method. After this, **Sensor calibrated** must be activated.
Sensor must be calibrated	■ **Activated**: The sensor is recalibrated next time the Check Calibration instruction is executed. If calibration data already exist, these are overwritten. After calibration, the parameter is automatically deactivated. ■ **Deactivated**: The calibration data of the sensor are checked next time the Check Calibration instruction is executed. If the deviation from the initial calibration exceeds the defined limits, this is indicated by a message. Depending on the setting in Check Calibration, the newly determined data are either adopted or not. The initial calibration data remain intact in either case.
Messaging level	■ **Low**: Only the most important messages are displayed, including safety messages. ■ **Medium**: The displayed messages enable a diagnosis to be carried out by the user. ■ **High**: The displayed messages enable a diagnosis to be carried out by the developer. **Note**: For a change in this value to take effect, the submit interpreter must be reselected.
"Feature found" interrupt no.	Number of the interrupt for detection of the feature ■ **10 … 32** **Note**: Only change this value if the preset interrupt is already assigned.

Parameter	Description
Cyclical measurement interrupt no.	Number of the interrupt for cyclical measurement ■ **10 … 32** **Note**: Only change this value if the preset interrupt is already assigned.
Cyclical measurement timer no.	Number of the timer for detection of the feature ■ **1 … 32** **Note**: Only change this value if the preset timer is already assigned.

6.6.2 “Search dynamic” tab

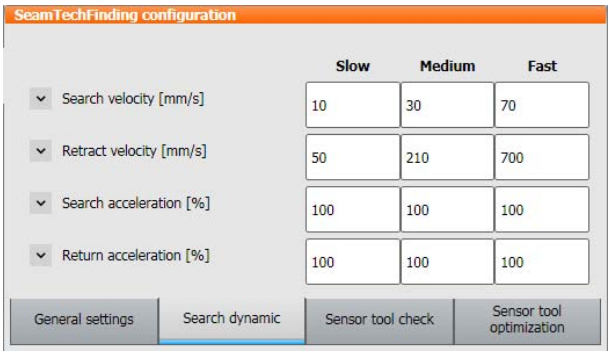

Fig. 6-10: “Search dynamic” tab

In the option window **Search parameter set** a dynamic profile can be selected for the search (**Fast**, **Medium** or **Fast**).

(>>> 7.3.5 "Option window “Search parameter set”" Page 46)

Here on the **Search dynamic** tab, the following velocities and accelerations can be configured for each profile:

Parameter	Description
Search velocity [mm/s]	Velocity for the search ■ **2 … 2000 mm/s**
Retract velocity [mm/s]	Velocity at which the robot returns to the start point after the search ■ **2 … 2000 mm/s**
Search acceleration [%]	Acceleration for the search and return motion The value refers to the maximum value specified in the machine data. The maximum value depends on the robot type and the selected operating mode. ■ **1 … 100 %**
Return acceleration [%]	

6.6.3 “Sensor tool check” tab

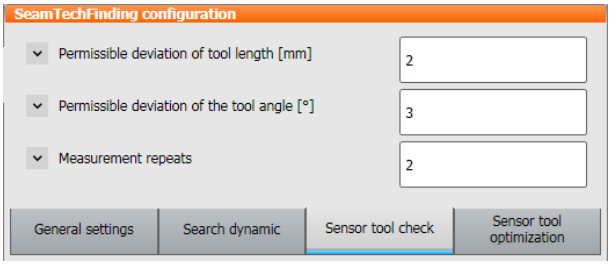

Fig. 6-11: “Sensor tool check” tab

These parameters are not relevant if a sensor is used that cannot be calibrated semi-automatically (e.g. a fixed sensor).

Parameter	Description
Permissible deviation of tool length [mm]	Maximum permissible deviation between the X, Y and Z values determined in the initial calibration of the sensor and those determined in the Check Calibration procedure. If the deviation threshold is exceeded, the robot controller issues a message. ■ **0.1 … 20 mm**
Permissible deviation of the tool angle [°]	Maximum permissible deviation between the A, B and C angles determined in the initial calibration of the sensor and those determined in the Check Calibration procedure. If the deviation threshold is exceeded, the robot controller issues a message. ■ **0.1 … 10°**
Measurement repeats	Number of measurements at a single position during sensor checking. The higher the value, the more accurate the measurement. Recommended value: 5 ■ **1 … 5**

6.6.4 “Sensor tool optimization” tab

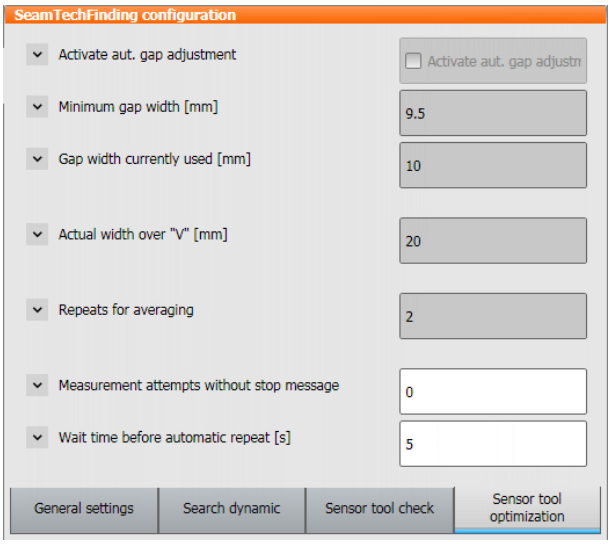

Fig. 6-12: “Sensor tool optimization” tab

These parameters are not relevant if a sensor is used that cannot be calibrated semi-automatically (e.g. a fixed sensor).

The following parameters are valid for all sensor calibrations (i.e. for the initial calibration and for the calibration check):

- **Automatic gap adjustment**
- **Averaging**
- **Automatic repeat**

The following parameter applies only to optimization of the calibration:

- **Manual gap width correction**

Parameter	Description
Automatic gap adjustment	
Activate aut. gap adjustment	In semi-automatic sensor calibration the sensor measures the gap on the calibration plate at the beginning. The gap is 10 mm wide, but some sensors measure a smaller width. A greater accuracy can be achieved overall in calibration if the robot controller takes the width determined by the sensor as a basis for the further calculations instead of the actual width. **Activated:** The robot controller uses the width currently determined by the sensor. **Deactivated:** The robot controller uses the actual width (10 mm). Can only be changed in the “Administrator” user group.
Minimum gap width [mm]	Minimum permissible value for **Gap width currently used [mm]**. If **Activate aut. gap adjustment** is activated and the sensor has determined a width that lies below this value, an acknowledgement message will be displayed. ■ **9.50 … 10.00 mm** Can only be changed in the “Administrator” user group.
Gap width currently used [mm]	The value for the gap width that is currently used by the robot controller is displayed here. Not editable
Manual gap width correction	
Actual width over "V" [mm]	In optimization, the sensor measures the triangle on the calibration plate at a particular point. The gap is 20 mm wide at this point, but some sensors measure a different width. A greater accuracy is achieved overall in calibration if the robot controller takes the width determined by the sensor as a basis for the further calculations instead of the actual width. The value measured by the sensor during optimization must be read off in the WeldCom software and entered here. ■ **19.50 … 20.50 mm** Can only be changed in the “Administrator” user group. (>>> 6.4 "Calibrating the sensor semi-automatically – Optimization" Page 27)
Averaging	
Repeats for averaging	The overall sensor calibration consists of several individual runs. Each individual run in turn consists of *x* sub-runs. An average value is calculated from the sub-runs. (This is then the result of the individual run.) The number of sub-runs can be configured here. The higher the value, the more accurate the measurement. Recommended value: 5 ■ **1 … 5** Can only be changed in the “Administrator” user group.
Automatic repeat	

Parameter	Description
Measurement attempts without stop message	During sensor calibration: ■ Value **0**: If an error occurs in a measurement, the robot stops and the robot controller generates a message. ■ Value **1 … 5**: If an error occurs during a measurement, the robot controller automatically repeats the measurement up to the specified number of retries (as long as errors still occur). After the last repetition, the robot stops and the robot controller generates a message.
Wait time before automatic repeat [s]	Before the repetitions configured under **Measurement attempts without stop message**, the robot controller waits for the time specified here. ■ **0.3 … 5.0 s**

7 Programming

7.1 Instructions for programming

When a new program is created or an existing program is changed, a test run must be performed in T1 mode.

The programming descriptions refer to a sensor installed on the mounting flange unless stated otherwise. If a fixed sensor is used, the programming must be adapted accordingly.

7.2 Preparation

The following questions must be considered in preparation for programming:

1. In what ways are the workpieces liable to be offset in relation to the reference workpiece?
   - Linear offset along the length, width and/or height
   - And/or: Tilted along the length and/or width, and/or rotated in the plane
2. If only linear offsets are able to occur: Can the reference workpiece be calibrated as a BASE?

   (If so, calibrate the workpiece as a BASE. The sensor does not then need to have a specific alignment for measurement of the position.)
3. At what points do measurements have to be carried out in order to detect the offsets?
4. Are these points accessible for the sensor?

   What alignment must the sensor have? (>>> 7.4 "Overview of correction instructions" Page 46)
5. What joint types must be selected to enable the sensor to measure at these points?
6. Which CD*x* data of the measurement register the offset? (Usually not all the CD*x* data of a measurement are relevant.)
7. To what extent are the workpieces liable to be offset in relation to the reference workpiece? Therefore, do the measurements have to be programmed with or without a search?

7.3 “Measurement” – Measure

Description

This instruction is used to measure the position of the workpiece.

A measuring instruction is also a motion instruction (PTP, LIN, CIRC, SLIN or SCIRC). At the end point of this motion, the sensor can measure the position of the workpiece, or a search can be performed from there first.

A search is necessary if the workpiece might possibly be displaced to the extent that it is no longer in the field of view of the sensor at the end point. The user specifies in the inline form whether a search is to be performed. If yes, he also defines the direction and maximum length of the search motion and additional properties of the search.

The sensor must have a specific alignment during measurement depending on the correction instructions that are used.

Precondition

- The connection to the sensor is established.

Procedure

1. Select the menu sequence **Commands** > **SeamTech Finding** > **Measurement**.
2. Select the motion type in the inline form.
3. Only if CIRC or SCIRC has been selected as the motion type:
   Move the TCP to the position for the auxiliary point. Press **Teach Aux**.
4. Move the TCP to the position for the end point. Press **Teach End**.
5. Set the other parameters in the inline form.
6. Only if **Dynamic** has been selected: Move the TCP to the position for the via point. Press **Touchup via**.
7. Save instruction with **Cmd Ok**.

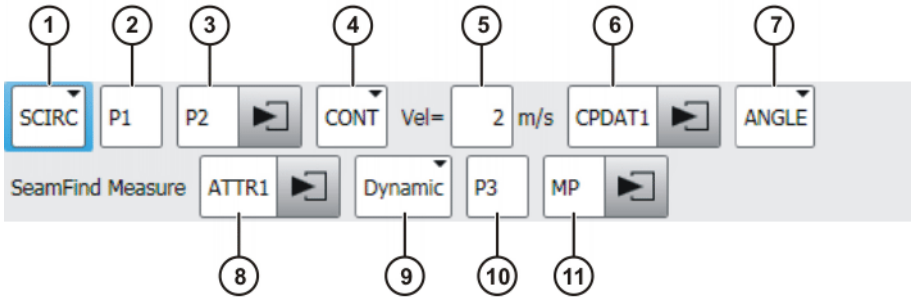

Fig. 7-1: Inline form “Measure”

NOTICE Define the via point and search distance so there is no risk of a collision if the sensor does not acquire useful measurements and the robot therefore has to cover the full length of the search path. Damage to property may otherwise result.

Item	Description
1	Select motion type. ■ **PTP**, **LIN**, **CIRC**, **SLIN** or **SCIRC**
2	Only for CIRC and SCIRC motions: Name of the auxiliary point The system automatically generates a name. The name can be changed. (>>> 7.14 "Names in inline forms" Page 63)
3	End point. The system automatically generates a name. The name can be changed. To edit the data, position the cursor in the box. The corresponding option window is opened. (>>> 7.3.1 "Option window “Frames”" Page 43)
4	Only for SLIN and SCIRC motions: Approximate positioning
5	Velocity ■ For PTP: **1 … 100 %** ■ For LIN, CIRC, SLIN, SCIRC: **0.001 … 2 m/s** **Note:** This velocity does not apply to the search. The velocity profile for the search is defined in the option window **Search parameter set**.

