Inspection & Gaging

ITCD – 301-001

Workpiece drawing factors

- Size
- Shape
- Composition
- Dimensions
- Specifications

Tolerance

- Total amount of dimensional variation
- Designer specifies an unattainable condition
- Designer specifies a degree of error
- Two limits must be set
- Individual limits for critical drawings
- General limits for not so critical drawings
- May be indirectly placed in BOM
- Function, appearance and cost

Positional Tolerance

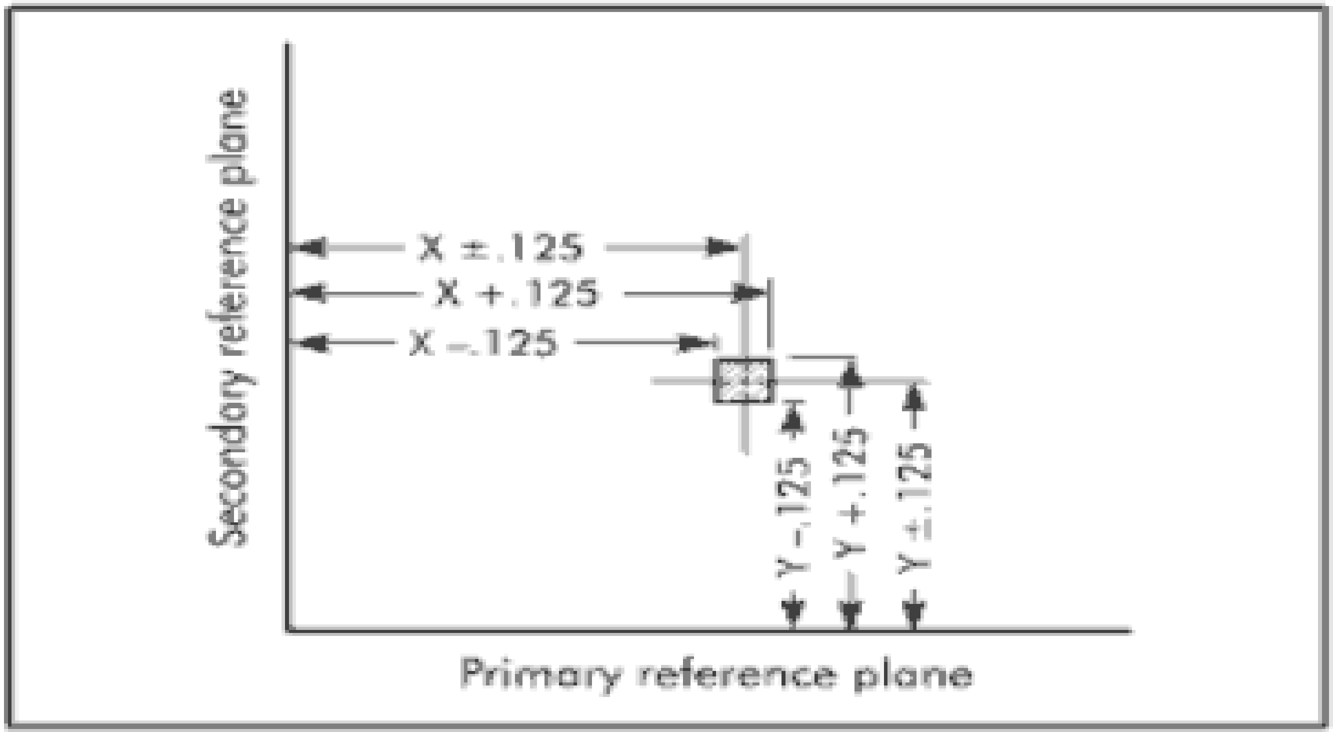


Figure 9-1. *Coordinate dimensioning and positioning tolerance illustrate the element. Dimension may be located anywhere within the shaded rectangle.*

Conversion Charts

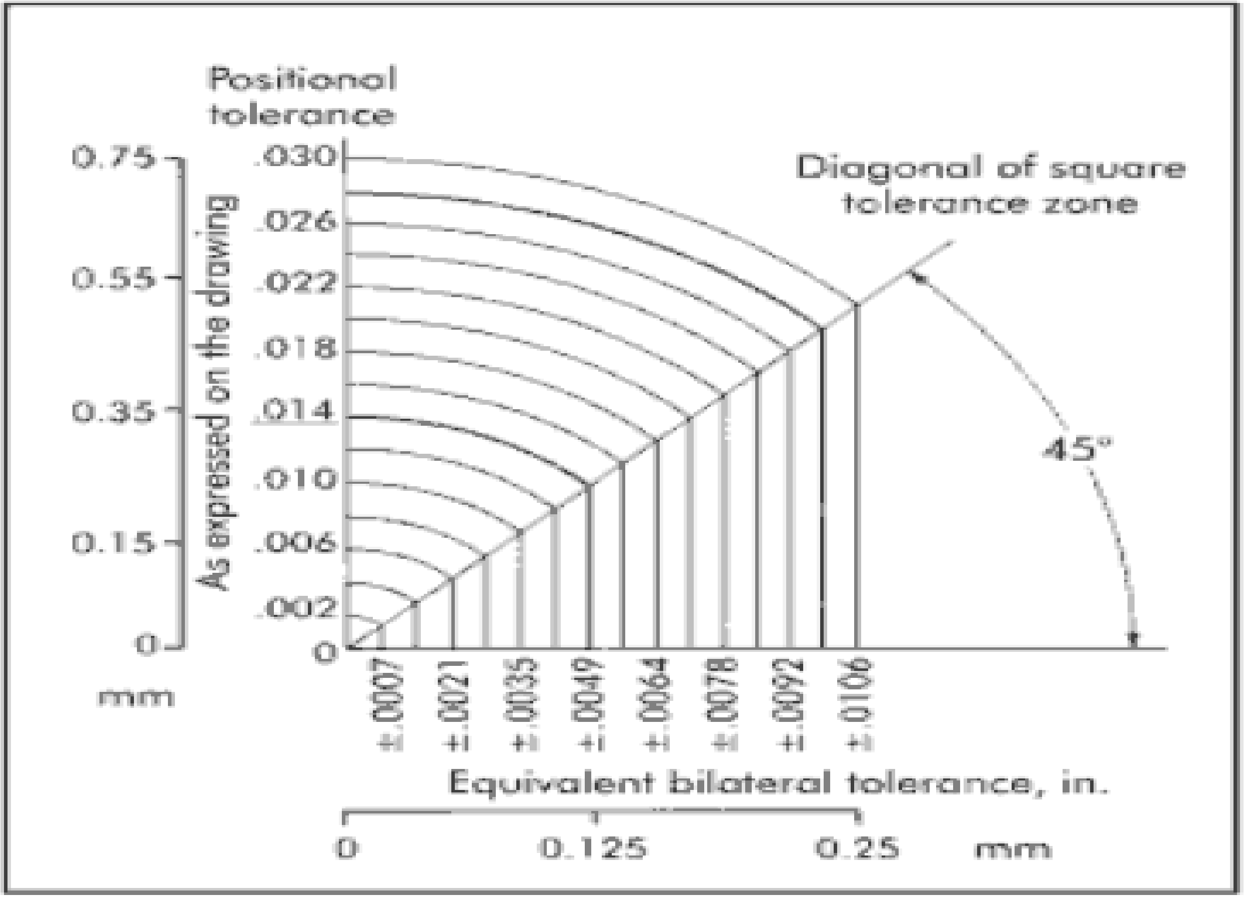


Figure 9-2. *Conversion chart: positional tolerance to bilateral.* (Courtesy Sandia Corp.)

Conversion Charts

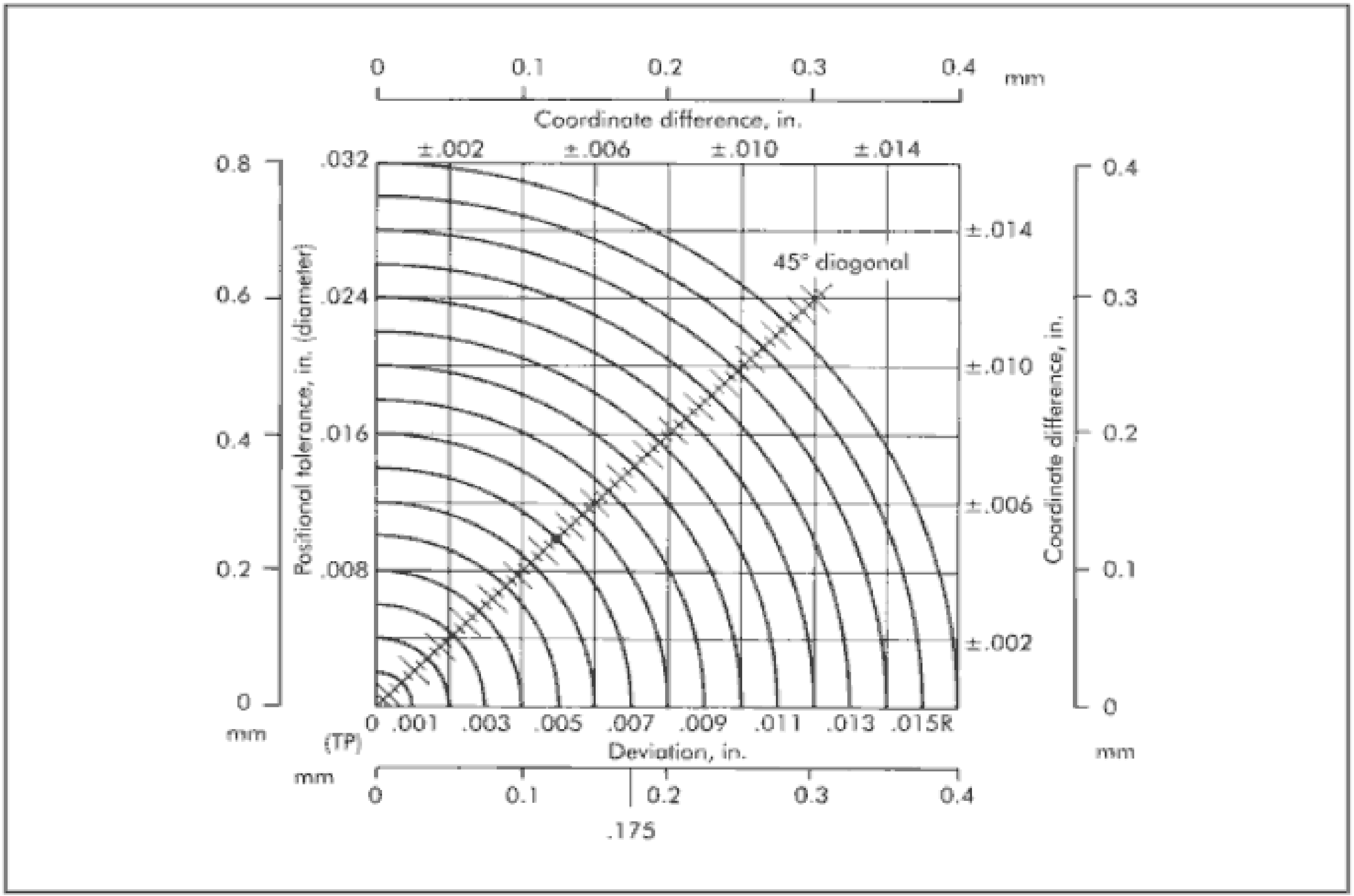


Figure 9-3. *Conversion chart: bilateral to positional tolerance.* (Courtesy Sandia Corp.)

Gaging Principles

•Gage tolerance determined from the amount of workpiece tolerance
•10% rule applied for a working gages
•Working gage used by production workers during manufacture
•5% rule applied for inspection gages
•Inspection gages are used by the inspection department
•10% rule applied to master gages
•Master gages used for checking the accuracy of other gages

Classes of gagemakers' tolerances

- Class XX gages are precision-smoothed to the closest tolerances possible and used as master gages for final close-tolerance inspection
- Class X gages are precision-smoothed to close tolerances and used for some types of master gage work and close-tolerance inspection and working gages
- Class Y gages are precision-smoothed to slightly larger tolerances than Class X gages and used for inspection and working gages
- Class Z gages are precision-lapped and used as working gages where part tolerances are large and number of pieces to be gages is small

Standard gagemakers' tolerances

Table 9-1. Standard gagemakers' tolerances, in. (mm)

Above	To and Including	Class XX	Class X	Class Y	Class Z
.010 (0.25)	.825 (20.95)	.00002 (0.0005)	.00004 (0.0010)	.00007 (0.0018)	.00010 (0.0025)
.825 (20.95)	1.510 (38.35)	.00003 (0.0008)	.00006 (0.0015)	.00009 (0.0023)	.00012 (0.0031)
1.510 (38.35)	2.510 (63.75)	.00004 (0.0010)	.00008 (0.0020)	.00012 (0.0031)	.00016 (0.0041)
2.510 (63.75)	4.510 (114.55)	.00005 (0.0013)	.00010 (0.0025)	.00015 (0.0038)	.00020 (0.0051)
4.510 (114.55)	6.510 (165.35)	.000065 (0.00165)	.00013 (0.0033)	.00019 (0.0048)	.00025 (0.0064)
6.510 (165.35)	9.010 (228.85)	.00008 (0.0020)	.00016 (0.0041)	.00024 (0.0061)	.00032 (0.00813)
9.010 (228.85)	12.010 (305.05)	.00010 (0.0025)	.00020 (0.0051)	.00030 (0.0076)	.00040 (0.0102)

Allocation of gage tolerances

- Decide the tolerance for a specific gage
- Direction of that allowance should be decided
- Bilateral system
- Unilateral system
- Choice depends on the product and facilities for production
- Objective is the economical production of full usable parts
- Rejection of bad pieces and acceptance of good parts

