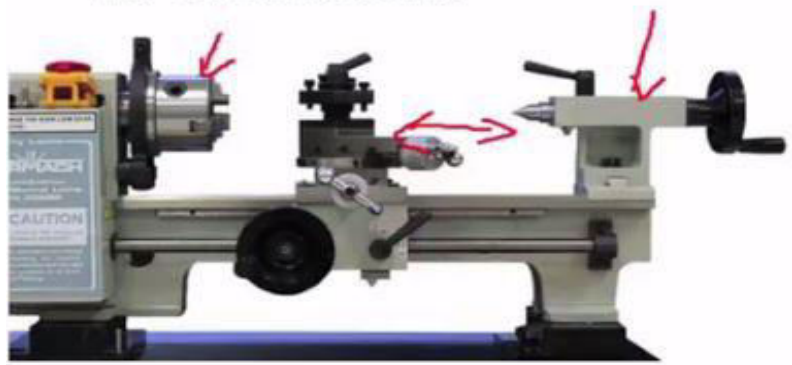
Alignment tests on lathe

Need for machine tool metrology:

- The continuously **increasing demands for highly accurately machined components** has led to considerable research in machine tool design, and particularly towards means by which the **geometric accuracy of machines** may be improved and maintained.
- A distinct field of metrology, has matured, concerned primarily with the geometric tests of the **alignment accuracy of machine tools** under static conditions.
- Determination of the alignment accuracy of machine tools under **dynamic loading conditions**, is also very important

- In order to ascertain the condition or performance of a machine tool, **inspection charts** are available which enable the manufacturer or inspector to check the various **alignments against prescribed limits**.
- Alignment tests check the relationship between various elements such as **forms and positions of machine tool parts and displacement relative to one another,** when the machine tool is unloaded.



Alignment testing instruments

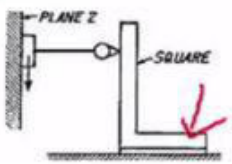
- **Dial gauge: Measuring pressure from 20 to 100 gm.** The **graduation** must be clear and accuracy to be **0.01 mm**. The dial gauge must be fixed to robust and stiff bases in order to avoid displacements due to shock or vibration.

- **Test Mandrel:** To check true running of the spindle. They are hardened, stress-relieved and ground and are made to a **length from 100 to 300 mm**. The quality of mandrel (especially **straightness and roundness**) is of supreme importance for accurate results. **Two types** of test mandrel are used:

a) Mandrels with a **cylindrical surface and a taper shank,** which can be inserted into the taper bore of the main spindle

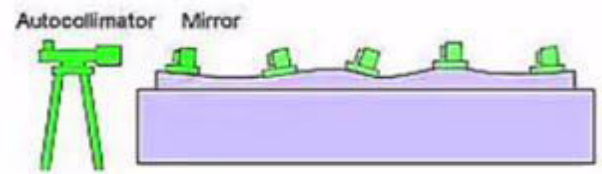
b) Cylindrical mandrel that can be held between centers

- **Straight edge** : Straight - edges of cast iron or steel, should be heavy, well ribbed and free of internal stresses.
- **Standard square**: A square must have a wider bearing surface. The error at the top of a standard square should be less than ± 0.01mm, and for a precision square less than ± 0.005 mm.



- **Spirit levels:** These are used in the shape of a bubble tube, which is mounted on a cast-iron base. The two main types are the horizontal, and the frame spirit level with **sensitivity of 0.04 to 0.06 mm per meter** for each deflected division.

- **Auto collimator**: To check deflections of long beds in horizontal, vertical and inclined planes.

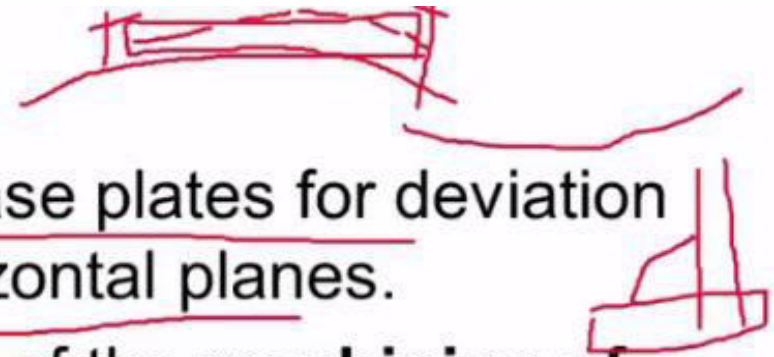


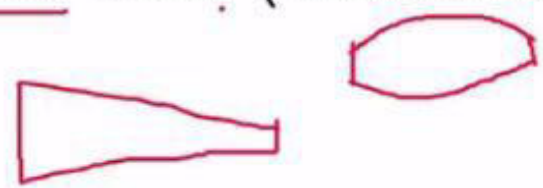
- **Waviness meter**: To record surface waviness with 50:1 magnification

Alignment tests

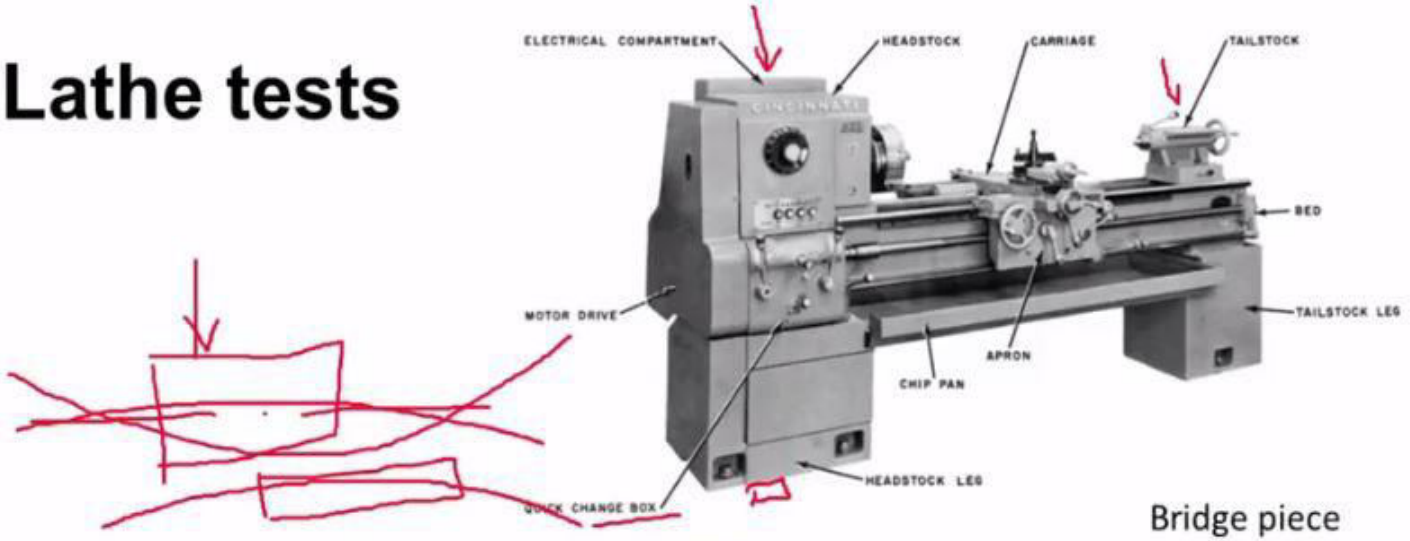
- The level of installation of the machine in the horizontal and vertical planes
- The main spindle is tested for periodical axial movement, camming and true running about its axis
- The bed-ways are tested for straightness and parallelism
- The line of movement of members such as saddles and tables along bed-ways is tested
- Checking of lead screws, indexing devices and other subassemblies for specific errors.