Item	Description
6	Name for the motion data set. The system automatically generates a name. The name can be changed. For PTP: (>>> 7.3.2 "Option window “Motion parameter” (PTP)" Page 44) For LIN, CIRC, SLIN, SCIRC: (>>> 7.3.3 "Option window “Motion parameter” (LIN/CIRC/SLIN/SCIRC)" Page 45)
7	Only for SCIRC motions: Overall angle of the circular motion
8	Name of the attribute. The system automatically generates a name. The name can be changed. (>>> 7.3.4 "Option window “Search profile”" Page 45)
9	■ **Static**: Without search. The measurement is carried out at the end point (item 3). ■ **Dynamic**: With search. The search starts at the end point (item 3). **Note**: In the case of measurement with search, it must be ensured that the search path is clear. Otherwise, collisions may result.
10	This box is only displayed if **Dynamic** has been selected for item 9. Via point. The system automatically generates a name. The name can be changed. The via point defines the direction of the search. It does not specify the end point of the search. (This is derived from the search distance.)
11	This box is only displayed if **Dynamic** has been selected for item 9. Search settings. The system automatically generates a name. The name can be changed. Position the cursor in this box to edit the settings. The corresponding option window is opened. The search distance and the velocity profile for the search are defined here. (>>> 7.3.5 "Option window “Search parameter set”" Page 46)

7.3.1 Option window “Frames”

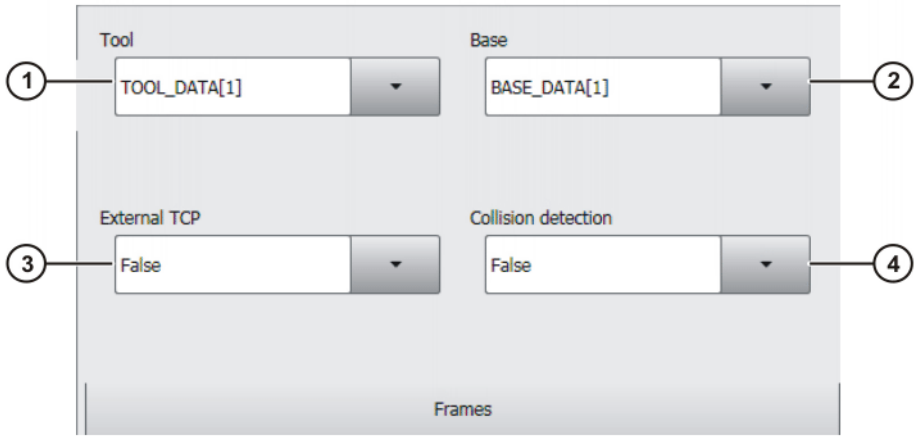

Fig. 7-2: Option window: Frames

Item	Description
1	Select the TOOL coordinate system. **Recommendation:** Select the sensor coordinate system. If **True** in the box **External TCP**: Select the workpiece. ■ **[1] … [16]**
2	Select the BASE coordinate system. If **True** in the box **External TCP**: Select the BASE coordinate system that was selected for calibration of the fixed sensor. ■ **[1] … [32]**
3	Specify the interpolation mode: ■ **False**: The sensor is installed on the mounting flange. ■ **True**: The sensor is fixed.
4	Specify whether axis torques are to be determined: ■ **True**: For this motion, the robot controller calculates the axis torques. These are required for collision detection. ■ **False**: For this motion, the robot controller does not calculate the axis torques. Collision detection is thus not possible for this motion.

7.3.2 Option window “Motion parameter” (PTP)

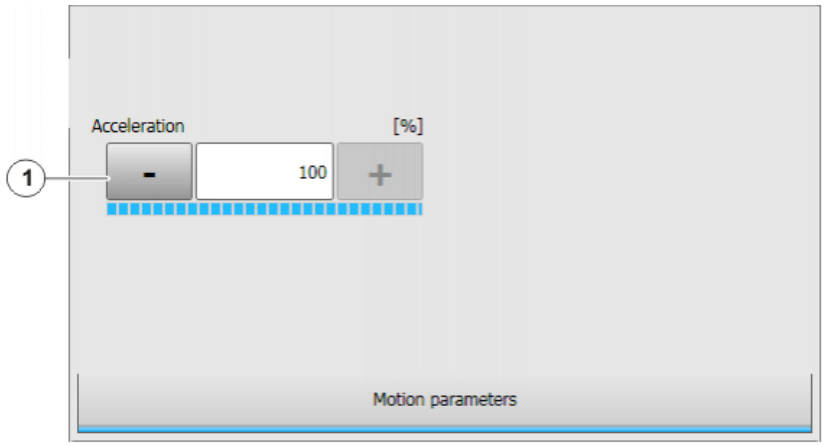

Fig. 7-3: Option window “Motion parameter” (PTP)

Item	Description
1	Acceleration Refers to the maximum value specified in the machine data. The maximum value depends on the robot type and the selected operating mode.

7.3.3 Option window “Motion parameter” (LIN/CIRC/SLIN/SCIRC)

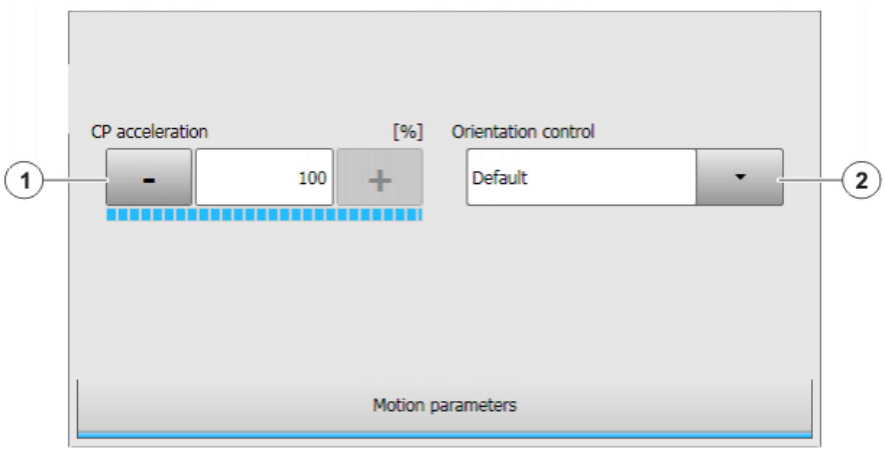

Fig. 7-4: Option window “Motion parameter” (LIN/CIRC/SLIN/SCIRC)

Item	Description
1	Acceleration Refers to the maximum value specified in the machine data. The maximum value depends on the robot type and the selected operating mode.
2	Orientation control selection.

7.3.4 Option window “Search profile”

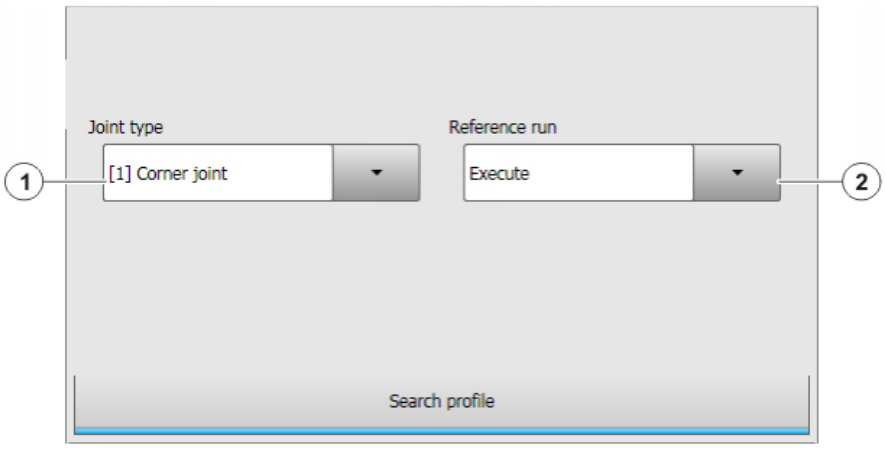

Fig. 7-5: Option window: Search profile

Item	Description
1	Select the seam type. (>>> 9.1 "Overview of joint types" Page 75)
2	■ **Execute**: Must be selected if the reference workpiece is to be measured. After successful measurement, the value is automatically set to **Executed**. ■ **Executed**: Must be selected if other workpieces are to be measured.

If **Executed** is set and a reference run is to be executed again, all measuring instructions can be set to **Execute** at once for this purpose.
(>>> 7.13 "Changing several motion blocks at once" Page 63)

7.3.5 Option window “Search parameter set”

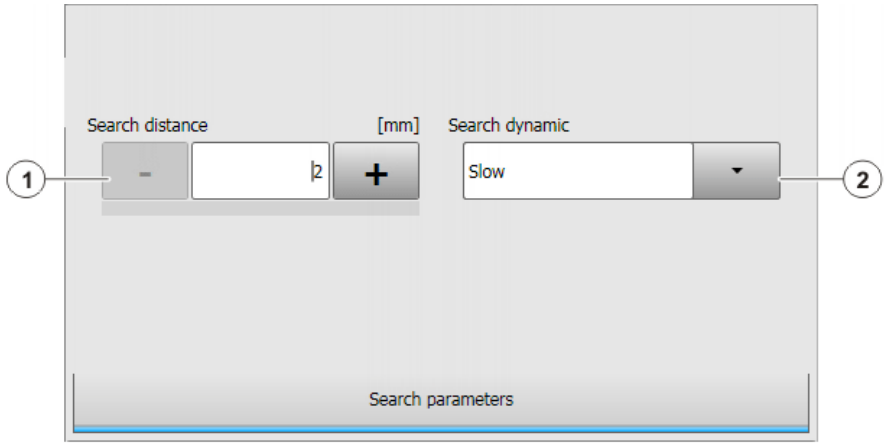

Fig. 7-6: Option window: Search parameter set

Item	Description
1	Search distance
2	Velocity and acceleration for the search ■ **Slow**, **Medium** or **Fast** The exact values can be configured on the **Search dynamic** configuration screen.

NOTICE Define the via point and search distance so there is no risk of a collision if the sensor does not acquire useful measurements and the robot therefore has to cover the full length of the search path. Damage to property may otherwise result.

7.4 Overview of correction instructions

A correction instruction overwrites the data of a previous correction instruction.

Corr XYZ BASE

Corr XYZ BASE is used in the following case:

- The possible offsets are linear; along the length, width and/or height.
- Inclinations or rotations are not possible.
- The workpiece was calibrated as BASE.

Advantage of Corr XYZ BASE over Corr XYZ TCP: The sensor does not need a particular alignment.

Corr XYZ TCP

Corr XYZ TCP is used in the following case:

- The possible offsets are linear; along the length, width and/or height.
- Inclinations or rotations are not possible.
- The sensor can be aligned as follows:
  - CDa is parallel to the offset to be measured, or is located at an angle of 90° to it.
  - Or: CDa is parallel to the vector resulting from the offsets.

Advantage of Corr XYZ TCP over Corr XYZ BASE: The workpiece does not have to be calibrated as BASE.

Corr ABC

Corr ABC is used in the following case:

- The workpieces are possibly inclined and/or rotated in relation to the reference workpiece.

If linear offsets are additionally liable to occur, these can likewise be measured with Corr ABC.

7.4.1 "Correction in base system" – Corr XYZ BASE

Precondition

- The workpiece was calibrated as BASE. This BASE coordinate system is currently selected.
- All measuring instructions have been programmed.

Call

- Select the menu sequence **Commands** > **SeamTechFinding** > **Correction in base system**.

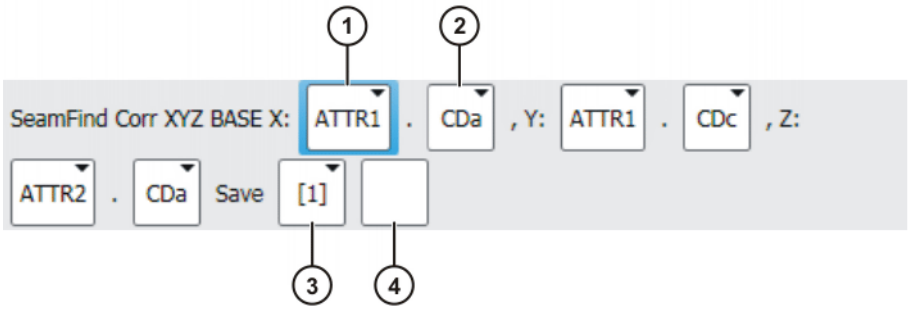

Fig. 7-7: Inline form "Corr XYZ BASE"

Item	Description
1	Select the attribute that contains the required CD*x*. The same attribute can also be selected more than once. Not all 3 attribute boxes must be filled out. The number of entries required depends on the number of directions in which the workpiece can be offset.
2	Select CD*x*. ■ **X**: If the workpiece is offset parallel to the X axis of the BASE coordinate system, select the CD*x* here that has measured this offset. ■ **Y**: If the workpiece is offset parallel to the Y axis of the BASE coordinate system, select the CD*x* here that has measured this offset. ■ **Z**: If the workpiece is offset parallel to the Z axis of the BASE coordinate system, select the CD*x* here that has measured this offset. **Note:** ■ The boxes for CD*x* are only available if the corresponding attribute box has been filled. ■ One and the same CD*x* may not be used more than once, e.g. not ATTR1.CDa and then ATTR1.CDa again.