Systems of gage tolerance allocation

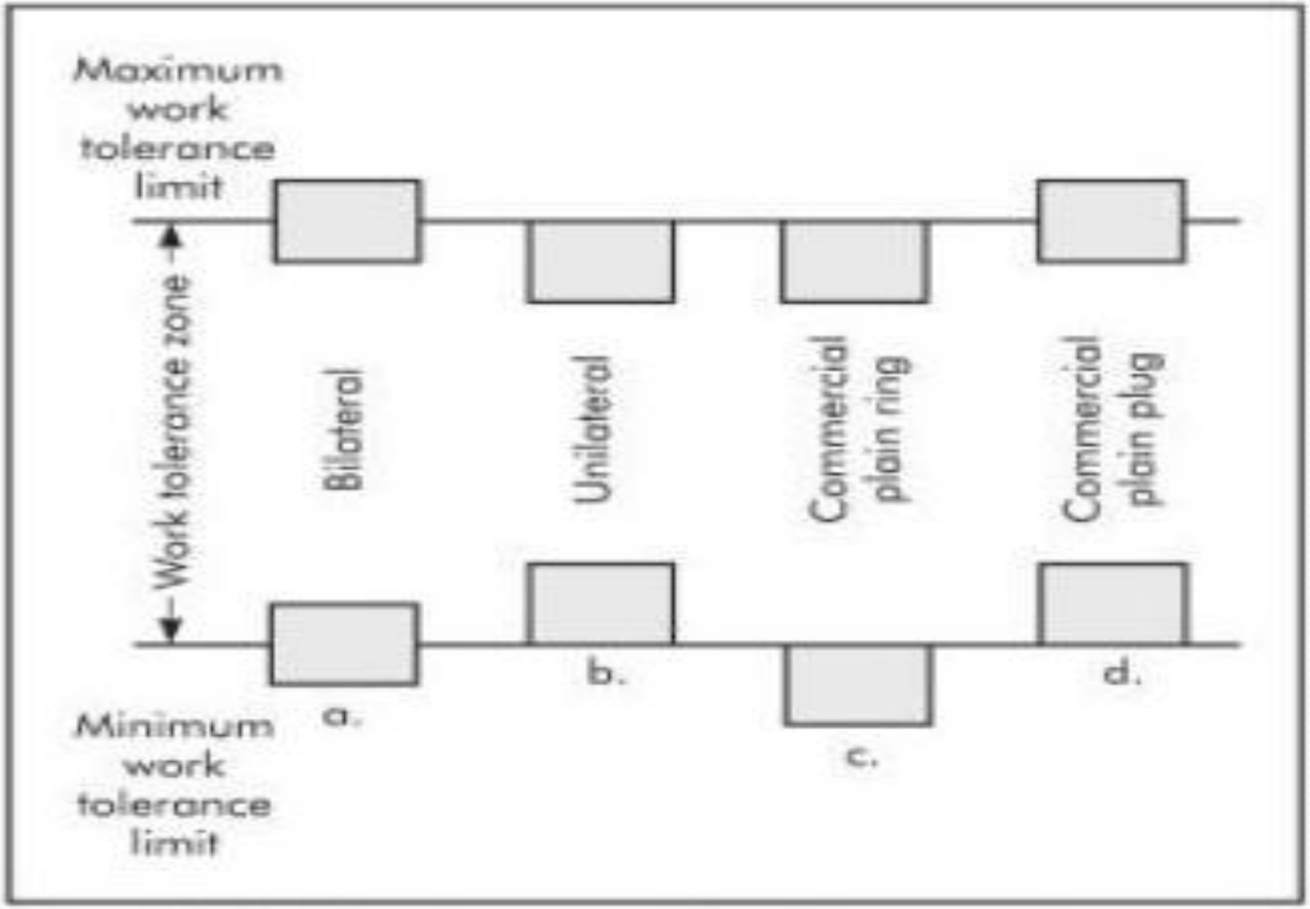


Figure 9-4. *Different systems of gage tolerance allocation.*

Bilateral System

- If the diameter of the hole to be gaged is 1.2500+/- 0.0006 in., then the work tolerance is 0.0012 in.
- Hole size may vary from 1.2506 to 1.2494 in.
- Use 10% of the total work tolerance as gage tolerance
- Gage tolerance is then 0.00012 in.
- From table 9.1, this diameter requires a class Z gage tolerance
- Hence, the diameter of the no-go gage would be 1.2506 +/- 0.00006 in.
- Disadvantage – If the hole to be gaged is reamed to the low limit, say, 1.2494 in., and if the no-go gage is at the low limit, 1.24934 in, then the gage enters the hole and part passes inspection

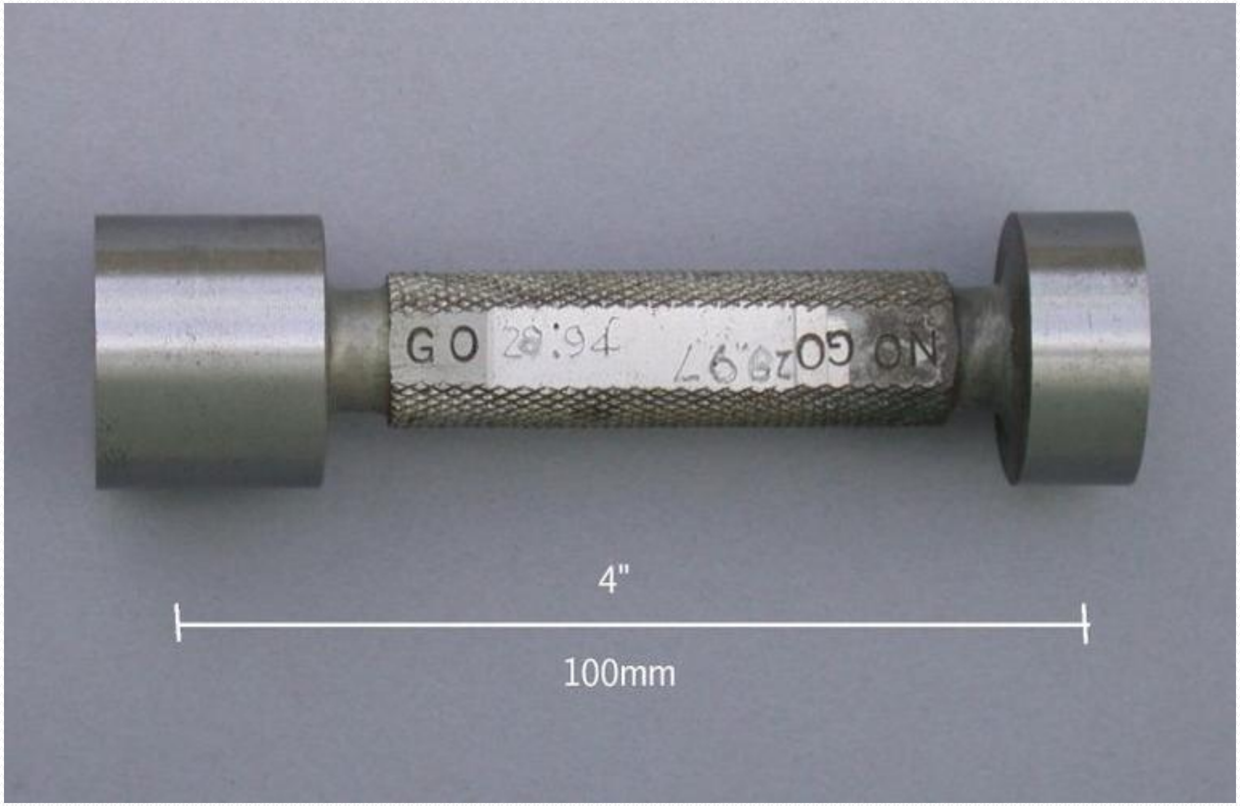
Unilateral System

- Work tolerance zone includes the gage tolerance zone
- If the diameter of the hole to be gaged is 1.2500+/- 0.0006 in., then the work tolerance is 0.00012 in.
- Use 10% of the working tolerance as the gage tolerance
- Go-gage diameter would be 1.24940 + 0.00012 in.
- No-go-gage diameter would be 1.25060 -0.00012 in.

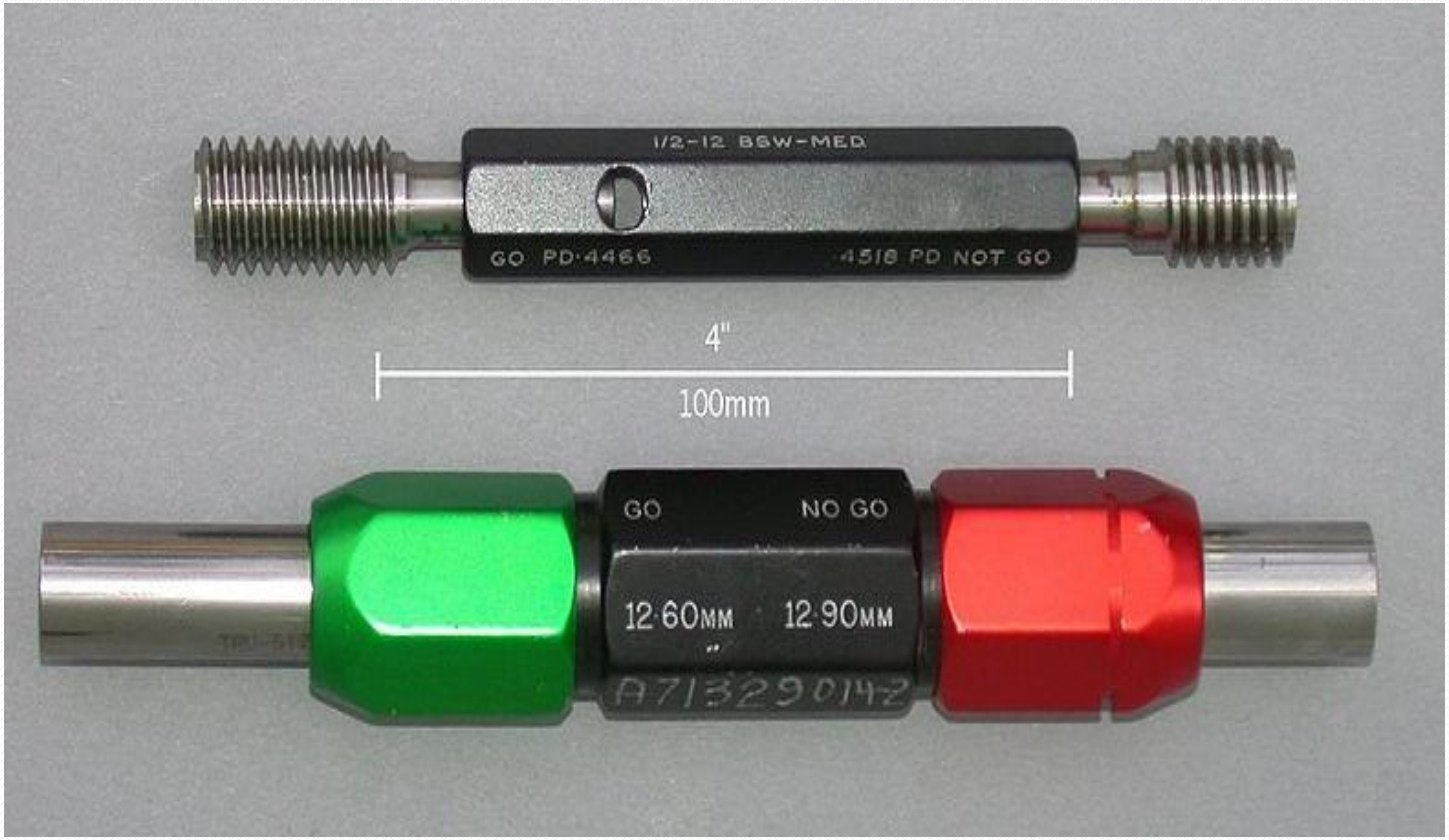
Gage wear allowance

- Multiple measurements create gage wear
- Wear allowance is added to the nominal diameter of a go-plug and subtracted from that of a go-ring gage
- Material from which gage and work are to be made is important
- Quantity of work
- Type of gaging operation to be performed
- Important to establish a specific amount of wear allowance
- Avoids any controversy to the accuracy of the gage

Hardened and ground plug gauge



Replaceable thread and plug gauges



Gage measurement

- Measurement compares an amount or length with a known standard
- All dimensional measurement is end measurement
- End measurement is determined by origin, both the standard and the property being measured should start at the same point
- Every workpiece related to the primary, secondary and tertiary datums must be measured by three planes at right angles to each other
- Every dimension has its origin in one of the three planes

Surface plate

Figure 9-5. *Typical surface plate setup.*

Templates

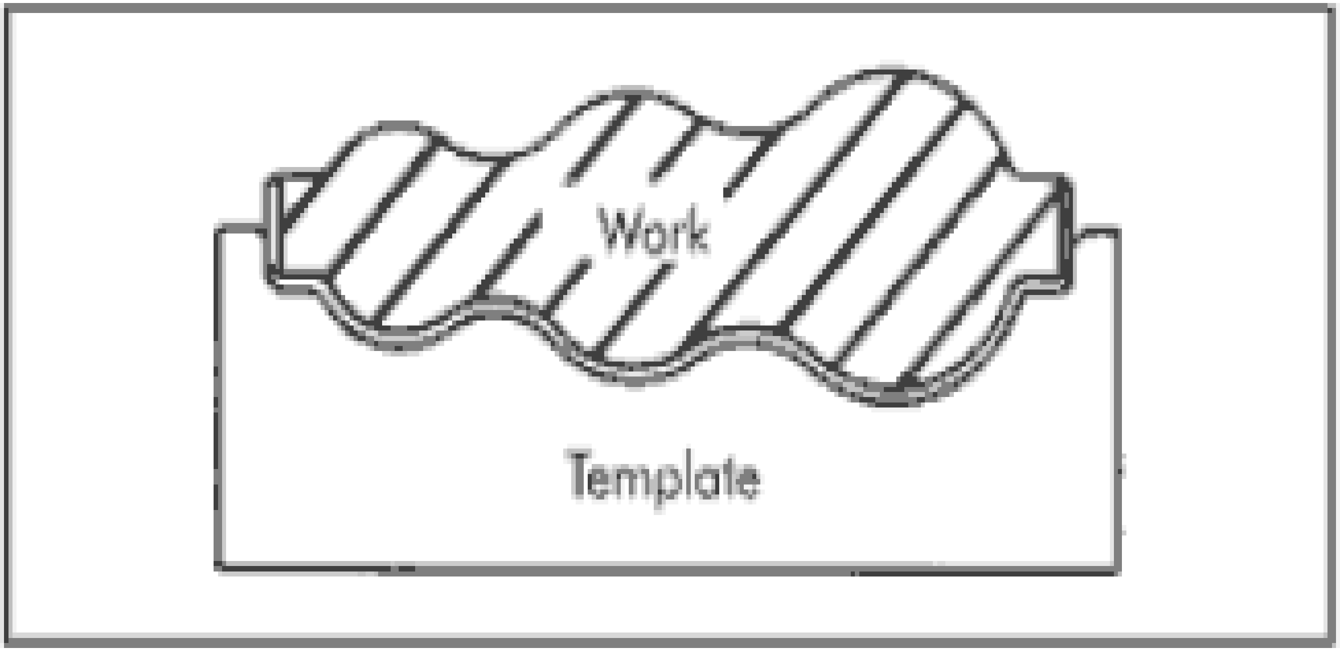


Figure 9-6. *Gaging the profile of a workpiece with a template.*

Commercial Gages

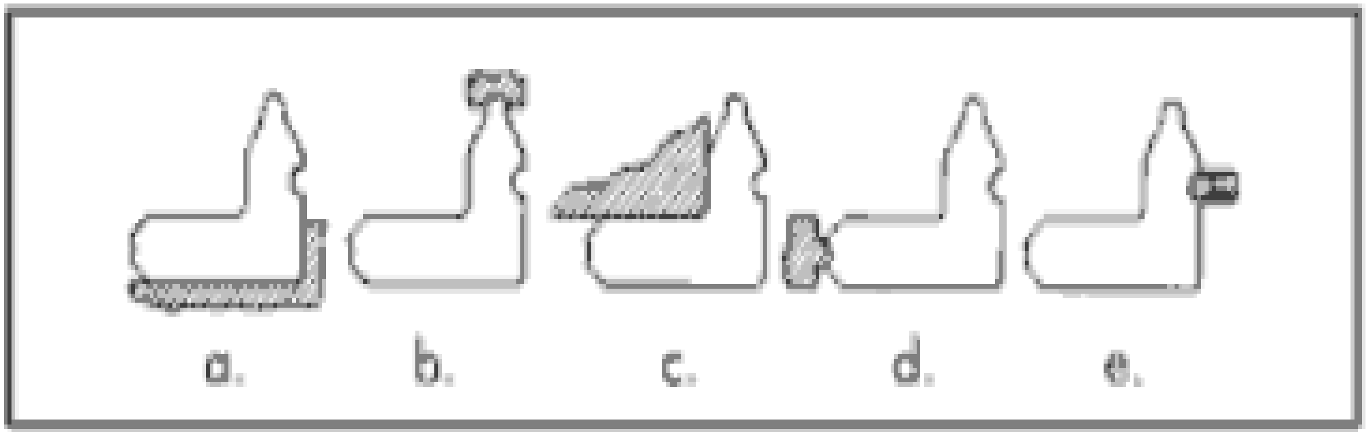


Figure 9-7. *Commercial radius gage and applications:* (a) *inspection of an inside radius tangent to two perpendicular planes;* (b) *inspection of a groove;* (c) *inspection of an outside radius tangent to two perpendicular planes;* (d) *inspection of a ridge segment;* (e) *inspection of roundness and diameter of a shaft.*