- Work table for flatness
- Columns, uprights and base plates for deviation from the vertical and horizontal planes.
- Practical tests in the form of the **machining of test specimens,** followed by careful study of **size, shape and surface finish** of the specimen
- Reference: Test chart for general purpose parallel lathes IS 1878 (part 3): 1998 (Reaffirmed 2004)
- Reference: Test chart for pillar type vertical drilling machine IS 2425: 1982 (Reaffirmed 2005)

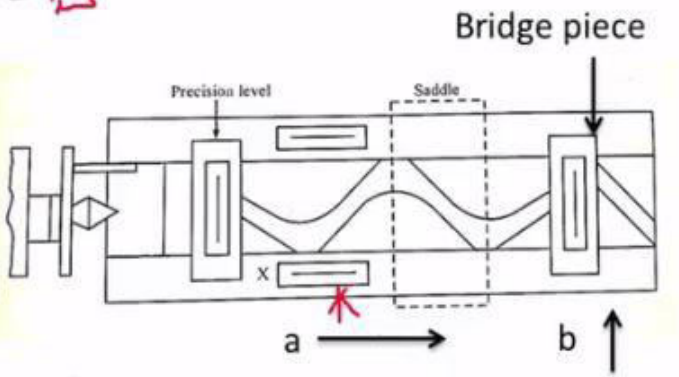




Lathe tests



- **Leveling of the lathe:**



a. Longitudinal direction leveling
b. Transverse direction leveling

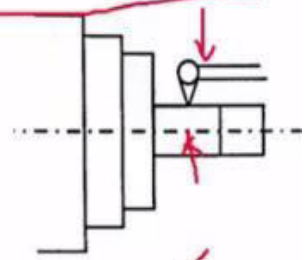
Permissible error 0.01 to 0.02 mm for any length of 500 mm

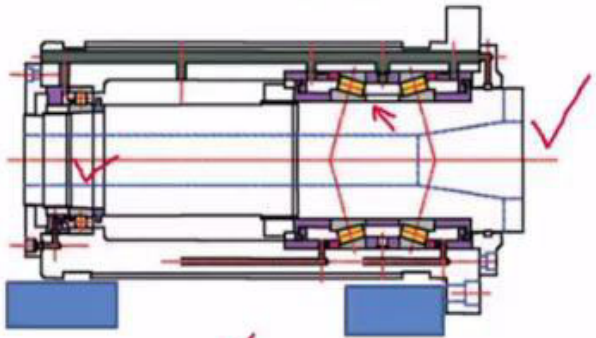
Guideways should be **convex only** along the length.

Leveling error may be corrected by setting wedges or shims under the support feet of lathe

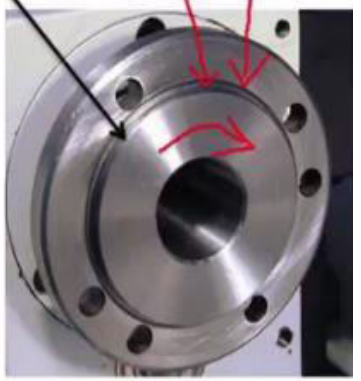
- **True running of locating cylinder of main spindle**

Locating cylinder is provided to locate the chuck or face plate, this must run truly. Dial plunger should touch the locating surface. The surface is rotated and indicator should not show any reading

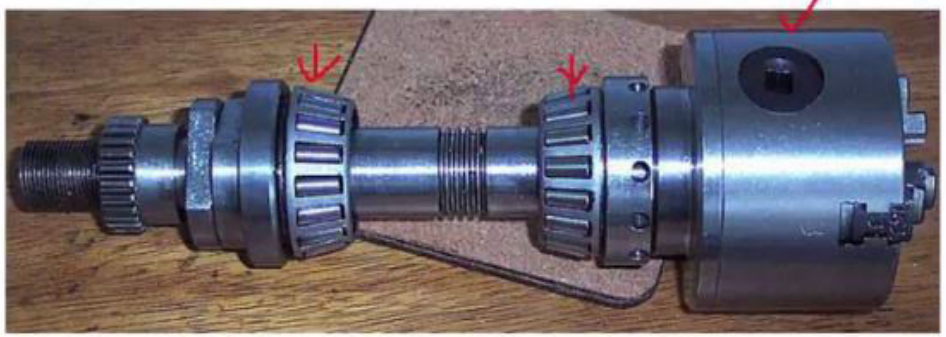


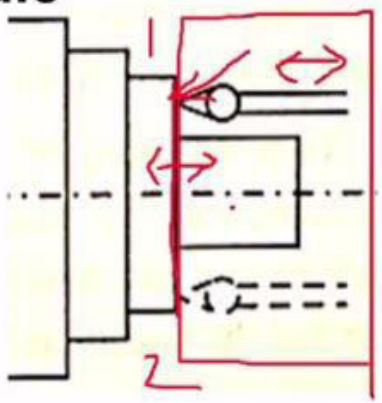


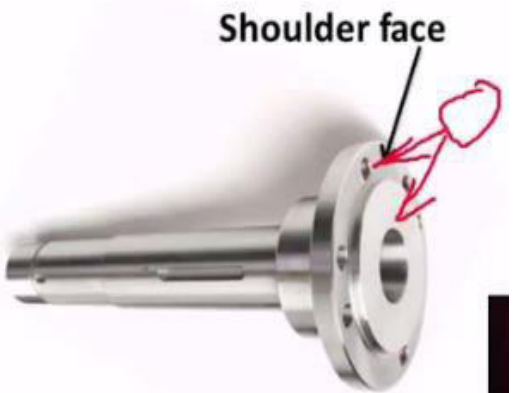
Locating cylinder



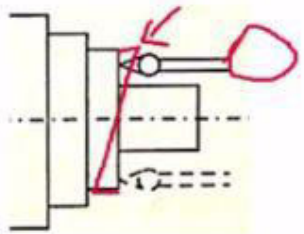
- **Axial slip of main spindle and true running of shoulder face of spindle nose**