Item	Description
3	The correction can be saved under a number. It can then be loaded again later using **Corr Load And On**. It is available globally. If you do not wish to save the correction, select [*blank*].
4	This box is only available in the “Expert” user group. If the correction is saved under a number, a name can be added here.

7.4.2 “Correction in base system” – example

In this example the possible offset is to be an offset in terms of height. The sensor is aligned so that it can detect the height of the workpiece. X and Y of the example BASE coordinate system are shown in the diagrams.

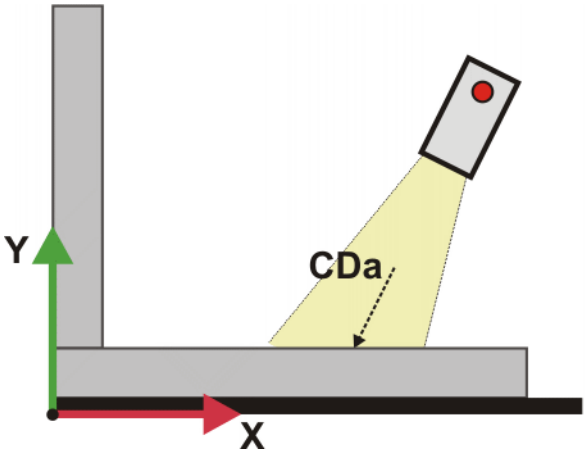

Fig. 7-8: Measurement of the reference workpiece

The new workpiece is higher than the reference workpiece:

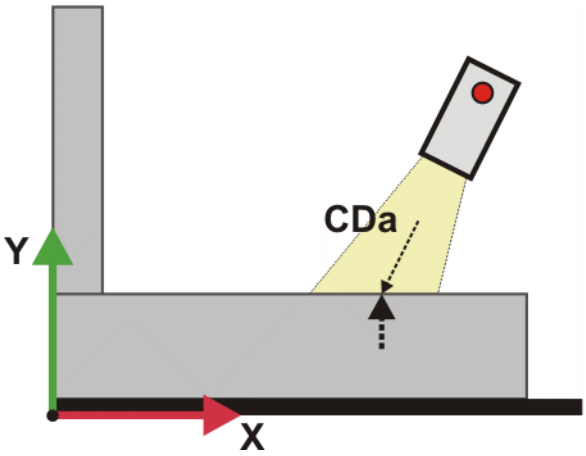

Fig. 7-9: Measurement of the new workpiece

The offset is an offset in the Y direction of the BASE coordinate system. In the inline form the offset must therefore be entered in the **Y** box:

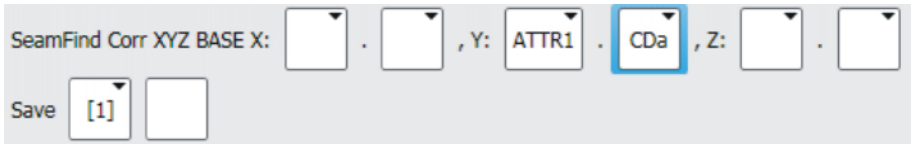

Fig. 7-10: Inline form

The CD*x* data that have measured the offset are CDa and CDb. Only 1 specification per offset is required in the inline form, however. CDb could also be entered instead of CDa.

7.4.3 "Correction in search direction" – Corr XYZ TCP

Precondition

- All measuring instructions have been programmed.

Call

- Select the menu sequence **Commands** > **SeamTech Finding** > **Correction in search direction**.

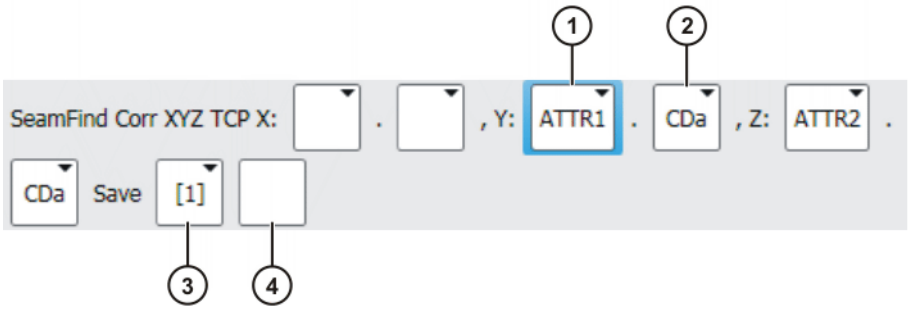

Fig. 7-11: Inline form "Corr XYZ TCP"

Item	Description
1	Select the attribute that contains the required CD*x*. The same attribute can also be selected more than once. Not all 3 attribute boxes must be filled out. The number of entries required depends on the number of directions in which the workpiece can be offset: ■ Offset in 1 direction: Fill out box **Z**. ■ Offset in 2 directions: Fill out boxes **Z** and **Y**. It does not matter which offset is entered in which box. ■ Offset in 3 directions: Fill out all the boxes. **Note: X**, **Y** and **Z** do not refer to the sensor coordinate system or another coordinate system known to the user.
2	Select CD*x*. For each offset direction select the CD*x* that measured this offset. **Note:** ■ The boxes for CD*x* are only available if the corresponding attribute box has been filled. ■ One and the same CD*x* may not be used more than once, e.g. not ATTR1.CDa and then ATTR1.CDa again.
3	The correction can be saved under a number. It can then be loaded again later using **Corr Load And On**. It is available globally. If you do not wish to save the correction, select [*blank*].
4	This box is only available in the "Expert" user group. If the correction is saved under a number, a name can be added here.

7.4.4 "Correction in search direction" – example

The example shows how the same offset can be measured in different ways. The inline form must be filled out differently, according to the measurement

method. The measurement method selected in the specific application depends on the geometry of the workpiece and the alignment of the sensor.

In this example the possible offsets are to be lateral and in terms of height.

Variant A

2 measurements are carried out here: One to detect the side and one to detect the height. For both measurements the sensor is aligned so that CDa is parallel to the offset.

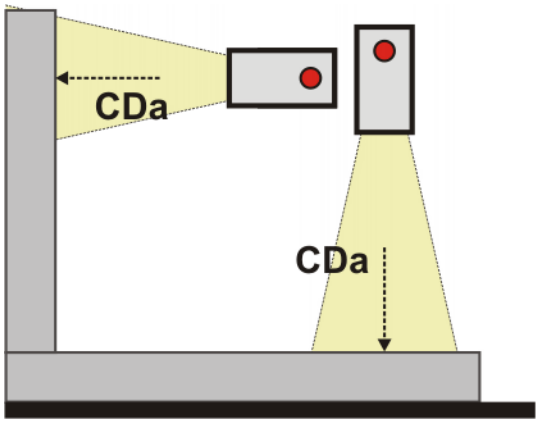

Fig. 7-12: Measurement of the reference workpiece

The new workpiece is laterally offset and higher than the reference workpiece:

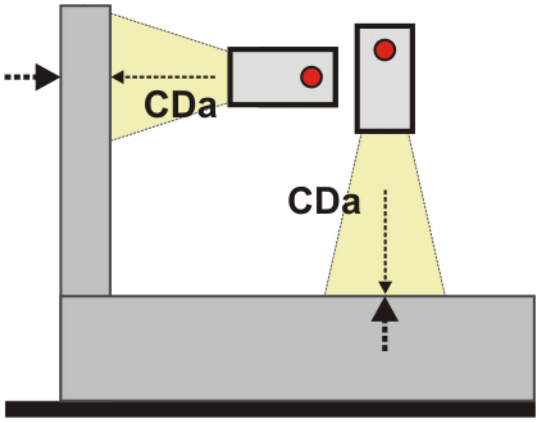

Fig. 7-13: Measurement of the new workpiece

In the inline form the two offsets must be entered in the **Y** and **Z** boxes. (It does not matter which offset is entered in **Y** and which in **Z**.)

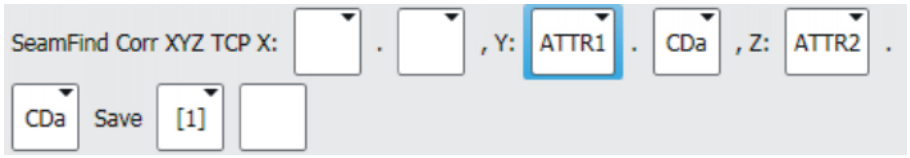

Fig. 7-14: Inline form for variant A

The CD*x* that are parallel to the offsets are CDa and CDb in both measurements. Only 1 specification per offset is required in the inline form, however. Instead of entering CDa twice, CDb could be entered twice or also CDa once and CDb once.

Variant B

Only 1 measurement is carried out here: At a characteristic point (here the inner corner) the vector resulting from the lateral and vertical offset is measured. The sensor is aligned so that CDa is parallel to the vector.

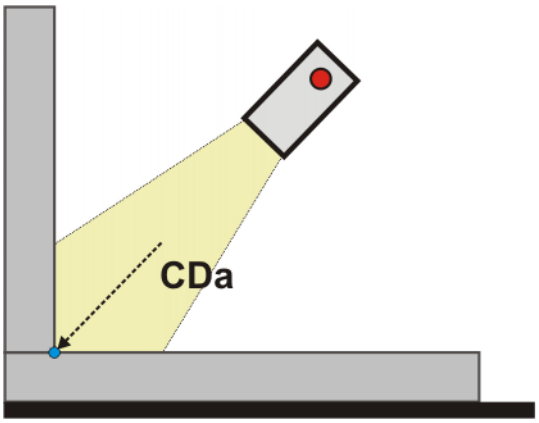

Fig. 7-15: Measurement of the reference workpiece

The new workpiece is laterally offset and higher than the reference workpiece. The small blue dot indicates the original position of the inner corner:

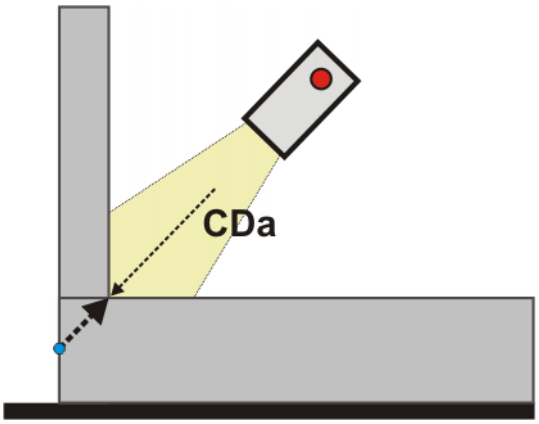

Fig. 7-16: Measurement of the new workpiece

In the inline form the offset must be entered in the **Z** box:

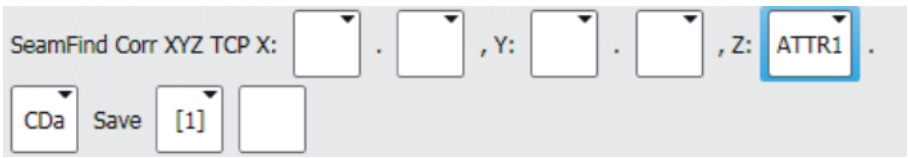

Fig. 7-17: Inline form for variant B

The CD*x* that are parallel to the offset are CDa and CDb. Only 1 specification per offset is required in the inline form, however. CDb could also be entered instead of CDa.

7.4.5 "Correction freely programmable" – Corr ABC

Precondition

- All measuring instructions have been programmed.

Call

- Select the menu sequence **Commands** > **SeamTech Finding** > **Correction freely programmable**.

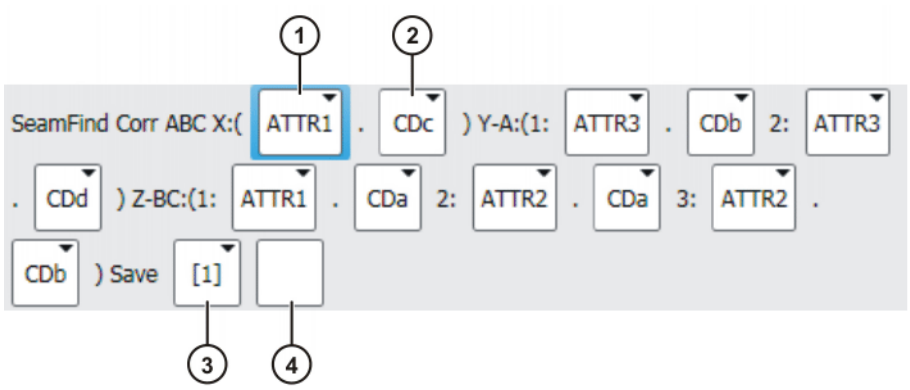

Fig. 7-18: Inline form “Corr ABC”

Item	Description
1	Select the attribute that contains the required CD*x*. The same attribute can also be selected more than once. Not all 6 attribute boxes must be filled out. The number of entries required depends on the required correction. (>>> "XYZ boxes" Page 52)
2	Select CD*x*. **Note:** ■ The boxes for CD*x* are only available if the corresponding attribute box has been filled. ■ One and the same CD*x* may not be used more than once, e.g. not ATTR1.CDa and then ATTR1.CDa again.
3	The correction can be saved under a number. It can then be loaded again later using **Corr Load And On**. It is available globally. If you do not wish to save the correction, select [*blank*].
4	This box is only available in the “Expert” user group. If the correction is saved under a number, a name can be added here.