Screw pitch gage

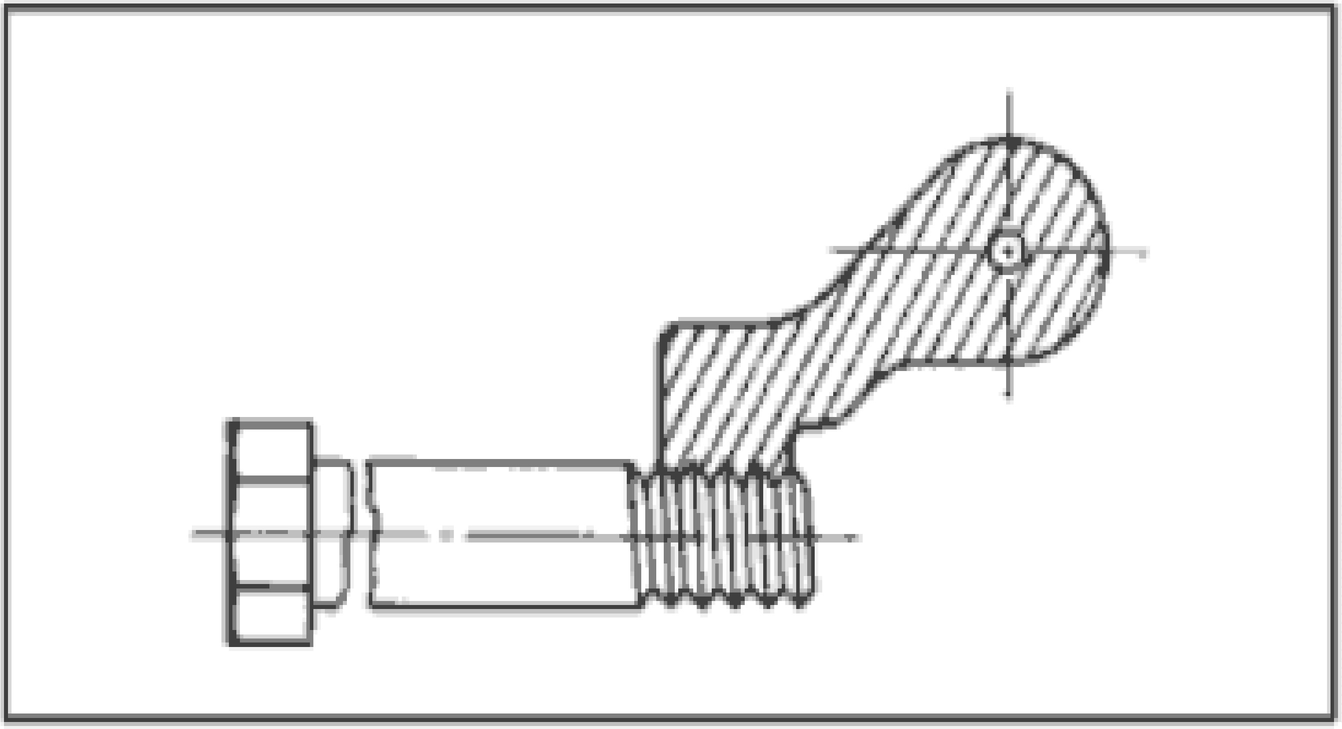


Figure 9-8. Screw pitch gage and method of application.

Plug gages

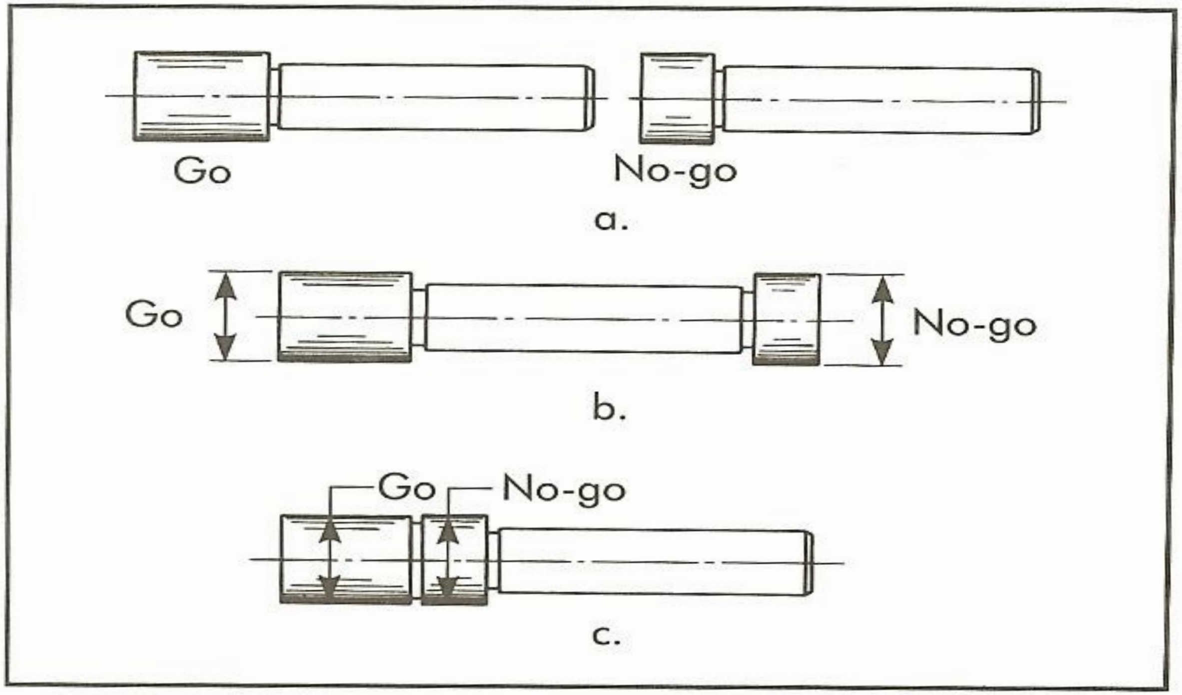


Figure 9-9. *AGD cylindrical plug gages used to inspect the diameter of holes.*

Cylindrical plug gages

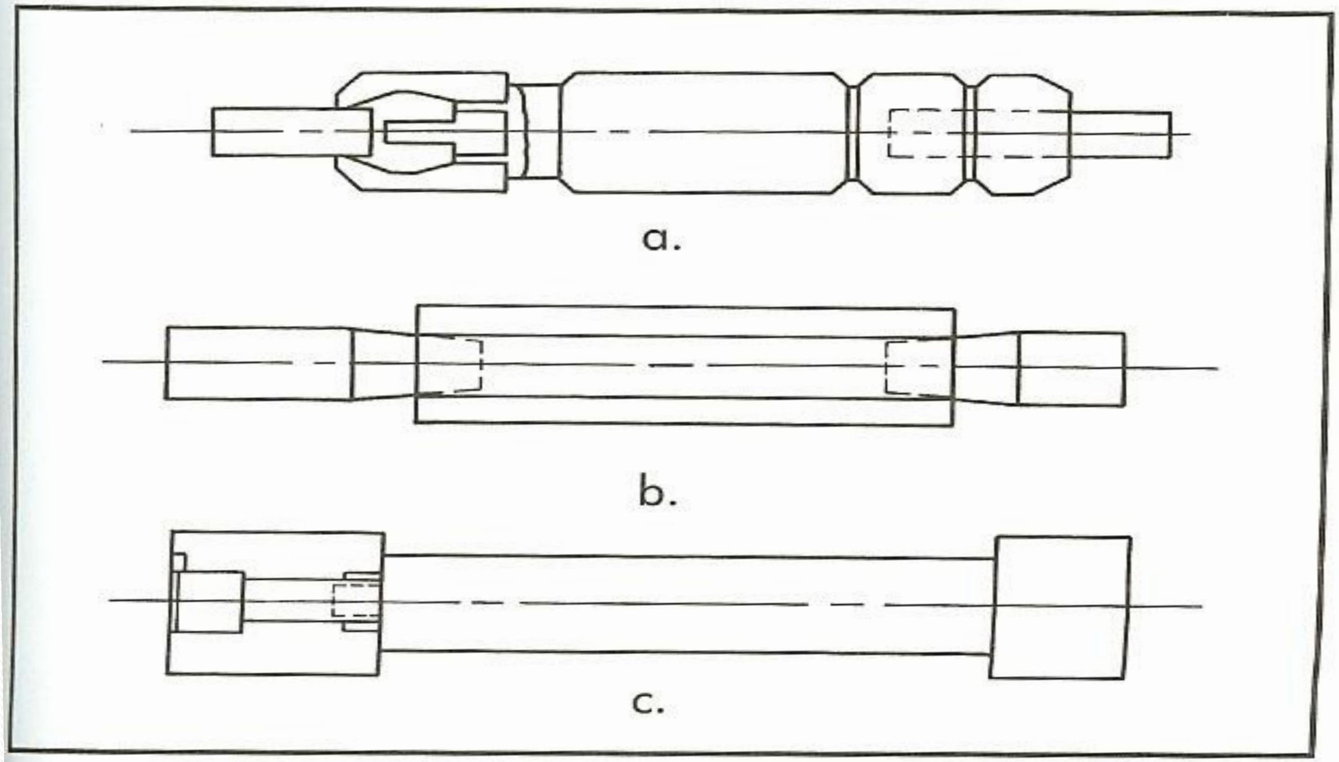


Figure 9-10. *AGD cylindrical plug gages: (a) reversible wire type, (b) taper-lock design (c) trilock design.*

Special plug gages

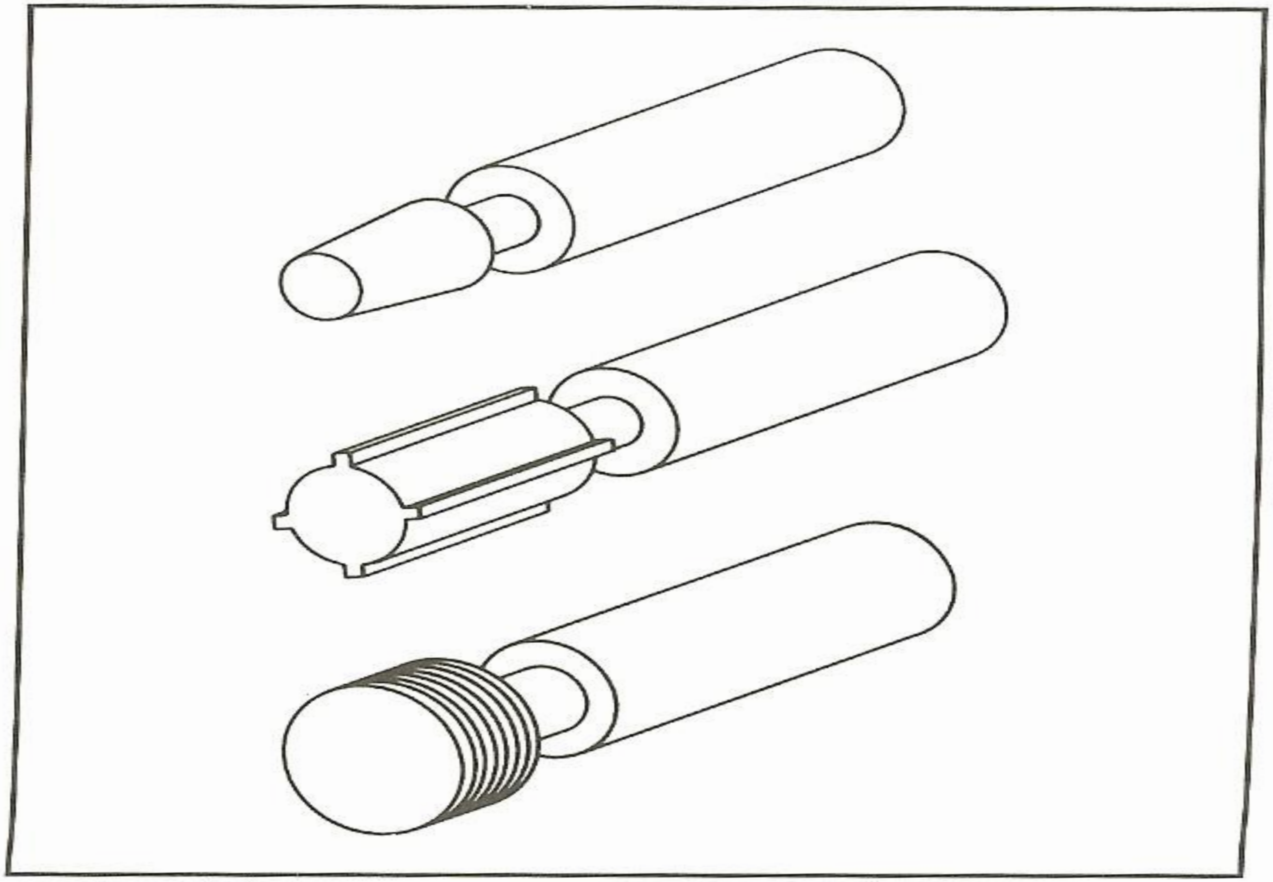


Figure 9-11. *Special plug gages used to inspect the profile or taper of holes. They check the individual feature elements but they do not check the boundary of perfect form.*