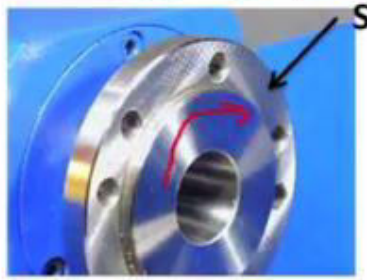


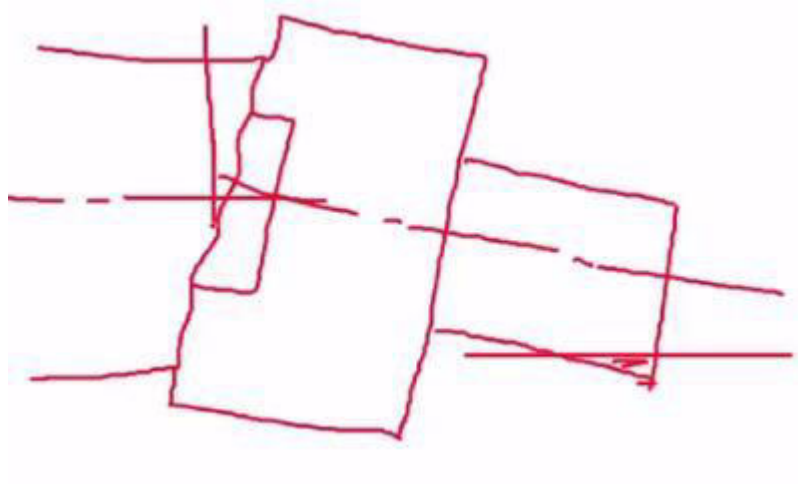




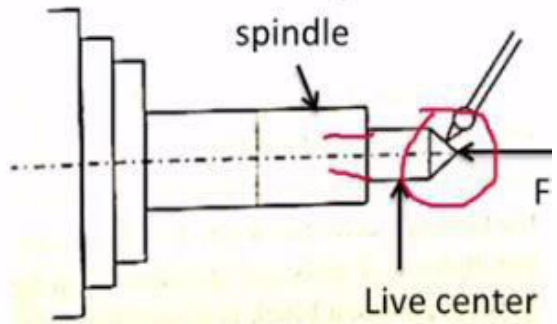
- Axial slip is **axial movement of spindle** which follows the same pattern and is due to manufacturing error
- The plunger of dial indicator rests on the **face of the shoulder** and the dial gauge is clamped to the bed. The locating cylinder is then rotated and the change in the reading is noted down
- The readings are taken at two diametrically opposite points. Error includes error in bearings, **shoulder face not perpendicular to the axis, irregularities in shoulder face**.
- During screw cutting, pitch will vary due to axial slip.





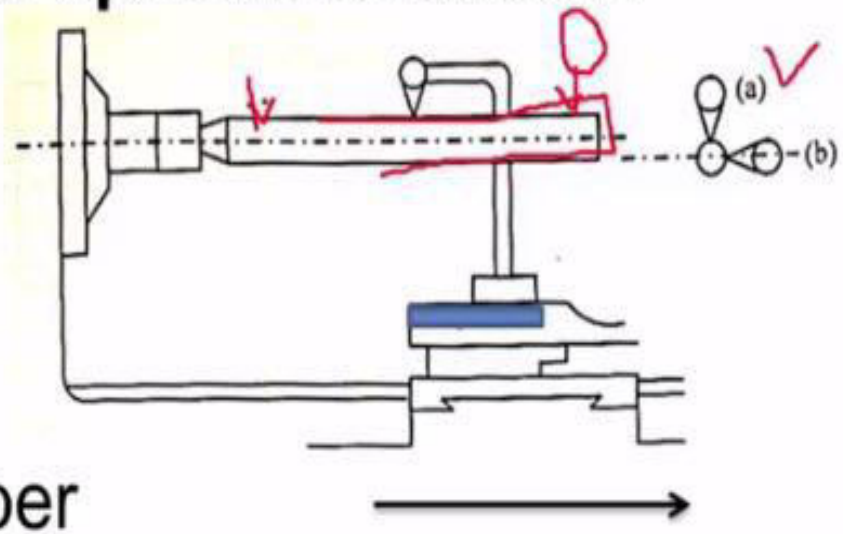


- **True running of head stock center**



Work piece has to rotate with head stock/live center
Head stock center/live center should
rotate truly with spindle axis, otherwise
eccentricity is caused while turning.
Dial plunger to be perpendicular to taper surface
Dial reading should not exceed 0.03 mm
F : a constant force F is applied to reduce axial play