XYZ boxes

The table explains which boxes have to be filled out for which possible offsets.

X, **Y** and **Z** do not refer to the sensor coordinate system or another coordinate system known to the user. They serve only to describe the possible offsets.

X/Y/Z	Description
X	■ For a linear offset in 1 direction, with no inclination The sensor must be aligned so that CDa is parallel to the offset or at an angle of 90° to it.

X/Y/Z	Description
Y	■ For inclination of a plane in 1 direction ■ Or if **X** is already assigned and the workpiece can be linearly offset in a 2nd direction. The sensor must be aligned on the reference workpiece so that CDa meets the plane at an angle of 90°. **Note:** The Y measurements must be located on a line. The workpiece may not have any steps here, for example.
Z	■ For inclination of a plane in 2 directions ■ Or if **Y** is already assigned and another plane can also be inclined in 1 direction. The sensor does not need a specific alignment. **Note:** As a basic principle, it is possible for none of the Z boxes, all of them or 1 of them to be filled out. 2 Z boxes are not allowed. If only 1 Z box is filled out, this may not be Z-BC3. **Note:** The Z measurements must be located on 1 plane. The workpiece surfaces may not have any steps, for example.

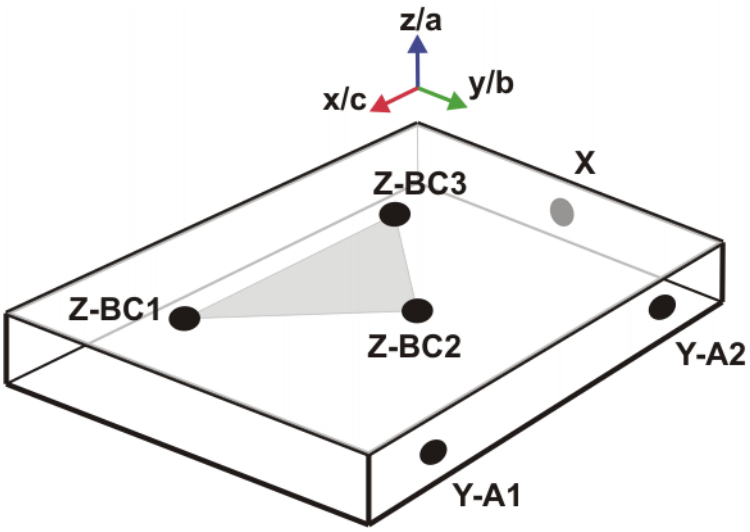

Fig. 7-19: Corr ABC

If not all the attribute boxes in the inline form are filled out, the robot controller makes the following substitutions:

If missing:	Substituted by:
All Z	Z direction of the base is used as the Z direction. Offsets in this direction cannot be determined however.
Z-BC1 and Z-BC3	Z direction of the base is used as the Z direction.
Z-BC2 and Z-BC3	Z direction of the sensor coordinate system is used as the Z direction.
Y-A1	Y direction of the base is used as the Y direction.
Y-A2	Y direction of the sensor coordinate system is used as the Y direction.

If missing:	Substituted by:
All Y	Y direction of the base is used as the Y direction. Offsets in this direction cannot be determined however.
X	If Y and Z are defined, the X direction is automatically given. Offsets in this direction cannot be determined however. If Y and Z are not defined, the X direction of the base is used as the X direction.

7.4.6 "Correction freely programmable" – example 1

The example shows how the same offset can be measured in different ways. The inline form must be filled out differently, according to the measurement method. The measurement method selected in the specific application depends on the geometry of the workpiece and the alignment of the sensor.

In this example the workpiece will be linearly offset to the side and inclined in 1 direction. The shape of the workpiece stays the same.

- 1 CD*x* is required for the lateral offset. This must be entered in the **X** box.
  For the measurement the sensor must be aligned so that CDa is parallel to the offset or at an angle of 90° to it.
- 2 CD*x* are needed to measure the inclination. These must be entered in the **Y** boxes of the inline form. It does not matter which CDx is entered in which **Y** box.
  For the measurements the sensor must be aligned so that CDa is at an angle of 90° to the plane to be measured on the reference workpiece.

Variant A

1 measurement is carried out here. The sensor is aligned on the reference workpiece so that CDa is at an angle of 90° to the plane to be measured. As this plane is slightly inclined, so too is the sensor.

- The plane is measured by CDa and CDb.
- The side is measured by CDc.

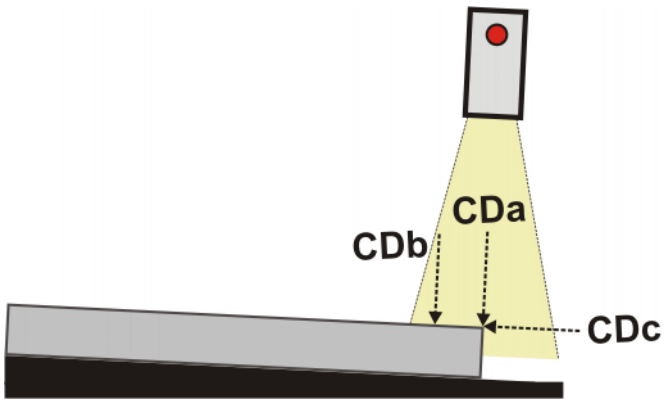

Fig. 7-20: Measurement of the reference workpiece

The new workpiece has a greater inclination and is laterally offset:

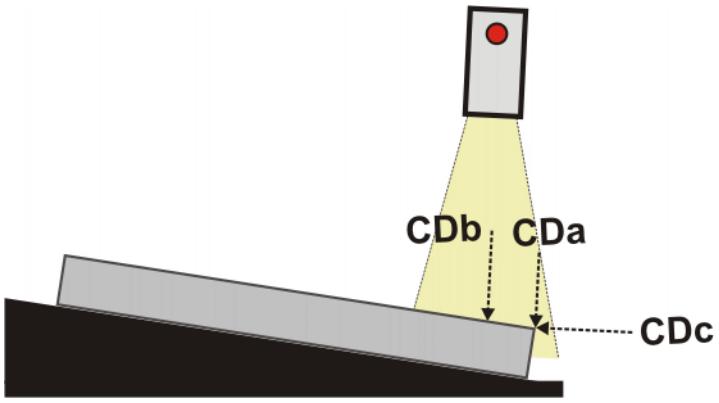

Fig. 7-21: Measurement of the new workpiece

Inline form:

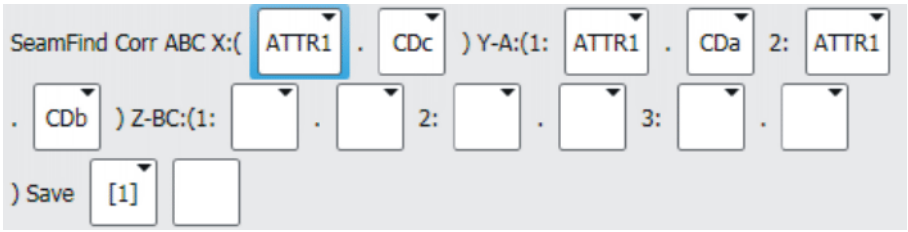

Fig. 7-22: Inline form for variant A

The CD*x* data that have measured the lateral offset are CDc and CDd. Only 1 specification per offset is required in the inline form, however. CDd could also be entered instead of CDc.

Variant B

Variant B is more complex than variant A because 2 measurements are performed in this case. This variant can be used if variant A does not provide a sufficiently accurate measurement, e.g. because the workpiece is very large and the change in inclination is very slight.

The sensor is again aligned on the reference workpiece so that CDa is at an angle of 90° to the plane to be measured. As this plane is slightly inclined, so too is the sensor.

- The plane is measured by the CDa of the 1st and 2nd measurement.
- The side is measured by the CDc of the 2nd measurement.

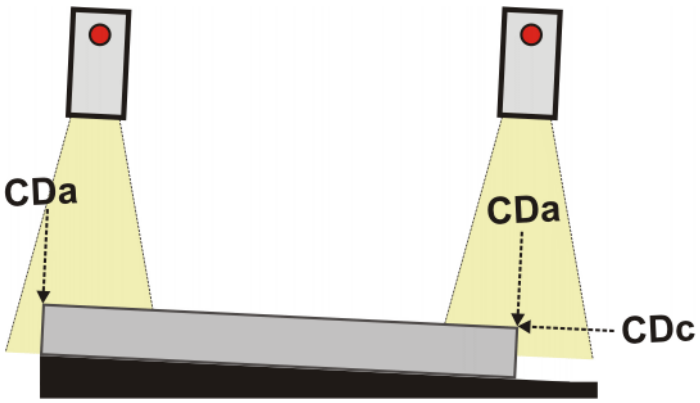

Fig. 7-23: Measurement of the reference workpiece

The new workpiece has a greater inclination and is laterally offset:

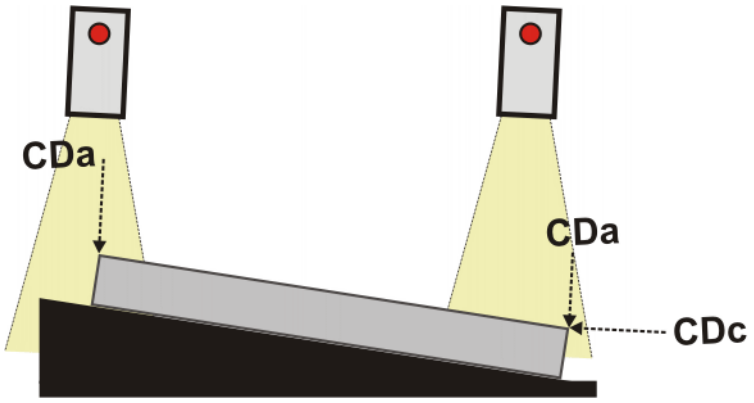

Fig. 7-24: Measurement of the new workpiece

Inline form:

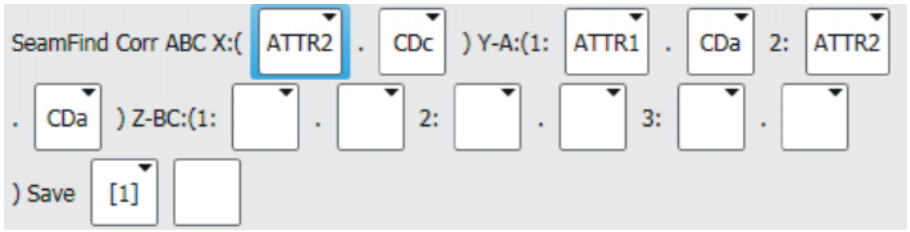

Fig. 7-25: Inline form for variant B

The CD*x* data that have measured the lateral offset are CDc and CDd. Only 1 specification per offset is required in the inline form, however. CDd could also be entered instead of CDc.

7.4.7 “Correction freely programmable” – example 2

This example shows how typical position changes can be measured and how the inline form has to be filled out.

Reference workpiece

Position of the reference workpiece:

Fig. 7-26: Position of the reference workpiece

Other workpieces

The other workpieces can be inclined in 1 direction in relation to the reference workpiece:

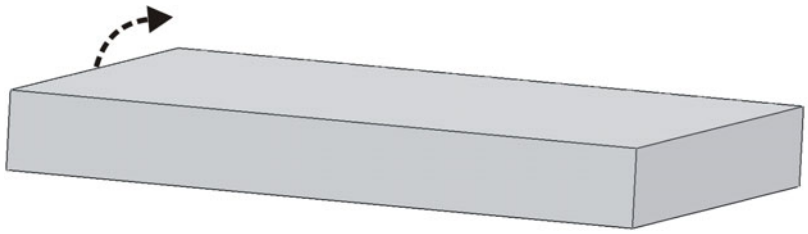

Fig. 7-27: Possible inclination

They can be additionally rotated in the plane:

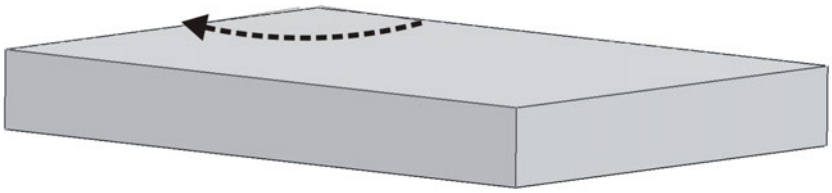

Fig. 7-28: Possible rotation

Measurements

CD*x* required:

- 2 CD*x* are needed to measure the inclination.
- 2 CD*x* are needed to measure the rotation.
- It is possible for an additional offset in longitudinal direction to result depending on the center of rotation. 1 CD*x* is needed to measure this offset.