Ring gage

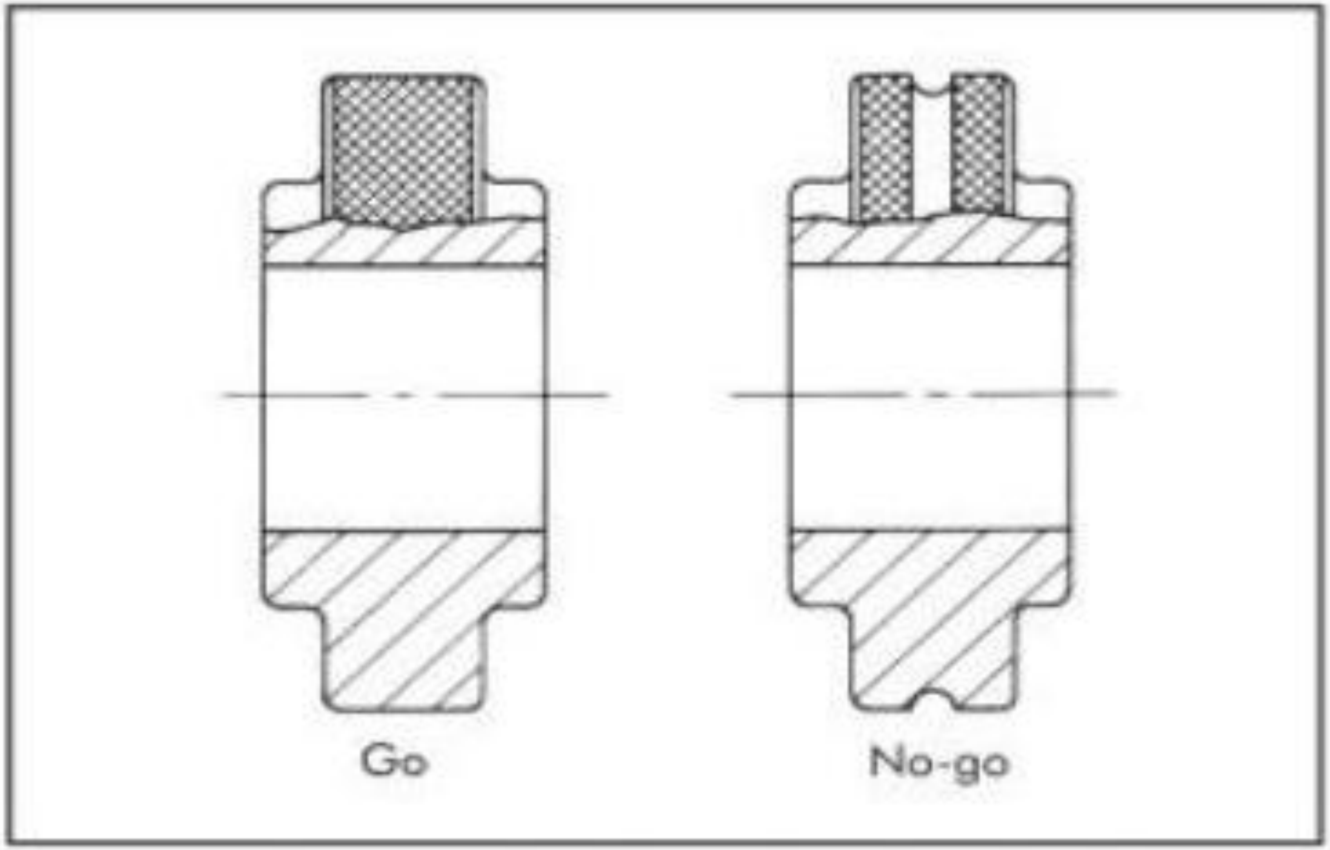


Figure 9-12. *Ring gage set used to inspect the diameter of shafts.*

Special ring gages

Figure 9-13. *Special ring gages to check profile or taper on parts.* *(Courtesy Hemco)*

Snap gage

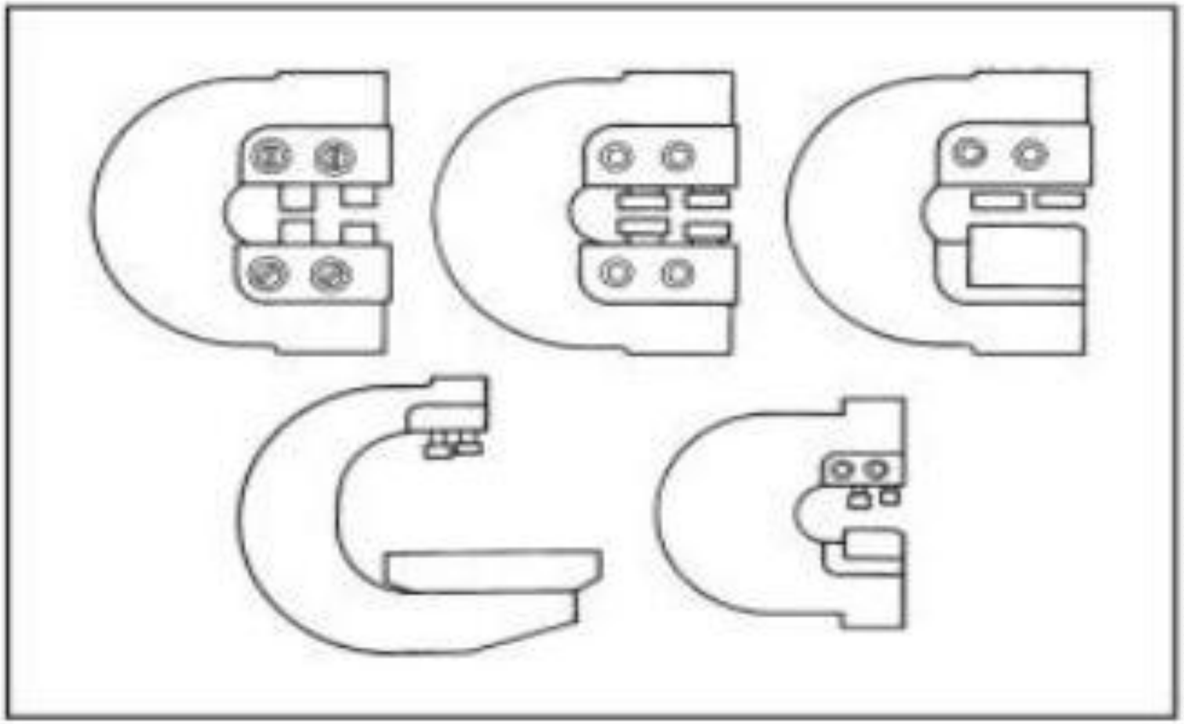


Figure 9-14. *AGD adjustable snap gages.*

Snap gages

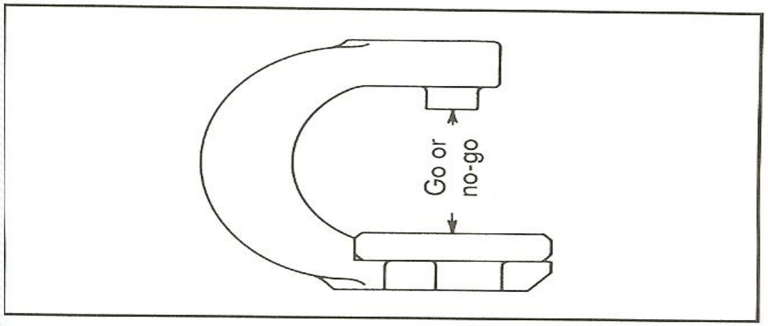


Figure 9-15. *Plain snap gage.*

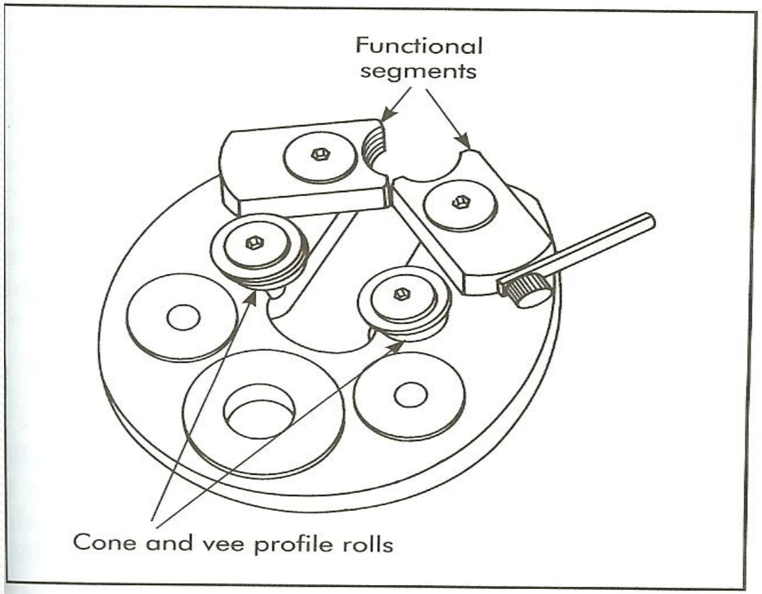


Figure 9-16. *Thread-roll snap gage.*

Snap gages

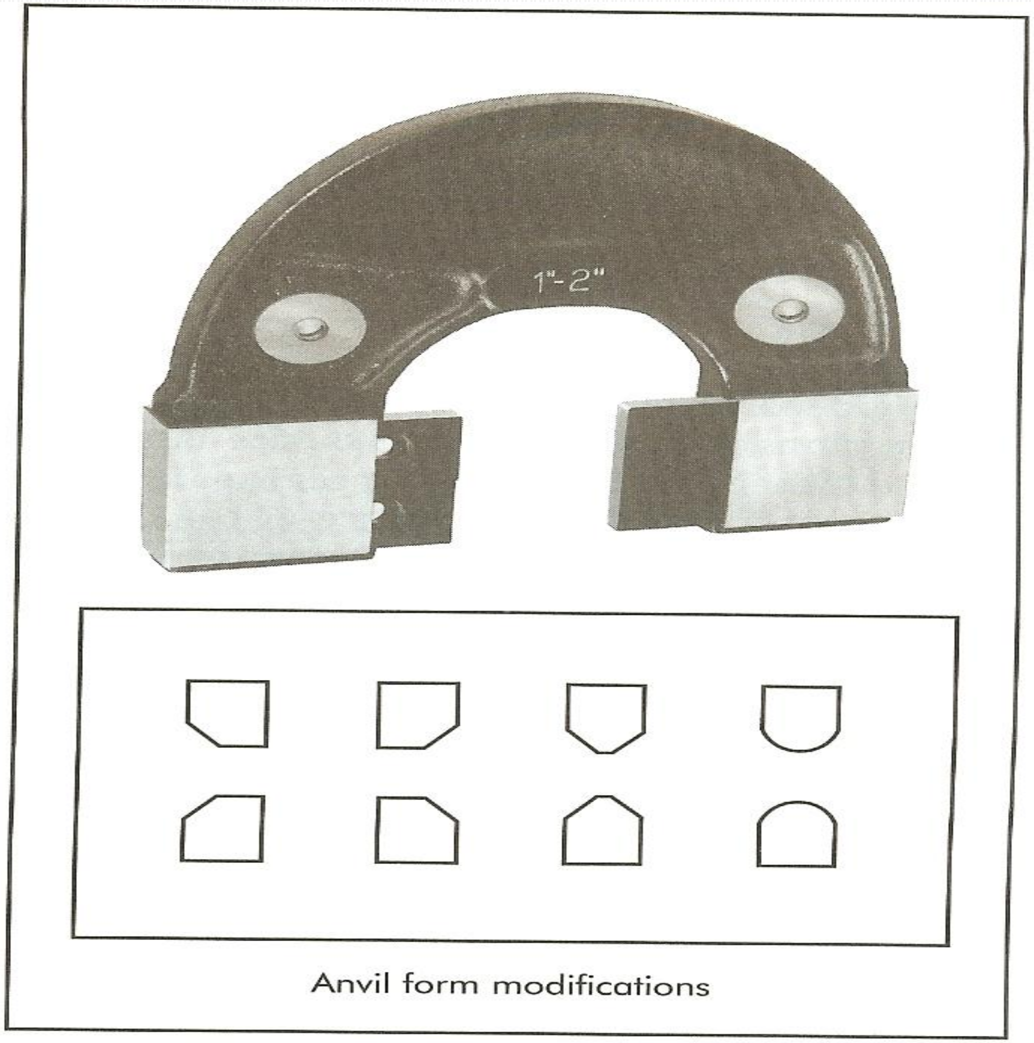


Figure 9-17. *Adjustable form-and-groove snap gage shown with typical anvil form modifications.* (Courtesy Standard Gage Co.)