- **Parallelism of the main spindle to saddle movement**



a. Vertical plane

b. Horizontal plane

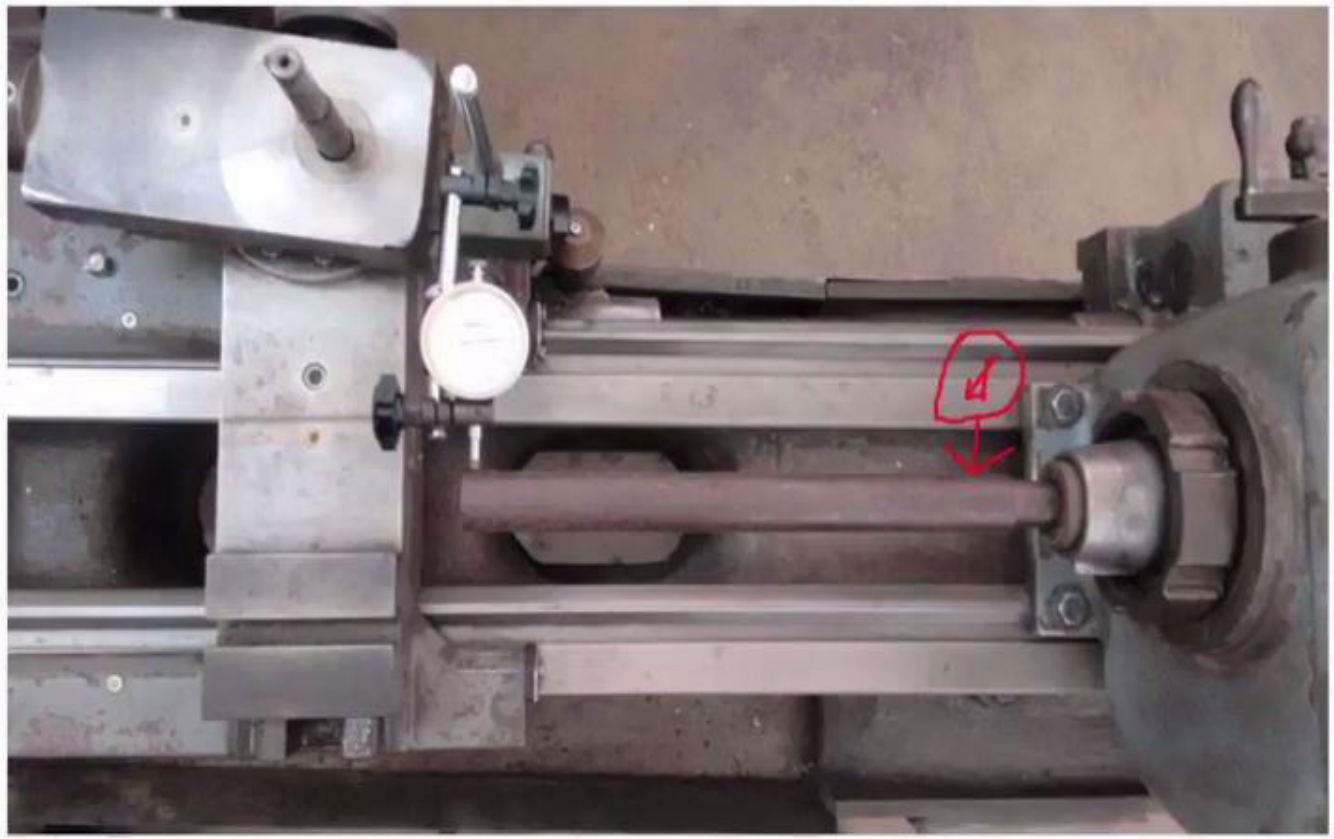
Mandrel is fitted in the taper socket of the spindle. Dial plunger is pressed on the mandrel. Saddle is moved and dial readings are recorded. If spindle axis not parallel to guide ways then taper results

Permissible error : 0.02 mm/300 mm in both the

Parallelism of the main spindle to saddle movement

Measurement in vertical plane, free end upwards

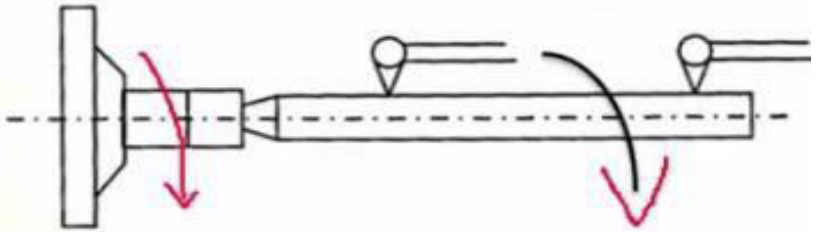
Parallelism of the main spindle to saddle movement

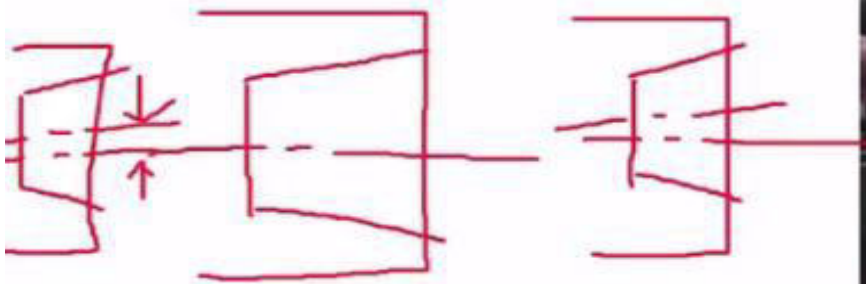


Measurement in horizontal plane, free end frontwards

- **True running of taper socket in main spindle**

If the axis of tapered hole is not concentric with main spindle axis, eccentric and tapered jobs will be produced.

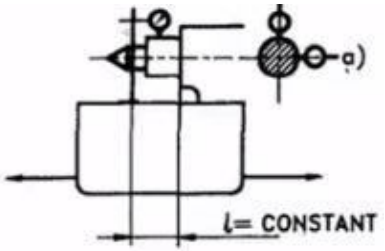




To test it, a mandrel is fitted into tapered hole, it is rotated slowly and dial gauge readings are taken at two extreme places: near the spindle and at a distance of 300 mm from spindle.

Error not to exceed 0.02 mm at both the places

- **Parallelism of tailstock guide ways with carriage movement**



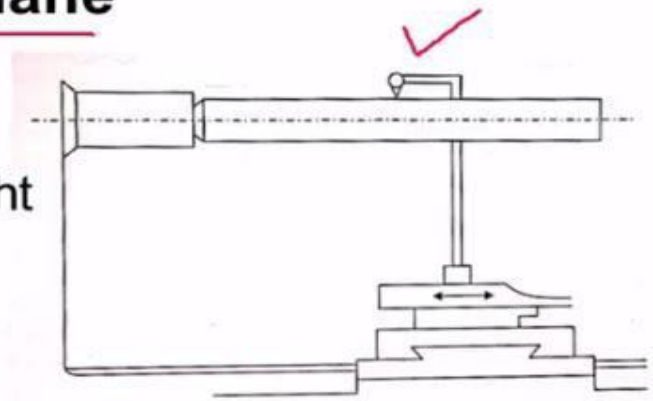
If the tailstock guide ways are not parallel with the carriage movement, there will be some offset of tailstock center and this results in taper turning (when job is held between the two centers)

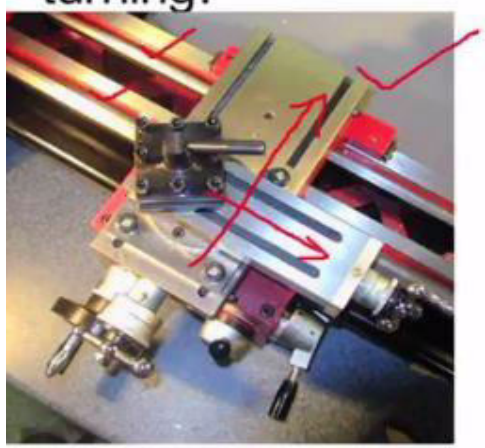
Carriage and tailstock are displaced together. Tailstock and tailstock sleeve clamped as in normal working condition.