The following measurements are suitable for obtaining the CD*x* required. The red lines represent the laser lines.

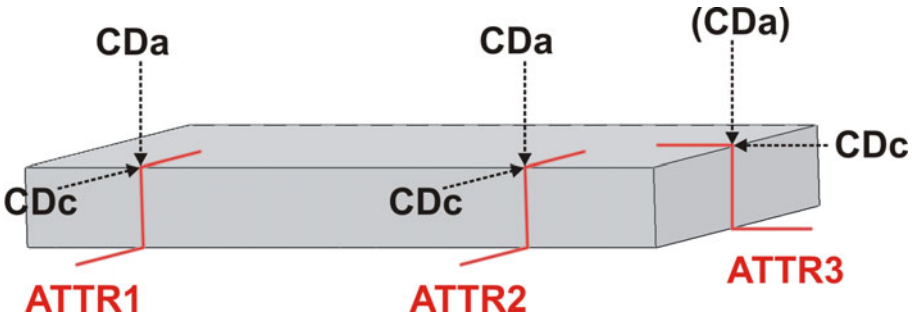

Fig. 7-29: Measurement of the reference workpiece

Inline form

2 CD*x* are sufficient to measure the rotation. However, either 1 or 3 Z boxes have to filled out; 2 Z boxes are not allowed. CDa from ATTR3 is therefore additionally used.

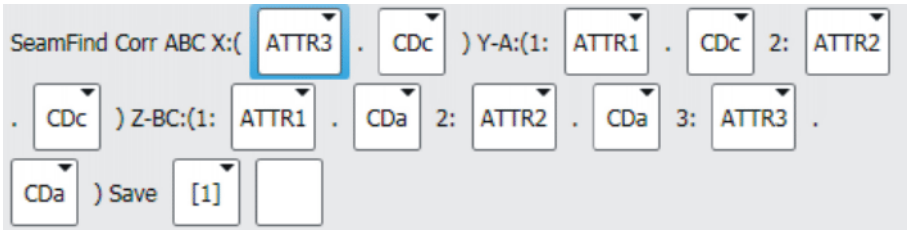

Fig. 7-30: Inline form

7.5 “Switch off correction” – Corr Off

Call

- Select the menu sequence **Commands** > **SeamTech Finding** > **Switch off correction**.

Description

Each correction instruction switches the correction mode on. This instruction switches the correction mode off. This means that all following motion commands are executed without correction.

NOTICE If correction mode is switched off and the position of the workpiece does not correspond to the reference position, collisions may result.

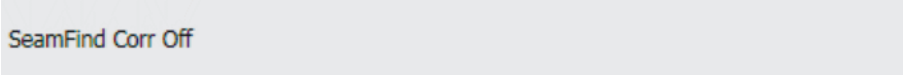

Fig. 7-31: Inline form “Corr Off”

7.6 “Load and enable correction” – Corr Load and On

Call

- Select the menu sequence **Commands** > **SeamTech Finding** > **Load and enable correction**.

Description

This instruction loads a correction that has been saved. The correction mode is switched on again if it was switched off.

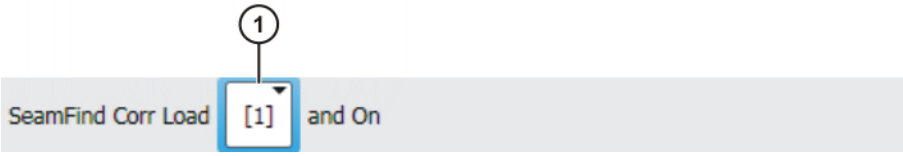

Fig. 7-32: Inline form “Corr Load and On”

Item	Description
1	Select the correction to be loaded. ■ **1 … 20**

7.7 “Check position correction” – Check Point

Description

This instruction checks whether a point is still within certain limits after the correction. If the limits are exceeded, a message is displayed. This enables incorrectly loaded workpieces to be detected, for example.

Recommendation: Always use Check Point to check the corrections.

The Check Point instruction should be programmed directly after the correction instruction. It may be inserted at any distance before the point to be checked.

The limits can be defined as a sphere about the original point, or as X, Y, Z and angle values.

Robot controller response after the check:

- There is no reaction if the point lies within the defined limits. The program continues without interruption.
- If the point coes not lie within the defined limits, the robot controller indicates this by means of a dialog message. The user can choose between the following answers:

Answer	Effect
NoCorr	The robot controller sets the correction values to “0”, i.e. the program is continued without correction. **Note:** Even if the dialog message refers to just one single exceeded limit, e.g. to the X value, **NoCorr** results in all correction values being set to “0”.
Ignore	The robot controller ignores the fact that the point lies outside the limits and continues the program with correction. (= The same response as if the point had been within the limits.)

Call

- Select the menu sequence **Commands** > **SeamTech Finding** > **Check position correction**.

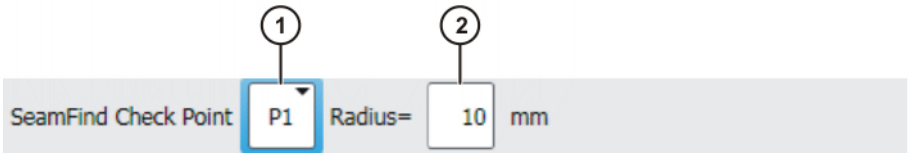

Fig. 7-33: Check Point (Radius)

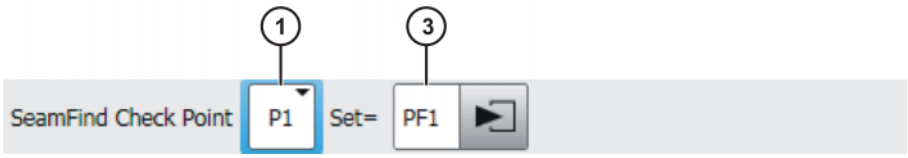

Fig. 7-34: Check Point (Set)

Radius/PL can be used to toggle between the **Radius** box and the **Set** box.

Item	Description
1	Point whose position is to be checked. All points created in the current program are available for selection.
2	The system checks whether the point is still within a sphere of this radius. ■ **0.1 … 200 mm**
3	The system checks whether the point lies within the defined limits. Name of the data set containing the limit values. The system automatically generates a name. The name can be changed. (>>> 7.14 "Names in inline forms" Page 63) To change the limit values, place the cursor in the box. The corresponding option window is opened. (>>> 7.7.1 "Option window “Position test criteria”" Page 59)

7.7.1 Option window “Position test criteria”

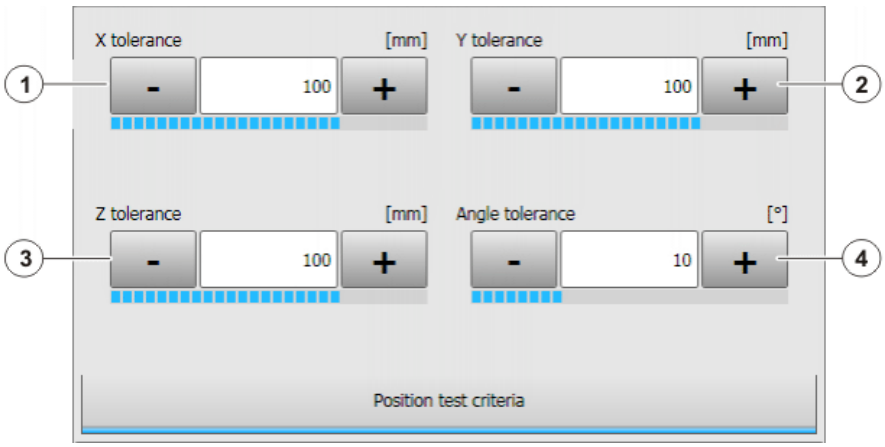

Fig. 7-35: Option window: Position test criteria

The values refer to the BASE coordinate system in which the point was taught.

For X, Y and Z a deviation is permitted in either the plus or the minus direction, but not in both directions at once.

Item	Description
1	Permitted deviation in the X direction
2	Permitted deviation in the Y direction
3	Permitted deviation in the Z direction
4	Permitted deviation in the angle values

7.8 “Calibration (check)” – Check Calibration

Check Calibration cannot be used for a sensor that could not be calibrated semi-automatically (e.g. a fixed sensor).

Precondition

- The connection to the sensor is established.

Call

- Select the menu sequence **Commands** > **SeamTech Finding** > **Calibration (check)**.

Description

Due to external factors, such as tool change, maintenance work or temperature changes, the sensor may deviate from its original calibration. With **Check Calibration**, the sensor can be checked and the calibration corrected.

The function of this instruction varies depending on whether the configuration parameter **Sensor must be calibrated** is activated or not.

Sensor must be calibrated = activated:

The sensor will be calibrated. If a calibration already exists, these data will be overwritten. After calibration, the parameter is automatically deactivated.

Sensor must be calibrated = deactivated:

The sensor will be checked.

- If the deviation from the calibration exceeds the limits defined on the **Sensor tool check** tab, this is indicated by a message. The following options are then available:
  - Recalibrate the sensor.
  - Manually bring the sensor as well as possible into the original position, then check the sensor again.
- If the deviation from the calibration lies within the limits, the setting in the inline form becomes relevant:
  - If **with Adjustment** is selected, the current data are saved as the tool data of the sensor.

    The data of the original calibration remain saved separately, however. The limits for deviations defined on the **Sensor tool check** tab continue to relate to the original calibration and not to the adapted data.
  - If [*blank*] is selected, the existing tool data of the sensor remain unchanged.

This instruction must always come after a motion command, so that the robot is in a defined position.

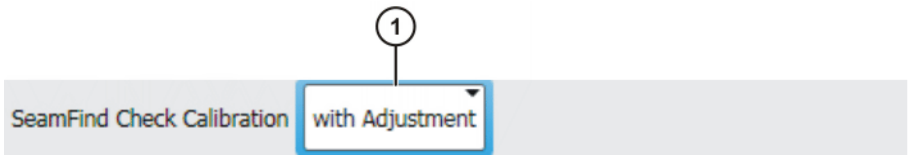

Fig. 7-36: Inline form “Check Calibration”

Item	Description
1	This setting is only relevant if the configuration parameter **Sensor must be calibrated** = deactivated ■ **with Adjustment**: The sensor coordinate system is adapted. ■ [*blank*]: The sensor coordinate system is not adapted.

7.9 “Initialize sensor” – Init

Precondition
- The connection to the sensor is established.

Call
- Select the menu sequence **Commands** > **SeamTech Finding** > **Initialize sensor**.

Description
This instruction re-initializes the sensor. It must be located at the start of each program.

```
SeamFind Init
```

Fig. 7-37: Inline form “Init”

7.10 “Reset sensor” – Clear

Call
- Select the menu sequence **Commands** > **SeamTech Finding** > **Reset sensor**.

Description
This instruction resets the sensor.

```
SeamFind Clear
```

Fig. 7-38: Inline form “Clear”

7.11 Example program

This example illustrates the basic program structure for SeamTech Finding.

```
    ...
 1  PTP HOME  Vel= 100 % DEFAULT
 2
 3  PTP P1 Vel= 100 % PDAT2 SeamFind Measure ATTR1 Tool[16]:mySensor
    Base[1]
 4  SeamFind Corr XYZ BASE X: ., Y: ATTR1.CDa, Z: ATTR1.CDc Save [1]
 5
 6  SeamFind Check Point P2 Radius=5 mm
 7
 8  PTP P2 Vel=100 % PDAT1 Tool[1]:myTestTool Base[0]
 9  LIN P3 Vel=0.1 m/s CPDAT2 Tool[1]:myTestTool Base[0]
10
11  PTP HOME  Vel= 100 % DEFAULT
    ...
```

Line	Description
3	Measurement of the workpiece position (without a search) With the first program run, the reference workpiece is measured. Precondition: **Execute** is selected under **Reference run** in the **Search profile** option window. After successful measurement of the reference workpiece, the selection is automatically changed to **Executed**. With the subsequent program runs, the other workpieces can be measured.
4	The correction is calculated on the basis of the measurement in line 3 (= ATTR1). If the reference workpiece was measured in line 3, a correction of “0” is calculated here.
6	**Check Point** checks that point P2 is no more than 5 mm away from the original position following the correction.
8, 9	Conventional motions The robot controller corrects these motions on the basis of the calculation in line 4.