Special snap gage

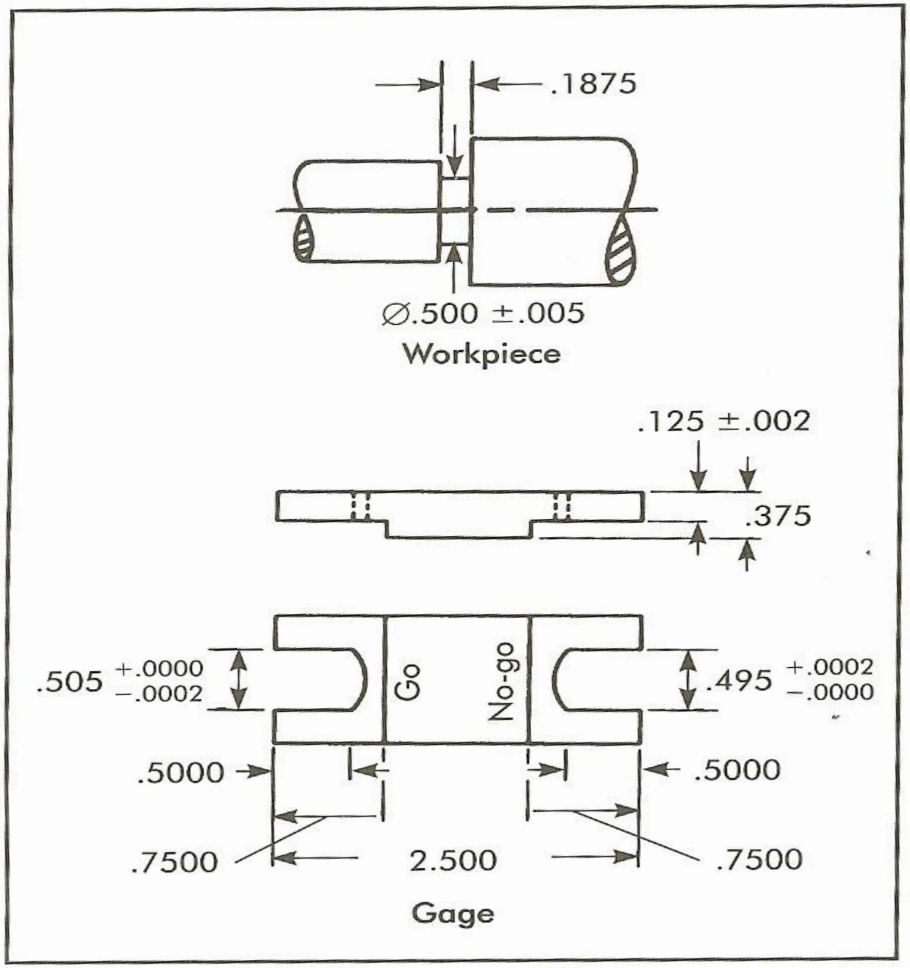
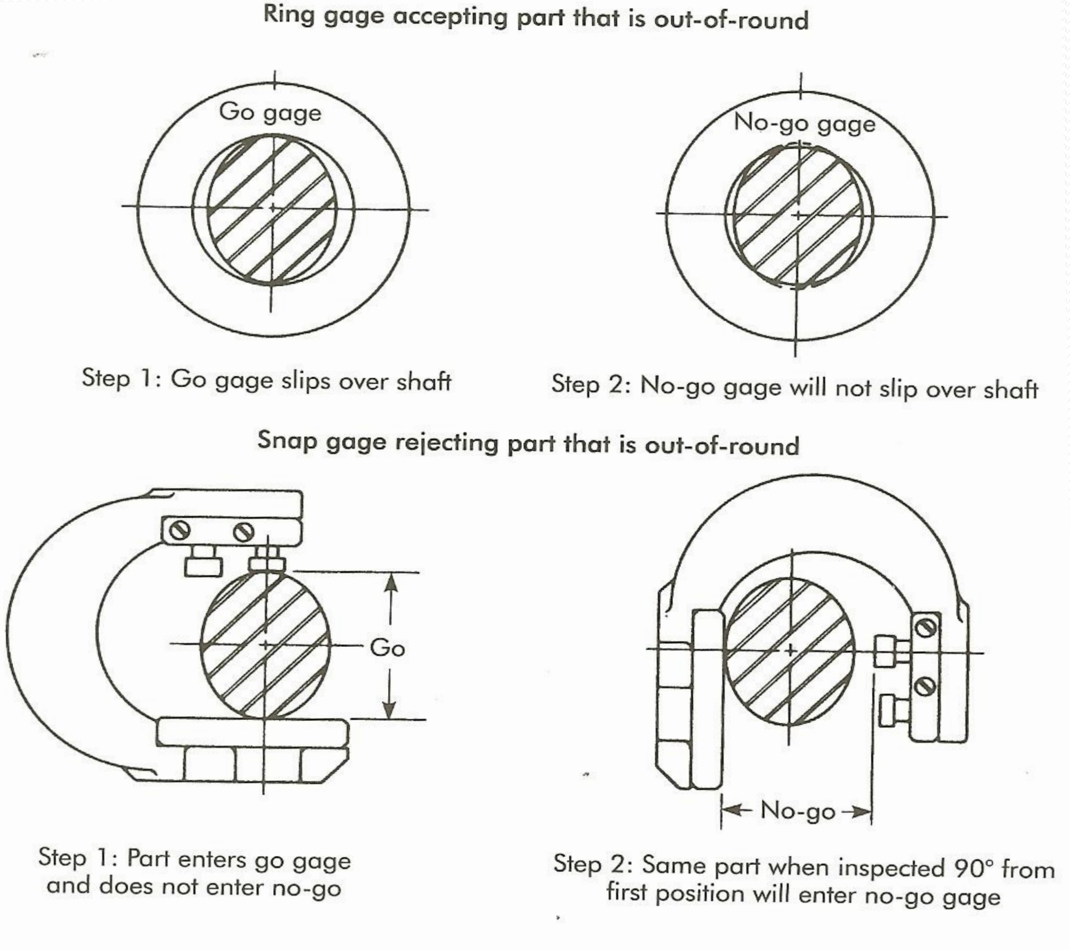


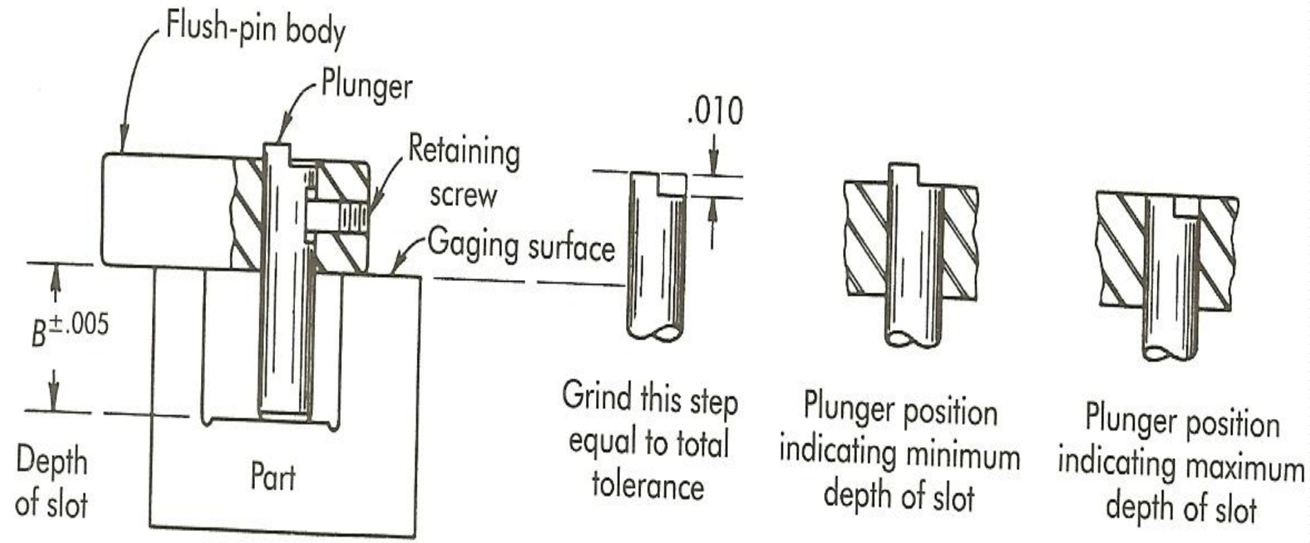
Figure 9-18. *Special snap gage.*

Gage comparison



Gage comparison.

Flush-pin gage



Basic application of flush-pin gage indicating various positions of plunger.

Dial indicators

Figure 9-22. *Dial indicators.* (Courtesy Federal Products Corp.)

Application of dial indicator

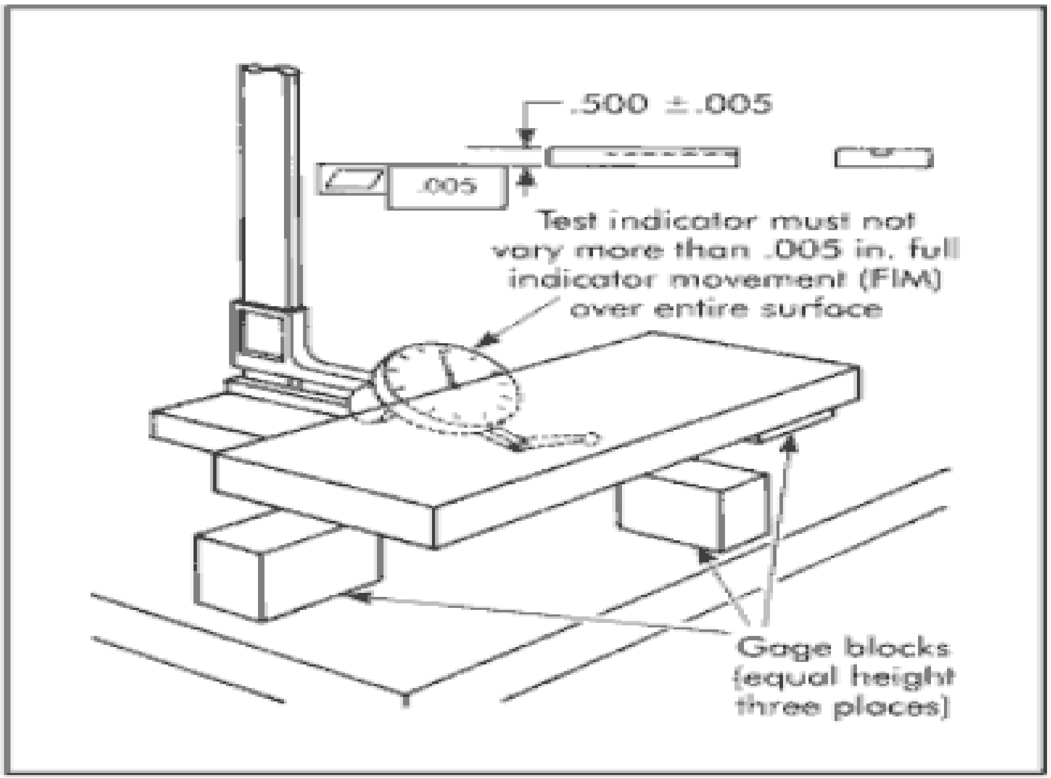


Figure 9-23. *Application of a dial indicator for inspecting flatness by placing the workpiece on gage blocks and checking full indicator movement (FIM).*

