Performance of Light Weight MIRO Medical Robot By ISO 9283:1998(E)

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Common Information

- **Operating and Environmental conditions**:
  - Operating conditions
    - Electrical,power fluctuations and distrubance…...
  - Environmental conditions.
    - Temperature,humidity, electromagnetic ans static fields**.**
- **Instrumentation:**
  - Measuring instruments are calibrated and the uncertainty should estimated and stated in report.
  - Errors should be consider like: instrument, calculation and systematic errors.

Common Information

- **Load to the mechanical Interface:**
  - Executed witha test load equal to100% of rated conditions like
    - Mass, position of centre of gravity and moments of inertia waacording to manufacture's.
  - Optional test can be with the mass of rated load 10%.
  - Part of Instrumentation is attached then its mass and position be considered as load for end effector.

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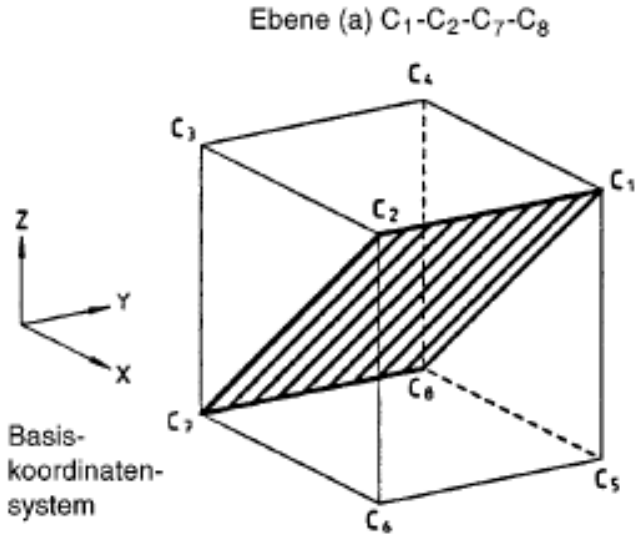
Common Information

- **Test velocities:**
  - All pose characteristics are tested with Max velocity i.e100%.
  - Path characteristics with 100%, 50% and 10% also be conducted.
    - Robot should achieve the required velocity atleast 50% of the test path…….

Working space of pose and path

- A single cube with corners C1 to C8..
  - Edges are should parallel to base coordinate frame



Working space of pose and path

- One of the following planes should be selected for pose
- C1-C2-C7-C8, C2-C3-C8-C5, C3-C4-C5C-6,C4-C1-C6-C7.

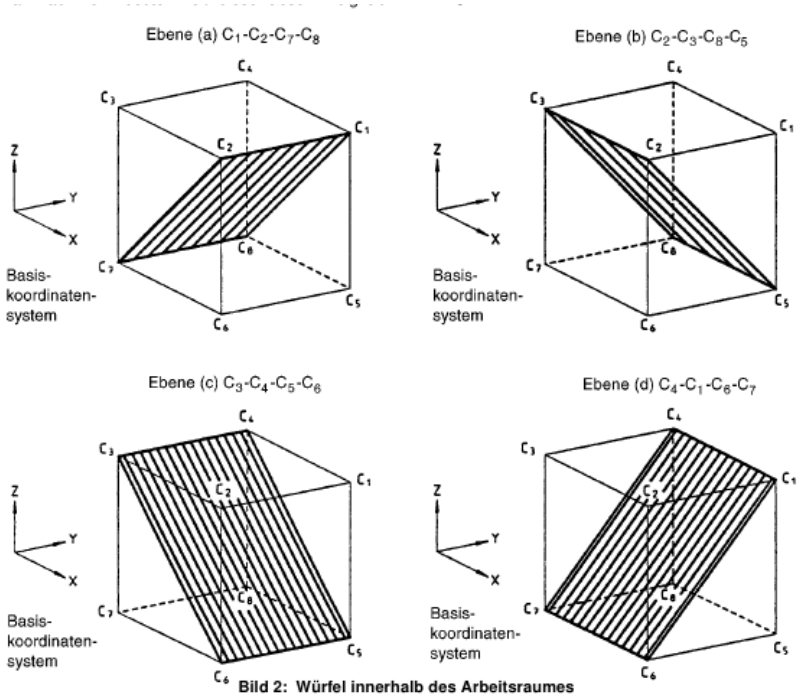
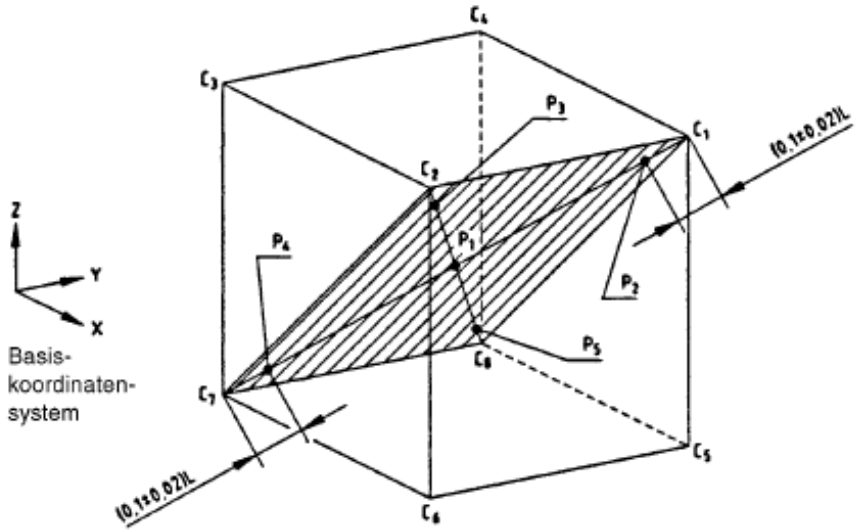


