9. Inspection and Gaging Tools

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Inspection

- Nominal dimension
- Tolerance
  - Use
  - Appearance
  - Cost
- Datum or Reference

Basic principles of gaging

- Measurement
  - Measuring can be defined as the determination of a dimension.
- Gaging
  - Gauging is defined as the acceptability of a given dimension whether it lies in its specified or allowable limits or not.
- Gage tolerance
  - 10% work tolerance

Gage maker tolerances

Table 9-1 Standard Gage Maker’s Tolerances

<table>
<thead>
<tr>
<th>Above (in)</th>
<th>To and including (in)</th>
<th>XX</th>
<th>X</th>
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<tbody>
<tr>
<td>0.010</td>
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Gage tolerances

- Plug gage for 1 ± 0.0006 inches
- Gage tolerance = 0.00012 inch
- From table Z class
- If Plug gage for 1 ± 0.0006 inches
- Gage tolerance = 0.00006 inch
- From table X class
Gage tolerances

- Plug gage for 1 ± 0.0075 inches
- Gage tolerance = 0.0015 inch
- From table Z class
- Smaller degree of gage tolerance means more expensive
- Gage tolerances should be realistically applied.

Allocation of gage tolerances

- Bilateral system
  - The GO and NOGO gage tolerance zones are divided into two parts by the high and low limits of the workpiece tolerance zone

Allocation of Gage Tolerances

- Hole to be gaged 1.2500 ± 0.0006 inch
- Work tolerance = 0.0012 inch
- Hole size from 1.2506 to 1.2494 inch
- Gage tolerance (10%) = 0.00012 inch
- Z-class tolerance zone
  - GO gage size 1.2494 ± 0.00006 inch
  - NOGO gage size 1.2506 ± 0.00006 inch

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Allocation of Gage Tolerances

- Unilateral system
  - The work tolerance zone entirely includes the gage tolerance zone
  - Work tolerance smaller by the sum of the gage tolerance

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Maximum Work Tolerance limit

Minimum Work Tolerance limit

Work tolerance zone

Bilateral

Unilateral

Allocation of gage tolerances

- Commercial gages
  - Allocate gage tolerance negatively with reference to both the maximum and minimum limits of the workpiece tolerance (C)
  - NOGO gage tolerance is divided by the maximum limit of the workpiece tolerance and the GO gage tolerance is held within the minimum limit of the workpiece tolerance.

Allocation of gage tolerances

- Hole to be gaged 1.2500 ± 0.0006 inch
- Work tolerance = 0.0012 inch
- Hole size from 1.2506 to 1.2494 inch
- Gage tolerance (10%) = 0.00012 inch
- Z-class tolerance zone
- GO gage size 1.24940 + 0.00012 inch
- NOGO gage size 1.25060 - 0.00012 inch

Gage Wear Allowance

- Wear allowance is an amount added to the nominal diameter of a GO-plug and subtracted from that of a GO-ring gage.
- It is used up during the gage life by wearing away of the gage metal.

The objectives in choosing an allowance system should be the economic production of as near 100% usable parts as possible, and the acceptance of the good pieces and rejection of the bad.
Hole diameter 1.5000 ± 0.0006 inch
Work tolerance = 0.0012 inch
Gage tolerance (10%) = 0.00012 inch
GO gage size 1.49940 + 0.00006 = 1.49946 inch
Add gage maker tolerance as shown previously, 1.49946 +0.00012 and –0.00000 as limits

Gage Wear Allowance (5%)

Gage Materials
- Chrome plated
- Tungsten carbide tipped

Surface Plate
- Main horizontal reference plane
- Rigid block of granite or cast iron
- Generally have three-point suspension to prevent rocking when mounted on uneven surface
- Two types
  - Cast-iron plates
  - Granite surface plates