Squareness gaging fixture

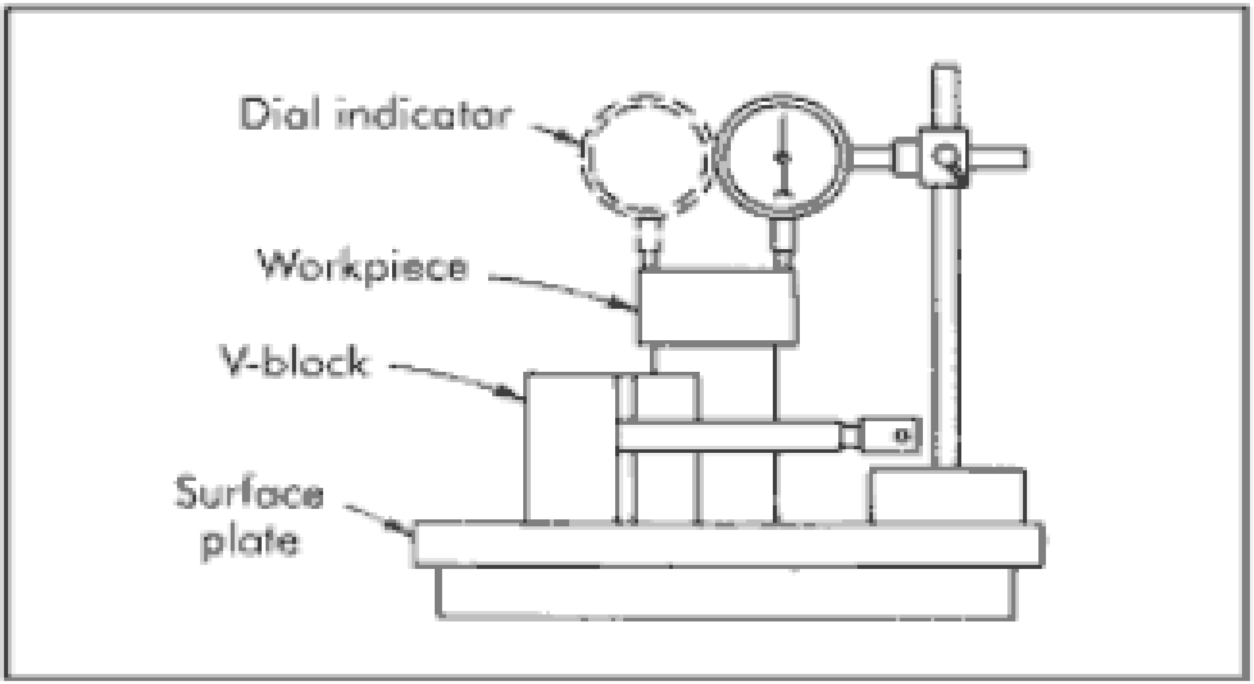


Figure 9-24. *Squareness gaging fixture composed of standard inspection tools.*

Gaging fixture - Accessories

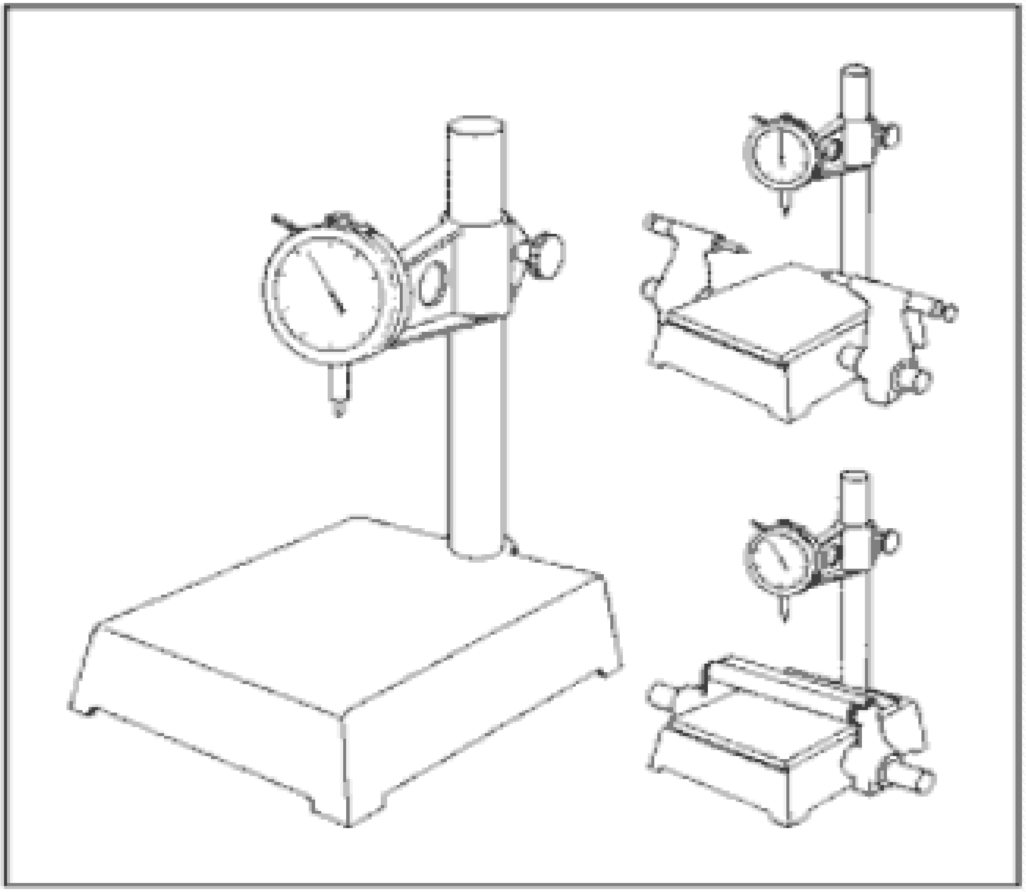


Figure 9-25. *Gaging fixture with accessories.*

Electric or electronic gages

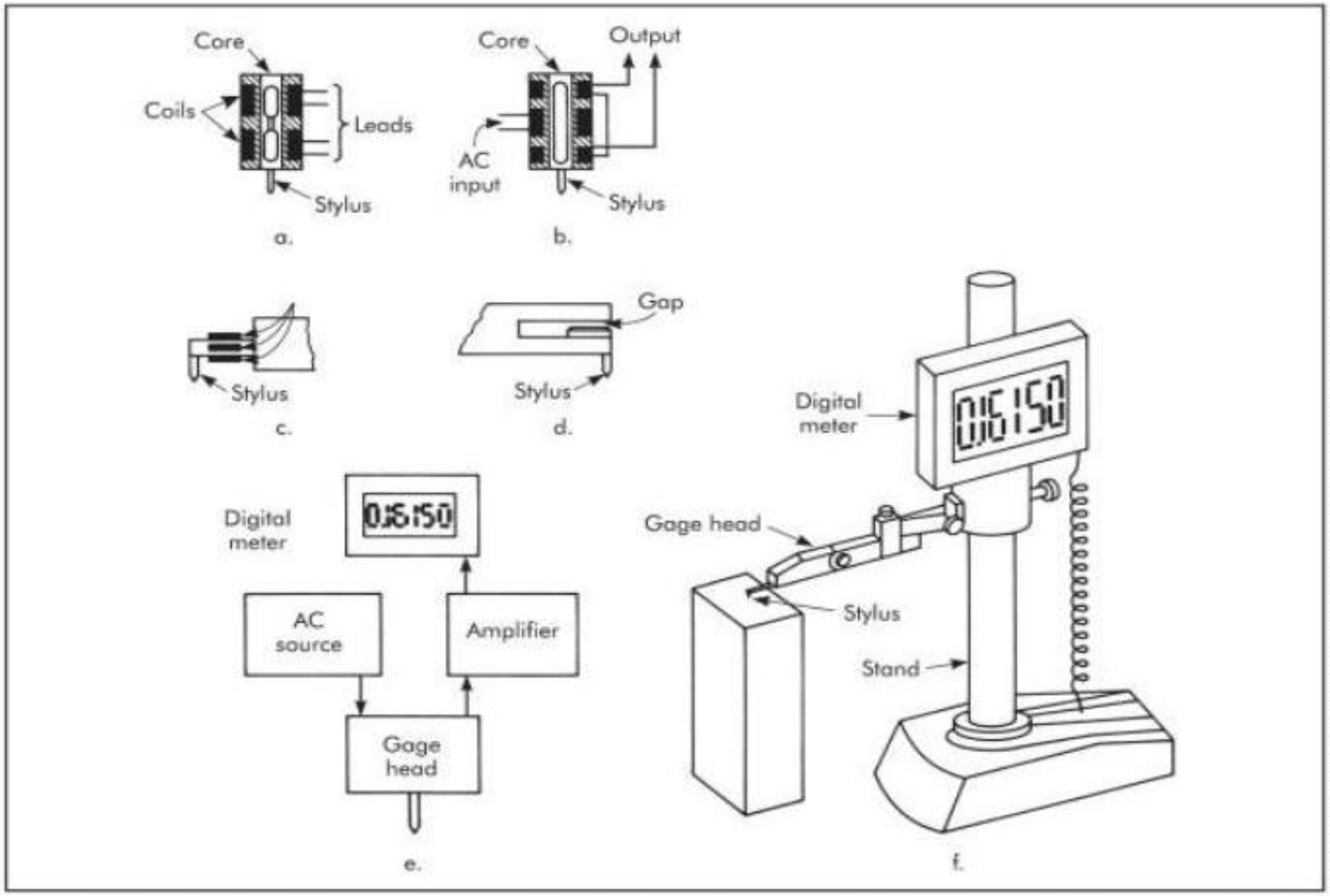
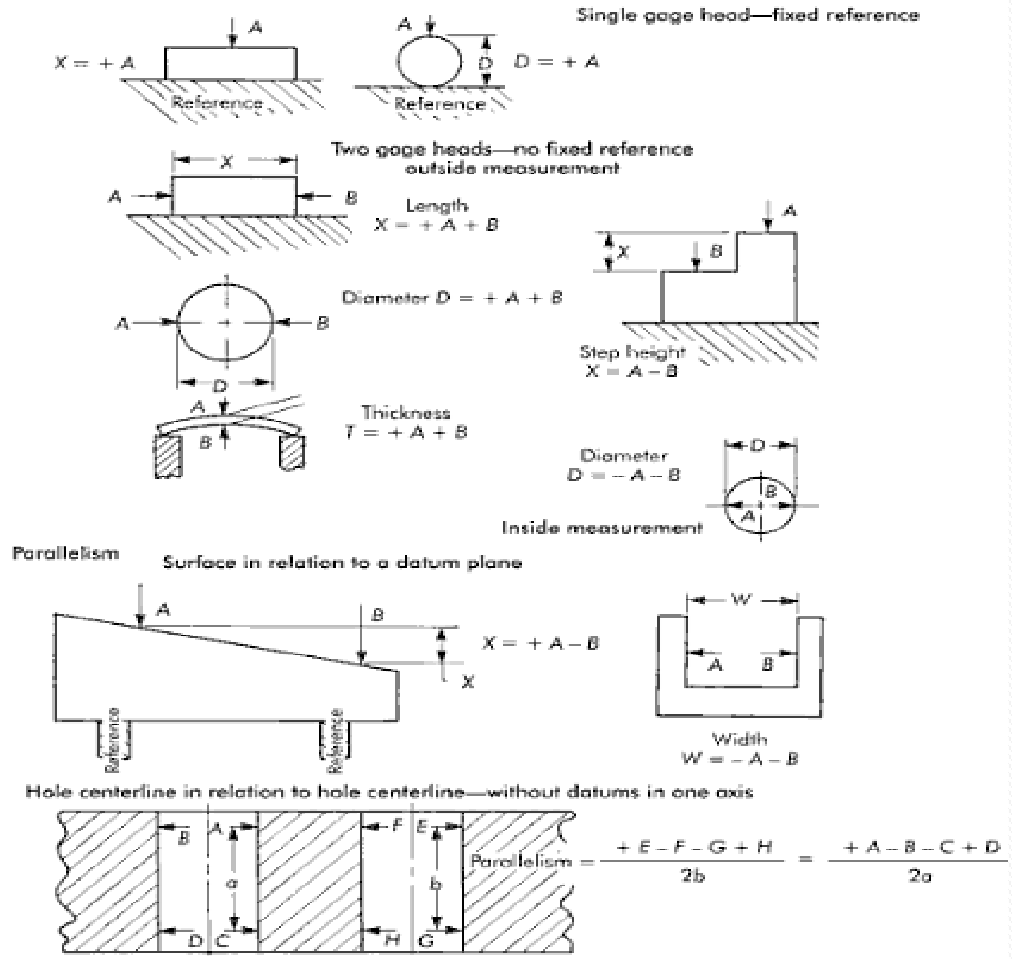


Figure 9-26. *Elements of electronic gages. Types of gage heads: (a) variable inductance; (b) variable transformer; (c) strain gage; (d) variable capacitance; (e) block diagram of typical electronic gage circuit; (f) one model of electronic gage.*

Application data for electronic gaging



Optical projection gaging

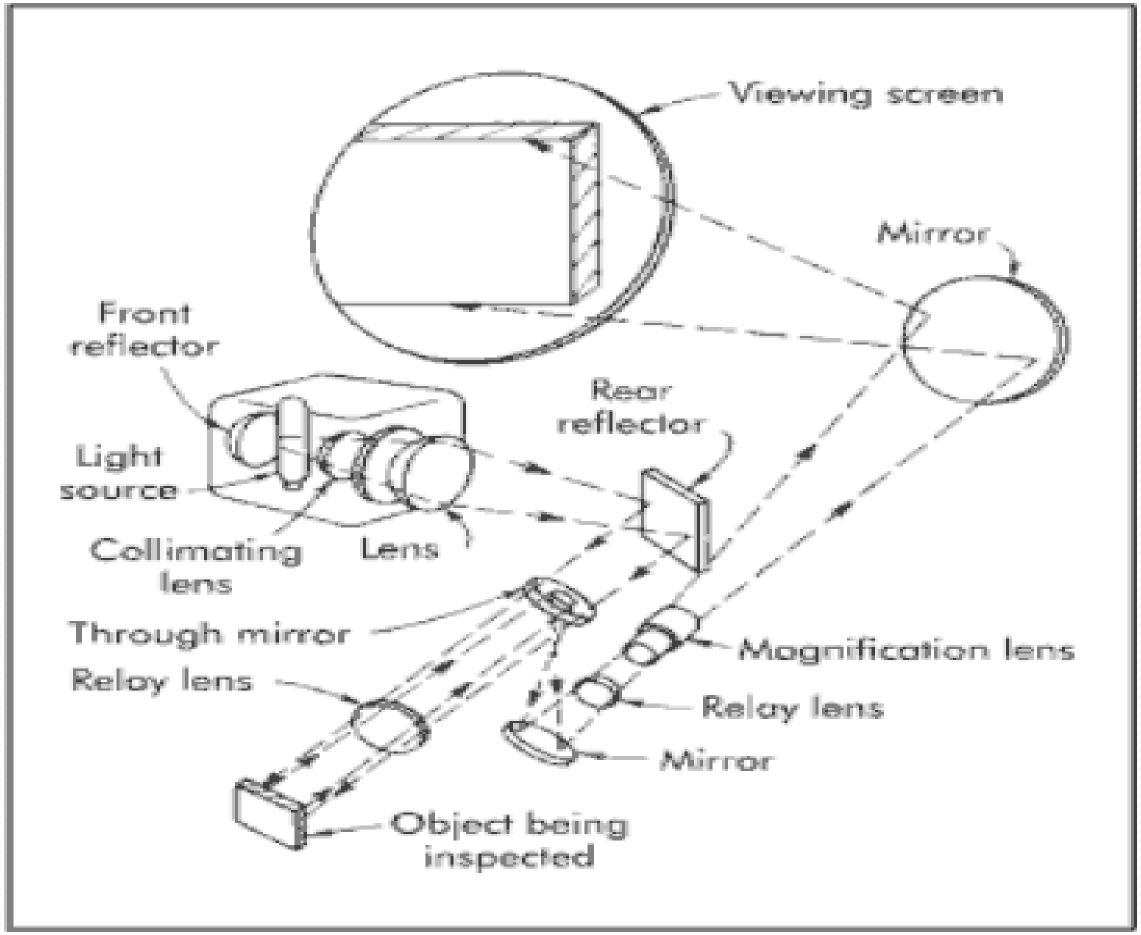


Figure 9-29. *Optical projection gaging principle.*

Chart gages for optical gage

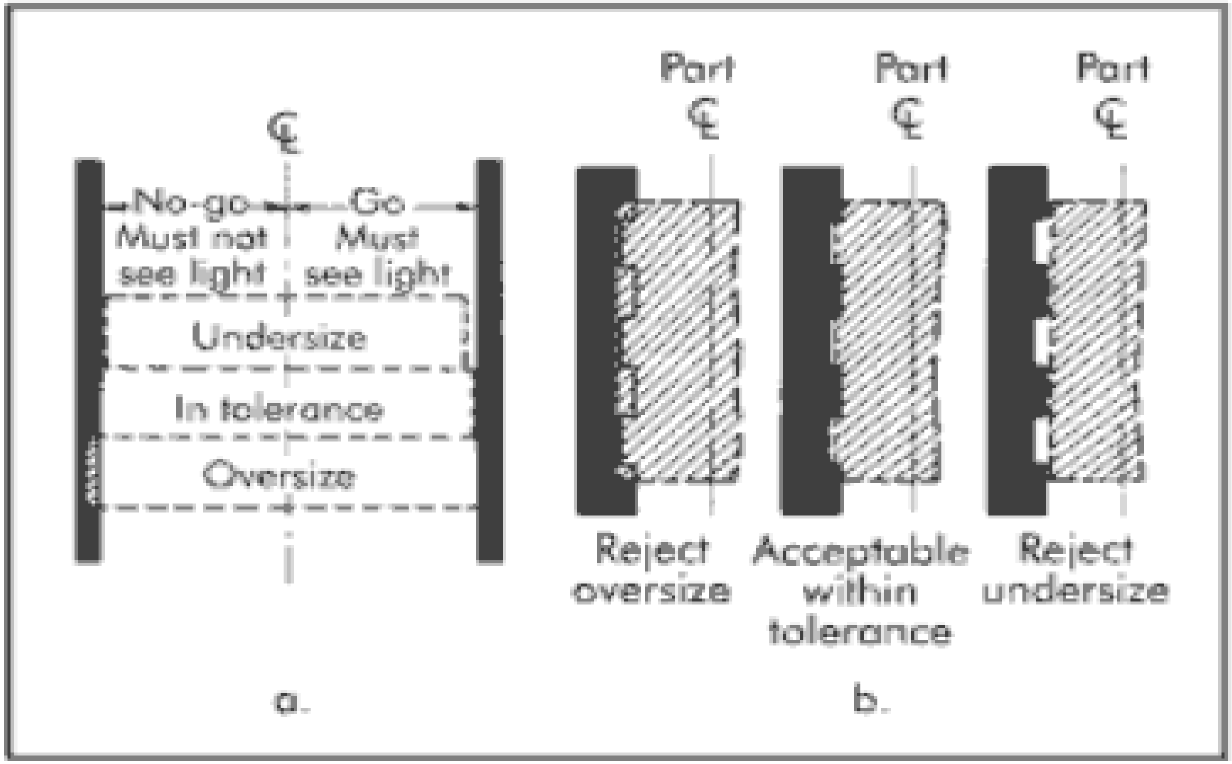


Figure 9-31. *Chart gage segments: (a) maximum and minimum tolerance lines; (b) close-tolerance bridge arrangement.*