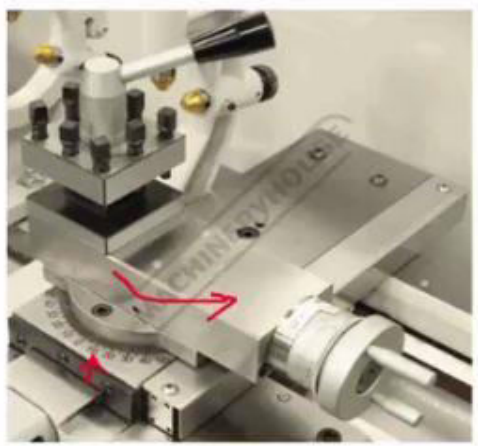
Error not to exceed 0.04 mm for both the planes.

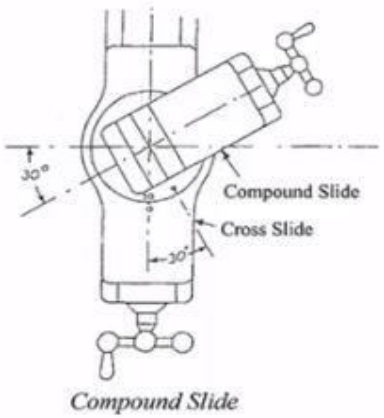
- **Movement of upper slide parallel with main spindle in vertical plane**

Permissible error is 0.04 mm/300 mm. The free end of mandrel inclined up, to counter act the weight of job. This error is not tested in horizontal plane, because there is swiveling arrangement for taper turning.



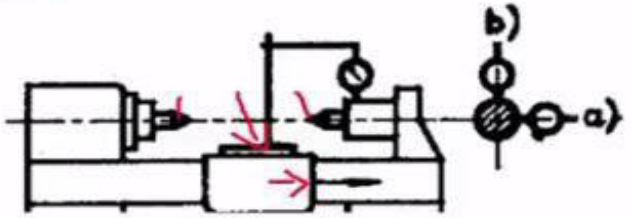






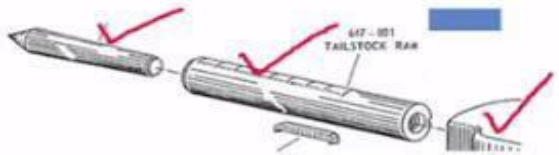
Compound Slide

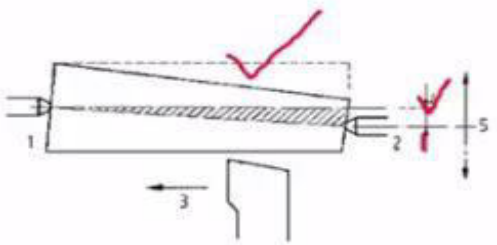
Parallelism of tailstock sleeve to the saddle movement

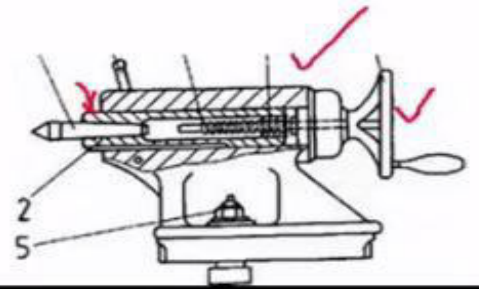


For the jobs held between 2 centers, the axis of dead center should be coaxial with the job axis in both the planes.

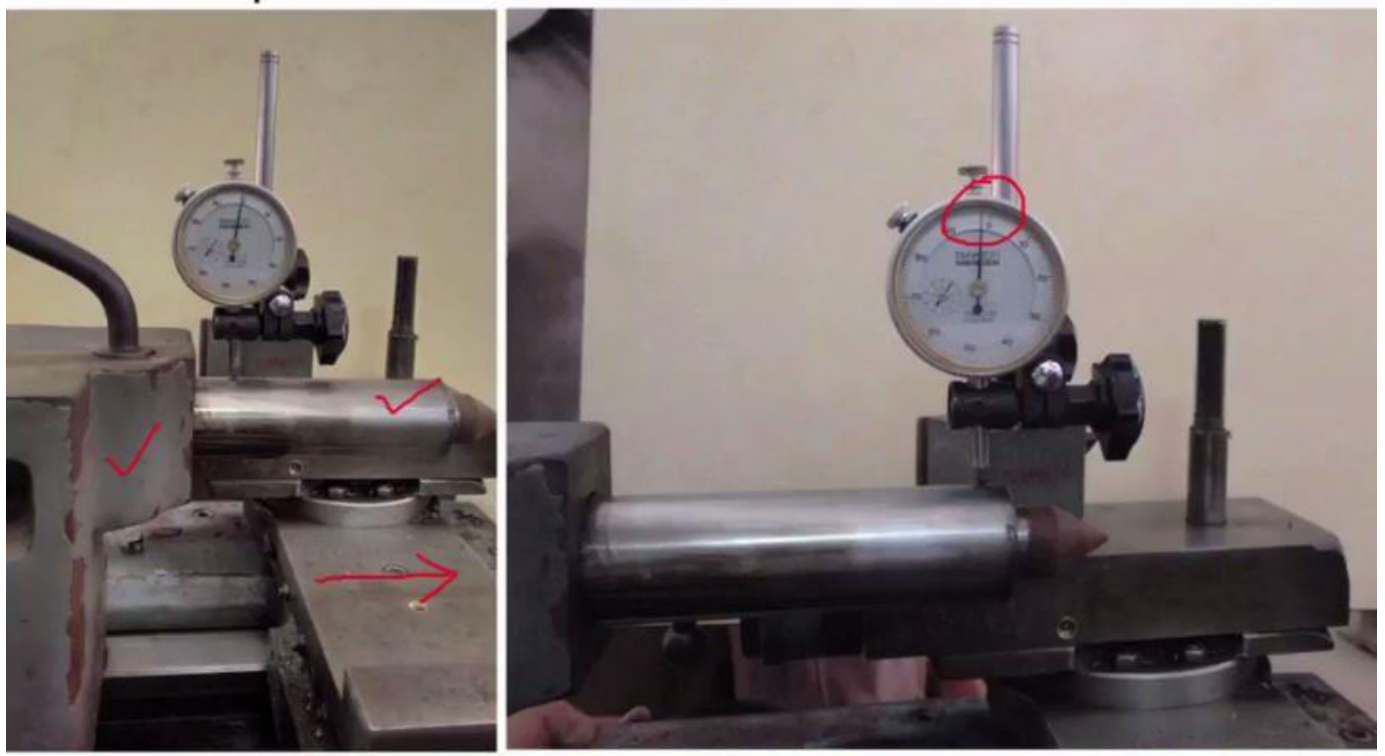
Extend the sleeve to the maximum extent.
Dial plunger to touch the sleeve.
Saddle is moved along the full length of sleeve (sleeve and tail stock in locked condition) and dial readings are noted down.
Error not to exceed 0.02 mm/100 mm in both the planes