Bild 2: Würfel innerhalb des Arbeitsraumes

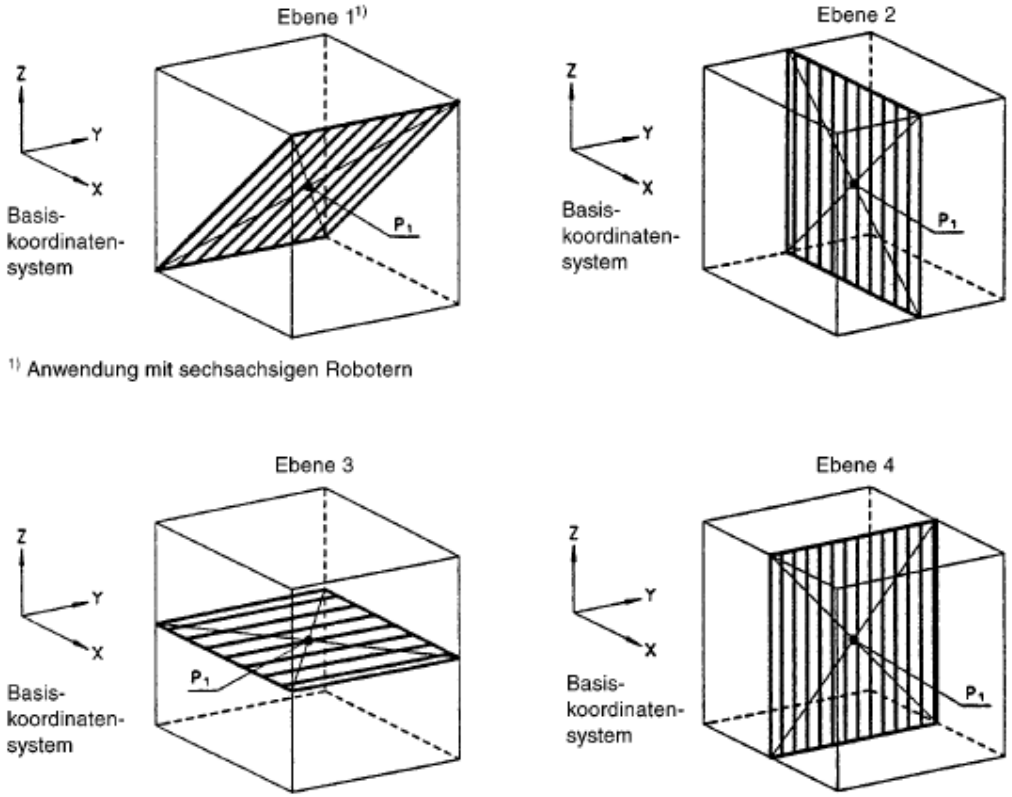
Pose to be tested

- Five diagonal points are located P1-P5 in any selected plane out of four planes.
  - Ponit P1 is the centre of cube i.e. intersection of diagonal point.
    - P2 to P5 are located at distance from ends of the diagonal equal to (10 +- 2%)



Path to be followed

- The location test path is seleced from 4 planes below



[1)] Anwendung mit sechsachsigen Robotern

Bild 5: Festlegung von Ebenen zur Anordnung der Prüfbahn

Path to be followed

- **Size and shapes**
  - For a linear path in the diagonal , the length of the path must be 80 % of the distance between the plane corners

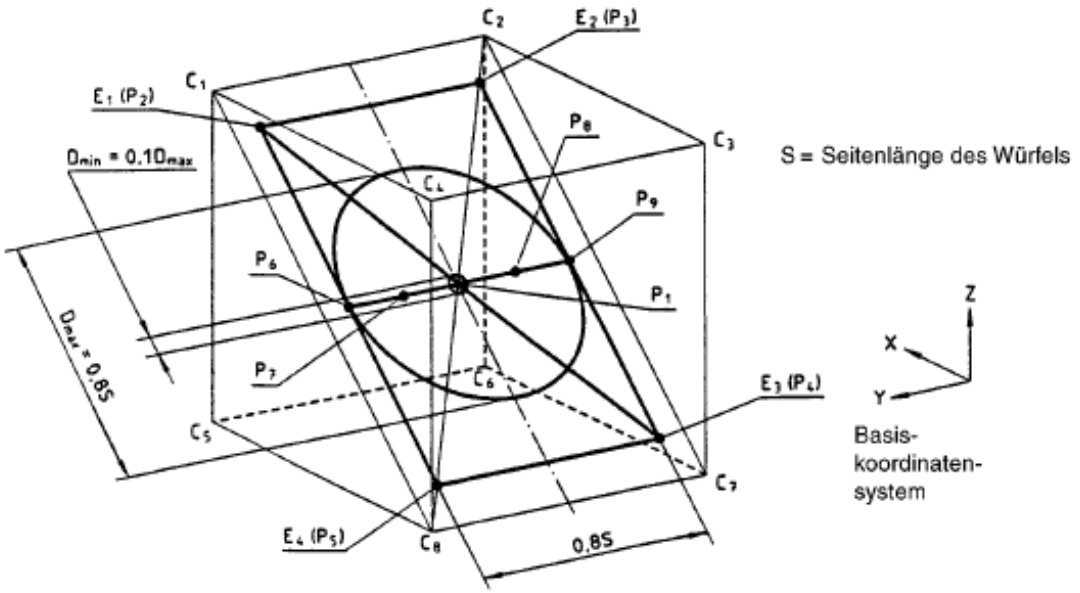


Bild 6: Beispiele für Prüfbahnen

Path to be followed

- **Size and shapes**
  - Small and Large circles
    - Centre is P1 and Large circle shall be 80 % of the side of the cube.
    - Smaller is 10 % of large circle.