CMM

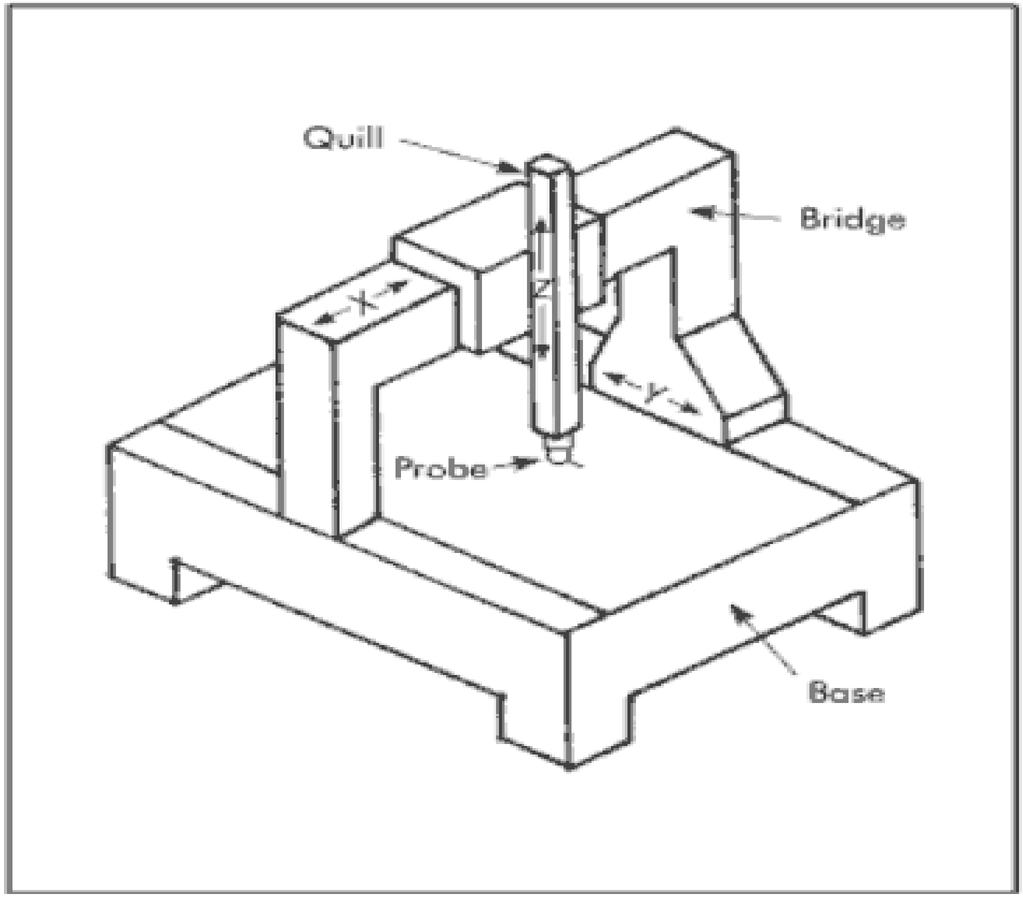


Figure 9-33. *Typical moving-bridge coordinate measuring machine configuration.*

Gaging methods - Flatness

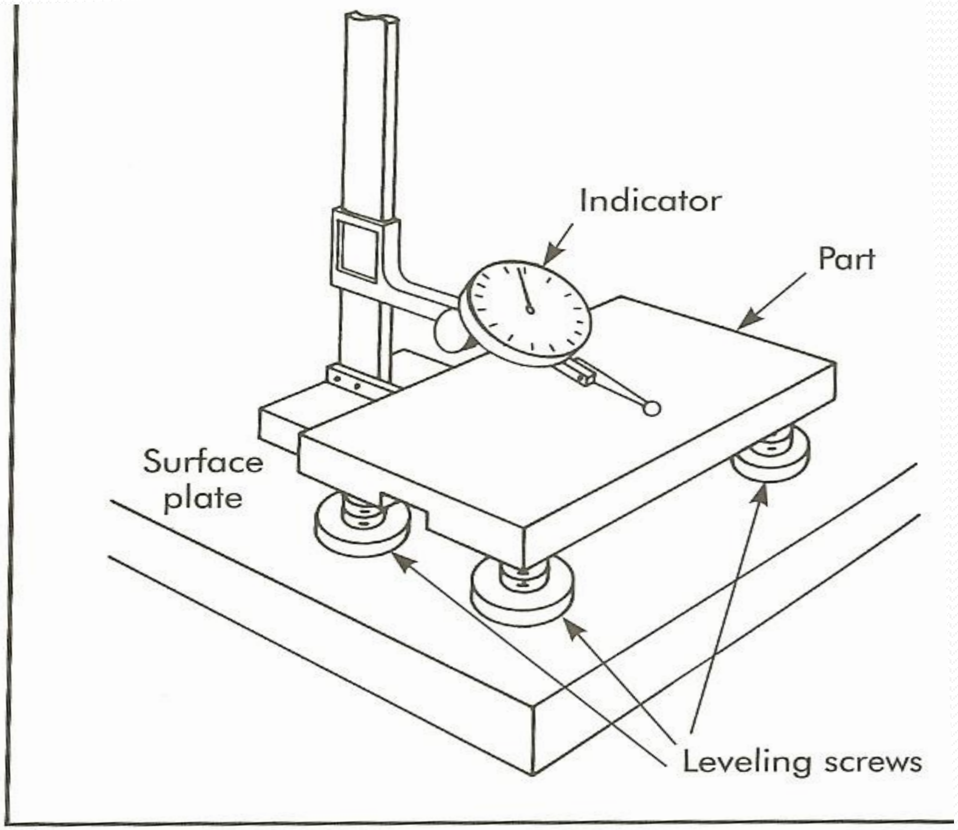


Figure 9-39. *Leveling a part.*

Gaging methods – Straightness

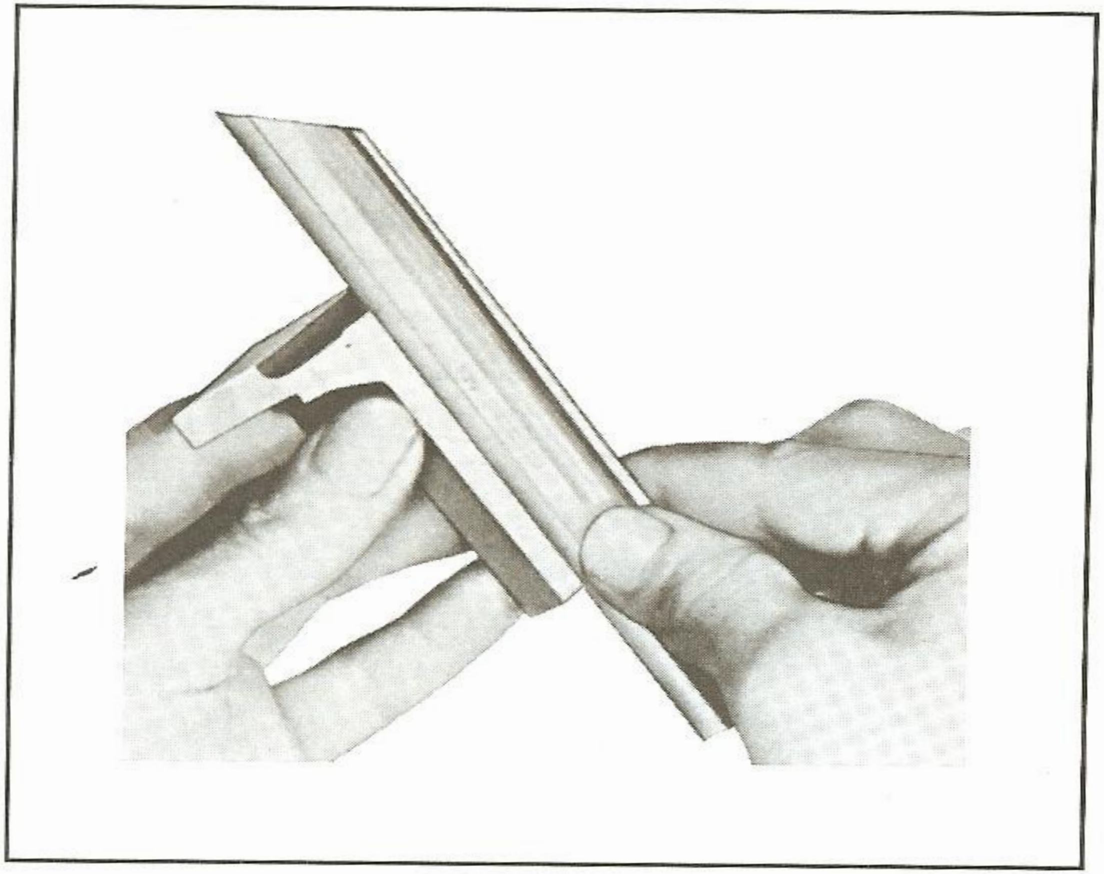


Figure 9-40. *Checking surface element straightness with a toolmaker's straightedge.*

Gaging methods – Straightness

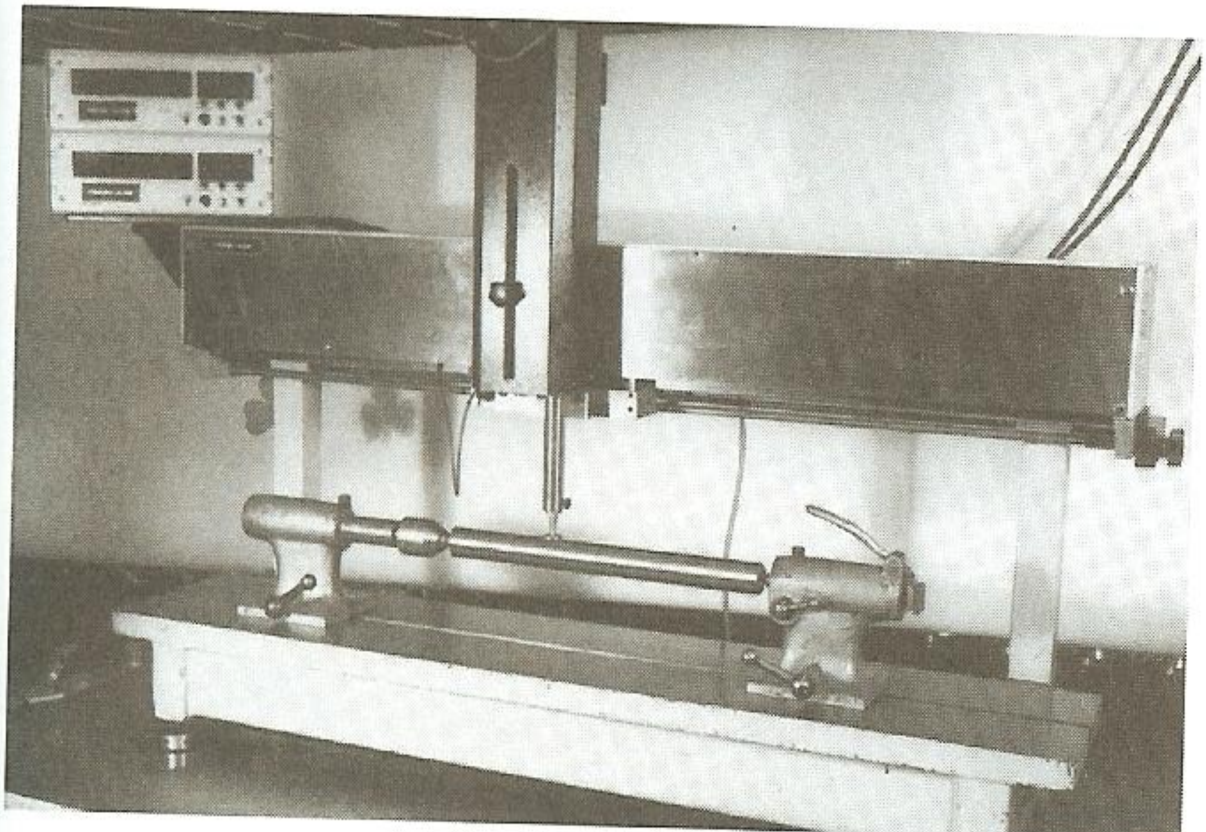
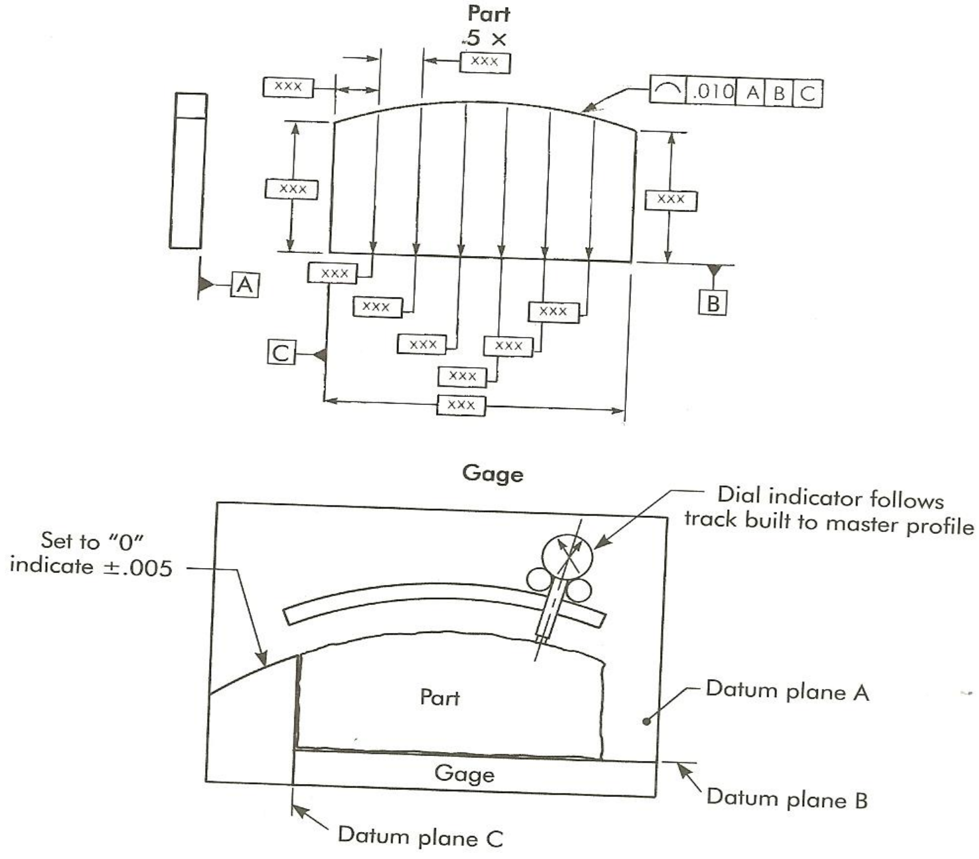


Figure 9-41. *Checking straightness while the part is held motionless.*

Gaging methods – Line Profile



Checking profile—indicator following a master profile.