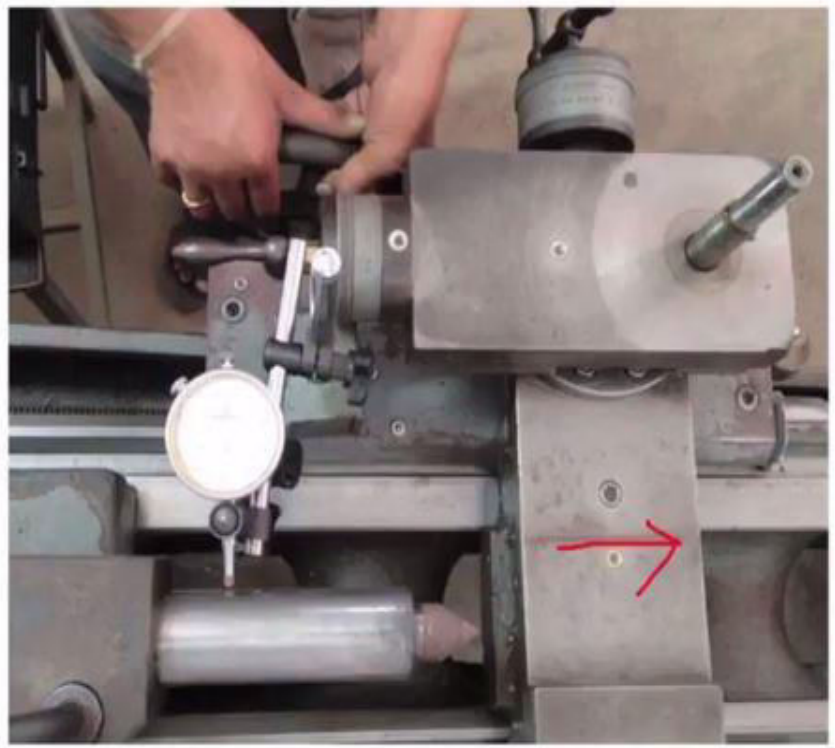


Parallelism of tailstock sleeve to the saddle movement – vertical plane

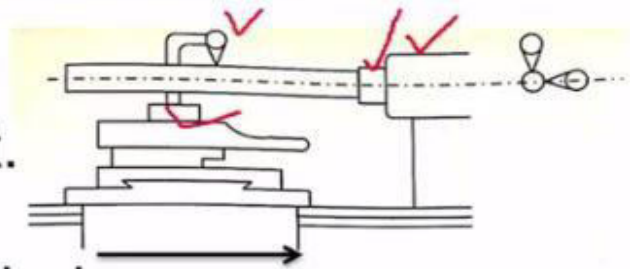


Free end of sleeve should be raising upwards in vertical plane to counteract weight of work

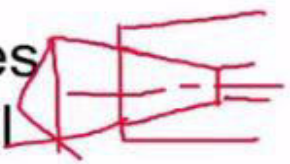
Parallelism of tailstock sleeve to the saddle movement – Horizontal plane



Parallelism of tailstock sleeve taper bore to the saddle movement



Mandrel is fixed in taper bore.
Dial indicator is fixed to tool post.
Plunger is pressed on mandrel.
Saddle is moved along the mandrel.
Dial readings are recorded, in both the planes
Tail stock and sleeve are locked as in normal working condition.



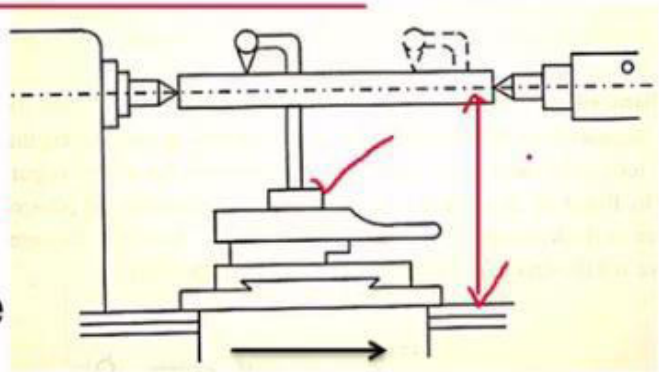
Error not to exceed:

0.03/300, free end towards frontwards in horizontal plane
0.04/300, free end towards upwards in vertical plane

Parallelism of tailstock sleeve taper bore to the saddle movement – Vertical plane

Parallelism of tailstock sleeve taper bore to the saddle movement – Horizontal plane

- **Alignment of both the centers in vertical plane**



Besides testing the parallelism of the axes individually (main spindle and tailstock axis), it is necessary to check the relative position of the two axes.

Both the axes may be parallel to carriage movement but they may not be coinciding. Due to this when a job is fitted between the centers, the axis of the job will not be parallel to the carriage movement.