7.12 Linked search

Description

If several measuring instructions with search are used, it might happen that with a relatively large offset in one direction a further search no longer locates the workpiece. This can be avoided by linking searches.

Linking the searches leads to a higher hit rate and greater accuracy. The linked search is suitable for all linear offsets and slight rotations.

Example

```
...
PTP P1
LIN P2 Vel=2 m/s CPDAT2 SeamFind Measure ATTR1 Dynamic P3 ...
PTP P4
LIN P5 Vel=2 m/s CPDAT3 SeamFind Measure ATTR2 Dynamic P6 ...
SeamFind Corr XYZ TCP X: ATTR1.CDa, Y: ATTR2.CDa
...
```

Measurement of the reference workpiece:

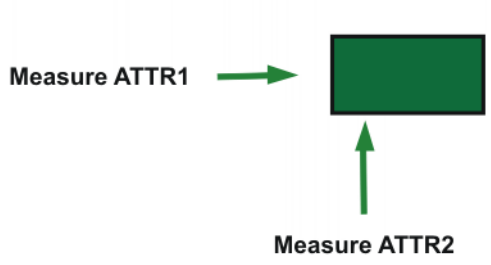

Fig. 7-39: Reference workpiece

Measurement of the other workpieces:

The other workpieces might be offset to such an extent that the second measuring instruction no longer locates the workpiece.

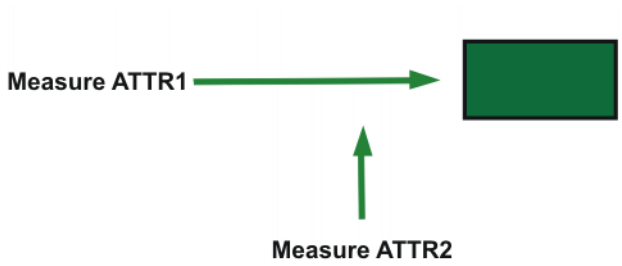

Fig. 7-40: New workpiece, without linked search

Remedy: Program a linked search. The second measuring instruction then takes into account the first change in position.

```
...
PTP P1
LIN P2 Vel=2 m/s CPDAT2 SeamFind Measure ATTR1 Dynamic P3 ...
SeamFind Corr XYZ TCP X: ATTR1.CDa
PTP P4
LIN P5 Vel=2 m/s CPDAT3 SeamFind Measure ATTR2 Dynamic P6 ...
SeamFind Corr XYZ TCP Y: ATTR2.CDa
...
```

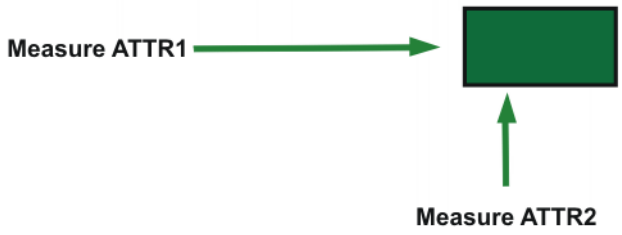

Fig. 7-41: New workpiece, with linked search

7.13 Changing several motion blocks at once

Description

It is possible for several motion blocks to be changed at once. This can be used, for example, if the setting for the reference run has to be reset to **Execute** in all measuring instructions.

Precondition

- "Expert" user group
- A program is selected.
- Operating mode T1

Procedure

1. Select the motion instructions to be modified. (Only consecutive motion instructions can be modified as a block.)
2. Press **Change**. The inline form of the first selected motion block opens.
3. Modify parameters.
4. Press **Cmd OK**. The changes will be applied to the selected motion blocks where possible.

   Some changes will not be applied in every motion block, e.g. it is not possible to apply the PTP parameter **Velocity** in a LIN motion block.

7.14 Names in inline forms

Names for data sets can be entered in inline forms. These include, for example, point names, names for motion data sets, etc.

The following restrictions apply to names:

- Maximum length 24 characters
  Individual boxes may be restricted to fewer than 24 characters.
- No special characters are permissible, with the exception of _.
- The first character must not be a number.

The restrictions do not apply to output names.

8 Messages

Message	Cause / remedy
Calculation of normalized vector cross product is not possible!	Cause: ■ Unsuitable CD*x* were selected in the correction instruction. The required values cannot be calculated from them. ■ Or: CD*x* were selected in the correction instruction whose directions meet at an angle of 90°. Remedy: ■ Check the correction instruction and select suitable CD*x*. ■ Or: Repeat the measurements, altering the angle of the sensor slightly between measurements.
CD4 can not be calculated by KLM_Solve2X3 subroutine	Cause: CD*x* of measurements were possibly used which are located too close together. Remedy: Check the CD*x* used in the inline form and choose others if necessary.
Current interpolation mode (BASE) differs from IPO mode of measurement data. A mixture is not allowed and can not be calculated.	Cause: The interpolation mode in which the measuring instructions were executed differs from the current interpolation mode. This mixture is not permissible. Remedy: Change the modes so that they match. The current interpolation mode can be changed using the system variable $TCP_IPO.
The current interpolation mode (TCP) differs from IPO mode of measurement data. A mixture is not allowed and can not be calculated.	Cause: The interpolation mode in which the measuring instructions were executed differs from the current interpolation mode. This mixture is not permissible. Remedy: Change the modes so that they match. The current interpolation mode can be changed using the system variable $TCP_IPO.
Normalized vector N4 can not be calculated	Cause: ■ Unsuitable CD*x* were selected in the correction instruction. The required values cannot be calculated from them. ■ Or: CD*x* were selected in the correction instruction whose directions meet at an angle of 90°. Remedy: ■ Check the correction instruction and select suitable CD*x*. ■ Or: Repeat the measurements, altering the angle of the sensor slightly between measurements.
No correction can be calculated. Search motion in CD4 is too short.	Cause: The search distance defined in the **Search parameter set** option window is too short. Remedy: Define a longer search distance.
No correction calculated. Search motion in CD1 is too short.	Cause: The search distance defined in the **Search parameter set** option window is too short. Remedy: Define a longer search distance.

Message	Cause / remedy
No correction calculated. Correction data set type mismatch.	Cause: The CD*x* originate from measuring instructions that are executed partly with interpolation mode = TRUE and partly with FALSE. This mixture is not permissible. Remedy: Execute all measuring instructions in the same mode. (The interpolation mode is defined in the **Frames** option window.)
No correction calculated. Individual data sets are incorrectly preset.	Cause: For some CD*x* either no measurement or no successful measurement has been performed. Remedy: Repeat all the measurements.
Could not find branch to check mathematical properness	Cause: In the correction instruction **Corr ABC** a combination of CD*x* was used that cannot be calculated. Remedy: Use other CD*x*.
No frame correction can be calculated with the current coordinate system.	Initial situation: The sensor is defined as a fixed tool (= BASE), the workpiece is moving (= TOOL). Cause: Before the correction instruction a motion must have been carried out with the moving workpiece. This is not the case. Therefore the robot controller cannot determine the current TOOL. Remedy: Program a motion with the workpiece before the correction instruction.
Normalized vector N4 can not be calculated	Cause: ■ Unsuitable CD*x* were selected in the correction instruction. The required values cannot be calculated from them. ■ Or: CD*x* were selected in the correction instruction whose directions meet at an angle of 90°. Remedy: ■ Check the correction instruction and select suitable CD*x*. ■ Or: Repeat the measurements, altering the angle of the sensor slightly between measurements.
Normalized vector cross product for CD4 not solvable	Cause: ■ Unsuitable CD*x* were selected in the correction instruction. The required values cannot be calculated from them. ■ Or: CD*x* were selected in the correction instruction whose directions meet at an angle of 90°. Remedy: ■ Check the correction instruction and select suitable CD*x*. ■ Or: Repeat the measurements, altering the angle of the sensor slightly between measurements.
Unknown value for IPO mode configuration	Cause: The interpolation mode is not defined. Remedy: Execute all measuring instructions with interpolation mode = FALSE. Furthermore, the interpolation mode must also be FALSE at the time of the correction instruction.
A transfer error occurred on adaption of subroutine BF_SetCorrData().	Remedy: Reset the program and contact KUKA Support if the message occurs again.

Message	Cause / remedy
The sensor is deactivated. A new correction frame was not calculated.	Remedy: Activate the sensor.
Calculation of the motion frame for dynamic measurements is not possible! Check the taught positions of the search motion.	Cause: The distance between the start point and the Via point is too small. Remedy: Increase the distance by reteaching the start point and/or the Via point.
Error on sensor switch-off.	Remedy: Check the communication between the sensor and the robot controller (cables, interface, IP address).
Error occurred during sensor reset.	Remedy: Check the communication between the sensor and the robot controller (cables, interface, IP address).
Initialization of sensor failed! Check sensor IP address, possibly also necessary to check network communication: sensor <-> robot. Laser enable signal possibly missing: external key switch for laser enable, or internal or external laser enable	Remedy: ■ Check the communication between the sensor and the robot controller (cables, interface, IP address). ■ Check whether the sensor was switched off by means of the keyswitch on the sensor controller.
Adapting an interface subroutine on saving data failed.	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Correction data cannot be calculated	Cause: One or all CD*x* could not be calculated. The exact cause is indicated in the preceding messages. (If not, set a higher messaging level in the **Messaging level** configuration parameter in order to display more messages.) Remedy: Depends on the exact cause.
Measurement failed: no measurement value available	Cause: A measurement has failed during the measuring procedure. (This does not mean that the entire measuring procedure has failed.) Remedy: Reduce the quantity of messages via the **Messaging level** configuration parameter. The message will then no longer be displayed. The message is primarily relevant during start-up and/or troubleshooting. It can usually be disregarded in the normal process sequence.
Process state #ErrorSearchLimit not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Process state #MeasureOkSenOffMovOff not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Process state #SenInitializedMoveNot not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Process state #SensorAndMoveInitialized not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Process state #SensorOn not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Process state #SensorOnMovementOn not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Process state #SetCorrDataDoneFirstDoub not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Process state #StopAfterError not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.

Message	Cause / remedy
Process state #TouchSenseHadContact not possible!	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Sensor cannot be calibrated.	Remedy: Activate the sensor.
Sensor calibration failed!	Cause: The sensor is not calibrated. The exact cause is indicated in the preceding messages. (If not, set a higher messaging level in the **Messaging level** configuration parameter in order to display more messages.) Remedy: Depends on the exact cause.
Unknown state of state machine	Remedy: Reset the program and contact KUKA Support if the message occurs again.
Search direction cannot be determined!	Cause: The distance between the start point and the Via point is too small. Remedy: Increase the distance by reteaching the start point and/or the Via point.
Laser beam could not be muted by sensor command.	Remedy: Check the communication between the sensor and the robot controller (cables, interface, IP address).
Unknown motion type on preparing search motion	Remedy: 1. Open the inline form **Measure**, check the entries and close the form again with **Cmd OK**. 2. Execute the measuring instruction again. 3. Contact KUKA Support if the message occurs again.
Unknown motion type in subroutine BFM_SearchLoop()	Remedy: 1. Open the inline form **Measure**, check the entries and close the form again with **Cmd OK**. 2. Execute the measuring instruction again. 3. Contact KUKA Support if the message occurs again.
Unknown process state in subroutine SearchLoopCP()	Remedy: 1. Open the inline form **Measure**, check the entries and close the form again with **Cmd OK**. 2. Execute the measuring instruction again. 3. Contact KUKA Support if the message occurs again.
Calculated target position reached but workpiece not recognized	Cause: The complete search distance was covered without the workpiece being detected. Many possible reasons, including: The workpiece is located outside the search window of the sensor. Or the joint type selected in the inline form does not correspond to the actual type. Or fouling in the field of view of the sensor. Remedy: Depends on the reason, for example: Reprogram the search. Program a longer search distance and/or a different joint type.
Internal sensor calibration cannot be switched off. Possible remedy: reboot the controller with a cold start.	Remedy: ■ Reboot robot controller with cold restart. ■ Or: With several sensor types, the internal calibration cannot be switched off. Ignore the message in this case.