Gaging methods – Squareness

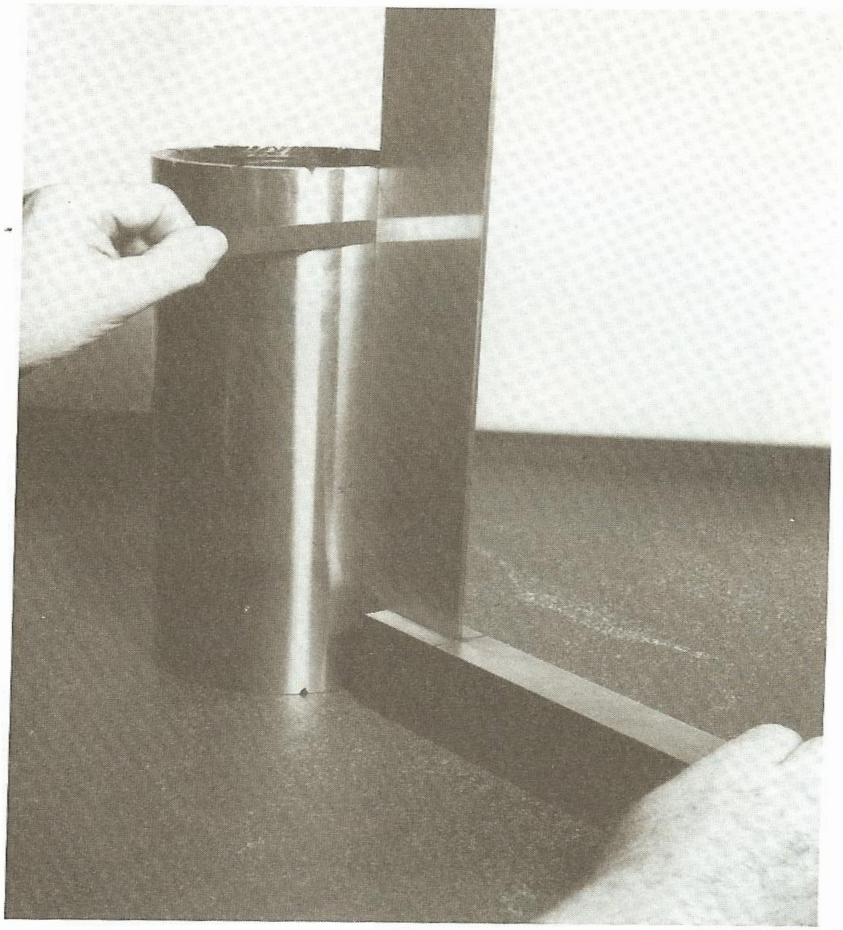


Figure 9-45. *Checking squareness with a square.* (Courtesy L.S. Starrett Co.)

Gaging methods – Perpendicularity

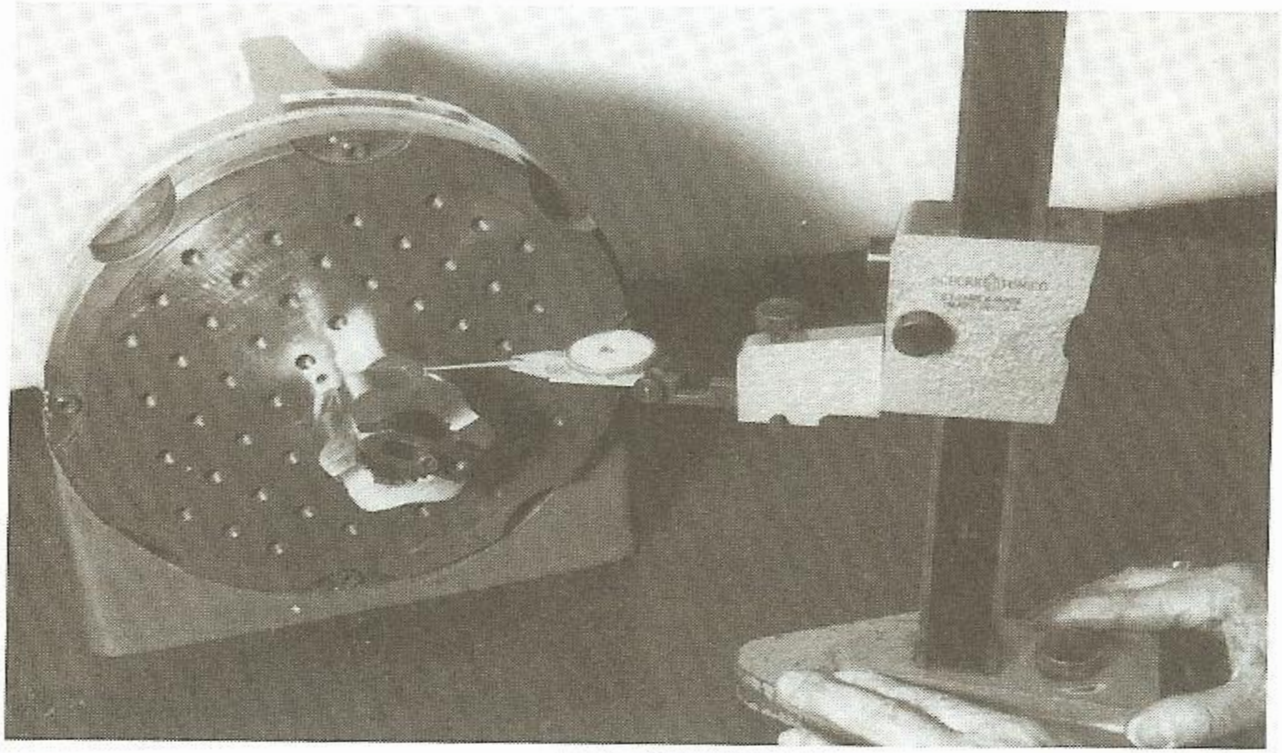


Figure 9-50. *Checking perpendicularity with a height stand and an indicator.* (Courtesy Scherr-Tumico)

Functional gage

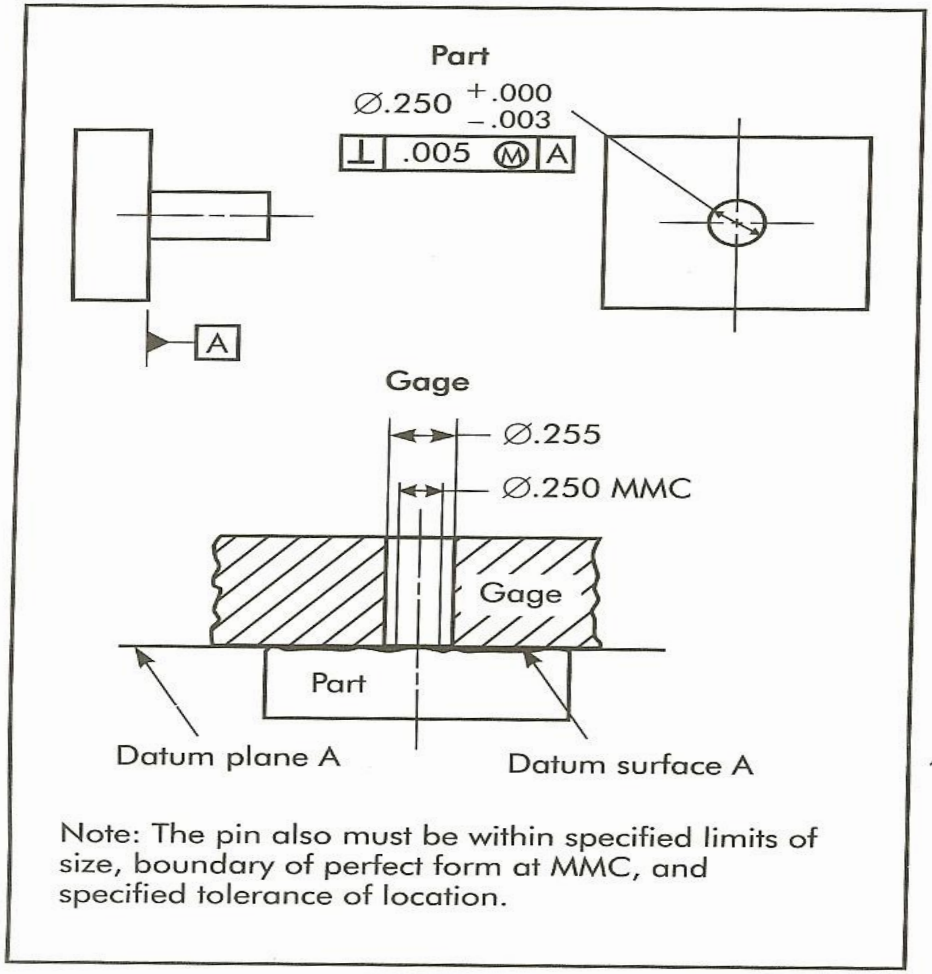


Figure 9-51. *Functional gage to check perpendicularity, cylindrical size feature, and MMC.*

Parallelism

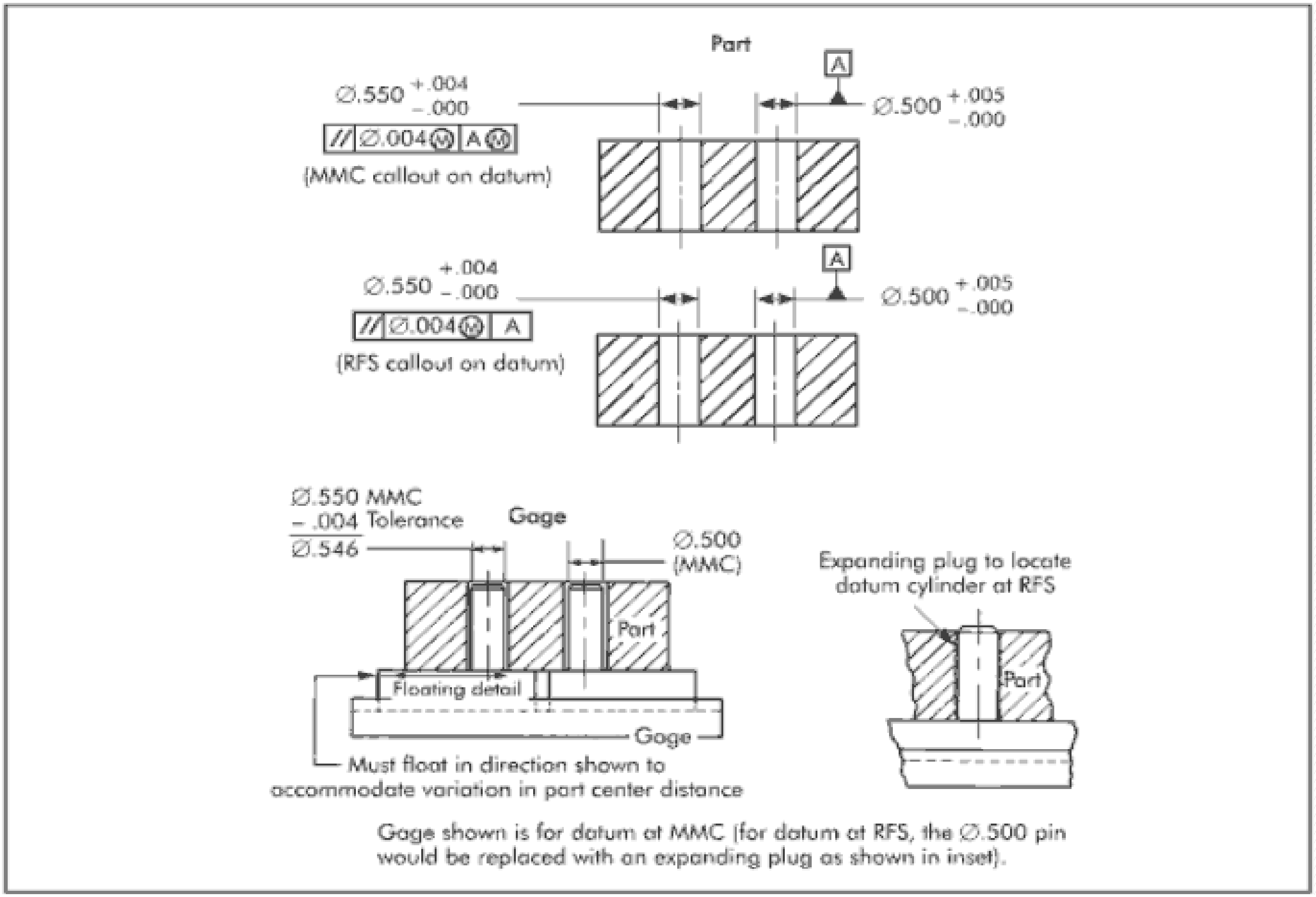


Figure 9-52. *Gage for checking parallelism—cylindrical size feature.*

Runout

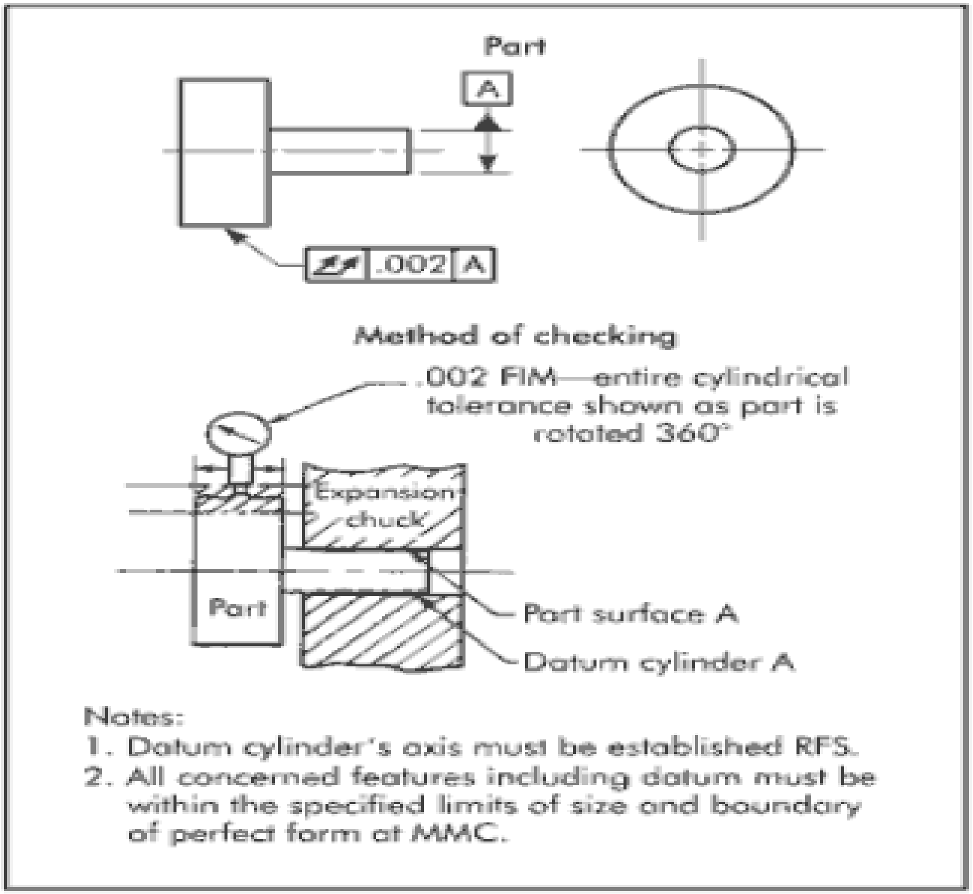


Figure 9-54. *Checking runout from an OD datum.*

References

- Fundamentals of tool design, fifth edition, Society of Manufacturing Engineers
- Donaldson, and Lecain, Tool Design, McGraw Hill

Questions?