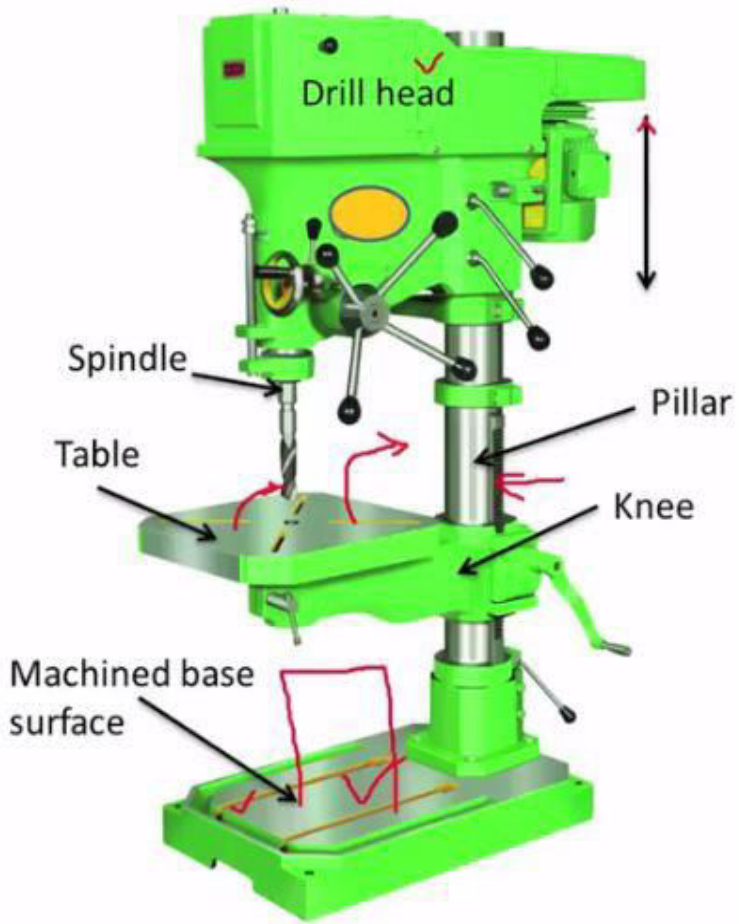
In horizontal plane this test may not be conducted, since tailstock can be adjusted in horizontal plane.

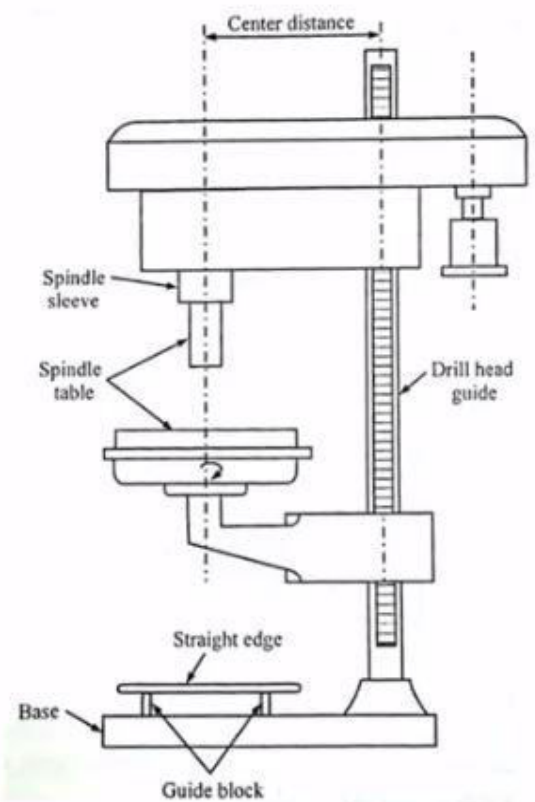
Tailstock and tailstock sleeve are locked, during measurement, as in normal working conditions.

Alignment of both the centers in vertical plane

Error not to exceed 0.06mm/300mm, tail stock center higher than headstock center.

Tests on pillar type vertical drilling machine

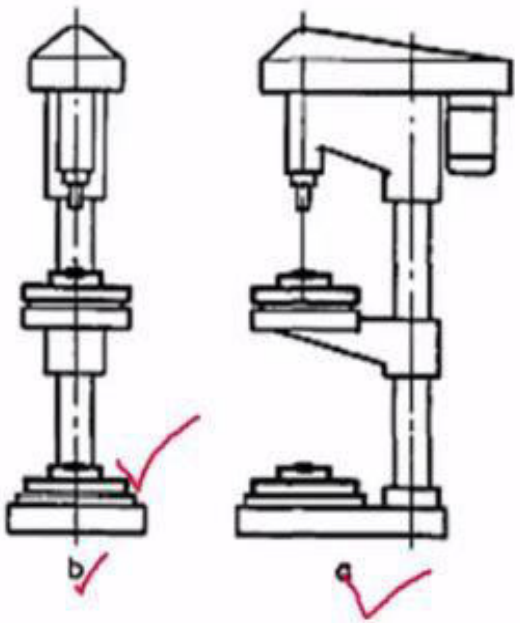




Leveling of the machine

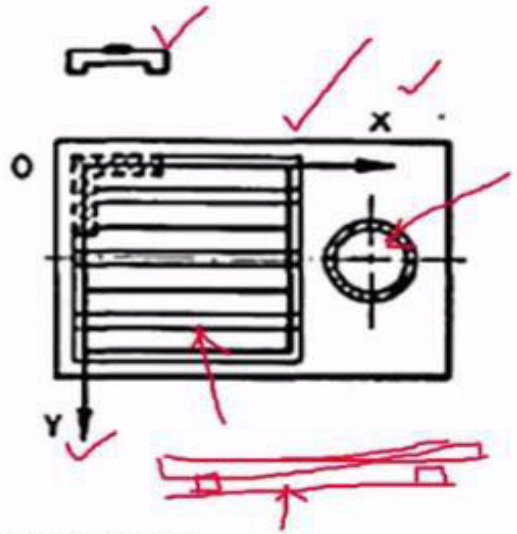
Level and straight edge are used.
Table locked in mid position.
Measurement is taken:

a. In a **plane of symmetry** of the machine
b. In the **plane perpendicular to the plane of symmetry** and passing through the spindle axis (error not to exceed 0.03/300 in both the cases)



Flatness of the table surface
(and of the base plate)

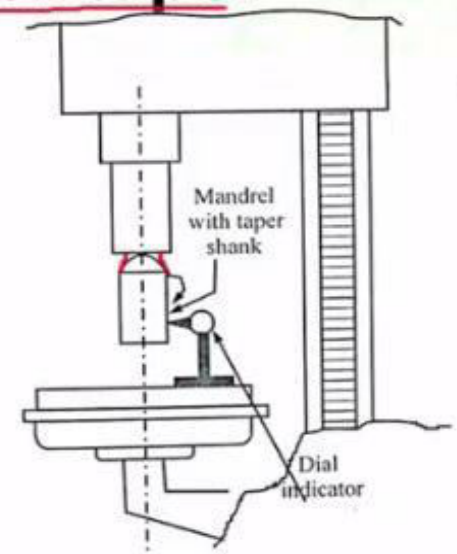
Precision level or straight edge and gauge blocks are used. The test is performed by placing a straight edge on two gauge blocks on the base plate in various positions and the error is noted down by inserting the feeler gauges.