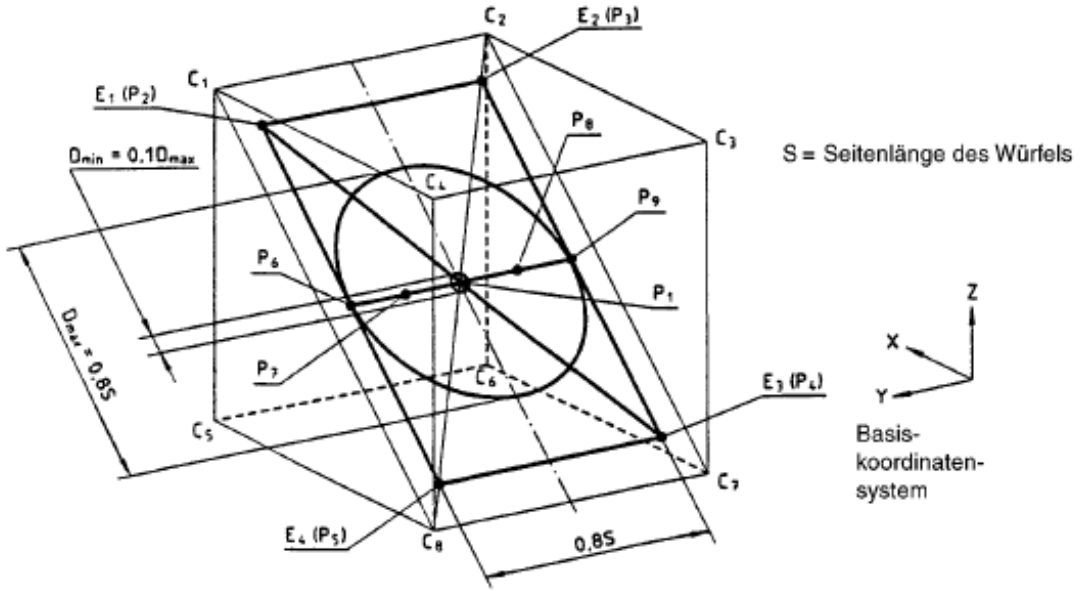


Bild 6: Beispiele für Prüfbahnen

Test procedure

- Pose characteristics shall be tested under pose to pose or continuous path control.
- Path characteristics be tested under path control.
- Path accuracy and repeatability can be done in parallel.
- Velocity tests are performed prior to the measurement of the path accuracy.

    - Simultaneous testing could be
        - Path accuarcy/ repeatability and velocity characteristics.
        - Cornering overshoot and round-off error.

Perforamce criteria

- This International Standard describes methods of specifying and testing the following performance characteristics of manipulating industrial robots:

- - pose accuracy and pose repeatability;
- - multi-directional pose accuracy variation;
- - distance accuracy and distance repeatability;
- - position stabilization time;
- - position overshoot;
- - drift of pose characteristics;
- - exchangeability;
- - path accuracy and path repeatability;
- - path accuracy on reorientation

Pose characteristics

Command pose:

- Pose is specified through programming, numerical data entry, or off-line.

- The coordinates registered on the measuring system are then used as “command pose“
- **Attained pose:**
  - Pose achieved by the robot under automatic mode in response to the command.
- Pose accuracy and repeatability characteristics , quantify the differences which occur between command and attained poses.

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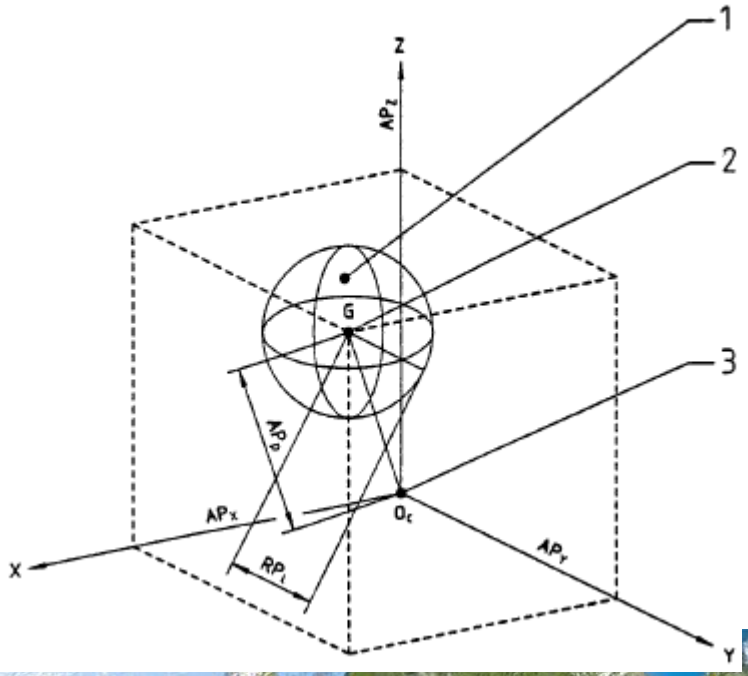
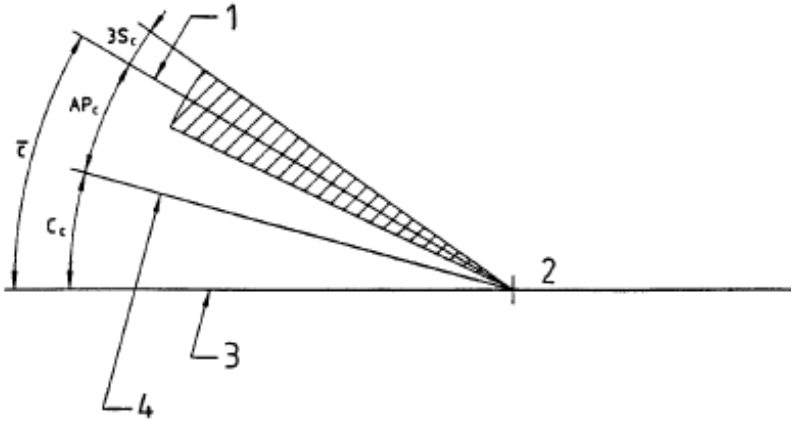
Pose accuracy and Pose repeatability