Surface Plate
- Cast-iron plates
  - Well ribbed and high strength
  - Good wear-resistance qualities
  - After machined, surface scraped by hand to flat
  - Operation long and cost high
- Granite surface plates
  - Manufactured from gray, pink, or black granite
  - Several degrees of accuracy
  - Extremely flat finishes produced by lapping

Advantages of Granite Plates
- Not appreciably affected by temperature change
- Will not burr; therefore, accuracy not impaired
- Nonmagnetic
- Rustproof
- Abrasives will not embed themselves as easily in the surface
Chapter 9: Gaging and template

Template

- Specified profile
- Guide to the location of workpiece features with reference to a single plane.
  - A straight edge is a template for checking straightness.
  - Radius gages
  - Screw pitch gages

Fig 9-6 Gaging the profile of a workpiece with a template

Fig 9-7. Typical surface plate setup.

Plug Gages

- A plug gage is a fixed gage usually made up of two members
- One member is called the GO end and the other the NO-GO or NOT-GO end
- AGD – American Gage Design standards

Fig 9-10. Screw pitch gage and method of application.
Ring gages

- Ring gages are usually used in pairs, consisting of go member and no-go member.

Figure 9-11. AGD cylindrical plug gages used to inspect the diameter of holes.

Figure 9-12. AGD cylindrical plug gage (A) reversible ring type, (B) taper lock design, (C) rivet design.

Figure 9-13. Special plug gages used to inspect the profile or taper of holes. They check the individual features elements but they do not check the boundary of perfect form.

Figure 9-14. Ring gage set used to inspect the diameter of shafts.

Figure 9-15. Special ring gages to check profile or taper on parts. (Courtesy, Heineco)
Snap Gages

- For measuring length, diameter, thickness or width

Figure 9-17. Plain snap gage.

Figure 9-18. AGD adjustable snap gages.

Figure 9-19. Adjustable form and groove snap gage shown with typical anvil form modifications. (Courtesy, Standard Gage Co.)

Figure 9-20. Special snap gage.
As the measurable error becomes small, it is difficult for direct reading and hence some means of magnification is required.

- Dial indicators
- Optical
- Pneumatic gauging
Geometric Dimensioning and Tolerancing

- ASME Y14.5-1994 (Rev. 2009)
- ISO 1101, 129, 3040

Modifiers

- Maximum Material Condition (MMC) -
  - Minimum diameter of a hole and maximum diameter of a shaft
- Least Material Condition (LMC)
  - Maximum diameter of a hole and minimum diameter of a shaft
Checking process depends upon the accuracy required.
- Using a dial indicator
- After the surface is leveled, the indicator explores the entire area and the full indicator movement is a measure of flatness.

Flatness checking

Checking a Profile
- Follow a master part as shown in Fig 9-42.
- Number of dial indicators set in a plane confirming the contour as shown in Fig 9-43.

Checking for Parallelism/Perpendicularity
- Parallelism can be checked by placing a part on a surface plate and searching for out of parallel condition with an indicator.
- Some times a special fixture may be required as shown in Fig 9-49.
- Perpendicularity of a cylindrical feature and its MMC can be checked with a functional gage as shown in Fig 9-51.
Checking a Runout

- Total runout consists, by definition, of two concentric cylinders that encompass a feature about a defined axis.
- Generally, total runout is measured by taking single runout at intervals along an entire cylinder.
- The extremes of needle deflection for the entire set of intervals yields total runout.
Checking a Position

- Two holes that need to be gaged.
- Shown is a hole relation gage to check hole-to-hole relationship.
- If RFS (Regardless of Feature Size) is used in place of MMC, gaging will become difficult.
- To maintain the positional tolerance of 0.10 in eleven gage pins will be required for all sizes between MMC and LMC.
For parts with internal features, the nominal gage feature size is directly determined by subtracting the total positional tolerance specified at MMC from the specified MMC size of the feature to be gaged for location.

For parts with external features, the nominal gage feature size is directly determined by adding the total positional tolerance specified at MMC size of the feature to be gaged for location.