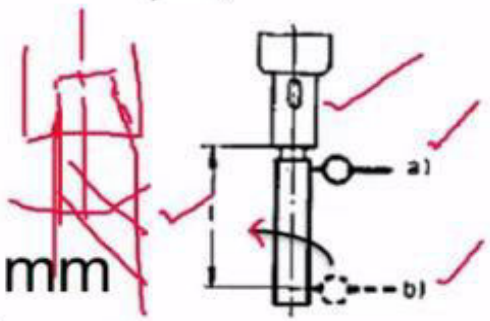


Error not to exceed:
0.03 mm for any measuring length of 300 mm (the surface should be **flat or concave only**)

True running of spindle internal taper

The test mandrel is placed in the tapered hole of the spindle.
The dial indicator is fixed on the table and plunger to touch mandrel.
The spindle is rotated slowly and dial readings are noted down at two places: (a) near and (b) away from spindle nose





Error not to exceed:

a. 0.02 mm; b. 0.035 mm for l= 200 mm
a. 0.025 mm; b. 0.05 mm for l = 300 mm

Parallelism of the spindle axis with its vertical movement

Test mandrel is fixed in the tapered hole of the spindle.

The dial gage is fixed on the table with Plunger touching the mandrel.

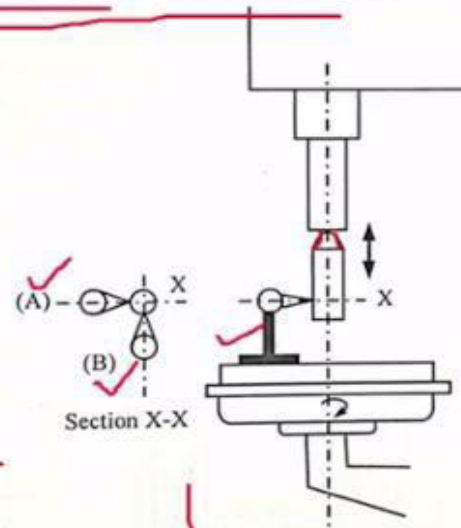
Spindle is adjusted in the middle position of its travel. Dial readings are noted when the spindle is moved in upper and lower directions of the middle position.

Measurement is taken:

A. In a plane of symmetry of the machine

B. In the plane perpendicular to the plane of symmetry

Error not to exceed 0.1/300 in both the planes



Straightness of the pillar and square ness of the spindle axis to the table and base plate surface

Dial gauge and straight edges are used

Straightness checking shall be carried out at a number of positions equally spaced between the extreme positions of the table.

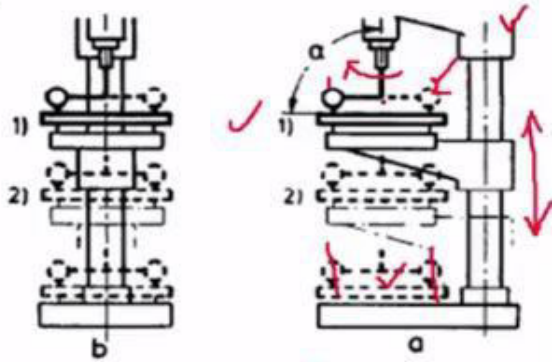


Table and knee locked while taking readings, spindle head locked in mid position (for machines having an elevating spindle head)

Measurement is taken:

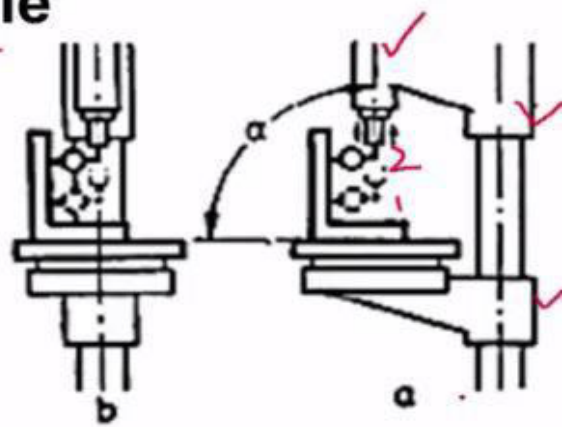
a. In a plane of symmetry of the machine

b. In the plane perpendicular to the plane of symmetry

Error not to exceed 0.06/300* in both the cases,

*distance between the 2 points touched, α ≤ 90 degree

Square ness of the table surface to the vertical movement of the spindle



Dial gauge, straight edge and square are used.

Table and knee are locked in mid position, spindle head locked in mid position (for machines having an elevating spindle head).

Spindle moved slowly and dial readings noted

Measurement is taken:

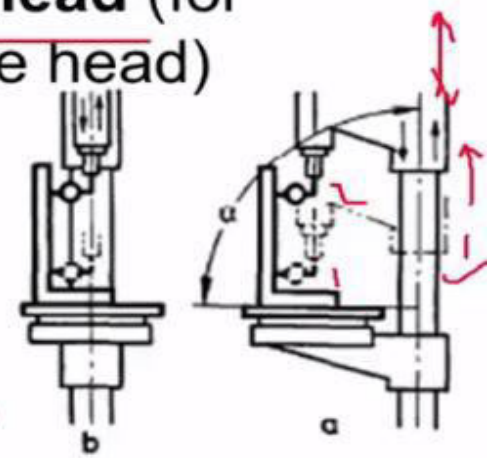
a. In a plane of symmetry of the machine

b. In the plane perpendicular to the plane of symmetry

Error not to exceed 0.1/300* in both the cases,

*spindle movement , α ≤ 90 degree.

Square ness of the table surface to the vertical movement of the spindle head (for machines having an elevating spindle head)



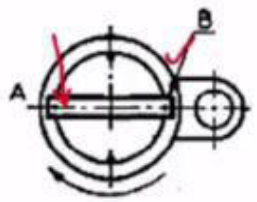
Dial gauge, straight edge and square are used.
Table and knee are locked in mid position.
Spindle head locked while taking readings.
Spindle head moved slowly, locked and dial readings noted

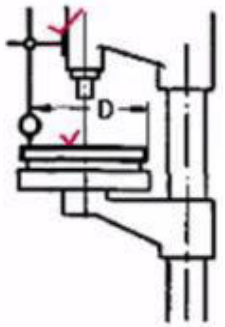
Measurement is taken:

a. In a plane of symmetry of the machine
b. In the plane perpendicular to the plane of symmetry
Error not to exceed 0.1/300* in both the cases,
*spindle head movement , $\alpha \leq 90$ degree.

Camming of the rotating table

Dial gauge and straight edge are used.
Set the straight edge approximately in a diametral plane of the table.
Touch a point A on straight edge, then touch a point B after rotating table by 180 degree
Repeat the experiment, setting the straight edge in another plane perpendicular to the preceding one.
Lock the table before taking reading.
Error not to exceed 0.05 for D=300 mm





D = Table diameter