- **Pose accuracy(AP)**
- **Position accuracy**: command and the barycentre of the attained position.
  - 1 :-jth attained position
  - 2:-position of G: x`, y`, z`. (G is the mean of the all attained poses)
  - 3:- given command pose.



Pose accuracy and Pose repeatability

- **Orientation accuracy: orientation of the command pose and the average of the attained orientations.**
- 1:- mean of the attained orientations.
- 2:- virtual projection point of the different attained positions.
- 3:-cooradinate system.
- 4:-command orientation.

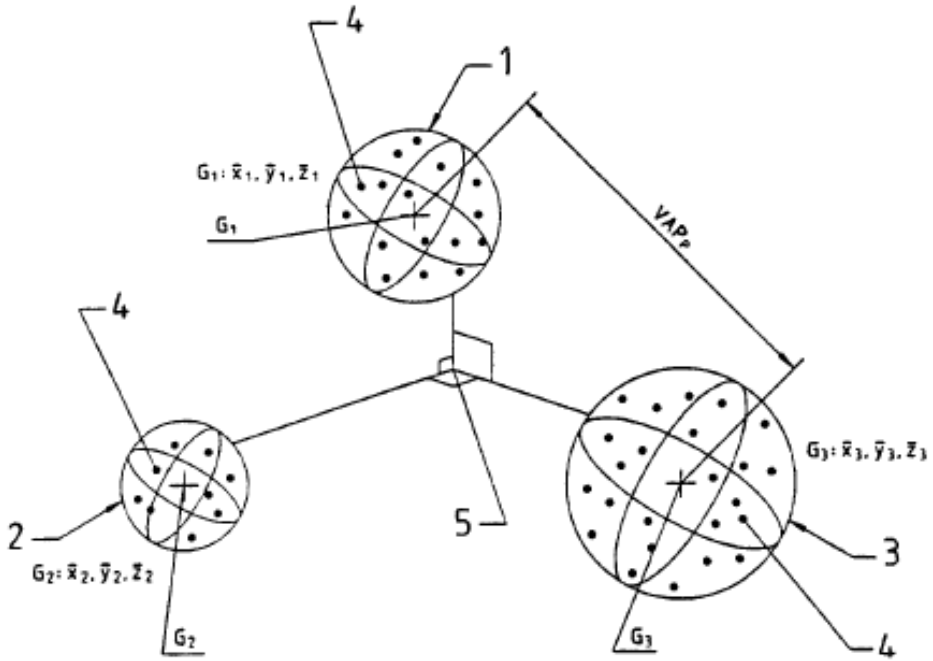


Pose accuracy and Pose repeatability

- **Pose repeatability(PR):**
  - The closeness of agreement between the attained poses after n repeat vists to the same command pose in the same direction.
- Position repeatability
  - Expressed by the radius of the sphere whose centre(barycentre).
- Orientation repeatability
  - The spread angles(standard deviation) about the mean attained oreintation values.

Multi-directional pose accuraccy variation(vAP)

- The deviation between the different attained mean attained poses achieved when visiting the same command pose n times from 3 directions.

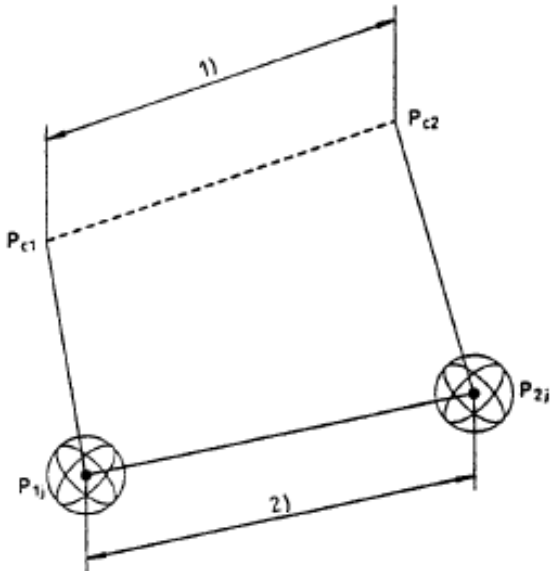


Distance accuracy and repeatability

- **Applicable only to robots with facility of off-line programming and manual data input.**
- The deviations occur in the distance between two command poses and 2 sets of attained poses and fluctuations in the distances for a series of repeat movements between the two poses.
- **Measure in two ways:**
  - Commanding both poses using off-line programming.
  - Commanding one pose by teach and programming a distance through manual data point.