Message	Cause / remedy
Sensor could not be initialized because sensor is inactive!	Remedy: Activate the sensor.
Sensor cannot measure, because it has not been calibrated	Remedy: Calibrate the sensor.
No measurement since sensor was not switched on	Cause: A block selection was carried out to a line inside the fold of the measuring instruction. Remedy: Execute the measuring instruction again. (Either by block selection to the complete instruction, or reset the program and restart it.)
Number of sensor task not defined	Remedy: ■ Open the inline form **Measure**, check the entries and close the form again with **Cmd OK**. Execute the measuring instruction again. ■ Contact KUKA Support if the message occurs again.
Sensor switch-on failed with selected sensor task number: Sensor profile possibly not yet available in the sensor!	Cause: ■ The task number does not exist in the WeldCom software. ■ Or: Error in communication with the sensor. Remedy: ■ Create or rename the task number in the WeldCom software. ■ Or: Check the communication between the sensor and the robot controller (cables, interface, IP address).
Sensor does not supply all necessary information of its field of view.	Cause: ■ Error in communication between the robot controller and the sensor ■ Or: This sensor type is not provided with the function of supplying information about the optimal position or the maximum position. Remedy: ■ Check the communication between the sensor and the robot controller (cables, interface, IP address). ■ Or: Ignore the message.
Sensor delivers invalid or no new measurement	Cause: ■ The workpiece is located outside the measuring window. ■ Or: A joint type was selected in the inline form that does not correspond to the actual joint type. ■ Or: A joint type was selected in the inline form for which the configuration parameter **Dimension** is not correct. Remedy: ■ Reprogram the measuring instructions, adapting them to the actual position of the workpiece. ■ Select the correct joint type in the inline form. ■ Correct the **Dimension** configuration parameter on the **Seam shapes** configuration screen.

Message	Cause / remedy
Sensor initialization not yet carried out	Cause: ■ The INI fold in the program was not executed, e.g. because a block selection was performed to a later instruction. ■ Or: The **Clear** instruction was executed. Remedy: ■ Always execute the INI fold. ■ Program an **Init** after **Clear** in order to initialize the sensor again. ■ Create the program again.
Sensor state unknown	Remedy: 1. Reset and restart the program. 2. If the message occurs again, perform a hardware reset of the sensor. This means switch it off and reboot it or, if the sensor does not offer these functions, remove the power briefly. 3. Contact KUKA Support if the message occurs again.
Cyclic measurement failed	Cause: A measurement has failed during the measuring procedure. (This does not mean that the entire measuring procedure has failed.) Remedy: Reduce the quantity of messages via the **Messaging level** configuration parameter. The message will then no longer be displayed. The message is primarily relevant during start-up and/or troubleshooting. It can usually be disregarded in the normal process sequence.
The deviation upon calculation of angle A to the reference data is too big.	Cause: The deviation is greater than the maximum value defined. This has caused an error in the calculation. (The maximum value is defined on the **Sensor tool check** configuration screen.)
The deviation upon calculation of angle B to the reference data is too big.	Cause: The deviation is greater than the maximum value defined. This has caused an error in the calculation. (The maximum value is defined on the **Sensor tool check** configuration screen.)
The deviation upon calculation of the x-component to the reference data is too big.	Cause: The deviation is greater than the maximum value defined. This has caused an error in the calculation. (The maximum value is defined on the **Sensor tool check** configuration screen.)
The deviation upon calculation of the Y/Z/C-components to the reference data is too big.	Cause: The deviation is greater than the maximum value defined. This has caused an error in the calculation. (The maximum value is defined on the **Sensor tool check** configuration screen.)
The base number for the calibration plate is zero. A base number not equal to zero has to be selected in the configuration plug-in (page: Calibration)	Cause: The configuration parameter **Base number for calibration plate** is set to “0”. Remedy: Enter the base number in the configuration parameter that was (or will be) selected for calibration of the calibration plate.

Message	Cause / remedy
During identification of tool-B using two measurements no change of the Z-coordinate was detected.	Cause: ■ The sensor supplies incorrect data. ■ Or: After the calibration plate was calibrated its position was changed. Remedy: ■ Check the task in the WeldCom software. ■ Recalibrate the calibration plate.
Sensor calibration is allowed in operation mode “T1” only since robot motions are calculated dynamically. The calibration procedure can be continued by changing the operation mode to T1.	Remedy: Select operating mode T1.
The variable “BFSCAL_SensorToolNr” is wrong or points to a non-organized TOOL_DATA[] array element.	Cause: The configuration parameter **Tool number of sensor** was not edited in WorkVisual but by other means. When doing so, an inadmissible value was set. Remedy: Enter an admissible value in the configuration parameter **Tool number of sensor**. Then calibrate the sensor.
Wrong base for BASE measurement of the calibration plate: the content of the variable "BFSCAL_CalibPlateBaseNr" is wrong or points to a non-organized BASE_DATA[] array element.	Cause: ■ The base number selected for calibration of the calibration plate does not match the number specified in the configuration parameter **Base number for calibration plate**. ■ Or: The configuration parameter **Base number for calibration plate** was not edited in WorkVisual but by other means. When doing so, an incorrect value was set. Remedy: ■ Enter the base number in the configuration parameter **Base number for calibration plate** that was selected for calibration of the calibration plate.
Erroneous result of the last two measurements. The program cannot be continued correctly. Please restart the program.	Remedy: Restart the program.
Spread of measurement values of the gap is too big	Cause: The differences between the measurement repetitions in **Check Calibration** are larger than allowed. (The maximum value is defined internally and cannot be configured.) Remedy: 1. Make sure that there is no dirt in the field of view of the sensor (e.g. large dust particles). Also clean the calibration plate. 2. Repeat **Check Calibration**.

Message	Cause / remedy
Spread of measurement values of component “Y” is too big	Cause: The differences between the measurement repetitions in **Check Calibration** are larger than allowed. (The maximum value is defined internally and cannot be configured.) Remedy: 1. Make sure that there is no dirt in the field of view of the sensor (e.g. very large dust particles). Also clean the calibration plate. 2. Repeat **Check Calibration**.
Spread of measurement values of component “Z” is too big	Cause: The differences between the measurement repetitions in **Check Calibration** are larger than allowed. (The maximum value is defined internally and cannot be configured.) Remedy: 1. Make sure that there is no dirt in the field of view of the sensor (e.g. very large dust particles). Also clean the calibration plate. 2. Repeat **Check Calibration**.
Reference data of X-component are still missing for a successful calibration!	Cause: Initial calibration of the sensor has not yet been (fully) carried out. Remedy: Carry out complete initial calibration of the sensor.
Reference data of Y,Z,C-components are still missing for a successful calibration!	Cause: Initial calibration of the sensor has not yet been (fully) carried out. Remedy: Carry out complete initial calibration of the sensor.
Spread of measurement values of angle “C” is too big	Cause: The differences between the measurement repetitions in **Check Calibration** are larger than allowed. (The maximum value is defined internally and cannot be configured.) Remedy: 1. Make sure that there is no dirt in the field of view of the sensor (e.g. very large dust particles). Also clean the calibration plate. 2. Repeat **Check Calibration**.
Reference data of angle A for calibration still missing!	Cause: Initial calibration of the sensor has not yet been (fully) carried out. Remedy: Carry out complete initial calibration of the sensor.
Reference data of angle B for calibration still missing!	Cause: Initial calibration of the sensor has not yet been (fully) carried out. Remedy: Carry out complete initial calibration of the sensor.
Calibration plate is not measured as BASE. BASE_DATA[BFSCAL_CalibPlateBaseNr] has the value $NULLFRAME. Execute BASE measurement of the calibration plate.	Remedy: Calibrate the calibration plate.

Message	Cause / remedy
Reference data of master calibration for calibration are still missing!	Cause: Initial calibration of the sensor has not yet been (fully) carried out. Remedy: Carry out complete initial calibration of the sensor.
Sensor cannot be switched off	Remedy: Check the communication between the sensor and the robot controller (cables, interface, IP address).
Gap too small: the established result leads to the conclusion that the sensor could not recognize a profile correctly.	Remedy: Restart the program. Contact KUKA Support if the error occurs again.
Negative or zero gap width: the calculated result suggests that the gap was not correctly detected. The program cannot be continued without errors. Please restart the program.	Remedy: Restart the program. Contact KUKA Support if the error occurs again.
The tool length is out of tolerance: the calculated data deviate too much from the reference data.	Cause: The deviation is greater than the maximum value defined. (The maximum value is defined on the **Sensor tool check** configuration screen.)
Tool angle A is out of tolerance: the calculated value deviates too much from the reference value.	Cause: The deviation is greater than the maximum value defined. (The maximum value is defined on the **Sensor tool check** configuration screen.)
Tool angle B is out of tolerance: The calculated value deviates too much from the reference value.	Cause: The deviation is greater than the maximum value defined. (The maximum value is defined on the **Sensor tool check** configuration screen.)
Tool angle C is out of tolerance: the calculated value deviates too much from the reference value.	Cause: The deviation is greater than the maximum value defined. (The maximum value is defined on the **Sensor tool check** configuration screen.)
Sensor Tool number for calibration is zero. Change the sensor tool number by using the configuration plugin (page: Calibration) to the desired TOOL_DATA element.	Cause: The configuration parameter **Tool number of sensor** is set to “0”. Remedy: Set a value other than “0”.
Dimension of the detection profile not defined	Cause: A joint type with an invalid configuration was selected in the inline form **Measure**. Either this joint type was not correctly created by the user. Or it is a predefined joint type whose configuration has been modified. Remedy: Correct the configuration of the joint type in WorkVisual on the **Seam shapes** configuration screen.
Dimension too big	Cause: The configuration parameter **Dimension** on the **Seam shapes** configuration screen was not edited in WorkVisual but by other means. When doing so, an incorrect value (too high) was set. Remedy: Set the parameter to the correct value in WorkVisual.
Sensor deactivated: individual correction data sets will not be calculated.	Remedy: Activate the sensor.
Sensor error: sensor has not supplied any valid data.	Cause: The sensor has not supplied any valid data. Remedy: Execute the measuring instruction again.
Unknown IPO mode of the robot	Remedy: Contact KUKA Support.

9 Appendix

9.1 Overview of joint types

A joint type is a characteristic form (seam shape, sheet edge, punched hole, …) to be detected by the sensor on the workpiece. In this documentation, the characteristic form is generally referred to as the “joint type”. The joint type to be detected by the sensor is selected by the user in the measuring instruction. A large number of predefined joint types are offered for selection in SeamTech Finding.

The red star in the diagrams of the joint types indicates the recommended positions for the tracking point. Which position is more advantageous depends on the specific application.

Names

Names of the joint types:

In SeamTech Finding	Usual name
Corner joint	Corner weld
Fillet joint	Fillet weld
Butt joint	Butt weld
Lap joint	Lap weld
V groove joint	Single-V butt weld
Half V groove joint	Single-bevel butt weld
J groove joint	Single-U butt weld
TWB joint	Offset butt joint (rounded)
Melt run	Melt run
Dot	Spot weld

Corner joint

4 dimensions (CDa … CDd)

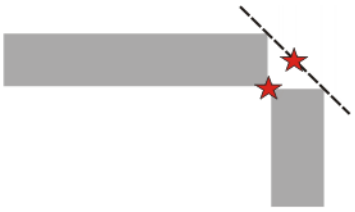

Fig. 9-1: Corner joint

Fillet joint

4 dimensions (CDa … CDd)

Fig. 9-2: Fillet joint

Butt joint

3 dimensions (CDa … CDc)

Fig. 9-3: Butt joint

Lap joint 3 dimensions (CDa … CDc)

Fig. 9-4: Lap joint

V groove joint 3 dimensions (CDa … CDc)

Fig. 9-5: V groove joint

Half V groove joint 4 dimensions (CDa … CDd)

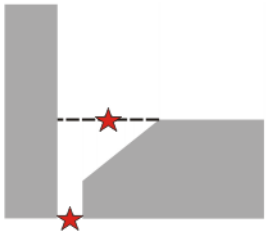

Fig. 9-6: Half V groove joint

J groove joint 3 dimensions (CDa … CDc)

Fig. 9-7: J groove joint

TWB joint 3 dimensions (CDa … CDc)

Fig. 9-8: TWB joint

Melt run 2 dimensions (CDa, CDb)

Fig. 9-9: Melt run

For the “melt run”, the WeldCom software places the tracking point by default at the edge of the field of view of the sensor. This results in an error message. Therefore shift the tracking point in WeldCom into the center of the field of view.