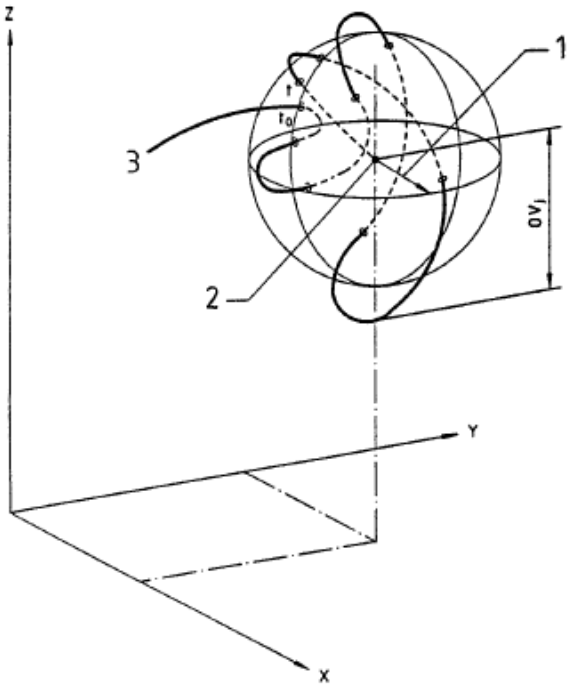
Distance accuracy and repeatability

- **Distance accuracy(AD):**
  - The deviation in position and orientation between the command distance and the mean of the attained distances.
- **Distance repeatability**
  - The closeness of agreement between several attained distances for same command distance and includes.
    - Position and
    - Orientation repeatability.



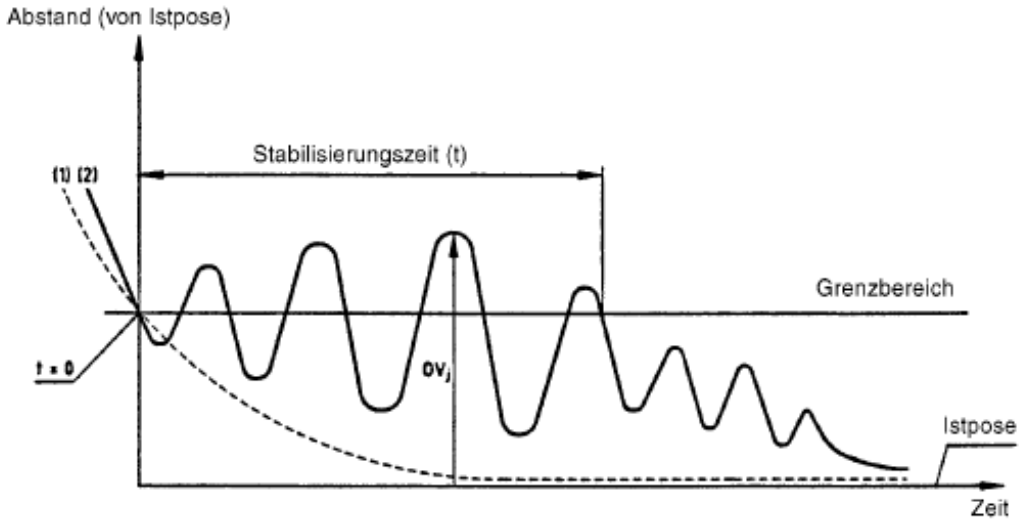
Position stabilization time(PST)

- Which quantifies how quickly a robot can stop at the attained pose.
  - **PST** is also related to the overshoot and other performance parameters of robots.
    - 1:- limit band
    - 2:-attained position.
    - 3:- approaching path.



Position overshoot

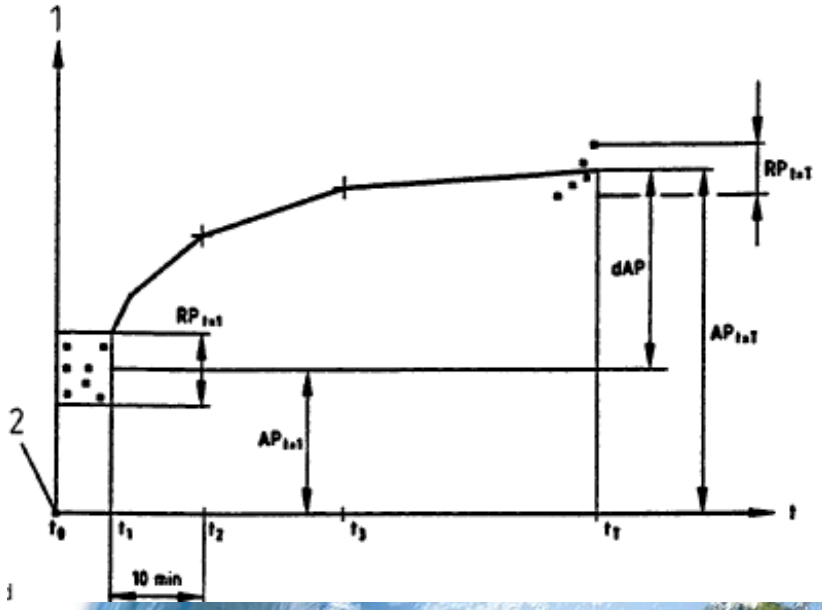
- It quantify the robot capability to make smooth and accurate stops at attained poses.
  - The maximum distance from the attained position after the intial crossing into the limit band and the robot goes outside the limit band again.



Drift of pose characteristics

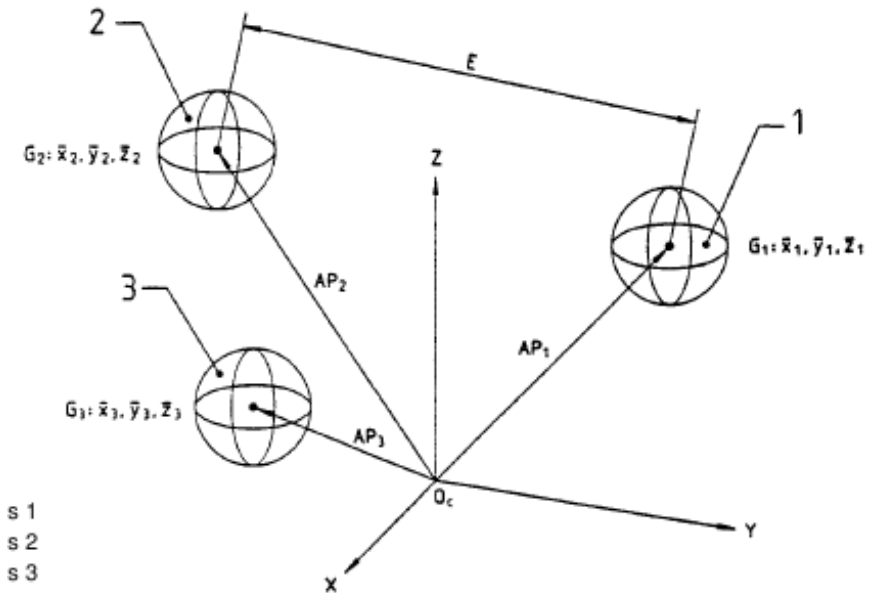
The variation of pose accuracy over specified time **(T)**

- Should begin after power on
- Power off after 8 hours
- Restart the robot.
- All joints have to move 70 % of its full range with maximum velocity.



Exchangeability(E)

- The deviation of the barycentre when different robots of the same type are exchanged under the same environment conditions.



Path characteristics

- The ability of robot to move its mechanical along the commadn path in the same direction n times.
- **Path accuracy(AT):**
  - Difference between the positions of the command path and the barycentre line(position) of attained path.
  - Difference between the command orientation and average attained orienatation.
- It is the maximum path deviation along the path obtained in position and orientation.

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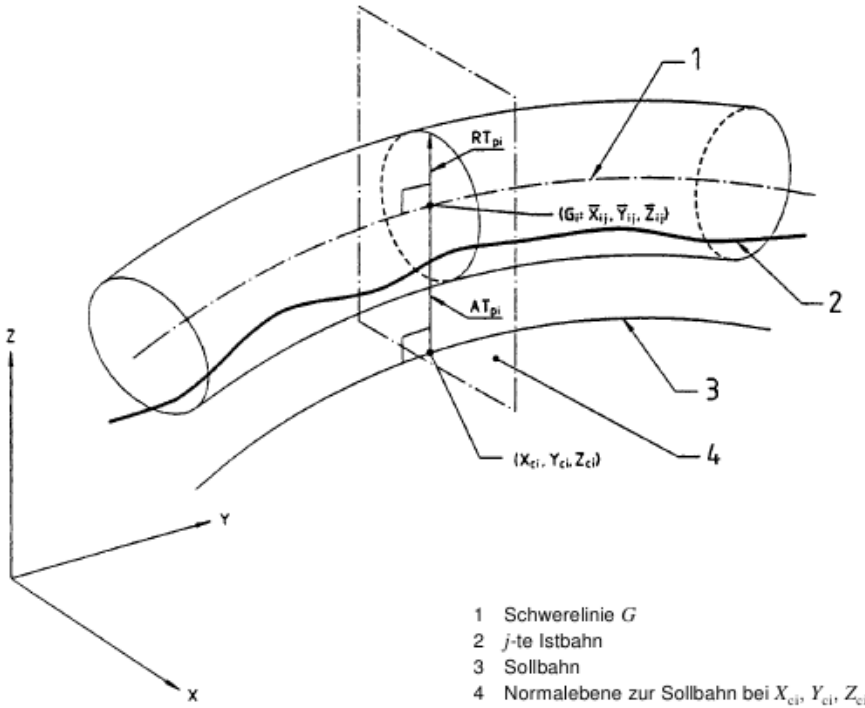
Path characteristics

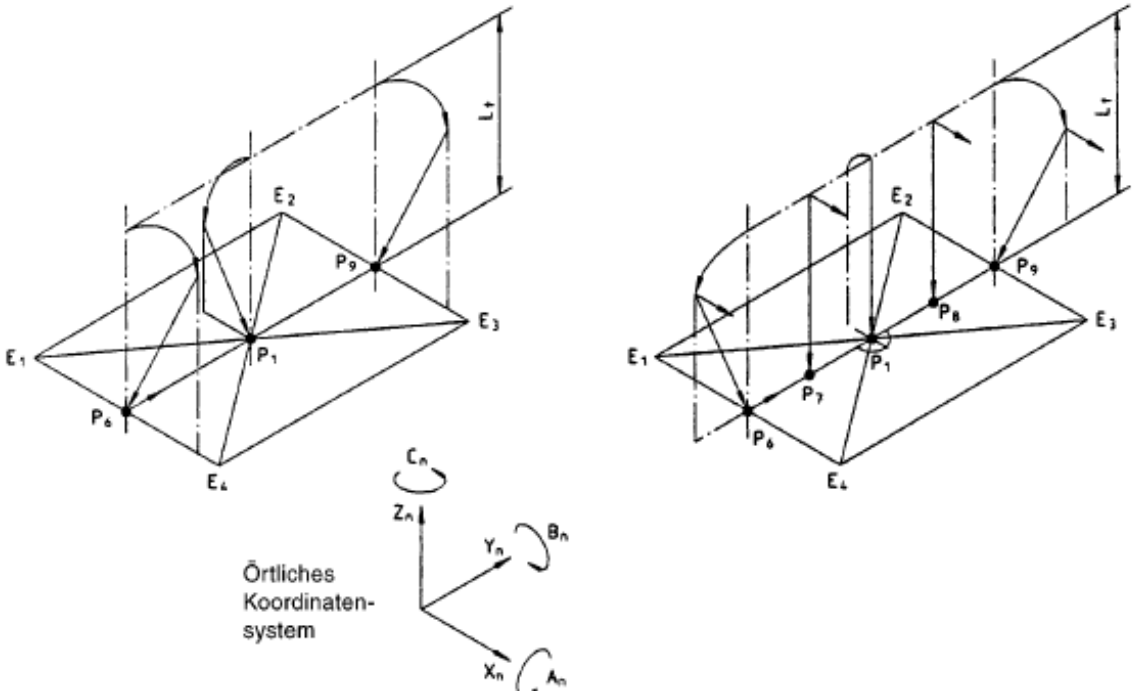
- **Path repeatability(RT)**
  - The closeness of the agreement between the attained paths for the same command path repeated n times.