Dot 1 dimension (CDa)

Fig. 9-10: Dot

9.2 Dimensions of the calibration plate

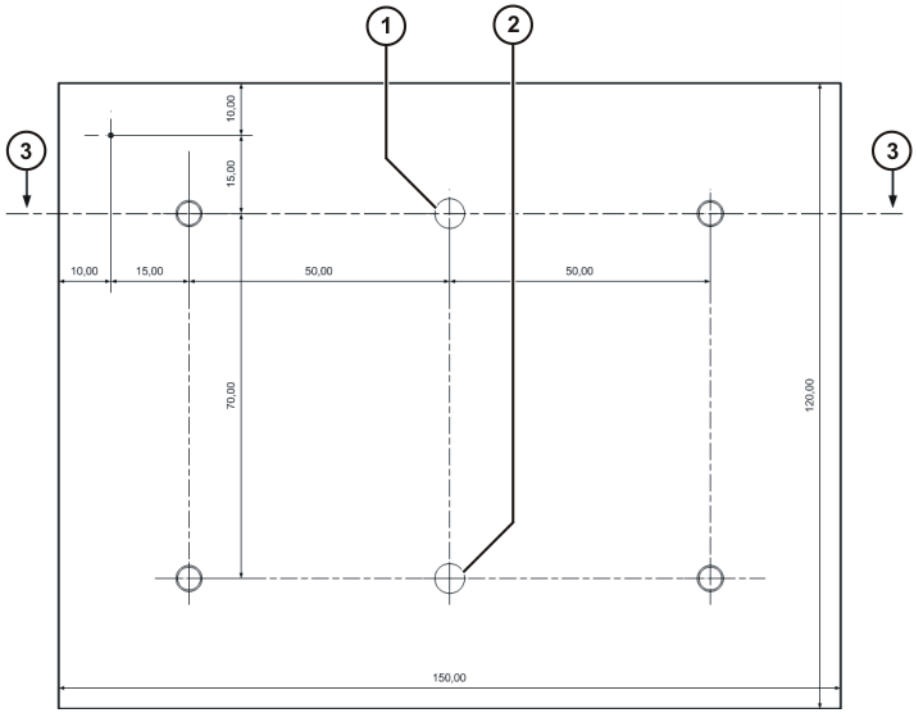

Fig. 9-11: Dimensions of the calibration plate: underside

Item	Description
1	For dowel pin
2	For dowel pin
3	Position of the cross-section (>>> Fig. 9-12)

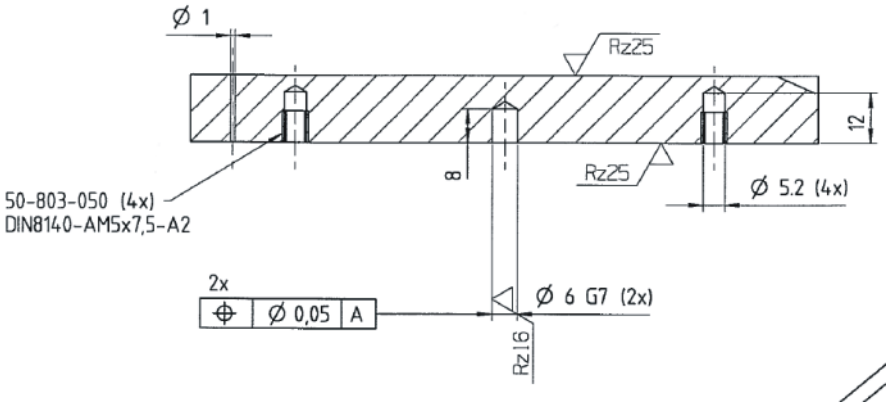

Fig. 9-12: Dimensions of the calibration plate: cross-section

9.3 Fields of view of the sensors

9.3.1 SERVO-ROBOT sensors (type DIGI-I)

The following parameters define the field of view of the sensor:

- $-Y_{near}$; $+Y_{near}$
- $-Y_{far}$; $+Y_{far}$
- $+Z_{near}$; $+Z_{far}$

The parameters refer to the optical reference frame. The optical reference frame is a sensor-specific coordinate system. It is independent of the coordinate systems of the robot controller and cannot be modified by the user.

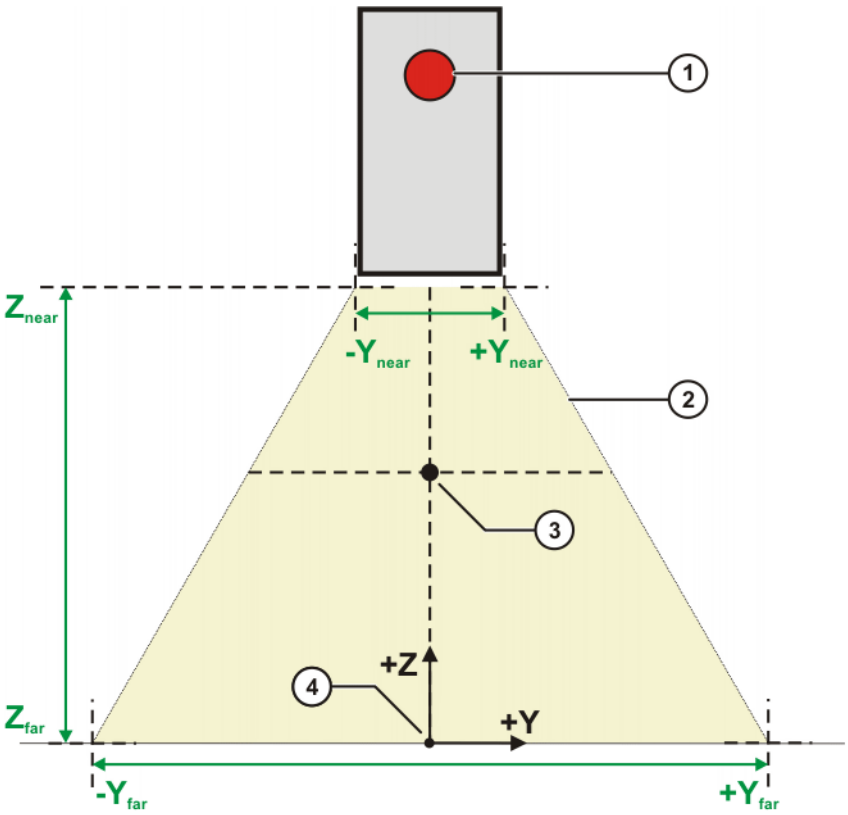

Fig. 9-13: Front view (not to scale)

1 LED on sensor housing
2 Field of view of sensor (yellow area)
3 Optimal view point of the sensor

The robot controller places the TCP of the TOOL coordinate system at this point for semi-automatic sensor calibration. (>>> 9.4 "Sensor coordinate systems" Page 80)

4 Optical reference frame

9.3.2 SERVO-ROBOT sensors (types SF/D)

The following parameters define the field of view of the sensor:

- $-Y_{near}$; $+Y_{near}$
- $-Y_{far}$; $+Y_{far}$
- $+Z_{near}$; $+Z_{far}$

> The parameters refer to the optical reference frame. The values must be entered in WorkVisual on the **Field of view** tab. The relevant values can be taken from the documentation of the sensor manufacturer.

The optical reference frame is a sensor-specific coordinate system. It is independent of the coordinate systems of the robot controller and cannot be modified by the user.

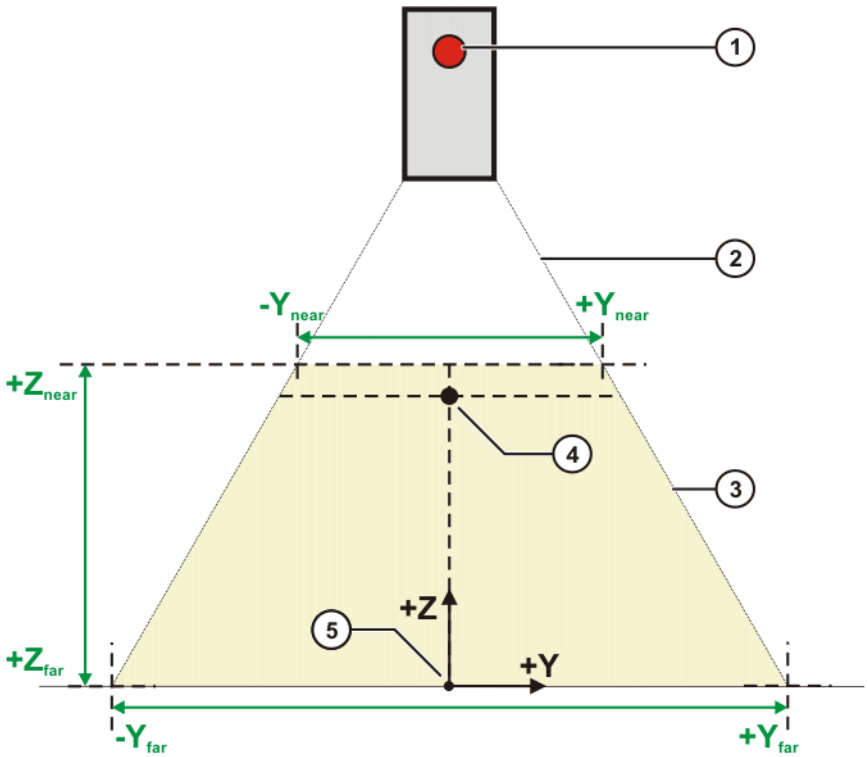

Fig. 9-14: Front view (not to scale)

1 LED on sensor housing
2 Distance (white area) between sensor and field of view of sensor; in reality approx. 18 cm
3 Field of view of sensor (yellow area)

4 Optimal view point of the sensor

This point should be configured so that it is as close as possible to $+Z_{near}$, i.e. at the upper limit of the field of view. It must be placed at least in the upper third of the field of view.

The robot controller places the TCP of the TOOL coordinate system at this point for semi-automatic sensor calibration. (>>> 9.4 "Sensor coordinate systems" Page 80)

5 Optical reference frame

9.4 Sensor coordinate systems

DIGI-I

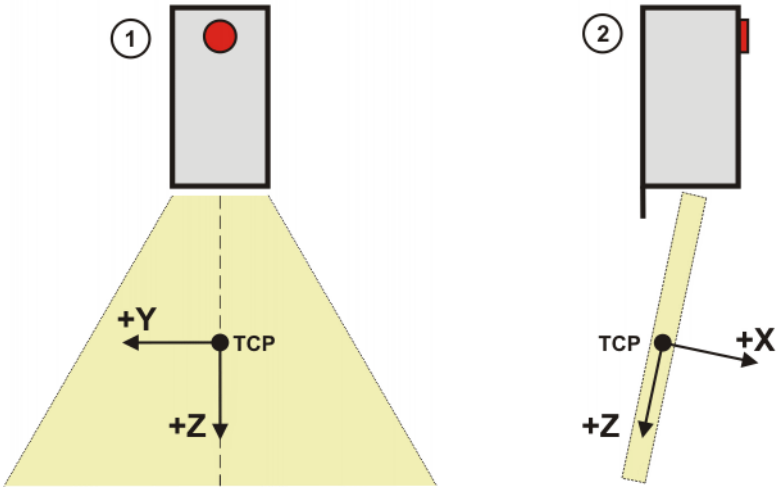

Fig. 9-15: DIGI-I coordinate system

1 Front view of the sensor
2 Side view of the sensor

SF/D

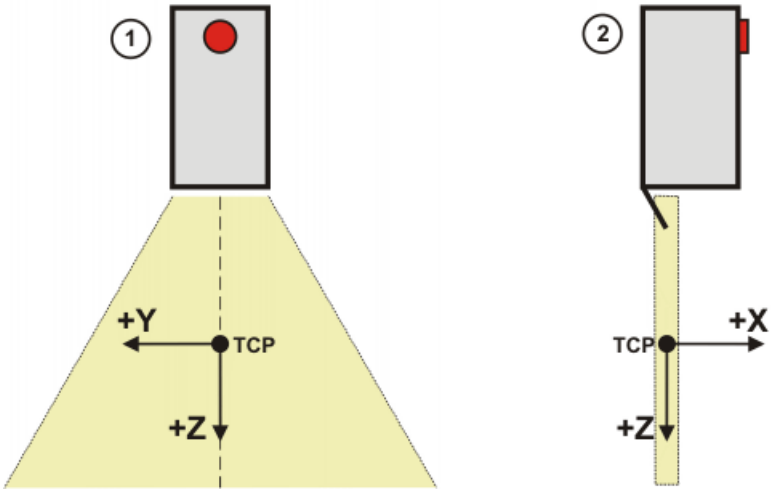

Fig. 9-16: SF/D coordinate system

1 Front view of the sensor
2 Side view of the sensor

9.5 User-specific subprograms

SeamTech Finding contains a large number of subprograms that the user can adapt individually to his requirements.

For further information about subprograms, please contact KUKA Service (>>> 10 "KUKA Service" Page 83).

10 KUKA Service

10.1 Requesting support

Introduction

This documentation provides information on operation and operator control, and provides assistance with troubleshooting. For further assistance, please contact your local KUKA subsidiary.

Information

The following information is required for processing a support request:

- Model and serial number of the manipulator
- Model and serial number of the controller
- Model and serial number of the linear unit (if present)
- Model and serial number of the energy supply system (if present)
- Version of the control software
- Optional software or modifications
- Archive of the software
- Application used
- External axes used
- Description of the problem, duration and frequency of the fault

10.2 KUKA Customer Support

Availability

KUKA Customer Support is available in many countries. Please do not hesitate to contact us if you have any questions.

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Index

WeldCom 6