1 Schwerelinie G
2 j-te Istbahn
3 Sollbahn
4 Normalebene zur Sollbahn bei X_{ci}, Y_{ci}, Z_{ci}

Path characteristics

- **Path accuracy on Reorientation:**

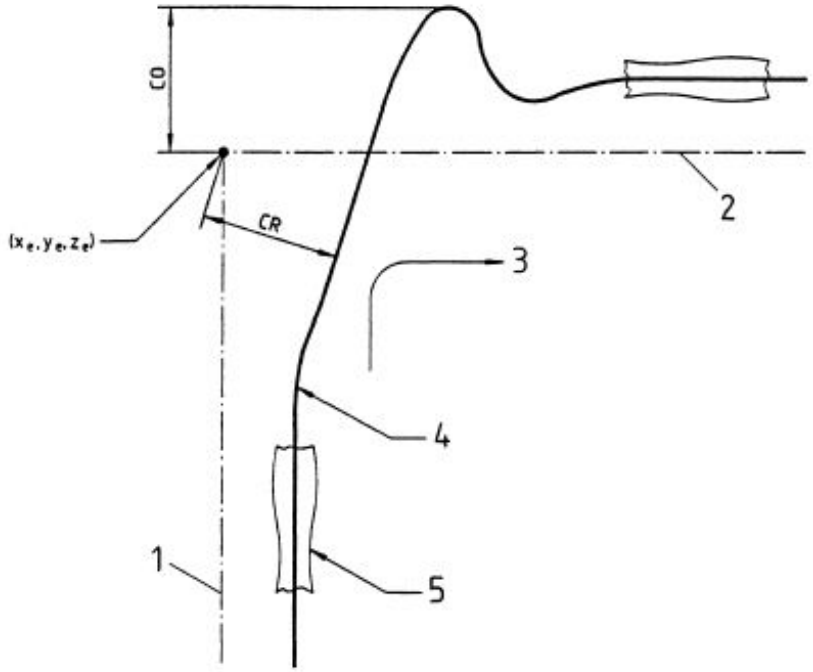


Cornering deviations

- Two types:
- Shrap corners
  - When robot moves from first path towithout delay time to second path orthogonal to first.
- Rounded corners
  - Used to prevent overshoot and keep mechanical strain under limits.
  - Smoothing methods like spline and radii

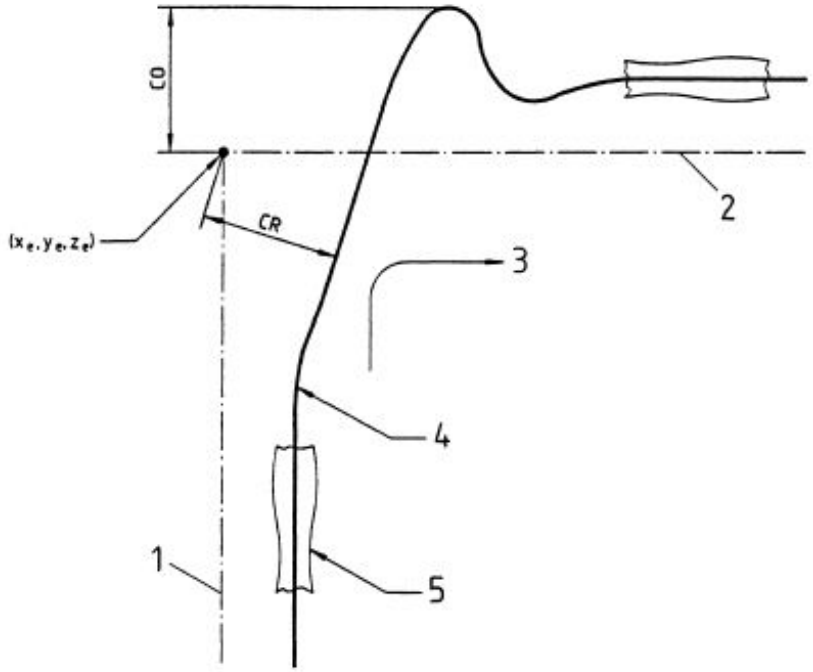
Cornering deviations

- **Cornering round-off error(CR)**
  - Minimum distance from the corner ponit to attained path.



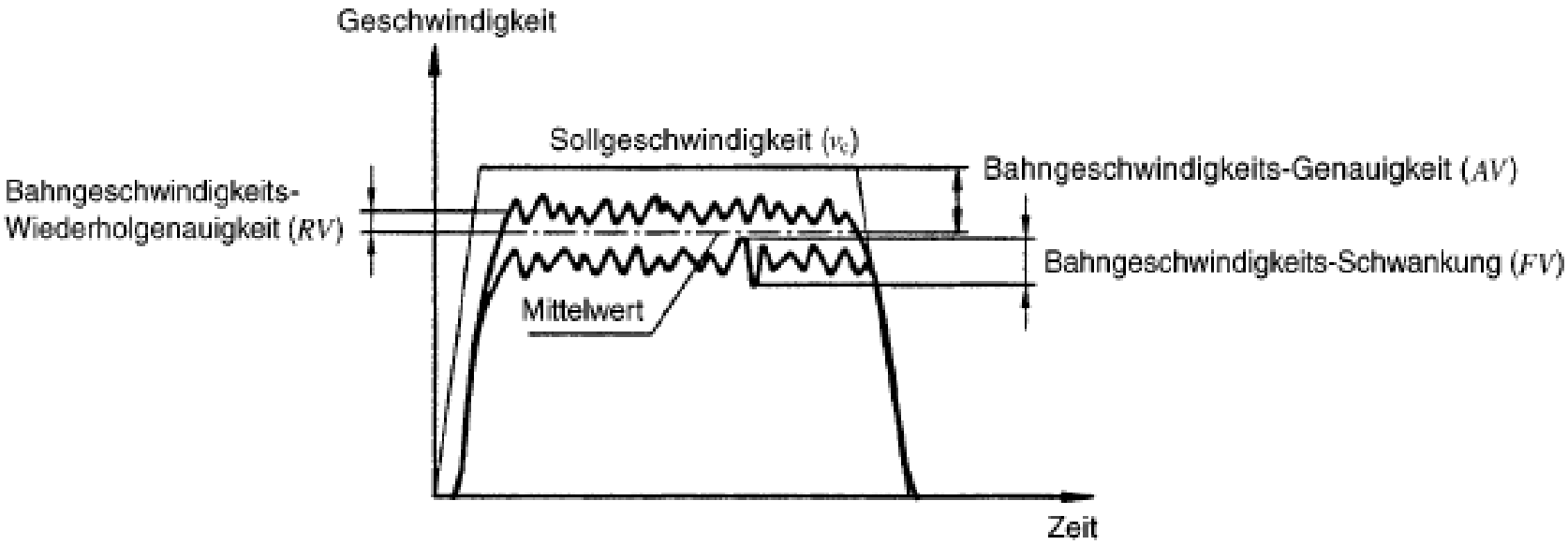
Cornering deviations

- **Cornering overshoot(CO)**
  - Maximum deviation from command path after robot started 2nd path without delat tim



Path velocity characterisctics

- Divide into three criteria
  - Path velocity accuracy(AV).
  - Path velocity repeatability(RV)
  - Path velocity fluctuation(FV).



Miminum posing time

- The time between departure and arrival at a stationary state when traversing a predetermined distance.
- It is a a non linear function of the distance travelled.

Static compliance

- Maximum amount of displacement per unit of applied load.
  - The forces used in the tests shall be in three dimensions
  - Forces shall be increased in steps of 10% of rated up to 100%, one direction at a time.
  - Measurements are made by servo motors on and brakes off.

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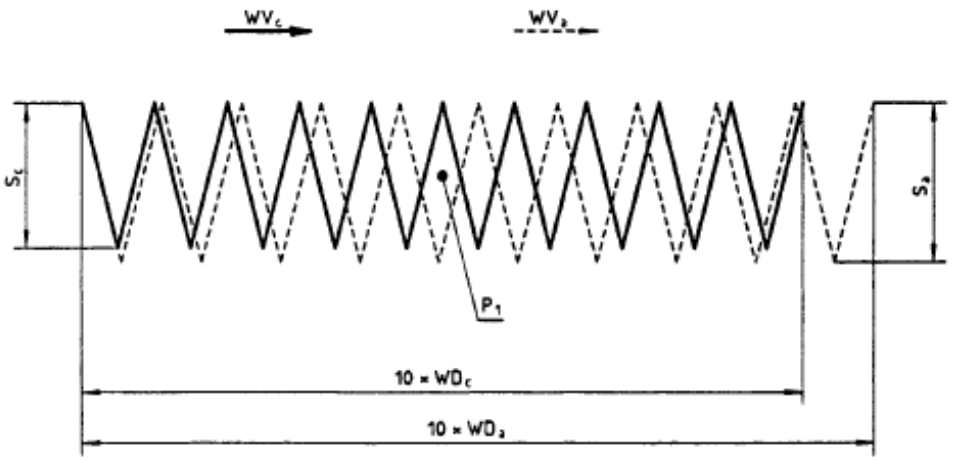
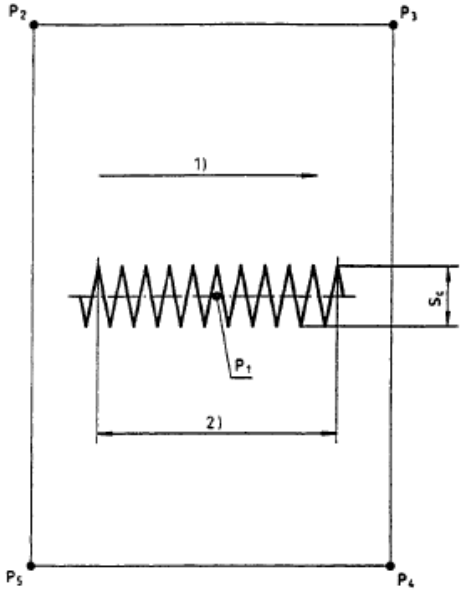
Weaving deviations

- Weaving stroke error(WS)
  - Difference between the command weaving stroke Sc and mean attained weaving stroke Sa.
- Weaving frequency (WF)
  - Difference of Command weaving frequency Fc and attained weaving frequency Fa.





Affects of performance criteria

- The robot mounting erros, mechanical tolerances and errors of axis calibration - *Exchangeability.*
- There is delay time in communication system also affect the position overshoot.
- Controlling methods also change over all performance.
- Errors caused by :
  - Internal control definitions.
  - Coordinate transformations errors.
  - Differences between the dimensions of the articulated structure and used in the robot control system model.
  - Mechanical faults such as clearances,hysteristics , friction and external influences like temperature.

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Thank you